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土 木 研 究 所 資 料

Technical Note of Public Works Research Institute No. 4050 June 2007

第 4 回 日米水道水質管理及び下水道技術に関する政府間会議 報 告 書

PROCEEDINGS OF THE 4TH JAPAN-U.S. GOVERNMENTAL CONFERENCE ON DRINKING WATER QUALITY MANAGEMENT AND WASTEWATER CONTROL

平成19年1月22日~25日 沖縄・万国津梁館

January 22-25, 2007 Bankoku Shinryokan, Okinawa, Japan

国土交通省 国土技術政策総合研究所

National Institute for Land and Infrastructure Management Ministry of Land, Infrastructure and Transport, Japan

独立行政法人 土木研究所

Incorporated Administrative Agency Public Works Research Institute

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国土技術政策総合研究所資料 第402号 平成19年6月 土 木 研 究 所 資 料 第4050号 平成19年6月

第4回 日米水道水質管理及び下水道技術に関する政府間会議 報告書

国土交通省 国土技術政策総合研究所 下水道研究部 独立行政法人 土木研究所 リサイクルチーム/水質チーム

概要

この報告書は、平成19年1月22日~25日に沖縄県名護市にある万国津梁館で行われた「第4回日米水道水質管理及び下水道技術に関する政府間会議」における議事録及び発表資料等を取りまとめたものである。同会議では、日米の政府・自治体・研究機関の代表者により、水道水質管理及び下水道技術に関する両国の現状と課題について発表と意見交換が行われた。

キーワード: 水道水質管理、下水道技術、流域管理、二国間協力

Technical Note of NILIM No. 402 June 2007 Technical Note of PWRI No. 4050 June 2007

PROCEEDINGS OF THE 4TH JAPAN-U.S. GOVERNMENTAL CONFERENCE ON DRINKING WATER QUALITY MANAGEMENT AND WASTEWATER CONTROL

Water Quality Control Department, National Institute for Land and Infrastructure Management Ministry of Land, Infrastructure and Transport, Japan

Recycling Research Team & Water Quality Research Team, Incorporated Administrative Agency Public Works Research Institute

Synopsis

This publication contains the proceedings of the 4th Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control, which was held at Bankoku Shinryokan, Okinawa, Japan during January 22-25, 2007. In this Conference, current status and subjects of drinking water quality management and wastewater control were presented and discussed by government and municipal officials and researchers of Japan and U.S.

Key Words: Drinking Water Quality Management, Wastewater Control, Watershed Management, Bilateral Cooperative Research

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1 はじめに

平成 19 年 1 月に、沖縄県にある万国津梁舘において「第 4 回日米水道水質管理及び下水道技術に関する政府間会議」が開催され、日米両国の上下水道を巡る最近の話題について、和やかな中にも熱心な討議が行われた。11 分野の議題に対し、日米双方から 31 編の発表があり、最終日には討議の総括が行われ、議論の確認と次回の会議を 2 年後に米国で開催すること等が合意された。

本報告書は、今後の下水道分野における政策研究、技術開発の推進及び国際協力の促進のために、日本の下水道分野から本会議に参加した国土交通省都市・地域整備局、国土交通省国土技術政策総合研究所、独立行政法人土木研究所、地方共同法人日本下水道事業団、財団法人下水道新技術推進機構及び沖縄県庁が本会議の概要をとりまとめたものである。なお、水道分野の発表と討議の概要については、とりまとめにあたり国立保健医療科学院の国包部長をはじめとする水道分野の参加者の御協力をいただいた。

2 経緯

日米水道水質管理及び下水道技術に関する政府間会議(以下、日米会議という。)は、第 1 回会議が平成 11 年 7 月に米国コロラドスプリングスにて開催された後、第 2 回会議が平成 14 年 10 月に東京にて、第 3 回会議が平成 16 年 7 月に米国ハワイ州にて開催された。本会議は、第 3 回会議における合意に基づき日本で開催されたものである。

そもそも、日米両国間の水道、下水道分野の技術交流はかつて分野別に実施されていて、下水道分野では日米環境保護協力協定(US-Japan Environmental Protection Agreement)に基づき、昭和46年より日米下水処理技術委員会(US-Japan Conference on Sewage Treatment Technology)、さらに平成2年より日米下水道ワークショップが継続的に開催されていた。水道分野については、日米環境保護協力協定に基づく日米水道水質管理会合が昭和62年から開催されていた。しかし、上下水道を取り巻く環境として、流域を一体として捉えた水量・水質の管理、クリプトスポリジウムや内分泌かく乱物質の問題等共通の課題や共有すべき情報が多く、上下水道関係者が一堂に会して意見・情報交換を行うことが有益であることから、平成11年に両分野の会議を日米会議として統合することとなった。

3 会議開催の意義

下水道技術に関しては、公共用水域の利用や生態系の保全のために化学物質のリスク管理及び下水処理の新技術は重要度を増しており、流域管理の視点からは、高度処理推進のため流域別下水道整備総合計画制度を見直す下水道法の改正が平成17年6月になされた。同年4月には、下水処理水の再利用につき水質基準等に関するマニュアルが策定されたところである。また、老朽化する下水道施設の管理は喫緊の課題であることから、アセットマネジメントの導入の取組が進展しており、下水道の地震対策については知見が集積されてきた。さらに、同年9月に「下水道ビジョン2100」が策定され、長期の将来像を見据えた下水道の方向性及び具体化のための施策が示された。

水道水質の管理については、水安全計画の水道システムへの適用が貯水槽も含め推進されており、統合的な水資源保全に向けて水道における流域管理は高い重要度を有している。また、海水淡水化等水道水質管理に関する新技術は、継続的な進展を見せているところである。さらに、消毒副生成物の問題、クリプトスポリジウム等耐塩素性病原微生物の問題等、多様な問題が提議されてきていることを踏まえ、微生物や化学物質による健康リスクの評価及びその管理の充実・強化が重要な課題として取り組まれて

いる。

一方、米国でも、水道水や環境における化学物質のリスクアセスメント・リスクマネジメント、気候変動の水資源への影響及び水の再利用は重要な課題となっており、流域管理の一層の推進が求められている。また、ハリケーン・カトリーナの経験から緊急時対応の教訓が得られており、淡水化や下水処理等につき新技術の開発が進められているところである。上下水道施設の持続可能な管理は、事業経営という観点からも大きな課題となっている。

このように日米両国は、水道水質管理及び下水道技術の分野において、多くの共通の問題を抱えており、相互に情報を交換し、対策について議論することは、両国のみならず国際的にも意義が深く、また、上下水道が連携した流域管理を推進する観点からも重要である。

4 日程及び参加者

「第4回日米水道水質管理及び下水道技術に関する政府間会議」は、平成19年1月22日~25日の4日間にわたり沖縄県にある万国津梁舘で開催された。このうち3日間は発表及び討議が行われ、1月23日午後と1月25日には水関連施設の視察が行われた。本会議には、米国環境保護庁研究開発局水道水資源課長のジェームス・グッドリッチ氏を団長とする13名の米国代表団と、日本国側の清水亨国土交通省都市・地域整備局下水道部流域管理官を団長とする下水道分野11名、山村 尊房厚生労働省健康局水道課長を団長とする水道分野11名が参加した。参加者の所属と氏名を表1と表2に示す。また、会議次第を表3に示す。

表 1 参加者名簿(日本国代表団)

【下水道分野】		
○清水	亨	国土交通省都市・地域整備局下水道部 流域管理官
那須	基	国土交通省都市・地域整備局下水道部下水道企画課 下水道技術開発官
田中	修司	国土交通省国土技術政策総合研究所 下水道研究部長
松宮	洋介	国土交通省国土技術政策総合研究所下水道研究部下水道研究室 主任研究官
吉澤	正宏	国土交通省国土技術政策総合研究所下水道研究部下水処理研究室 主任研究官
尾崎	正明	土木研究所材料地盤研究グループ(リサイクル) 上席研究員
鈴木	穣	土木研究所水環境研究グループ(水質) 上席研究員
山下	洋正	土木研究所材料地盤研究グループ(リサイクル) 主任研究員
村上	孝雄	日本下水道事業団技術開発研修本部技術開発部 先端研究役・総括主任研究員
藤木	修	下水道新技術推進機構 研究審議役・研究第一部長
黒島	隆	沖縄県下水道建設事務所 主任技師
【水道分	分野 】	
○山村	尊房	厚生労働省健康局 水道課長
立川	裕隆	厚生労働省健康局水道課 水道水質管理官
服部	麻友子	厚生労働省健康局水道課 調査指導係長
国包	章一	国立保健医療科学院 水道工学部長
	真理	国立保健医療科学院水道工学部 水質管理室長
	卓郎	国立感染症研究所 寄生動物部長
	泰基	北海道大学創成科学研究機構 特任教授
	哲夫	麻布大学環境保健学研究科環境衛生政策専攻長 教授
/******	正弘	財団法人水道技術研究センター 理事長
'	大 隆	阪神水道企業団 管理部長
山里	徹	沖縄県企業局北谷浄水管理事務所

※ ○は団長を示す。所属及び役職は会議開催時点のものである。

表 2 参加者名簿(米国代表団)

OJames Goodrich	Acting Director, Water Supply and Water Resources Division, Office of Research and Development, U.S. Environmental Protection Agency (米国環境保護庁研究開発局)		
James A. Hanlon	Director, Office of Wastewater Management, Office of Water, U.S. Environmental Protection Agency (米国環境保護庁下水道管理部)		
Kathleen Schenck	Environmental Scientist, U.S. Environmental Protection Agency (米国環境保護庁)		
Jerry N. Johnson	General Manager, D.C. Water and Sewer Authority (コロンビア特別区上下水道庁)		
Shane Snyder	R&D Project Manager, Southern Nevada Water Authority (南ネヴァダ水組合)		
Alan H. Vicory	Executive Director and Chief Engineer, Ohio River Valley Water Sanitation Commission		
	(オハイオ川流域水質保全委員会)		
Dennis M. Diemer	General Manager, East Bay Municipal Utility District (イーストベイ上下水道組合)		
Robert C. Renner	Executive Director, American Water Works Association Research Foundation		
	(米国水道協会研究財団)		
Daniel M. Woltering	Director of Research, Water Environment Research Foundation (米国水環境研究財団)		
Martin J. Allen	Director, Technology Transfer, American Water Works Association Research Foundation		
	(米国水道協会研究財団)		
David Yates	National Center for Atmospheric Research (国立気象研究センター)		
James H. Clark	Vice President, Black & Veatch Corporation (ブラック・アンド・ヴィーチ社)		
Mary E. Buzby	Director, Environmental Technology, Merck & Co., Inc. (メルク社)		

^{※ ○}は団長を示す。所属及び役職は会議開催時点のものである。

表 3 会議次第

表3 会	議 次第				
第1日 1月22日					
歓迎挨拶	(首里)				
開会挨拶	(立川、清水、J. Hanlon)				
議題 1: 水道水質管理及び下水道管理の概観	(服部、那須、J. Goodrich、A.H. Vicory)				
議題 2: 水道システムのリスクアセスメント					
・リスクマネジメント	(国包、J. Goodrich、早川)				
議題 3: 下水道施設の管理	(松宮、J.N. Johnson)				
議題 4: 流域管理	(佐々木、Y. David)				
議題 5: 水の再利用	(吉澤、黒島、D.M. Diemer)				
第2日 1月23日					
議題 6: 生物学的リスクアセスメント					
・リスクマネジメント	(遠藤)				
議題 7: 化学的汚濁物質のリスクアセスメント					
・リスクマネジメント	(M.E. Buzby、山下、鈴木、S. Snyder、浅見)				
視察 [国営沖縄記念公園]					
第 3 日 1 月 24 日					
議題 8: 緊急事態対策	(田中、J.H. Clark)				
議題 9: 水道事業のリスクアセスメント					
・リスクマネジメント					
議題 10:統合的な流域管理	(藤木、J.A. Hanlon)				
議題 11:新技術	(山里、M.J. Allen、藤原、村上、D.M. Woltering)				
会議要約への署名	(J. Goodrich、山村、田中)				
閉会挨拶	(J. Goodrich、山村、田中)				
第 4 日 1 月 25 日					
視察 [北谷浄水場、那覇浄化センター]					
※ () 内け発表者等を示す					

^{※ ()} 内は発表者等を示す。

5 会議の概要

5.1 開会

現地を代表して、沖縄県土木建築部部長 首里 勇治 氏より、会議参加者に歓迎の挨拶が行われ、会場である万国津梁舘並びに沖縄県の歴史、特性及び上下水道事業を取り巻く現状につき紹介がなされた。次に、厚生労働省健康局水道課水道水質管理官 立川 裕隆 氏より、日本の水道システムの特徴、持続可能性及び地震対策等上水道事業の現状と課題に関する紹介とともに、開会の挨拶が行われた。国土交通省都市・地域整備局下水道部流域管理管 清水 亨 氏からは、日本の下水道事業の現況及びこれまでの会議の経緯につき紹介がなされ、本会議の成功を祈念する旨挨拶がなされた。

続いて、米国環境保護庁下水道管理部長 ジェームス・ハンロン氏から、本会議開催にあたり日本側の尽力及び歓待に対する謝意が述べられ、両国共通の水道水質管理及び下水道管理の重要性につき指摘がなされた。

5.2 議題 1: 水道水質管理及び下水道管理の概観

(1) 日本における水道水質管理の現況

Overview on Drinking Water Quality Management in Japan (厚生労働省 服部 麻友子)

現在の水道水の水質基準は、2004 年 4 月から施行されており、水質基準 50 項目の他に、水質管理目標設定項目 27 項目、要検討項目 40 項目が定められている。このうち、水質管理目標設定項目として定められている塩素酸について、その検出状況を踏まえ、水質基準に追加することについて食品安全委員会に諮問したところである。

飲料水の水質管理については、水道事業体の努力により良好な状況であるが、毎年、水質事故が少なからず発生しており、2006年も、飲用停止を求めることとなった事故の報告が10件以上あった。厚生労働省では、衛生管理の徹底等について全国の水道関係者に情報提供することにより、再発の防止を図っている。日本での飲料水起因の感染症発生事例をみると、施設の不適切管理や消毒不備に起因しているものがほとんどで、小規模水道での水質管理の徹底が必要である。

厚生労働省では未規制の物質についても調査を行っており、昨年、利根川から過塩素酸が他に比べて 高濃度で検出されることが明らかとなり、調査の継続や、拡大などの対応を行っている。

日本では、水道水に対して味や安全性の点で問題があるというイメージを持つ人々が少なくないが、 実際には、高度浄水処理水とミネラルウォーターとの味くらべでは、おいしさについての違いは認められていない。厚生労働省では、全国の水道事業体と連携して、水道水のイメージを改善し、安全な水道水として国民の信頼を得るように、水質管理に係る諸施策を推進していきたい。

(2) 下水道ビジョン 2100

Strategy on Wastewater Control in Japan for 21st Century (国土交通省 那須 基)

地球温暖化やこれに伴う水不足や浸水、人口減少や急速な高齢化など、21世紀の日本を取り巻く状況は過去に類例を見ない深刻な課題を抱えている。普及率がようやく約7割になった日本の下水道事業においても、これらの課題を踏まえた対応を進める必要があり、長期的な展望に基づく下水道事業の戦略として、「下水道ビジョン2100」を取りまとめた。

日本の下水道が抱える課題としては、下水道未普及地域への対応や近年頻発する浸水や地震への対応など国民の安全な暮らしの確保をはじめとして、高度処理の推進や合流式下水道の改善などの水環境の保全、省エネルギーや創エネルギーなど地球環境保全への対応など広範囲にわたり、いずれも十分な取り組みが進んでいないのが現状である。

今後は、下水道を都市と環境の「循環のみち」としてとらえ、水と汚泥の循環利用を推進するとともに、下水道施設の適切な管理を行うなど、今後の下水道の目指すべき姿をとりまとめた「下水道ビジョン2100」を踏まえ、日本の下水道が建設から管理経営までを見据えた計画的な取り組みを進める必要がある。

【討議】

防災用水等への下水処理水の有効利用については、水道事業との連携も重要な視点である等の指摘が あった。

(3) 水道水質管理の現況

Overview of Drinking Water Quality Management

(米国環境保護庁 ジェームス・グッドリッチ)

飲料水の供給と管理は、最も適切な水源を選択し汚染から保護すること、汚染物質を取り除くための 浄水処理方式を用いること、配水システムでの水質悪化を防ぐこと、という三段階から成っている。こ の他、水道施設における事故の防止、汚染の検出、浄化といった取組がある。このような取組により、 コレラや腸チフスなどのトラディショナルな水道水起源の脅威は無くなったが、国民の健康面での関心 は残されている。

水道水起源の病気の発生は継続しており、処理が不十分である場合や、配水システムでの不備があった場合、病原生物により、水道水の安全性が未だに脅かされている。また、自然起因(ひ素)や人工起因(内分泌かく乱物質)の物質による汚染物質に関して新たな関心が高まってきている。また、消毒の過程自体が多くの消毒副生成物の発生につながっている。幼児、子供、妊婦、免疫システムの弱っている人々にとっても関心事となっている。

安全飲料水法(SDWA: Safe Drinking Water Act)は環境保護庁(EPA: Environmental Protection Agency)に対して、水の安全性を確実にするための水道水質基準の設定を求めている。SDWA は未規制の水道水起源の病原生物や規制物質候補リスト(CCL: Contaminant Candidate List)上の化学物質のみでなく、消毒副生成物についての研究を必要としている。また、配水システムにおける水道水質の維持のみでなく、水道水源の保護も重要視している。

最近では、ひ素の最大許容濃度(MCL: Maximum Contaminant Level)を 50ug/L から 10ug/L に変更した。過塩素酸やシアノバクテリア等の研究も進めている。EPA 研究開発局(Office of Research & Development)は、EPA 水局(Office of Water)の規制的活動と緊密に結びついた総合的な研究計画を設立した。この計画は、EPA 地方局(Regions)の規制とも密接に関連して動いている。最近では、水道水長期計画において、今後の数年間を通して研究計画を動かすことになる見直しを行った。主要な変更は、施設の老朽化と水源の保護に対して、より重点をおいたことである。これには、配水システムにおける水質維持とリアルタイムモニタリングが含まれている。また、新計画は水道水中の汚染物質の管理に対して重要な役割を持つことになる浄水データベースの側面も含んでおり、2007年には稼働する予定である。

(4) 米国における下水処理の進展と挑戦—オハイオ川流域及びオハイオ川に焦点をあてて—

Progress and Challenges in Wastewater Treatment in the United States with Focus on the Ohio Valley and the Ohio River

(オハイオ川流域水質保全委員会 アラン・ヴィコリー)

米国において、国としての下水道の進展への取組は、1948年の水質汚濁防止法(Water Pollution Control Act)に遡ることができる。同法では、規制的手法は採用されず、下水処理場の建設が推奨され連邦政府から補助金が交付された。そして、同法は多数にわたり改正され、連邦政府による制御が強化された。1950年代、1960年代は、水質目標の設定並びに公共の下水処理場(POTWs: Publicly Owned Treatment Works)及び工業用下水処理施設の設置が進まなかったが、中には注目すべきプログラムの実施も見られた。オハイオ川流域における「清浄河川プログラム」がその一つであり、オハイオ川流域水質保全委員会(ORSANCO: Ohio River Valley Water Sanitation Commission)の主導の下、主要な水質項目の特定、汚濁負荷排出事業種毎の最良可能処理技術(best available treatment technologies)の決定及び公共の下水処理場の建設に対する技術支援がなされ、成功が収められた。

公共用水域の水質状況に対する社会的関心を受けて、1972年の水清浄法(CWA: Clean Water Act)が制定され、点源負荷の処理に対して基準が設定された。公共の下水処理場については、最低限、二次処理が義務付けられ、施設の建設費に最大 75%の補助金が連邦政府から交付された。これにより、1968年から 1996年までの期間において、2次処理未満の処理しかなされない人口の割合は 39%から 9%に減少したり、放流水の BOD 負荷量が 45%削減されたりして、米国の公共用水域の水質は劇的に改善した。オハイオ川でも、乾期における溶存酸素の水準が改善し、sauger(スズキ目パーチ科の一種)のような魚の回帰が報告されている。しかしながら、2000年時点において、河川の 39%、湖沼の 45%、河口の51%は汚濁した状態にあり、下水処理場が主要な汚濁源となっている。

1980 年代中葉には、連邦政府による直接的な補助金の交付を削減するという方針転換がなされた。その代わりに、資本的支出に関する補助金が連邦政府から州の貸付機関に交付され、その機関は低利子の貸付を公的機関に行うこととなった。これまで 200 億ドルが交付されてきたが、その額は年々減少しており、2006 年度においては 9 億ドルに過ぎない。一方、今後 20 年にわたり、合流式下水道改善、1970年代に建設された施設の更新・拡張及び栄養塩類の排出削減のための技術の導入等、3,400 億ドルの必要事業量が見込まれており、新規の資金源の獲得及び現存施設の延命化の戦略に向けて大きな挑戦が待っているところである。

米国では下水道の整備は概ね完了し、深刻な水質汚濁の問題はもはや起こらないが、重大な挑戦を伴う課題が残っている。合流式下水道改善、施設の更新・拡張及び栄養塩類の除去だけでなく、水銀及びダイオキシンへの対応が必要となってくる地域もある。下水道管理者は、連邦政府からの財政支援がなければ下水道使用者から徴収を大幅に引き上げなければならないが、特にこの問題は人口と産業活動が減少している大都市において顕著である。これらの課題に対応するため、アセットマネジメント、環境システム手法(environmental systems approach)及び処理能力・管理・運営・保守(CMOM: Capacity, Management, Operations and Maintenance)の採用が進められつつある。また、水質取引プログラム、流域排出許可(watershed discharge permits)の活用も始まっており、下水道管理者は共通する利害に対処するため、関係者と積極的な協力・連携を行っている。

【討議】

1972 年 CWA に基づく下水処理場の建設に対する 75%の資金援助は、相当な程度と考えられるが、この資金援助の目的は何かという日本側からの質問があった。当初、二次処理の水準を達成するためには支援が必要であり、それに応じてなされたのがこの資金援助であったが、資金援助が終了してから、各下水道事業体は自ら持続可能な運営をしなければならなくなっているとの回答があった。

次に、日本側から、米国における分散型システムへのスタンスについて質問がなされた。米国側からは、「州及び地方自治体に対して分散型システムに関する技術支援を行っており、長期にわたる技術的に健全な設計及び維持管理を期している。また、分散型システムの改良に対して財政的支援があり貸付の対象となる。」との回答がなされた。

日本側からは、ダイオキシンの起源につき質問があり、米国側から「オハイオ川では水環境及び魚類中にダイオキシンが検出されており、下水処理場の放流水も排出源となっている。下水処理場以外の排出源を取り扱う戦略がなければ、下水処理場からのダイオキシンの処理に 2,000 万ドルの投入を要することとなる。また、水銀についても同様のことがあてはまる。」との回答がなされた。

また、日本側から、3,400 臆ドルにも及ぶ下水道の必要事業量に対してどのように資金を確保していくのか、つまり、下水道使用料を上げるのか、連邦政府からの補助金を増やすのかという質問があった。 米国側からは、「信託基金の創設という考えがあり、関連コストの増加という課題があるが、その解決のために対話が進められている。」という回答がなされた。

最後に、日本側から、下水道施設の更新の必要性はどのように誰によって決定されるのか、全体的な判断基準があるのかそれともケース毎に決定されるのかという質問があった。米国側から、基本的にはケース毎に更新の決定がなされるが、処理場への流入水量が能力の 85%程度に達すると将来の処理プロセスを評価し直すという州の基準があることが説明された。また、コンクリートの劣化や放流水質基準の違反といった要因もあることが付け加えられた。

5.3 議題 2: 水道システムのリスクアセスメント・リスクマネジメント

(5) 日本における「水安全計画」の水道システムへの適用

Application of "Water Safety Plan" to drinking water quality management in Japan (国立保健医療科学院 国包 章一)

水安全計画(WSP: Water Safety Plan)は、2004年に公表されたWHO飲料水水質ガイドライン(第3版)のハイライトであり、健康に基づく目標を達成するための非常に重要なツールである。水安全計画は、水源から消費者の給水栓までの組織的な水道水質管理を必要とする。

水安全計画が飲料水の安全性を確保するために不可欠であるということは疑いがない。危害分析は、 水安全計画の重要な構成要素で、水道事業者は、安全な飲料水を供給するために、集水域管理により注 意を払う必要がある。水安全計画の適用は、それぞれの水道事業の置かれた状況によって様々な方法が あり得る。

日本の水道質管理に水安全計画を導入・適用しようとする活動としては、地方自治体の水道事業体の水安全計画の適用についての研究と、水安全計画導入ガイドラインの作成の取組がある。

2004 年度から始まった厚生科学研究では、地方自治体の水道事業体への水安全計画の導入事例を示すことを目的として、5 つの水道事業体(東京都、横浜市、大阪市、大阪府(用水供給)、神戸市)で、水安全計画の概念を適用した水質管理の計画の見直しを行っている。研究での試行的な取組は合理化と改善にもつながっており、東京都水道局と大阪市水道局は、水安全計画の導入に加え、浄水処理や配水システムについて、ISO9001 の認証を取得している。

厚生労働省は、2005年に、水安全計画導入ガイドラインの作成のための委員会を日本水道協会に組織し、いくつかの小規模な水道施設への試行的な水安全計画の導入を行っている。現在、日本には、給水人口が101~5,000人の小規模な簡易水道が8,000以上あり、これらの施設の水質管理は不十分であることから、これらの管理の向上が飲料水の汚染による水系感染症の集団感染を防ぐためにも重要である。ほとんどの簡易水道は、人的資源、技術力、財源が不足しており、小規模水道のための水安全計画は、単純で、取扱が簡単で、容易に改善ができるものでなければならない。ガイドラインの素案は、2006年

度中に準備される予定である。

国立保健医療科学院がコーディネーターを務めるオペーレーション・アンド・メンテナンス・ネットワーク (OMN: Operation & Maintenance Network) は、世界保健機関(WHO: World Health Organization)の下で 1990 年に設立された NGO で、特に発展途上国における、飲料水の供給並びに衛生施設の運営及び維持の向上のため、経験、知識及び情報の交換を行うことを目的としている。 OMN の主な活動は、教育ツールの開発や、ワークショップ/セミナーの開催、ウェブを通じた情報交換で、近年は、WHO、国際厚生事業団(JICWELS: Japan International Corporation of Welfare Services)やその他の機関と協力して、アジアの発展途上国への水安全計画の普及による水道水質管理の改善に貢献している。

(6) 水道システムのリスクアセスメント・リスクマネジメント-21 世紀に向けた社会資本推進計画-

Risk Assessment and Management of Water Supply System - Infrastructure Initiative for the 21st Century -

(米国環境保護庁 ジェームス・グッドリッチ)

上水道と下水道の基盤施設は、きわめて重要であり、公衆衛生や環境だけでなく、強い経済を保護するためにも必須となるサービスを提供する。米国では、これまで、水関連の基盤施設に巨額の投資が行われてきた。16,000 施設を超える下水処理施設が設置され、60 万マイル(97 万 km)を超える下水管により、1 億 9000 万人に利用されている。飲料水は約 16 万の大小の上水道システムにより供給され、100 万マイル(160 万 km)の水道管を通じ、2 億 6400 万人に供給されている。

米国における現在の問題は、水関連の基盤施設の老朽化が進んでいるが、上水道や下水道のシステムの修繕や取り替えのために、十分な経費が負担されてこなかったことである。2005 年の米国土木学会による報告書(American Society of Civil Engineers Report Card)では、上水道と下水道の基盤施設は、「D-」の評価であった。このことは、もしもこのまま基盤施設の悪化を放置すれば、最近 30 年の、公衆衛生・環境の向上や経済の利益を帳消しにしてしまうリスクがあることを示している。下水管の破損による汚水の漏洩の発生は、毎年 100 億ガロン $(3,800\ {\rm Fm}^3)$ の生下水に相当する流出の原因と考えられている。水関連の基盤施設を改良するために必要な推計額と実際支払われた額の差は、上水道システムについては約 $0\sim130$ 億ドルに上り、下水道システムについては約 $30\sim130$ 億ドルに上る。

環境保護庁(EPA: Environmental Protection Agency)は、「持続可能な基盤施設戦略」でこの問題に応えてきた。この戦略は、「より良い管理」、「水利用効率の向上」、「全体としての経費積算」、「集水域からのアプローチ」の4つの柱と、「技術革新」、「パートナーシップ」、「技術」、「研究」の4つの横断的なテーマからなる。

「21世紀に向けた水関連の基盤施設の革新と研究」研究プログラムの目的は、革新的で費用対効果の高い次のような技術、つまり、「老朽化し劣化しつつある上水道や下水道システムの運用、維持管理、更新」、「新しい上水道や下水道システムのデザイン」を生み出すことである。

この研究イニシアチブの焦点分野は、「システムの状態の評価(自然流下の管渠/圧力管)」、「システムの改修(自然流下の管渠/圧力管)」、「先進的なデザインと管理(配水・収集、再利用システム/水処理システム)」である。

研究プロジェクトには、「技術実証評価プログラム」、「技術状況評価」、「決定を支援する応用研究」、「先進的デザインの基礎研究」、「センター・オブ・エクセレンス」が含まれる。

本研究プログラムの将来の目標は、浄水ロス量の低減、下水漏水の低減、リスクの高い給水本管の破損の低減、未処理下水の表流水への流入量の低減、施設運用やデザインの最適化、基盤施設の費用対効果(の向上)などであり、これらを通じ、公衆衛生の向上、環境の保全、経済発展を目指すことである。

(7) 日本の建物の貯水槽管理の現況―システムの安全管理のためのマニュアルの導入―

Overview of Current In-Building Water Supply System Management in Japan - Introduction of a Manual for Safety Management of these Systems -

(麻布大学 早川 哲夫)

世界保健機関 (WHO: World Health Organization) は、2005年に、「集水域から消費者までの水質管理」を副題とする「水安全計画 (WSP: Water Safety Plan)」を出版した。これらの文書によれば、飲料水の安全性を保証するため、水道水源の汚染防止、配水に到るまでの浄水処理、配水過程での汚染防止、建築物内での貯水と給水の安全性に考慮することとされている。

日本では、他の国と同様、配水過程までは、水道事業者(公共部門)が管理しており、規制部門が規制の遵守について指導することはそれほど難しくない。しかし、建築物内については、水道事業者の責務の範囲外となり、建築物の設置者により管理される。さらに、給水の最終段階であるため、失敗は許されない。

日本では、建築物内の貯水槽水道については、1977年から水道法により規制され、これら 100 万を超える施設の安全を確保するには、設置者が施設を安全に管理することとされている。

容量が 10m³ を超える貯水槽は、水道法に基づき、貯水槽の設置者が施設の安全な管理に責任を負い、管理基準として、少なくとも年に1回の定期的な検査や定期的な貯水槽の清掃と、汚染防止のために必要な措置、が定められている。一方、容量が 10m³ 以下の貯水槽は、水道法による規制の対象外だが、いくつかの地方自治体は、条例で規制を行っている。

水道法の規制対象施設においても不適合の水準は高く、前年の検査において不適合の指摘を受けた約1万の施設についての調査では、このうち約半数の施設では翌年も不適事項が改善されていなかった。 貯水槽の管理の不適合事例は、配管施設の設計、設置・改修工事、維持管理が不適切であることに起因する。幸いにも、このような特に衛生上の問題がある事例は非常に少ないが、このような状況を改善する必要がある。

改善のためには、貯水槽施設の直結化を図ること及び貯水槽施設の管理水準を向上することが主な対策である。建築物の設置者や管理者の知識は十分でない場合も多く、このような知識の乏しい設置者のための建築物内の貯水槽の管理マニュアルが望まれる。

管理マニュアルでは、「管理基本計画」の策定と、貯水槽の清掃・検査業者の選択について述べている。

建築物の設置者・管理者は、「管理基本計画」を策定することが望まれる。管理計画は、管理目標、施設の定期的な点検、定期的な清掃、緊急時の給水停止、記録の保管、管理の費用からなる。また、貯水槽の清掃・検査業者の選択にあたっては、貯水槽の清掃・検査業者に関する情報公開、建築物の管理者の立ち会い、清掃・検査結果についての説明聴取、改善提案書の受領等が重要となる。管理マニュアルの実施にあたっては、適正な管理が行われている建築物を周知するシステムの導入(建築物の価値も高まる)や、建築物の管理者、清掃・検査業者、配管業者、水道事業者、行政の関係の強化について考慮が必要となる。

近い将来、多くの建築物内の貯水槽の設置者・管理者や関係者が、このマニュアルを活用することで、 建築物内の給水システムの管理水準が向上し、全ての利用者への安全な飲料水の供給につながることが 期待される。

【討議】

米国での革新的な下水管の開発について日本側から質問があり、用途別に事故や経済性のデータを収集しているとの回答があった。

米国側から建物内給水施設の水安全計画について、米国、カナダでは作成しておらず、病院や建物の

オーナーが水安全計画を作成すべきだと考えているという意見があり、日本側からは作成したマニュアルによりオーナーが知識を得、水安全計画を作成する意識が高まるものと考えていると説明された。

日本側から米国の施設更新マニュアルについて質問があり、基本的には事業体が調査し、作成しているが、政府側でもその支援を行っていると回答があり、米国水道協会研財団(AwwaRF: Awwa Research Foundation)の資金で調査研究を行っているとの回答があった。

日本側から上下水道共同で調査することのメリットについて質問があり、施設、機材を共有し、同じ 思考でアプローチすることが効果的であると回答があった。

5.4 議題 3: 下水道施設の管理

(8) 下水道管路施設の老朽化にどう対処すべきか?―管渠の統計学的寿命のデータ解析―

How to Deal with Aging Sewers? - Statistical Life Data Analysis of Sewer -

(国土技術政策総合研究所 松宮 洋介)

近年、下水道管の不具合に起因した道路陥没が多発しており、昨年度は約5,000 件発生した。東京や大阪などの大都市で特に多発している。これらの都市では標準耐用年数である50 年を過ぎた管渠が増えつつある。しかし、国全体で見た場合、敷設後50 年を経過した経年管は4,000km に過ぎない。しかし経年管は10年後に13,000km、20年後には46,000km に増える。陥没件数のさらなる増加、ひいては大規模な交通障害が生じないようアセットマネジメントによる効果、効率的な管路管理が必要となっている。

アセットメネジメントの実施において、特に日本が重点的に取り組むべき点は、リスク評価と長期(10~20年以上)事業量予測である。リスク評価がない場合、例えば交通量の少ない住宅街の末端管渠の損傷と幹線道路下の幹線管渠の損傷が同じ重要度で扱われる可能性がある。陥没件数自体は大きく減少したが、幹線道路で大規模な陥没が生じたといった事態を避ける必要がある。そのためにリスク評価が必要である。また、財政難の時代にあっては長期事業計画を避ける傾向がある。しかしながら、金がないからこそ長期の事業量予測を行い、効率的な実施計画を立てることが必要である。

国総研では自治体がアセットマネジメントを円滑に進められるように、生存曲線、劣化曲線、劣化管 渠箇所予測モデル、陥没リスク判定資料の作成、開発に取り組んでいる。

(9) 老朽化する下水道施設の管理—挑戦と戦略—

Management of Aging Wastewater Infrastructure - Challenges and Strategies - (コロンビア特別区上下水道庁 ジェリー・ジョンソン)

米国の首都であるコロンビア特別区は、米国の他の大都市と同様、老朽化した下水道施設の改築、更新、維持管理に係るコストと必要性に頭を痛めている。全米の下水道管理者にとって老朽化施設、法的要求事項、人口移動への対応が大きな課題となっている。

米国では2000年の人口2億3100万人が2020年に3億2500万人に増加すると予測されている。さらにこの人口増が大都市の周辺都市で生じ、大都市では人口減少が予測されている。大都市は住民減少により、料金収入が減少するなかで老朽化施設を維持していく必要性に迫られている。

30年前、連邦政府は下水道施設の建設費用の75%を負担していた。それが今日では5%を下回っている。環境保護庁(EPA: Environmental Protection Agency)は今後10年間必要な投資が行われなければ、過去35年間で達成された水環境の改善が失われるだろうと予測している。

コロンビア特別区は他の大都市とともに連邦政府による下水道信託基金の設立を働きかける一方、毎年、料金値上げを実施している。この間、長期施設計画、法的事項に係る交渉、アセットマネジメント、

住民啓発などにより米国の老朽化する上下水道インフラが直面する事業上、規制上及び財政上の課題に 取り組んでいる。

【討議】

米国側から、生存曲線モデルの適用について、異なる場所ではどうなのか、意思決定のプロセスはどうなのか、単純に生存曲線で判断するのは問題で個々に判断すべきではないのか、他のパラメータはどうなのかという質問がなされた。これに対して、本生存曲線モデルは、管渠の更新戦略を立案するためのものであること、生存曲線は所要コストを概略推定するのに用いていること、他の目的に対してはその他のパラメータを用いることになるという回答がなされた。

日本側からは、陥没が少ないが大事故は生じていないのかという質問がなされ、大事故はないが大事故になりそうなものはあったこと及び陥没があると目立つという回答がなされた。また、ケンタッキーでは爆発事故があったというコメントがあった。

料金システムに関する日本側からの質問に対しては、料金は水道使用量に基づいており携帯ツールにより流量を計測することと及び異常が認められれば訪問して確認するという回答がなされた。料金を値上げすれば水道使用量は減少するのかという点については、値上げしたら水道使用量は減少し、収入が1.5%減少したという回答があった。

民営化についてはどのように考えているのかという日本側からの質問に対して、「民間会社の参加も含めて、ベストパフォーマンスを評価した。すなわち、5年間の人員整理やコスト削減について検討した結果、業務を直営で行いコストを削減してゆくのがよいことになった。」という回答であった。

また、日本側から、回転融資基金(revolving fund)の原資と 2004 年からその額が急激に減少している理由に関して質問がなされ、「連邦政府が運用する資金が原資であり、額の減少については連邦政府により優先度が低いと判断されたためである。」との回答がなされた。施設更新のための信託資金設立について、政府にどのようにアピールするのかという質問に対しては、「議論は以前からされていること、ガソリン税や航空税の一部が信託資金に若干行くことになるが、税と思われるため誰も払いたくなく、政治的になかなか難しいため何か代替案が必要である。」という説明があった。また、議員等と協力して何か良い方法を見つける必要があり持続可能な資金が必要であるという回答がなされた。

5.5 議題 4: 流域管理

(10) 緊急事態に備えた水道における流域管理―琵琶湖・淀川水系の事例―

Watershed Management in Drinking Water for Emergency: A Case of Lake Biwa-Yodo River System (阪神水道企業団 佐々木 隆)

琵琶湖-淀川水系は日本の中西部に位置しており、近畿地方 1,400 万人の水源として、都市生活と活動を支えている。水系の特徴は上流域で都市化と工業化が発達し、下流域で大量の生活用水を利用していることである。このことは水の循環利用が行われていることを意味し、そこには水の安全性への多くの危害因子が存在している。

1960年代には淀川の水質が下水放流水や他の生活又は工場排水により急激に悪化したため、下流の水道事業体はこれらの問題の対策が必要になった。水道事業体は、統合的な水資源保全のために共同して対応することが最善であるとし、1965年に淀川水質協議会を設立した。現在、10水道事業体が参画している。協議会は種々な活動を行っている。

- ・水源水質の定期監視
- 水源保全に係る調査研究
- ・汚染防止に関する要望活動

- ・水源保全に関する啓蒙活動
- · 緊急連絡体制

水源で水質事故が発生した場合、発見者から河川管理者が情報を収集し、協議会に連絡が入る。それから、協議会はあらかじめ設定した緊急連絡網により、全メンバーに連絡する。

水道に直接影響を与える事故は減少している一方、油流出事故の比率は近年増加している。協議会は 油流出事故の原因となる施設を監督する行政部署に定期的に要望し、一定の成果が得られている。

2003 年 10 月の油流出事故の対応例を示す。水源事故は淀川の支流で起こり、下流の水道事業体に影響を及ぼした。一つの浄水場は 4 時間取水を停止しなければならず、6 浄水場では取水制限、油処理、粉末活性炭の投入等の対応を実施した。事故の迅速な情報伝達、適切な対応により供給水が汚染されるのを防ぐことができた。

水源事故が発生した場合、取水地点への汚染物質の到着時間は重要な情報である。協議会は、河川の 形状等の影響を考慮した「淀川到達時間表示システム」を開発した。また協議会では流域の各種事業所 の位置、取り扱われている有害物質の情報を整理した「淀川流域環境マップ」も構築した。環境マップ は、収録されたデータを基に有害物質等の汚染の危険性を具体的に示すことができる。

水道は、水源から蛇口まで連続した施設であり、脆弱さを内包している。そのため、もし水源事故への対応に遅れが生じると、社会生活に大きな損害を引き起こす可能性がある。この観点から、できるだけ速く水源事故を発見し、適切な対応をとることが重要である。淀川水質協議会は、共同で水源を監視し、水源保全活動に携わっている。これらの努力により、今日まで水道水の安全性が確保されている。

(11) 気候変動と水資源--水道事業体のための手引き--

Climate Change and Water Resources: A Primer for Municipal Water Providers (国立気象研究センター デービット・イェーツ)

米国水道協会研財団(AwwaRF: Awwa Research Foundation)と国立気象研究センター(NCAR: National Center for Atmospheric Research)との共同作業により、新刊書「気候変動と水資源―水道事業体のための手引き―」が発刊された。この本は、気候変動に関しての誤解を解くことによって、気候変動が無視しても問題が生じないような作り話でもなければ、切迫した大災害でもないことを示している。

手引きには、自然による気候変化と人間の活動によって引き起こされた気候変化の両方に関する科学的な証拠が要約され、気候変動による水循環への影響とこれがもたらす水道事業者への潜在的な影響について書かれ、これらの将来予測における不確実性がどのようなものであり何が原因であるかについて書かれており、さらに、計画策定及び適応の戦略に関する指導が記述されている。特に手引きは、さらなる温暖化が、どのようにして、世界的な平均年降雨量の増加、集中豪雨の激化及び日照りの長期化に至り、地球規模の水循環を集中化するのかにつき説明している。

気候変動の見通しに注意を促す善意の(しかし誤った)試みは、地球の気候システムが大変動の変化に対応できる、若しくは世界的な気候変化を見過ごすことができるという作り話であるという印象を多くの人に残した。それらの極端な見解はどちらにしても、気候変動に影響を受けやすい資源の管理に決定を下そうとする人に有用な手引きとはならない。よって、自然由来の気候変動及び人間の活動によって引き起こされるかもしれない気候変動の両方を含んでいる気候変動に関する科学的知見の要約により、いくらかの誤解の解消を狙っている。この手引きは、特に、気候変動が水循環や水資源の量や質に与える影響はどのようなものかに焦点を当てている。この手引きの最終的な狙いは、水道事業体の管理者に気候変動に関する科学的知識を紹介し、それが水資源に与える影響の種類を示して、計画策定及び適応の戦略に関する指導を提供するということである。この手引きは、研究者によるいくつかの最新の知見とともに、気候変動のために計画を立て準備をし始めた前向きの事業者による活動を主として反映したものである。水産業の専門家は、気候変動が水資源の量及び質に影響を与えるという事実並びに極

端な雨水流出又は気温が関連施設の維持管理に影響を与えうるという事実を痛感している。未曾有の干ばつのような予想しがたい極端な気候変動は特に厳しい問題を提起するだろう。思慮深い管理は、このような自然の変動による悪影響の予想及び緩和に重点を置く。効率的な計画のためには、なぜ、どのように気候が将来変動するのか及び水産業が依存するところの資源は気候変動によりどのように影響を受けるのかを理解することが重要である。

【討議】

日本側から、地球規模の水資源の変化については気候変動よりも人口増加がウォーターストレスに影響を与えるという意見が日本の研究者にはあることを背景に、大気循環モデル (GCM: General Circulation Model) による降雨量推定の精度について質問があった。これに対し米国側から、「精度は難しい問題で、暖かい大気による湿気増加で降水量強度と頻度は変化するだろう。カリフォルニア州の場合でも気候変動に対処する方法を見つけようとしているもので、基本的に地域の気候をモデル化する方法の提供であり、必ずしもモデルの結果がそのまま利用できるわけではない。」との回答があった。

続いて、米国側から、オハイオ川でも油流出事故はみられるが、淀川の場合はどのようにして起こるのかとの質問があった。日本側から、京都府南部地域にある自動車廃車場から滲み出た油類が道路側溝に溜まり、この地域は低地のために降雨時の排水機場ポンプによる内水排除に伴って、その油類が淀川に流れ込むとの回答があった。

その他、淀川周辺の工場が記された環境マップにおける化学物質データの更新頻度について質問があった。これに対し、淀川水質協議会では、PRTR 等のデータ見直しが生ずれば環境マップが更新できるよう毎年予算を計上しているとの回答があった。

5.6 議題 5: 水の再利用

(12) 日本における再生水利用の現状と下水処理水の再利用水質基準等マニュアルの策定

Establishment of Guidelines for the Reuse of Treated Wastewater

(国土技術政策総合研究所 吉澤 正宏)

都市内における貴重な水資源確保や良好な水辺空間の創出等、下水処理水再利用の重要性は今後益々高まっていくと予想される。また、飲料水や食品を介したクリプトスポリジウム、ウイルス等による健康被害が近年大きな社会問題となり、水の安全性への関心が高まってきている。このように、下水処理水の適切な再利用の重要性が増している。

このため、国土交通省では検討委員会を設置して議論を重ね、「下水処理水の再利用水質基準等マニュアル」を策定し、下水処理水再利用における衛生学的安全性確保、美観・快適性確保、施設機能障害防止の観点から、利用用途に応じた水質基準等を示すとともに、下水処理水再利用の実施に当たり考慮すべき事項を示した。

本マニュアルが対象とする利用用途は、下水処理水を不特定多数の人が利用する施設に直接供給する 形態とし、日本の再利用の実態を踏まえて、水洗用水、散水用水、修景用水、親水用水の4用途とした。 技術基準のうち、衛生学的安全性の観点から、従前の大腸菌群に代えて、より糞便性汚染の指標性の 高い大腸菌を基準項目とした。ただし、修景用水は人が触れることを前提としないため、暫定的に大腸 菌群を基準項目とし、従前の基準値を採用した。

配管等の閉塞防止の観点からは、施設基準として砂ろ過施設又は同等施設の設置を義務づけ、施設の 適切な機能を担保する指標として濁度を設定した。ただし、親水用水は水浴等の全身的な接触も想定し ているため、利用者の衛生学的安全性確保の観点から凝集沈殿工程を追加した。また、再生水供給過程 における細菌類再増殖防止の観点から、残留効果の高い塩素消毒を行うことを基本とし、残留塩素を管 理目標値として規定した。管理目標値は、実態調査を踏まえ、日本の水道水質基準と同じ残留塩素濃度 を再利用水質基準に適用した。

下水処理水再利用の実施にあたって考慮すべき事項として、誤接合防止や誤飲防止の措置等について記載した。

マニュアルに提示した技術基準の一部は、下水道法を改正し、下水道施設の構造基準として規定した。 下水道法及び本マニュアルにより、下水処理水再利用の適正な管理と下水処理水の積極的な活用、都 市内の良好な水環境の創出が期待される。

(13) 沖縄における再生水利用下水道事業

Promotion of Treated Wastewater Reuse in Okinawa - In search of local community without water shortage -

(沖縄県下水道建設事務所 黒島 隆)

離島県である沖縄県は、水不足に悩まされ続けてきた。給水制限は年中行事のように繰り返され、特に 1981年の渇水時には約1年間にわたり給水制限が行われ、県民生活に多大な影響を与えた。このため本島北部には多くのダムが建設されてきたが、面積の小さな本県においてはダム建設のできる場所は限られており、そのため新たな水源を海水に求めて、1997年度には海水淡水化施設を導入し、水不足に悩む本県の貴重な水源として重要な役割を担ってきた。

水需要の伸びは、観光客の増加、県の人口が増加していることなどから、今後も続くことが予想される。浄化センターは「枯れないダム」であり、これを利用しないことは「もったいない」ことである。再生水利用下水道事業は、新たな街づくりが行われている天久新都心に、那覇浄化センターの処理水を高度処理して、トイレの洗浄水や公園の散水用水として送水しており、2002年度より供用開始している。再生水使用料金は、小口需要家が140円/m³(消費税抜き単価、以下同じ)、大口需要家が200円/m³に設定されており、上水道料金330円/m³(大口需要家)よりも割安である。

供給開始後、2002~2005 年度にかけて供給箇所数は 20 か所から 36 か所、日あたり使用水量も 200m³ から 462m³ へと着実に増加している。那覇市では再生水利用に関し那覇市水資源有効利用推進要綱を作成して市民への利活を促している。沖縄県でも更に需要が増やせないか検討しているところである。

県内において、糸満市と名護市は、二次処理水を高度処理し、修景用水として使用している。更に、 那覇浄化センターの処理水を高度処理し、沖縄中南部の農業用水として数万 m³ を使用する計画が策定 されている。

(14) 米国における水の再利用の現況

An Overview of Water Recycling in the United States

(イーストベイ上下水道組合 デニス・ディーマー)

再生水利用は、世界の多くの地域で、既に重要な給水源になっている。しかしながら、その大きな潜在的ポテンシャルは、十分に活用されていない。米国では約34億ガロン/日(1,300万 m³/日)の水が再利用されているが、下水発生量全体の9.7%に過ぎない。

米国において再生水利用が推進されるのには、干ばつに左右されない安定した水源であること、人口増に伴い水需要が増大していること、限られた飲料用水源を保全する必要があることなどの要因がある。再生水の利用用途は、今では、工業用水や、食用・非食用農作物の潅漑用水、オフィスビルのトイレ用水、さらには、地下水涵養や間接的な飲料用水利用もある。再生水利用には、水質が悪い又はそのおそれのある水域への処理水放流量の減少、他の地域からの送水量やその費用の縮減等の数多くの便益がある。

再生水基準は、州毎に異なっており、国の統一した基準はない。カリフォルニア州は、米国で最も厳しい基準が定められており、その衛生学的水質基準は、再生水との接触の程度に基づいて規定されている。また、再生水処理方法は、その利用用途に応じて決まる。例えば、利用用途が主に潅漑又は冷却塔用水であれば、2次処理水+砂ろ過過で十分であるが、間接的な飲料用水利用であれば、MF 膜ろ過、RO 膜ろ過及び紫外線消毒のような高度処理が必要である。膜ろ過は利用用途によっては必ずしも必要なものではないが、価格の低下により選択の幅が広がってきている処理方法である。なお、再生水供給費用は、ユーザーまでの距離、連邦又は州の助成金の有無等により、非常に広範囲にわたっている。

再生水利用の普及に際しての主な課題として、教育の必要、基金の拡大、再生水利用の経済性の向上、安全性に関する統一した基準の設定等がある。また、低コスト化のための革新的な新技術の開発、試験方法、モニタリング方法、さらには、内分泌かく乱化学物質や医薬品由来化合物等の新たな問題に対応するための更なる調査研究が必要である。

再生水利用は、単なる排水処理水の再利用と考えてはいけない。再生水利用は 21 世紀における新しい水源の選択肢の1つであり、水管理の重要なツールである。

【討議】

下水処理水のクーリングタワーでの再利用について意見交換がなされた。日本側から「クーリングタワーでの利用はエアロゾルの問題があり日本では許可されないが、米国ではどのような処理を行っているのか、また、危険性はないのか。」との質問がなされた。米国側より「物理化学処理の後、栄養塩除去のための生物処理、砂ろ過処理された処理水を石油精製工場のクーリングタワー水として使用している、15年以上供給しているが全く問題ない、周辺は工場地区である。」との回答があった。続けて、「商業地区やオフィス街でのクーリングタワー利用も可能なのか。」と日本側から尋ねたところ、米国側より、「可能である、どの程度の処理をすべきかについては個別案件毎に衛生部局と協議する必要がある。」との回答であった。

その他として、処理水の水資源としての位置づけ、色度及び供給先についての議論並びにクリプトスポルディウムが大発生したときの対応についての議論がなされた。また、沖縄で供給される再生水の使用料及び採算がとれるための供給量について質疑がなされた。

5.7 議題 6: 生物学的リスクアセスメント・リスクマネジメント

(15) クリプトスポリジウムの水系集団感染から得られる知見―予兆現象とオーシスト監視―

What Is Learned from Water-related Outbreak of Cryptosporidiosis - Sign Phenomenon and Oocyst Monitoring -

(国立感染症研究所 遠藤 卓郎)

世界保健機関(WHO: World Health Organization)の定義によれば、水系集団感染や食品由来の手段感染は、2人以上の人が同じ種類の食物又は同じ水源の水を摂取した後、類似した病気を発症し、かつ、疫学的証拠から、その食物又は水が病気の原因とされる時である。積極的な監視のためには、水系集団感染を、予期されるよりも多くの症例が地理的にも時間的にも集中して発生した時とする定義も有効である。

この観点から、既に発表された集団感染報告を再度吟味した。

小規模な下痢(クリプトスポリジウム)症患者が、ほとんどの大規模な集団感染の直前でみられ、このことは、集団感染に先立ち、給水栓水への少量のオーシストの漏出が少なくとも1か月程度続いていたことを示唆する。病原体の漏出は、原水中に高い濃度でオーシストが存在し、浄水処理プロセスで完全には除去できないためであると考えられる。このことから、水系集団感染が、原水に病原体が存在す

る状況で、浄水処理に問題が生じたか、施設に瑕疵があるときに発生すると考えられる。突然の気温変化により、煮沸されない水道水の飲水量の増加したことも、集団感染の原因となりえる。

この前兆現象(水道に関連する小規模な下痢患者の発生)は、一般的な感染症についての健康面から モニタリングでは検知することはできず、集団感染が判明した後の調査で初めて検知された。しかし、 原水中のオーシストの監視により、前兆現象を検知する見込みはまだある。また、その監視を行うこと ができれば、クリプトスポリジウムの大規模集団感染をあらかじめ警告するシステムを確立することが できる。

これまでの集団感染での前兆現象ではおよそ 0.02 個/L 程度の濃度に達していたと計算されるが、これは、クリプトスポリジウムの定期検査の検出限界よりはるかに小さい値である。一方で、浄水処理プロセスの粒子除去効率に応じて、原水中には(浄水の)10~1,000 倍程度の濃度のオーシストが存在すると予測される。仮に、浄水場の粒子除去能力が 2.7log 程度 (1/500) とすると、原水中のオーシスト数は10 個/L 程度と計算される。

多くの集団感染事例の事後調査により報告されているとおり、この前兆現象(原水中にオーシストが高濃度で存在すること)は一時的な現象ではなく数週間にわたって継続すること及び200~1000mLの原水からのオーシストの分離はそれほど時間がかからないことを考慮すれば、1~2週間ごとのクリプトスポリジウムの監視を日常の監視業務に取り入れることは可能と考えられる。

例えば、DNA 増幅手法を用いた新しいモニタリングシステムにより、オーシストを検出し大規模なクリプトスポリジウムの水系集団感染を未然に防ぐことが期待される。

5.8 議題 7: 化学的汚濁物質のリスクアセスメント・リスクマネジメント

(16) 環境における医薬品—PhRMA イニシアティブの概説—

Pharmaceuticals in the Environment - A Review of PhRMA Initiatives (メルク社 メアリー・バズビー)

米国研究製薬工業協会(PhRMA: Pharmaceutical Research and Manufacturers of America)は医薬品の環境中での挙動・環境影響について、科学的知見を提供するために活動してきた。医薬品が環境に与える影響をスクリーニングする目的で、医薬品の環境中での挙動モデル PhATE を開発した。これは、下水処理場を発生源として、水系における医薬品の放出、移動、分解等の挙動をシミュレートして、水中濃度の累積分布を予測するものである。代替指標物質(カフェイン等)で予測値と実測値を比較してモデルを検証し、良い結果が得られた。実際の医薬品に適用した結果、初期リスク評価で問題となる物質はなかった。また、医薬品の水生生物への生態影響評価に用いるための毒性データベース PhACT を作成し、リスク評価に活用している。ここでは、医薬品が魚類、甲殻類、藻類等の水生生物に与える影響について、生体影響試験結果の査読付き論文の報告事例が無影響濃度予測値(PNEC: Predicted No-Effect Concentration)等の形式で網羅的にデータベース化されている。

(17) 下水汚泥の化学物質管理

Management of Chemical Substances in Biosolids

(土木研究所 山下 洋正)

土木研究所リサイクルチームでは、下水汚泥中に含まれる化学物質について調査研究を行っている。極めて多数の化学物質が工業、農林水産業、病院、家庭等で使用されており、その相当部分が下水道へ放出されて下水処理場に流入している。近年になって環境汚染物質と考えられるようになった内分泌かく乱物質や医薬品類(PPCPs: Pharmaceuticals and Personal Care Products)は、環境保全面での法的規制が

なされておらず、懸念がもたれている。疎水性の化学物質は特に下水汚泥に移行する傾向があり、下水汚泥の緑農地利用等の有効利用の際の暴露等により、人の健康や環境への影響を与える可能性があるため検討が必要である。内分泌かく乱物質のうち、ノニルフェノール、ノニルフェノールエトキシレート、ノニルフェノールエトキシカルボキシレートについて調査した結果、下水汚泥コンポストにこれらの存在が確認された。また、35℃条件下でのコンポスト実験により、これらの物質の分解経路が明らかとなった。エストロゲン類については、下水汚泥コンポスト中にほとんど検出されず、比較的分解されやすいものと考えられた。医薬品類については、現在調査中であり、今後結果を報告していく予定である。

(18) 下水道における医薬品類の存在実態

Occurrence of Pharmaceuticals and Personal Care Products in Wastewater Systems (土木研究所 鈴木 穣)

近年、医薬品類(PPCPs: Pharmaceuticals and Personal Care Products)による環境汚染に関心が持たれている。医薬品類は下水処理場を通して環境中に排出されるため、下水処理場において医薬品類が適切に処理されることは重要である。現在、下水道システムにおける医薬品に関する情報が限られているため、数箇所の下水処理場において、流入下水中の医薬品類濃度の実態と下水処理過程における挙動について調査を行った。また、抗生物質の水生生物に対する毒性試験を実施し、下水処理水放流先水域における水生生態系への影響を評価した。

その結果、医薬品類の流入下水中の濃度はほぼ百 ng/L のオーダーであり、また、多くの医薬品類が溶解態で存在していた。生物処理の過程で、ある種の解熱鎮痛剤は効果的に除去されたが、抗生物質の除去率は約 50%であり、鎮痒剤等においてはほとんど除去されないものがあった。さらに、浮遊物質吸着態を含めた医薬品類の収支を検討することにより、生物分解や活性汚泥への吸着など、医薬品毎にその除去機構を評価した。

また、ある種の抗生物質は藻類に対して増殖阻害を示したことから、下水処理水放流先での希釈率が低い場合には、藻類に影響が生じる可能性が考えられた。

【討議】

日本側から、健康被害の指標とされる化学物質の一日摂取許容量(ADI: Acceptable Daily Intake)が日本ではなかなか手に入らないがアメリカでは知ることができるのかとの質問があり、政府だけでなく民間企業でも次第に公表を始めておりそれらを参考にすることができるとの回答があった。また、蓄積性について他の国の状況を教えてほしいとの質問があり、「イギリスでは問題となっていない。また、影響が出る一定の値があり、現状はそのレベル以下であると思う。」との回答があった。

米国側からは、下水汚泥の緑農地利用が増加しているように見受けられるが、利用の際に問題になっていることはあるかとの質問があった。これに対して、「緑農地利用はほぼ 14%で一定していて、むしろ、建設資材利用、特にセメント資源化が増加している。利用の際に問題となるのは科学的なものではなく感情的なものと思う。重金属を問題視する場合があるが、実際の測定では基準を満たしており、データを示し利用を促進するべきである。」との回答があった。

(19) 水道水における内分泌かく乱物質及び医薬品の存在実態、処理及び毒性評価との関連性

Occurrence, Treatment and Toxicological Relevance of Endocrine Disruptors and Pharmaceuticals in Drinking Water

(南ネヴァダ水組合 シェーン・スナイダー)

最初にラスベガスの特性(人口に比して観光客数が多いこと、降水量が少ないこと等)と持続性の観

点から水の再使用が極めて重要であることについて紹介があり、ラスベガスでは、Mead 湖やそこに生息するコイから、内分泌かく乱物質や医薬品が検出され注目されており、その除去対策としてオゾン、紫外線等による除去特性について調査し、この結果、オゾン処理が塩素処理より有効性が高いこと、紫外線処理は消毒に使用するレベルでは有効でないこと、オゾン添加濃度と臭素酸濃度の間に正の関係があること等が示された。

また、市販漂白剤中で過塩素酸濃度が経時的に増加すること、飲料水から検出される医薬品や内分泌かく乱物質については、飲料水等価レベル(DWEL: Drinking Water Equivalent Level)の評価結果や食品中の濃度から、飲料水に起因する健康影響が生じるとは考えにくいことについての報告がなされた。

最後に、市民の経済的負担増や副生成物等の課題に対応するため、協同的研究に関する意欲が示された。

(20) 水道水における消毒副生成物の存在実態及び管理

Occurrence and Control of Disinfection By-products in Drinking Water (国立保健医療科学院 浅見 真理)

消毒副生成物は、水道において検出される主要な化学物質グループの一つである。2004 年度の調査によれば、水道水質基準項目のうち臭素酸、トリハロメタン等で基準超過が見られたが、臭素酸はオゾン消毒副生成物としては制御が可能となる一方、消毒剤中の次亜塩素酸ナトリウム中の不純物として検出されている。次亜塩素酸ナトリウムは、塩素酸、臭素酸、過塩素酸等を生成し、特に塩素酸は保存温度により生成が大きく異なる。一方、過塩素酸は首都圏の水源である利根川及びその水を水源とする浄水から最高約 40μ g/l 検出されており、工場排水に起因すると見られている。これらの他、NDMA(ニトロソジメチルアミン)の検出や、トリハロメタンの室内空気汚染の現状、臭化物の排出起源について発表が行われ、室内空気汚染の寄与率が高いこと、親水性の汚染物質の重要性が指摘された。

【討議】

日本側から、内分泌かく乱物質の管理のためにシステムをどのように評価しているかとの質問があり、 米国側からは、非常に限られた知見しかないが、優先順位をつけて管理していると回答があった。

次に日本側から、過塩素酸について、取り除く良い方法はないかとの質問があり、地下水の場合は嫌気性の生物処理があるが、表流水については、現在のところ同じく生物処理のほかは費用面でも良い処理法がないようであるとの回答があった。

また、日本では魚を食べるが化学物質の蓄積が心配で、現状はどうかと質問があり、米国では問題となっておらず、影響が出る一定の値があるが、現状はそのレベル以下であるとの回答があった。

5.9 議題 8: 緊急事態対策

(21) 下水道システムの地震被害からの復旧対策

Measures for Recovery against Seismic Damages to Wastewater Systems (国土技術政策総合研究所 田中 修司)

1995年1月の兵庫県南部地震、2004年10月の新潟県中越地震では下水道施設は非常に大きな被害を受け、処理施設の運転停止のほか、管渠に大きなダメージを受けた。兵庫県南部地震と新潟県中越地震では住民が長期間にわたって避難生活を強いられるほどの被害が住宅や社会インフラに対してあった。この2つの地震では、下水道施設が処理不能になる被害を受け、汚水が公共用水域へ直接垂れ流しになる状況に陥った。本報告では①2つの地震による被害の特徴、②処理不能の施設を回復するまでの措置、

③地震被害に対する機能回復までの支援の方法及び④トイレ問題について論じ、特にトイレ問題に関して水道側の復旧との連携の必要性を述べた。

(22) 緊急事態対策—下水道事業に関連してハリケーン・カトリーナから得られた教訓—

Measures against Emergencies: Lessons from Hurricane Katrina Regarding Sewage Works (ブラック・アンド・ヴィーチ社 ジェームス・クラーク)

ハリケーン・カトリーナにより潮位が 15~25 フィート (4.5~7.5m) となった。これにより、ミシシッピー州の沿岸のほとんど、ルイジアナ州のかなりの部分及びアラバマ州の西側の沿岸部が水に漬かった。このため、下水道システムが被害を受け、いくつかの処理場では壊滅的な打撃を受けた。3 州の 896 か所の施設のうち 118 か所が、水位の上昇した場所に位置し、被害を受けた。被害総額は 14 億ドルになる。

被害を受けた施設の復旧に関わる中で、次のようなことが分かってきた。

- ① 被害後9か月経っても被害地域の地図が公表されておらず、それだけ被害が大きかったことを表している。
- ② 被害後、8 週間後でも現場調査は容易ではなく、RV 車で現場に入ってもすぐにタイヤが瓦礫と釘で だめになり、またホテルや現場に行く飛行機もなかなか確保が難しい状況であった。
- ③ 現場の状況については、担当職員が修理のために現場に踏み留まって活躍しており、このような職員からの情報入手が有効だった。
- ④ 被害を受けた地域内の道路は、救助や建設関係の車が溢れ渋滞が発生していた。
- ⑤ 電話は使い物にならず、常に話中という状態であった。
- ⑥ 地元の状況に精通した人の支援なしでは調査も十分にできなかった。
- (7) 処理施設の主要な被害は電気系統が水に漬かったためのものあった。
- ⑧ ポンプ場では、地上部は激しい被害を受けており、地下部は、砂等で埋まってしまっていた。
- ⑨ 下水道担当職員は多数が避難せず現場に留まり、英雄的な活躍をしていた。

【討議】

日本側から、ハリケーン被害の全容を把握するのに長期間要した理由について質問があり、これに対して、下水道事業体は何をなすべきかを捜していた状態にあって、被害の分類・分析を行う優先順位が低かったこと、また、調査地域への到達に困難が伴ったこと等が理由として挙げられた。さらに、被災後の下水処理場に最初に入ったのかとの質問に対して、処理場の維持管理の人々がまず被災への対応と被害箇所の確認を行っていたとの回答があった。

米国側から、処理場間をつなぐネットワーク管渠、管渠のループ化等耐震対策に対する国等の資金援助について質問があり、通常の建設事業と同じように国から約半分の補助が出されるとの回答があった。

5.10 議題 9: 水道事業のリスクアセスメント・リスクマネジメント

(23) 水道事業のリスクアセスメント・リスクマネジメント

Risk Assessment and Management of Water Supply Business (北海道大学 眞柄 泰基)

水道水は断水した場合、市民生活や社会活動に重大な被害をもたらすおそれがある。日本の水道供給システムのレベルは高く、全ての給水栓から、飲用可能な水にアクセスすることが可能であるが、経営の問題は水道事業を持続させていく上での課題となっている。

日本の水道は地方自治体により運営されており、その料金は政治的選択の影響を受け、事業の収支がとれず、施設の変更や更新のための財源が不足している事業体が多い。さらに今後 15 年のうちに水道事業に従事する職員のうち約 35%が引退することになるため、水道事業に従事する職員の数の大幅な減少が毎日の維持管理にも影響することが懸念される。

日本の多くの社会基盤事業は、収入等が毎年増加するという右肩上がりを前提に行われてきたが、人口減少と給水量の減少による収入の減少は避けられなくなくなったため、過去の配分の効率をよく考察して、資金の分配の新しい構造と労働力を確立しなければならない。サービスは最大化すべきであるが、収入が減ることを考慮にいれて、これまでの配分構造の見直しと、予算の制約を守ることが必要である。その際、効率性に重点を置くことも重要であるが、より重要なのは、隠された非効率を排除することであり、民間の経営政策を採用し、市場メカニズムにしたがった運営を検討する必要がある。

日本水道協会は、水道事業者の管理と運営状況を明らかにするための水道事業ガイドラインを 2005 年に策定した。ガイドラインは安全、安定性、持続性、環境配慮、管理、そして国際的な活動の見地からの 137 の性能指標から構成されている。また、水道事業の実態をふまえた水道法改正と PFI 法の公布により、第三者委託が可能となった。管理や技術の視点から、各地域の状況を踏まえて、水道事業を適切に管理するためにどのような管理形態を採用できるかをよく調べることが必要であり、民間セクターによる運営を客観的に評価し、よりよい運営方法をアドバイスできるような第三者監査システムを設けることが必要である。第三者による監査システムは、健康影響を守るという基本的な点から、水道事業への満足度といった高いレベルの点までを対象に行われるべきである。

また、日本水道協会が示したガイドラインは、水道事業者を評価する上で非常に有用であるが、資産管理に関係する性能指標が全て取り入れられているわけではない。ガイドラインはベンチマークを示していないため、水道事業のよりよい運営管理のためのベンチマークを開発することが必要であり、関係者による水道事業の監視と監査のための基準を開発することが必要である。

(24) 水道事業体の将来像の戦略的なアセスメント

A Strategic Assessment of the Future of Water Utilities (米国水道協会研究財団 ロバート・レナー)

水道事業の将来の傾向を整理し、対応をとるために、米国水道協会研財団(AwwaRF: Awwa Research Foundation)は、2004年に「水道事業の将来についての戦略的アセスメントの改訂」プロジェクトに資金を拠出した。プロジェクトは将来の傾向についてのレポートの策定に焦点をしぼって行われた。

ワークショップでは水道事業の長らがレポートを再検討し、水道事業の傾向について議論し、起こるだろう傾向と望まれる傾向に関して約 19 の将来の傾向を確認し、評価した。この傾向は、いくつかの将来シナリオに分類された。

グループディスカッションを通して得られた参加者の知恵と専門知識を集約するために水道の専門家等により構成されるワークショップが設けられた。ワークショップの主要な目的は、議論を深めることにより、上位から 10 番目までの将来の傾向を発展させ、それぞれの傾向について対処するための戦略をとりまとめることであった。

上位から 10 番目までの将来の傾向は以下のとおりであり、それぞれの概要が考えられる対応戦略とあわせて、レポートの中でまとめられている。①人口、②政治上の環境、③財源上の限界、④全体的水道管理、⑤消費者の期待、⑥水道事業従事者数の問題、⑦技術、⑧エネルギー、⑨リスクの増加、⑩規制

【討議】

日本側から、日本では汚泥処理にエネルギーとコストをかけているが、米国の事情はどうかという質

問があり、同様に重要な課題と考えており、汚泥量の削減や再利用が環境面から必要であるとの回答がなされた。

また、日本では政府が水道ビジョンを作成し、水道事業体が地域水道ビジョンを整備しているが、米国の状況はどうかという質問が日本側からあった。これに対して、「米国では、大きい事業体ではプランを作成しているが、小規模事業体では政府が作成をサポートしている。また、住民に対して公衆衛生改善を目的とした浄水場への資金の投入について説明する手法について現在研究している。」との回答があった。

米国側からは、リスクアセスメントの将来の課題について質問があり、今までは水質、施設が重点的に取り扱われていたが、今後は政府、地方自治体の財政状況から経営面が課題となっているとの回答がなされた。

5.11 議題 10: 統合的な流域管理

(25) 水質保全のための新しい流域管理施策—下水道法の改正—

Modified Watershed-Based Approach to Clean Water -Amendment to Sewerage Law-(下水道新技術推進機構 藤木 修)

日本では、2005年に下水道法が改正され、水質保全のための新しいアプローチが確立された。すなわち、閉鎖性水域を対象に、窒素及びりんに係る「移転可能な削減目標量」という概念が導入されたのである。

「移転可能な削減目標量」は米国で行われている水質取引における「移転可能な排出許可」にやや似た概念である。国土交通省が発表したガイドラインでは、下水道管理者である地方公共団体の間の公平性に重点を置いて、ベースラインとなる削減目標量を決めるやり方が提案されている。移転前後の環境に対する影響の等価性は、個々の排出負荷量の影響を評価することによって、おおよそ担保される。削減目標量の円滑な移転を促進するため、削減目標量の段階的プログラムと移転に係る情報を交換するための場が必要であろう。

国土交通省が発表した別のガイドライン案では、水質取引を参考に、移転される削減目標量と支払われる費用が比例するという関係に基づいて、支払われるべき費用が決められるべきだと提案している。また、削減目標量の移転を通じた円滑で効率的な負荷削減に補助金が悪影響を及ぼさないよう、補助制度に修正が加えられた。

現在、東京湾、大阪湾、伊勢湾及びその他の閉鎖性水域の水質保全を目的として、削減目標量の移転を可能とするための、流域別下水道整備総合計画の策定が進められている。その作業のなかで、削減目標量のベースラインの決定と並行して削減目標量の移転についても検討が行われている。

(26) 流域の保全及び再生を目的とした水清浄法の手段の適用

Application of Clean Water Act Tools to Restore and Protect Watersheds (米国環境保護庁 ジェームス・ハンロン)

米国における表流水の水質は、1972 年に制定された水清浄法(CWA: Clean Water Act)によって管理されている。本発表は、環境保護庁(EPA: Environmental Protection Agency)が、CWAという基盤とその政策手段を活用して、全米の流域をどのように保全、回復しているかを論じたものである。

CWA に基づく水質管理プログラムでは、水の用途、数値及び記述式の基準、モニタリング、評価、環境基準を達成するための許容負荷量(TMDL: Total Maximum Daily Load)の計算、汚濁負荷許可プログラムといった政策手段が用意されており、これらは、法に基づく測定及び規制とあわせて、34年間に

わたり米国の努力の基盤であった。初期の段階では、下水道整備に対する何十億ドルもの補助金制度があり、全国汚濁物質排出削減制度(NPDES: National Pollutant Discharge Elimination System)プログラムに基づき 5 万以上の排出者に対して排出許可証が発行された。排出許可は当初は技術に基づく必要最小レベルのものであったが、次の段階では水質目標を達成するレベルに移行した。1980 年代後から 1990 年代を通じて、有害物質の排出基準、分流式・合流式下水道からの越流汚濁、雨天時の汚濁流出が重点課題であった。1990 年代の中頃に初めて、TMDL と流域における点源・非点源対策の組み合せに関心が集まった。

これまでに、汚濁負荷は削減されたが、多くの場合、計画に沿った水質の改善は実現されなかった。 TMDLへの関心から始まり、点源・非点源の影響、土地利用パターン、水理・大気現象の影響を関連させた評価を通じて、流域管理の発想が発展してきた。

過去 10 年以上の間、全米水管理計画における EPA の取組は、流域に焦点を当てたものであった。米国では、EPA が全国にわたって、規制、政策、指導、CWA の施行を促進するための資金確保という仕組みを確立する責任を負っている。施策の大部分は、州又は地方レベルで実行されている。米国では、何千もの流域グループが、よりよい流域づくりをめざして、地方政府や大学、企業、市民グループと協力して活動している。

本発表では、ジョージア州アトランタにある EPA 第4地方局の水管理計画で採用されたヌーズ (Neuse) 川の流域管理アプローチが紹介された。このアプローチによって、ヌーズ川流域では 1997 年から 2003 年までの間に 30%の窒素負荷が削減された。現在は、窒素の水質取引を行うための 23 の自治体から構成される組合が組織されている。

2006 年から 2011 年までの戦略計画では、39,798 のうち 2,250 以上の流域で、すべての汚濁物質について、水質環境に係る基準を満足することとなっている。また、69,677 のうち少なくとも 5,600 の水域汚濁特定要因を取り除き、流域管理のアプローチを活用して、全米 250 の流域において水質改善を図ることとしている。

【討議】

日本側から「米国で流域管理を具体的に実施するのは誰か。専門的に取り扱っている人に依頼して行うのか、あるいは役所が行うのか。」という質問があり、「流域管理とは、関わる者みなが実施するものである。特に、地方レベルでは、市民が流域管理に参加して非常に精力的に活動している。国は、技術レベルのトレーニングを行って流域管理を支援している。」との回答がなされた。

米国側から「米国では国レベルでの排出規制もあり州レベルでの規制もあるが、日本では規制値の設定はどのようになっているのか。」との質問があり、「環境問題が基本的には日本では中央政府に責任があり、規制は基本的には法律に基づき行っているが、地方レベルでさらに厳しい規制をかけることができる。ただ体系については健康項目と生活項目で違いがある。」との回答がなされた。

「流域管理においては非点源汚濁源のコントロールが重要であり、水質取引で点源汚濁源と非点源汚濁源の間でやり取りを行うのは大変優れた方法と思われる。実際に、非点源汚濁源のコントロールが行われているかの確認は、どのように行われているのか。」という日本側からの質問に対しては、モニタリングステーションを設けてその実効性を監視しているとの回答があった。

5.12 議題 11: 新技術

(27) 沖縄県の海水淡水化施設

Seawater Desalination Facility on Okinawa (沖縄県企業局 山里 徹)

人口の増加と経済の発展により、沖縄本島の水需要は 1972 年の約 20 万 m³/日から 2002 年の約 42 万 m³/日へと倍増した。ダムや河川の開発のみに依存する水資源の不足が懸念される中、沖縄県企業局は、国政府の協力を得て海水淡水化事業に着手した。国政府によって 1977 年に最初の調査が行われ、1993年には 85%の高率国庫補助を受けて総工費 347 億円の建設が始まり、1997年に全施設が完成した。

海水淡水化センターは、沖縄本島の平均水道使用量の約10%に相当する4万m³/日の生産能力を有している。生産された水は、隣接する北谷浄水場に送られ、陸水から生産された水と混合された後、市町村の水道事業体に供給されている。

海水淡水化センターは、国内最大級の淡水化施設として、稼動開始以来 10 年間の運転を通して渇水期の水需要に応えるとともに、維持管理技術を含む多くの貴重な情報を蓄積してきた。中でも、連続フル稼動を支える膜差圧上昇対策と、水質劣化対策として行う逆浸透膜エレメントの交換について大きな進展があった。

生産水の水質については、膜エレメント劣化による塩分濃度の上昇が懸念されるため、主に導電率に重点を置いて管理を行っている。硬度やほう素濃度等の問題に関しては、北谷浄水場で処理された陸水との混合によって解決されている。また、1999年以降は、逆浸透膜エレメントの部分的交換手法を確立し、年次的交換によって水質劣化の防止及び改善が図られてきた。膜エレメントの交換によって、生産水の導電率、ほう素濃度、総溶解固形分(TDS: Total Dissolved Solid)がいずれも減少傾向にあることが実績データとして示されている。

運転管理に関しては、主にフル稼働時の膜差圧上昇が大きな課題である。膜差圧の上昇は、エレメント内で微生物が繁殖して海水流路内を狭くするバイオ・ファウリングが原因であると見られている。海水淡水化センターでは、バイオ・ファウリング対策として、主に膜洗浄と硫酸ショック処理を行っている。膜洗浄に関しては、効果的な手法が確立されてきたが、硫酸ショック処理については、確実な効果を得るためさらなる研究が必要である。

海水淡水化センターの稼働率は、2005年度には過去最高の44.2%に達し、稼動開始以来の総生産水量は3,700万m³以上に達している。また、淡水生産コストは、生産水量の増大とともに低下してきている。

近年の渇水傾向の中、施設の稼働率が上昇する一方で、過去 10 年以上にわたって給水制限がないことから、海水淡水化センターは、沖縄本島の重要な水資源として十分に機能し、水道用水供給の安定化に大きく寄与していると考えられる。

(28) 水道水供給の持続可能性向上のための再利用及び淡水化技術

Reuse and Desalination Technologies to Improve the Sustainability of Drinking Water Supplies (米国水道協会研究財団 マルティン・アレン)

持続性とは、重大な結果を引き起こすことなく、現在及び将来の需要を満たすということであり、1980 年代後半から 1990 年代前半にかけて、給水の戦略的計画において骨格となってきた。水道事業の観点からは、持続性における重要な着目点は、消費者のために、安全かつ妥当な価格で飲料水を利用できる状態が続くことを保証することである。その際、他の優先事項(例えば、生態系、環境、経済、福祉)も維持される必要がある。需要管理等の水道供給の管理戦略は飲料水の供給の持続性を達成する上で重要な役割を果たすが、水の再利用と淡水化のための技術もますます重要になってきている。

これらの技術については、米国水道協会研究財団(AwwaRF: Awwa Research Foundation)によって、調整や費用負担がされており、実用的な管理戦略と水源の大部分を支えることが可能となるような技術的進歩の両方が進められてきた。

水の再利用は、非飲用のための供給源として又は他の水源と混ぜることによる飲用(間接的飲用)のための供給源として、下水処理水を利用することであり、水のリサイクルや再生とも言える。AwwaRFは、他の組織と協力して水の再利用戦略と技術を進歩させるため、関連するプロジェクトに資金を供給してきた。

AwwaRF は持続可能な地下貯蔵の技術の進歩を目指し、関係機関と連携し、帯水層貯蔵について多くの研究を実施してきた。土壌帯水層浄化は、浄化と貯蔵のシステムであり、再生水とともに飲用可能な水の供給量を増加させることができる。AwwaRF では土壌帯水層浄化を調査する段階的な研究計画成し遂げた。

非飲用又は間接的飲用のために必要な水質を備えさせるために、高度浄水処理(例えば膜処理)を用いることができるが、主たる課題は、エネルギー消費と濃度管理である。AwwaRFでは、再利用のみでなく、淡水化の実用化に向けて、これらの問題について慎重に研究を行っている。現在、再生水の処理のために NF と ULPRO の効果についての研究を行っており、膜の選択や NF 膜と ULPRO 膜の処理間での汚染物質の除去の予測についてのガイダンスを提供することとなっている。また、内陸における水再生システムのための膜による濃縮処理についても開発されている。

水質の悪い水源の処理において、飲用できる新しい水源を用意するために水処理の中で淡水化技術が使用されている。新たに多くの淡水化プラントができてきているが、全てのプラントにおいて未だに課題となっているのは、エネルギー消費、環境影響、費用対効果、処分オプションであり、解決に向けて、高度処理や濃縮処理技術、処分技術等、様々な研究を進めている。

(29) 水道水質管理に関する新研究プロジェクト

New Research Project on Drinking Water Quality Management (水道技術研究センター 藤原 正弘)

浄水技術分野では、1991年からの膜ろ過の研究に始まり、現在実施中の安全でおいしい水を目指した高度な浄水処理技術の確立に関する研究(e-WaterIIプロジェクト)で5つ目となる。また、管路技術分野では老朽管路における水質劣化や老朽度診断に関する研究(New Epochプロジェクト)を行っている。

研究の背景としては、浄水では施設の老朽化、水源水質の変化、クリプトスポリジウムや臭気原因物質の問題があげられる。管路では老朽化が大きな問題であり、この研究が管路更新に役立つものになればと考えている。

研究費予算は3か年で浄水技術が約500万ドル、管路技術が約100万ドルの合計約600万ドルであり、研究関係者は総勢約200名である。

また、2002 年度から 3 か年で実施した e-Water の成果は、ガイドラインやマニュアルとして公表しており、国内の膜ろ過施設の普及促進に貢献している(2006 年 3 月現在、550 施設、累積施設能力 62 万 m^3 /日)。同時期に実施した管路技術の Epoch では、管路内濁質挙動を実験管路で解明した。研究成果は、セミナーや国際会議などで発表している。

【討議】

海水淡水化について、米国側から、膜差圧やコストを抑えるための膜ろ過の利用及び塩素消毒による 臭化物の生成について質問があった。これに対して、膜ろ過については検討していないが、臭化物など 消毒副生成物については、臭化物をあまり生成しない表流水処理水と混合で使用するため、濃度はそれ ほど高くないと回答がなされた。放流される塩水の影響について、米国側から質問があり、日本側から、 放流塔のノズルから放流される塩水は塩分濃度 5.8%であるが、12m離れた地点では、周囲の海水とほぼ同じ約 3.5%の塩分濃度となり問題ないと回答があった。また、バックアップではなくメインシステムとはならないのかとの質問に対しては、給水単価が海水淡水化 130 円/m³、一般の給水単価 102 円/m³ という差の問題もあり、2 つの水源をバランスよく使用することが沖縄県にとっては重要であるとの回答があった。さらに、米国側から「表流水処理と海水淡水化の割合は、渇水の状況で変わるということだが、その場合送水の水質が変わるのではないか。また、それについてユーザーからの苦情はないのか。」という質問があった。これに対して「北谷浄水場が 16 万 m^3 /日を供給しており、海水淡水化は通常 $5000m^3$ /日に対して最大で 4 万 m^3 /日と 8 倍の能力があり、表流水取水量に応じて運用しているため、水質の変化はあると考えられるが、特にそれに関する苦情はない。」と回答がなされた。

続いて、e-Water での膜ろ過普及について、米国側から普及の背景について質問があり、日本側からは「国庫補助があることや地方の小規模事業体にとってクリプトスポリジウム対策としてアウトソーシングしやすい技術であることが理由として挙げられ、近年は大容量化してきている。」との回答があった。

最後に、米国側から管路の老朽化や酸化、赤水についての状況について質問があった。日本側から、一般論だが日本の水道は残留塩素濃度が高く、そのため酸化や老朽化が他の国より進行することも考えられるが、最近はエポキシ樹脂ライニングなどの対策がされているとの回答があった。

(30) 下水処理の新技術—下水処理技術の最先端—

New Technology for Wastewater Control - Cutting-edge of Wastewater Treatment Technology - (日本下水道事業団 村上 孝雄)

○膜分離活性汚泥法

膜分離活性汚泥法(MBR: Membrane Bio Reactor)は、日本においては早くから産業排水処理、大規模ビル内個別循環等に利用されてきた。都市下水処理用 MBR は、他分野に比べて導入が遅れていたが、2005 年 3 月には下水道用 MBR 第 1 号が稼動した。これにより MBR 普及が進展しており、現在、5 か所の MBR が稼動中であり、約 10 か所が設計、計画段階である。下水道用 MBR は今後更に増加することが予想されている。MBR は良好なウイルス除去性能を示し、そのウイルス除去機構は、ウイルスの活性汚泥への吸着が主な要因であると考えられることが紹介された。また、生物学的窒素除去プロセスへの分離膜の適用に関して、ステップ流入三段硝化脱窒プロセスへ膜分離を適用した事例が紹介された。MBR は、水処理のコア技術として多様な展開が期待されている。現在、日本では小規模な施設への適用が主であるが、今後は大規模施設への展開が期待される。MBR の普及には、設計・維持管理方法の最適化、膜コスト低下と膜の長寿命化、洗浄用空気量の削減等が重要である。

○オゾンによる内分泌かく乱物質の除去

内分泌かく乱物質の中でも、エストロゲンは内分泌かく乱作用が強く、下水処理ではなかなか除去されない。このため、オゾンによる分解が有効と考えられる。本研究では、 $17\,\beta$ エストラジオール、エストロン、 $17\,\alpha$ エチニルエストラジオールを対象として、オゾン分解実験が行なわれた。この結果、1mg/L程度のオゾン添加量でエストロゲンは 90%程度除去され、3mg/L のオゾン添加量で検出限界以下となった。このことから、通常、消毒等の目的で使用されるオゾン添加量(最大約 5mg/L)の範囲で、エストロゲンは良好に除去されることが明らかになった。

○新しい窒素除去技術-アナモックスプロセス-

アナモックスプロセス(嫌気性アンモニア酸化)は、アナモックス菌の作用により、アンモニア性窒素と亜硝酸性窒素による脱窒で窒素が除去される反応である。本反応は、自栄養性細菌による反応であるため、消費エネルギーが小さく、外部炭素源が不要であるといった多くの利点がある。本プロセスは、生物学的窒素除去プロセス採用箇所での嫌気性消化脱離液からの窒素除去や汚泥乾燥プロセス排ガス

処理施設の返流水中の窒素除去に有効と期待されており、日本下水道事業団では、民間企業との共同研究を含めて本プロセスについて、実用化研究を行なっているこが紹介された。

(31) 下水処理の新技術—下水汚泥の臭気低減のための最先端処理技術—

New Technology for Wastewater Control - Cutting-edge Treatment Technology to Reduce Odors in Biosolids -

(米国水環境研究財団 ダニエル・ウォルタリング)

本発表では、嫌気性消化汚泥一脱水汚泥からの臭気削減方法の研究について紹介された。

汚泥臭気については、環境保護庁 (EPA: Environmental Protection Agency) による 40CFR 第 503 号規制 に適合することが求められている。汚泥臭気が削減できれば、下水処理施設の近隣への受入が容易になり、汚泥リサイクル用途も広がる。また、臭気対策に必要なコストが削減できるといった多くのメリットが期待できる。

本研究は、2000~2007年の7年間にわたって実施された。研究の第1段階(2000~2001)では、下水処理場臭気について文献調査、実態調査を実施した。第2段階(2002~2003)では、11処理施設において詳細な実態調査を実施した。その結果、脱水汚泥が最も悪臭源となること、高せん断力がかかる遠心脱水機の方が、加圧脱水よりも臭気が発生し易いことが明らかになった。また、臭気と健康の関係についても調査を行なった。

第3段階及び現時点での段階は2004年に開始された。この段階では、現在、下水処理場において使用されている脱水・消化プロセス及び40CFR第503号規制に適合するために提案されている技術について調査している。全米の11か所の下水処理施設において、データ収集、試料採取・分析を実施し、また、化学薬品、微生物製剤、酵素製剤等の臭気抑制剤(CEBA: Chemicals, Enzymes or Biological Agent)の製造者8社が参加して実験室レベルのテストを実施し、効果があったものについては実施設でのテストを行なった。

嫌気性消化汚泥の主な臭気原因物質は、メチルメルカプタンや二硫化メチル等の有機硫黄化合物であった。8種の CEBA の内、4種は消化プロセスの前、4種は消化プロセスの後に添加して効果を検証した。その結果、1種のみで臭気発生抑制効果が確認されたが、消化阻害が見られたため、使用には適さないという評価となった。消化後に硫酸バンドを添加する方法は、臭気抑制効果が見られ、重量で2%と4%の硫酸バンド添加で有機硫黄化合物ピーク濃度は著しく改善された。嫌気性消化の滞留時間については、10目から30日に延長した結果、有機硫黄化合物濃度は低下したが、臭気のある汚泥の目安である1,000ppmvを下回るには至らなかった。消化槽の形状については、卵形消化槽の方が、通常型消化槽よりも脱水汚泥からの発生臭気は少なかった。脱水機について検討では、遠心脱水機が最も発生臭気が強く、次にロータリープレスとベルトプレスであった。汚泥にかかるせん断力により、生物分解し易くなることが原因であると考えられる。

結果をまとめると、消化汚泥及び脱水汚泥の臭気抑制に効果的であるのは、消化前の汚泥分散処理、消化日数延長、下水の鉄濃度が低いこと、消化槽形状、脱水時での低せん断力である。消化後、脱水前の硫酸バンド添加は臭気抑制効果があった。8 種類の臭気抑制剤はいずれも効果が認められなかった。報告書は2007年第1四半期に発行する予定である。

【討議】

日本と比較して米国は国土が大きいので、悪臭問題はあまり重要でないとも思われるが、実際の都市にとって悪臭はどの程度問題となっているのかとの日本側の質問に対して、例えば十分な緩衝スペースを持っている処理場においては、大きな問題となっているわけでないとしながらも、悪臭は人によって受け止め方が異なることもあって、処理場は一般に住民監視のプレッシャーを受けており、悪臭も重要

な問題と認識される場合があるという回答がなされた。

また、日本側から、長期にわたって残留する脱水汚泥のアンモニア臭に関する質問がなされた。これに対して、「重要であると考えているが、特にアンモニアのみに特化しているということではない。コンポストでも大きな問題と認識されているほか、高温消化における臭気発生については現在実験中である。」とのコメントがあった。

オゾン処理における副産物の臭素酸の生成について米国側から質問があり、「臭素酸生成は重要な問題であるが、日本では水道ほど問題とはなっていない。臭素酸の測定は行っていないが、日本でもオゾン処理後に水道水源に排出するケースがあると考えられるため、今後確認していく必要があると考えている。」とのコメントがなされた。

5.13 総括及び閉会

11 議題、31 編の発表及び討議が終了した後に、本会議の総括が行われ、会議概要につき日米両国間の合意が得られた。日米両国間の合意内容は次のとおりである。

- ✓ 本会議は、水道水及び下水道の管理の分野において、研究及び政策の発展に関する情報共有のための特別な機会を提供し続けるものであり、浄水及び下水処理を含む流域管理に関するホリスティック・アプローチ(全体的な取組)は、水道水及び下水の適切な管理にとって極めて重要であり、日米両国にとって継続的に優先度を有することが確認された。
- ✓ 代表らは、この重要な情報交換は継続すべきものとして、2年後に米国にて以下に示すような課題について会議を開催することで合意した。
 - 一流域管理に関するホリスティック・アプローチ(全体的な取組)
 - 一 上下水道のサービス及び施設における財政及び環境上の持続可能性及び管理
 - 一 水道水質及び下水道の管理のための制度の進展
 - 一 微生物及び化学物質汚染の適切なリスクマネジメントにつながるリスクアセスメント
 - 一 浄水処理、下水処理、水道水配水及び下水収集等のための新技術
 - 緊急事態への備え及び対処するための方策
 - 一 水の再利用
- ✓ 次回会議に関する調整窓口は、米国環境保護庁 キャスリーン・シェンク氏と厚生労働省国立保健 医療科学院 浅見真理氏が務める。
- ✓ 次回会議の開催前に、上の課題について、技術的なワークグループ、情報交換及び/又は技術的なプロジェクトが二国間で行われ、人材交流が促進されることが望まれる。

6 視察の概要

(1) 国営沖縄記念公園

国営沖縄記念公園は、1975年に開催された沖縄国際海洋博覧会を記念して、その翌年に博覧会跡地に設置された国営公園であり、両国代表団は同公園に含まれる沖縄美ら海水族館を中心に現地調査を行った。同水族館は、送水量が1万m³で77の水槽を有する大規模なものであり、沖縄の海洋生物のみを展示していることが特徴的である。外海の水を取り込んでおり、水処理工程において濾過装置はあるが熱交換機がないため、外海と同じ水温の環境下で海洋生物を飼育することが可能となっている。両国の代表者は様々な海洋生物の生態等につき興味深く観察することができた。

(2) 北谷浄水場

北谷浄水場は、沖縄本島中部の北谷町の海岸沿いに立地しており、214,300m³/日の浄水能力を有する 県下最大の浄水場であり、高度浄水処理施設のほか、沖縄県企業局が進めている西系列水源開発事業、 海水淡水化事業の中核的な施設として位置づけられている。浄水場に隣接する海水淡水化センターは、 水需要の厳しい現実から、将来は陸水の水資源開発だけでは需給のバランスを維持することが困難と予 想されるため、建設されたものであり、逆浸透法により 4万 m³/日の淡水が生産されている。

北谷浄水場において、両国の代表者により、本会議の記念植樹が行われた。

(3) 那覇浄化センター

那覇浄化センターは、沖縄県で最初の下水処理場であり、2005 年度末現在の事業計画値は、処理区域面積4,717ha、処理人口365,032 人、処理水量179,000 m^3 /日となっている。流入水質は、BODで約300 $\mathrm{mg/L}$ 、SSで約200 $\mathrm{mg/L}$ である。沖縄の本土復帰前に整備された施設が、現在も使用されていることが特徴の一つである。流入BODが高くなっていることや台風時の流入量増加について質疑応答が行われた。

本施設には、再生水利用のための高度処理設備及び消化ガス発電設備が設置されている。

再生水事業は、生物膜ろ過及びオゾン処理により高度処理された再生水を、那覇新都心地区及び送水管周辺地域の公共施設や商業・業務施設等のトイレ用水及び公園等の散水用水として供給するものである。計画水量は、2,130m³/日である。また、消化ガス発電は、本施設の消化タンクから発生する汚泥消化ガス(発生量約 12,700Nm³/日、CH4成分約 67%)を有効利用するもので、3 台の消化ガス発電機により、本施設で使用する電力量の約 3 割をまかなっている。なお、本施設で発生する汚泥(発生量は脱水汚泥約 68t/日)は場外搬出されて、民間施設でコンポスト化後に有効利用されている。

7 おわりに

本会議は、沖縄県等関係者の協力のもと、参加者の積極的な貢献により成功裡に終了した。流域管理、 医薬品類等のマネジメント、上下水道施設の管理等、水道水質管理及び下水道技術に関する課題につき、 両国からの豊富な内容の発表のもと、積極的な技術交流が行われた。特に、交流における"Face-to-face communication"の重要性が共有され、会議の意義が再確認された。

総括においては、会議概要の詰めの最終段階でも多数の意見が代表団から出され、上下水道施設の持続可能性や財源水準の向上等有益なる内容が盛り込まれた。また、会議概要には、会議の機会以外においても個別の課題に応じたワークグループや人材交流を実施することについて記述が追加され、今後の更なる技術交流促進の礎が整備された。

次回会議は、2 年後に米国で開催される予定であり、その際には、今回の会議で得られた貴重な情報を有効に活用し、下水道が解決しなければならない諸課題に対する解決策を持ち寄り、報告できることを期待したい。

最後に、本会議の開催にあたり御協力いただいた日米両国の関係各位に厚く御礼申し上げたい。

別 添 資 料

第4回 日米水道水質管理及び下水道技術に関する 政府間会議の開催について

Japan-US Governmental Conference on Drinking Water Quality Management and Wastewater Control

国土交通省、厚生労働省、米国環境保護庁は、平成19年1月22日から25日にかけて沖縄県万国津 梁館において「第4回日米水道水質管理及び下水道技術に関する政府間会議」を開催します。

経緯

日米両国間の上下水道分野の技術交流を目的として、平成 11 年から 2~3 年に一度「日米水道水質管理及び下水道技術に関する政府間会議」を開催し、両国の上下水道に関する現状、先端的な技術の動向など有益な情報交換を行い、両国の上下水道技術の向上に寄与してきました。

今回、第3回会議における合意に基づき、第4回会議を日本で開催するものです。

会議の内容

会議は、上下水道技術に関する幅広い課題に対して、「リスク評価と管理」、「流域管理」などのテーマを中心として日米双方から発表を行い、情報交換、意見交換を行うこととしています。

出席予定者

国土交通省下水道部流域管理官、下水道企画課下水道技術開発官、国

日本側(下水道分野) 土技術政策総合研究所下水道研究部長、独立行政法人土木研究所、沖

縄県など 11 名

厚生労働省健康局水道課長、水道水質管理官、国立保健医療科学院水日本側(水道分野)

道工学部長、国立感染症研究所寄生動物部長、沖縄県など 12 名

米国環境保護庁(EPA)国立リスク管理研究所水道・水資源部長、EPA 下 米国側

^・・ 水道管理部、米国水道協会研究財団等の水道・下水道研究者など 13 人

その他

傍聴・撮影は会議冒頭挨拶のみ可能です。

【万国津梁館】住所 : 沖縄県名護市喜瀬 1792 番地 電話 : 0980-53-3155

問合せ先

国土交通省 都市·地域整備局下水道部下水道企画課 下水道技術開発官 那須 基

電話: 03-5253-8111(内線 34162)

http://www.mlit.go.jp/crd/city/sewerage/info/water_quality/20070116.html に平成 19 年 1 月 16 日に掲載

第4回日米水道水質及び下水道技術に関する政府間会議日程

平成19年1月22日-25日 万国津梁舘

1月22日 月曜日

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1353	=
1713	

9:00 - 9:05 歓迎挨拶

沖縄県 首里 勇治

9:05 - 9:15 開会挨拶

厚生労働省 立川 裕隆

9:15 - 9:25 開会挨拶

国土交通省 清水 徹

9:25 - 9:45 開会挨拶

米国環境保護庁 ジェームス・グッドリッチ

概観

座長:北海道大学 真柄 泰基

9:45 - 10:00 日本における水道水質管理の現況

厚生労働省 服部 麻友子

10:00 - 10:15 下水道ビジョン 2100

国土交通省 那須 基

10:15 - 10:30 休憩

10:30 - 10:45 水道水質管理の現況

米国環境保護庁 ジェームス・グッドリッチ

10:45 - 11:00 米国における下水処理の進展と挑戦―オハイオ川流域及びオハイオ川に焦点をあて

オハイオ川流域水質保全委員会 アラン・ヴィコリー

水道システムのリスクアセスメント・リスクマネジメント

座長:北海道大学 真柄 泰基

11:00 - 11:20 日本における「水安全計画」の水道システムへの適用

国立保健医療科学院 国包 章一

11:20 - 11:40 水道システムのリスクアセスメント・リスクマネジメント―21 世紀に向けた社会資本 推進計画―

米国環境保護庁 ジェームス・グッドリッチ

11:40 - 12:00 日本の建物の貯水槽管理の現況―システムの安全管理のためのマニュアルの導入― 麻布大学 早川 哲夫

12:00 - 12:20 討議

12:20 - 13:20 昼食

下水道施設の管理

座長:国立保健医療科学院 国包 章一

13:20 - 13:40 下水道管路施設の老朽化にどう対処すべきか?―管渠の統計学的寿命のデータ解析

—

国土技術政策総合研究所 松宮 洋介

13:40 - 14:00 老朽化する下水道施設の管理―挑戦と戦略―

コロンビア特別区上下水道庁 ジェリー・ジョンソン

14:00 - 14:20 討議

流域管理

座長:国立保健医療科学院 国包 章一

14:20 - 14:40 緊急事態に備えた水道における流域管理―琵琶湖・淀川水系の事例―

阪神水道企業団 佐々木 隆

14:40 - 15:00 気候変動と水資源-水道事業体のための手引き-

国立気象研究センター デービット・イェーツ

15:00 - 15:20 討議

15:20 - 15:35 休憩

水の再利用

座長:国立保健医療科学院 国包 章一

15:35 - 15:55 日本における再生水利用の現状と下水処理水の再利用水質基準等マニュアルの策定

国土技術政策総合研究所 吉澤 正宏

15:55 - 16:15 沖縄における再生水利用下水道事業

沖縄県下水道建設事務所 黒島 隆

16:15 - 16:35 米国における水の再利用の現況

イーストベイ上下水道組合 デニス・ディーマー

16:35 - 16:55 討議

16:55 - 18:00 準備

18:00 - 20:00 歓迎レセプション

1月23日 火曜日

生物学的リスクアセスメント・リスクマネジメント

座長:米国環境保護庁 キャスリーン・シェンク

9:10 - 9:30 クリプトスポリジウムの水系集団感染から得られる知見―予兆現象とオーシスト監

視一

国立感染症研究所 遠藤 卓郎

化学的汚濁物質のリスクアセスメント・リスクマネジメント

座長:米国環境保護庁 キャスリーン・シェンク

9:30 - 9:50 環境における医薬品—PhRMA イニシアティブの概説—

メルク社 メアリー・バズビー

9:50 - 10:10 下水汚泥の化学物質管理

土木研究所 山下 洋正

10:10 - 10:30 下水道における医薬品類の存在実態

土木研究所 鈴木 穣

10:30 - 11:00 討議

11:00 - 11:15 休憩

11:15 - 11:35 水道水における内分泌かく乱物質及び医薬品の存在実態、処理及び毒性評価との関連

脞

南ネヴァダ水組合 シェーン・スナイダー

11:35 - 11:55 水道水における消毒副生成物の存在実態及び管理

国立保健医療科学院 浅見 真理

11:55 - 12:15 討議

12:15 - 13:15 昼食

13:15 - 13:30 準備

13:30 - 万国津梁舘 出発

- 14:30 国営沖縄記念公園 到着

14:30 - 16:30 国営沖縄記念公園 観光

16:30 - 国営沖縄記念公園 出発

- 17:30 万国津梁舘 到着

17:30 - 18:30 準備

18:30 - 20:30 返礼レセプション

1月24日 水曜日

緊急事態対策

座長: 土木研究所 尾崎 正明

9:00 - 9:20 下水道システムの地震被害からの復旧対策

国土技術政策総合研究所 田中 修司

9:20 - 9:40 緊急事態対策一下水道事業に関連してハリケーン・カトリーナから得られた教訓—

ブラック・アンド・ヴィーチ社 ジェームス・クラーク

9:40 - 10:00 討議

水道事業のリスクアセスメント・リスクマネジメント

座長: 土木研究所 尾崎 正明

10:00 - 10:20 水道事業のリスクアセスメント・リスクマネジメント

北海道大学 真柄 泰基

10:20 - 10:40 水道事業体の将来像の戦略的なアセスメント

米国水道協会研究財団 ロバート・レナー

10:40 - 11:00 討議

11:00 - 11:15 休憩

統合的な流域管理

座長: 土木研究所 尾崎 正明

11:15 - 11:35 水質保全のための新しい流域管理施策-下水道法の改正-

下水道新技術推進機構 藤木 修

11:35 - 11:55 流域の保全及び再生を目的とした水清浄法の手段の適用

米国環境保護庁 ジェームス・ハンロン

11:55 - 12:15 討議

12:15 - 13:15 昼食

新技術

座長: 土木研究所 鈴木 穣

13:15 - 13:35 沖縄県の海水淡水化施設

沖縄県 山里 徹

13:35 - 13:55 水道水供給の持続可能性向上のための再利用及び淡水化技術

米国水道協会研究財団 マルティン・アレン

13:55 - 14:15 水道水質管理に関する新研究プロジェクト

水道技術研究センター 藤原 正弘

14:15 - 14:35 討議

14:35 - 14:50 休憩

14:50 - 15:10 下水処理の新技術―下水処理技術の最先端―

日本下水道事業団 村上 孝雄

15:10 - 15:30 下水処理の新技術―下水汚泥の臭気低減のための最先端処理技術―

米国水環境研究財団 ダニエル・ウォルタリング

15:30 - 15:50 討議

閉会

進行:国土技術政策総合研究所 松宮 洋介

15:50 - 16:50 総括及び閉会

16:50 - 18:00 準備

18:00 - 20:00 閉会レセプション

1月25日 木曜日

9:00 - ホテル 出発

10:00 - 北谷浄水場 到着

10:00 - 12:00 北谷浄水場 視察(記念植樹、記念撮影)

12:00 - 13:00 昼食

13:00 - 北谷浄水場 出発

- 14:00 那覇浄化センター 到着

14:00 - 16:00 那覇浄化センター 視察

16:00 - 那覇浄化センター 出発

- 16:20 那覇空港 到着

16:30 - 那覇空港 出発

- 17:30 ホテル 到着

Program for the 4th Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control January 22-25, 2007, Bankoku Shinryokan, Okinawa

Monday, January 22

Watershed Management

Monuay,	•					
Opening						
9:00 -	9:05	Welcome				
		SHURI, Yuji, Okinawa Pref.				
9:05 -	9:15	Opening Remarks, A few Hot Issues of Water Supply, Japan				
		TACHIKAWA, Hirotaka, MHLW				
9:15 -	9:25	Opening Remarks, Sewerage, Japan				
		SHIMIZU, Toru, MLIT				
9:25 -	9:45	Opening Remarks, US				
		HANLON, James A., USEPA				
Overviev	V					
		Moderator: MAGARA, Yasumoto, Hokkaido Univ.				
9:45 -	10:00	Overview on Drinking Water Quality Management in Japan				
		HATTORI, Mayuko, MHLW				
10:00 -	10:15	Strategy on Wastewater Control in Japan for 21st Century				
		NASU, Motoi, MLIT				
10:15 -	10:30	Break				
10:30 -	10:45	Overview of Drinking Water Quality Management				
		GOODRICH, James, USEPA				
10:45 -	11:00	Progress and Challenges in Wastewater Treatment in the United States - With Focus on the				
		Ohio Valley and the Ohio River				
		VICORY, Alan H., ORSANCO				
Risk Ass	Risk Assessment and Management of Water Supply System					
		Moderator: MAGARA, Yasumoto, Hokkaido Univ.				
11:00 -	11:20	Application of "Water Safety Plan" to drinking water quality management in Japan				
		KUNIKANE, Shoichi, NIPH				
11:20 -	11:40	Risk Assessment and Management of Water Supply System - Infrastructure Initiative for the				
		21st Century -				
		GOODRICH, James, USEPA				
11:40 -	12:00	Overview of Current In-Building Water Supply System Management in Japan - Introduction				
		of a Manual for Safety Management of these Systems -				
		HAYAKAWA, Tetsuo, Azabu Univ.				
12:00 -	12:20	Discussion				
12:20 -	13:20	Lunch				
Manager	nent of V	Vastewater Facilities				
		Moderator: KUNIKANE, Shoichi, NIPH				
13:20 -	13:40	How to Deal with Aging Sewers? - Statistical Life Data Analysis of Sewer -				
		MATSUMIYA, Yosuke, NILIM				
13:40 -	14:00	Management of Aging Wastewater Infrastructure - Challenges and Strategies -				
		JOHNSON, Jerry N., DCWSA				
14:00 -	14:20	Discussion				

		Moderator: KUNIKANE, Shoichi, NIPH
14:20 -	14:40	Watershed Management in Drinking Water for Emergency: A Case of Lake Biwa-Yodo River
		System
		SASAKI, Takashi, Yodo River Water Quality Committee
14:40 -	15:00	Climate Change and Water Resources: A Primer for Municipal Water Providers
15.00	15.00	YATES, David, NCAR
15:00 -	15:20	Discussion
15:20 -	15:35	Break
Water R	euse	Moderator: KUNIKANE, Shoichi, NIPH
15:35 -	15:55	Establishment of Guidelines for the Reuse of Treated Wastewater
10.00	10.00	YOSHIZAWA, Masahiro, NILIM
15:55 -	16:15	Promotion of Treated Wastewater Reuse in Okinawa - In search of local community without
		water shortage -
		KUROSHIMA, Takashi, Okinawa Pref.
16:15 -	16:35	An Overview of Water Recycling in the United States
		DIEMER, Dennis M., EBMUD
16:35 -	16:55	Discussion
16:55 -	18:00	Setup
18:00 -	20:00	Welcome Reception (Okinawa Pref.)
T	T	
Tuesday.	-	ssessment and Management
Diologica	ai Nisk A	Moderator: SCHENCK, Kathleen, USEPA
9:10 -	9:30	What Is Learned from Water-related Outbreak of Cryptosporidiosis - Sign Phenomenon and
J.10	y. .	Occyst Monitoring -
		ENDO, Takuro, NIID
Risk Ass	essment	and Management of Chemical Contaminants
		Moderator: SCHENCK, Kathleen, USEPA
9:30 -	9:50	Pharmaceuticals in the Environment - A Review of PhRMA Initiatives
		BUZBY, Mary E., Merck & Co., Inc.
9:50 -	10:10	Management of Chemical Substances in Biosolids
10.10	10.20	YAMASHITA, Hiromasa, PWRI
10:10 -	10:30	Occurrence of Pharmaceuticals and Personal Care Products in Wastewater Systems
10:30 -	11:00	SUZUKI, Yutaka, PWRI Discussion
11:00 -	11:15	Break
11:15 -	11:35	Occurrence, Treatment and Toxicological Relevance of Endocrine Disruptors and
		Pharmaceuticals in Drinking Water
		SNYDER, Shane, SNWA
11:35 -	11:55	Occurrence and Control of Disinfection By-products in Drinking Water
		ASAMI, Mari, NIPH
11:55 -	12:15	Discussion
12:15 -	13:15	Lunch
13:15 -	13:30	Setup
13:30 -		Leave Shinryokan
-	14:30	Arrive at Okinawa Commemorative National Government Park

14:30 -	16:30	Tour in Okinawa Commemorative National Government Park
16:30 -		Leave Okinawa Commemorative National Government Park
-	17:30	Arrive at Shinryokan
17:30 -	18:30	Setup
18:30 -	20:30	Return Reception (US)
Wednesd	ay, Janu	ary 24
Measure	s against	Emergencies
		Moderator: OZAKI, Masaaki, PWRI
9:00 -	9:20	Measures for Recovery against Seismic Damages to Wastewater Systems
		TANAKA, Shuji, NILIM
9:20 -	9:40	Measures against Emergencies: Lessons from Hurricane Katrina Regarding Sewage Works
		CLARK, James H., Black & Veatch Corporation
9:40 -	10:00	Discussion
Risk Asso	essment a	and Management of Water Supply Business
		Moderator: OZAKI, Masaaki, PWRI
10:00 -	10:20	Guidelines for Management of Water Supply
		MAGARA, Yasumoto, Hokkaido Univ.
10:20 -	10:40	A Strategic Assessment of the Future of Water Utilities
		RENNER, Robert C., AwwaRF
10:40 -	11:00	Discussion
11:00 -	11:15	Break
Integrate	d Waters	shed Management
		Moderator: OZAKI, Masaaki, PWRI
11:15 -	11:35	Modified Watershed-Based Approach to Clean Water - Amendment to Sewerage Law-
		FUJIKI, Osamu, JIWET
11:35 -	11:55	Application of Clean Water Act Tools to Restore and Protect Watersheds
		HANLON, James A., USEPA
11:55 -	12:15	Discussion
12:15 -	13:15	Lunch
New Tecl	nology	
		Moderator: SUZUKI, Yutaka, PWRI
13:15 -	13:35	Seawater Desalination Facility on Okinawa
12.25	10.55	YAMAZATO, Toru, Okinawa Pref.
13:35 -	13:55	Reuse and Desalination Technologies to Improve the Sustainability of Drinking Water
		Supplies
10.55	1415	ALLEN, Martin J., AwwaRF
13:55 -	14:15	New Research Project on Drinking Water Quality Management
	1.1.0.5	FUJIWARA, Masahiro, JWRC
14:15 -	14:35	Discussion
14:35 -	14:50	Break
14:50 -	15:10	New Technology for Wastewater Control -Cutting-edge of Wastewater Treatment Technology-MURAKAMI, Takao, JSWA
15:10 -	15:30	New Technology for Wastewater Control -Cutting-edge Treatment Technology to Reduce
		Odors in Biosolids-
		WOLTERING, Daniel M., WERF
15:30 -	15:50	Discussion

Summary and Closing

Moderator: MATSUMIYA, Yosuke, NILIM

15:50 - 16:50 Summary, Closing

16:50 - 18:00 Setup

18:00 - 20:00 Closing Reception (MHLW, MLIT)

Thursday, January 25

9:00 -		Leave Hotel
10:00 -		Arrive at Chatan Water Treatment Plant
10:00 -	12:00	Tour in Chatan Water Treatment Plant (Memorial Plantation, Photo)
12:00 -	13:00	Lunch
13:00 -		Leave Chatan Water Treatment Plant
-	14:00	Arrive at Naha Wastewater Treatment Plant
14:00 -	16:00	Tour in Naha Wastewater Treatment Plant
16:00 -		Leave Naha Wastewater Treatment Plant
-	16:20	Arrive at Naha Airport
16:30 -		Leave Naha Airport
_	17:30	Arrive at Hotel

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会議概要

第4回日米水道水質管理及び下水道技術に関する政府間会議(仮訳)

平成 19 年 1 月 22-25 日

平成19年1月22-25日、沖縄県にある万国津梁館において、第4回日米水道水質管理及び下水道技術に関する政府間会議が開催された。代表らは4日間にわたり、水道水質管理及び下水道技術の進展に関連する科学技術及び政策の課題について、情報交換を行った。会議の一部として、沖縄県の上下水道施設(北谷浄水場、那覇浄化センター)及び国営沖縄記念公園を視察した。

会議は、沖縄県土木建築部部長 首里勇治氏の歓迎挨拶により始まり、厚生労働省健康局水道課水道 水質管理官 立川裕隆氏、国土交通省都市・地域整備局下水道部流域管理管 清水亨氏及び米国環境保護 庁下水道管理部長 ジェームス・ハンロン氏の開会挨拶が行われた。

技術的な内容については、先ず日本側から、水道水質管理の概要及び下水道管理の 21 世紀に向けた 戦略についてそれぞれ発表が行われた。米国側からは、水道水質管理及び下水道管理の概要についてそ れぞれ発表が行われた。また、日本の水道水質管理への「水安全計画」の導入、米国における水道シス テムのリスクアセスメント・リスクマネジメント及び日本の建物の貯水槽管理の現況について、それぞ れ発表が行われた。

日米両国における老朽化する上下水道施設の管理について議論が行われ、日米両国の代表により、上下水道施設の老朽化に対する更新需要に充分に対応するため上下水道の財源の水準を高めなければならないという認識が共有された。日本の琵琶湖・淀川水系での流域管理について、また、気候変動並びに米国において水資源及び地方自治体の水道事業体が受ける潜在的影響に関する課題について、議論が行われた。日本での下水処理水の再利用に関するマニュアル策定、沖縄県での下水処理水の再利用事例及び米国における水の再利用の概要について議論が行われた。

クリプトスポリジウムの水系集団感染から知見が得られた予兆現象及び水源におけるオーシスト監視の必要性について発表が行われた。水道水、下水、汚泥及び環境における医薬品、内分泌かく乱物質、生活用品及び消毒副生成物等の化学物質の存在実態、処理及び毒性評価との関連性について、議論が行われた。

日本における下水道システムの地震被害等緊急事態への対策及び米国の下水道事業に関連してハリケーン・カトリーナから得られた教訓について議論が行われた。水道事業運営のガイドラインについて議論が行われ、水道事業体の将来像の戦略的なアセスメントについて発表が行われた。統合的な流域管理については、日本の下水道法改正による健全な水のための新しい流域ベースの手法並びに米国における流域の保全及び再生を目的とした水清浄法の手段の適用についてそれぞれ発表が行われた。

新技術の課題については、沖縄県の海水淡水化施設、米国での水道水供給の持続可能性を向上させる ための再利用及び淡水化技術並びに日本での水道水質管理に関する新研究プロジェクトについてそれ ぞれ発表が行われた。最先端の下水処理技術及び下水汚泥の臭気低減のための処理技術について両国の 代表から発表が行われた。

総括及び今後の活動:

本会議は、水道水及び下水道の管理の分野において、研究及び政策の発展に関する情報共有のための特別な機会を提供し続けるものである。浄水及び下水処理を含む流域管理に関するホリスティック・アプローチ(全体的な取組)は、水道水及び下水の適切な管理にとって極めて重要であり、日米両国にとって継続的に優先度を有する。代表らは、この重要な情報交換は継続すべきものとして、2年後に米国にて以下に示すような課題について会議を開催することで合意した。

課題:

- 一流域管理に関するホリスティック・アプローチ(全体的な取組)
- -上下水道のサービス及び施設における財政及び環境上の持続可能性及び管理
- 水道水質及び下水道の管理のための制度の進展
- 微生物及び化学物質汚染の適切なリスクマネジメントにつながるリスクアセスメント
- 浄水処理、下水処理、水道水配水及び下水収集等のための新技術
- 緊急事態への備え及び対処するための方策
- 一水の再利用

加えて、次回会議の開催前に、これらの課題について、技術的なワークグループ、情報交換及び/又は 技術的なプロジェクトが二国間で行われ、人材交流が促進されることが望まれる。

米国環境保護庁 キャスリーン・シェンク氏及び厚生労働省国立保健医療科学院 浅見真理氏が互いに 必要な連絡を行うこととする。

平成 19 年 1 月 25 日

厚生労働省健康局

水道課長

山村尊房

国土交通省国土技術政策総合研究所

田中修司

下水道研究部長

米国環境保護庁

研究開発局水道水資源課長

ジェームス・グッドリッチ

SUMMATION

The 4th Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control

January 22-25, 2007

The 4th Japan-U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control was held on January 22-25, 2007 in Bankoku Shinryokan, Okinawa, Japan. Over the four days, the delegates exchanged information on scientific and policy challenges related to advances in drinking water quality management and wastewater control. As a part of the conference, the delegates were also able to tour drinking water supply and wastewater treatment facilities of the Okinawa Prefectural Government (Chatan Water Treatment Plant and Naha Wastewater Treatment Plant) and Okinawa Commemorative National Government Park.

The meeting opened with a welcome by Mr. Yuji Shuri, Director General of Department of Civil Engineering & Construction, Okinawa Prefectural Government. Opening Remarks were made by Mr. Hirotaka Tachikawa, Director, Office of Drinking Water Quality Management, Water Supply Division, Health Service Bureau, MHLW, Japan, Mr. Toru Shimizu, Director for Watershed Management, Sewerage and Wastewater Management Department, City and Regional Development Bureau, MLIT, Japan, and Mr. James Hanlon, Director, Office of Wastewater Management, U.S. Environmental Protection Agency.

Technical presentations started with an overview of drinking water quality management in Japan and the strategy for wastewater control in Japan for the 21st century. Overviews were presented on U.S. drinking water quality and wastewater management. An application of a "Water Safety Plan" to drinking water quality management in Japan was presented as was a discussion on risk assessment and management of water supply systems in the U.S. An overview of current in-building water supply systems management in Japan was also presented.

The management of aging drinking water and wastewater infrastructure in the U.S. and Japan were discussed. There was an acknowledgement by the U.S. and Japan delegates that water/wastewater funding levels must be increased to adequately address the need to replace the aging water and wastewater infrastructures. The status of watershed management in Lake Biwa-Yodo River System, Japan was discussed as was the issue of climate change and the implications for water resources and potential impacts on municipal water providers in the U.S. Establishment of guidelines for the reuse of treated wastewater in Japan and a case of promotion of treated wastewater reuse in Okinawa were discussed as well as an overview of water recycling in the U.S.

Sign phenomenon learned from water-related outbreak of cryptosporidiosis and necessity of oocyst monitoring in source water was presented. The occurrence, treatment and toxicological relevance of chemical contaminants, including pharmaceuticals, endocrine disruptors, personal care products and disinfection by-products, in drinking water, wastewater, biosolids and the environment were discussed.

Measures against emergencies such as seismic damages to wastewater systems in Japan and lessons from Hurricane Katrina regarding sewage works in the U.S. were discussed. Guidelines for management of water supply were discussed and a strategic assessment of the future of water utilities was presented. Concerning integrated watershed management, modified watershed-based approach to clean water through amendment to Sewerage Law in Japan was presented as was

application of Clean Water Act tools to restore and protect watersheds in the U.S.

On the subject of new technology, the seawater desalination facility on Okinawa and reuse and desalination technologies to improve the sustainability of drinking water supplies in the U.S. were presented as was a new research project on drinking water quality management in Japan. Cutting-edge wastewater treatment technology and treatment technology to reduce odors in biosolids were presented by delegates of both countries.

Conclusions and actions:

This Conference continues to provide a unique opportunity for information sharing on research and policy developments in the area of drinking water and wastewater management. A holistic approach on watershed management, including water and wastewater treatment, is essential for the proper management of drinking water and wastewater, and is a continuing priority for both the U.S. and Japan. The delegates agreed that this important interaction should continue and a subsequent Conference on such topics as listed below will be held in two years in the U.S.

Topics:

- -Holistic approach on watershed management
- -Financial and environmental sustainability, and management of water and wastewater services and infrastructure
- -Advances in the regulations for drinking water quality and wastewater management
- -Risk assessment leading to appropriate risk management of microbial and chemical contaminants
- -New technologies for water and wastewater treatment, distribution, collection, etc.
- -Measures to prepare for and respond to emergencies
- -Water reuse

In addition, it is desired that technical work groups, information exchanges and/or technical projects be convened between the two countries on these topics as well as to encourage the exchange of personnel prior to the next conference.

Ms. Kathleen Schenck, U.S.EPA, and Dr. Mari Asami, NIPH, MHLW, Japan will make necessary contact with each other.

January 25, 2007

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Ministry of Health, Labour and Welfare

Mr. Shuji Tanaka, Director

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Ministry of Land, Infrastructure and Transport

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Water Supply and Water Resources Division

Office of Research and Development

United States Environmental Protection Agency

会議及び視察の写真



写真1 会議の様子



写真 2 参加者の集合写真



写真3 会議概要への署名



写真 4 沖縄国営記念公園の視察



写真 5 北谷浄水場の視察



写真6 那覇浄化センターの視察

発表 資料

Overview on Drinking Water Quality Management in Japan

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1. Introduction

In Japan, the Drinking Water Quality Standards (DWQSs) have been set as Ministry's order so that water supply systems are always able to supply potable water from taps. In 2003, responding to situational changes surrounding water quality management, as well as taking the third edition of the WHO's Guidelines for Drinking Water Quality into account, the Ministry of Health, Labour, and Welfare (MHLW) laid down a new set of the DWQSs, which went into effect on April 2004.

Considering some cases that took place in 2006, the government is now preparing for new revision of the DWQSs: there were several water quality incidents at small facilities, which involved some people infected by drinking water, a high level of unregulated substance was detected in Kanto Area (near Tokyo), Japan.

2. Revision of the DWQSs

2.1 Fundamental principles

In addition to the Drinking Water Quality Standards (50 items), which are based on the Water Works Law, the Complementary Items for Water Quality Management (27 items) have been set by the Director General of Health Bureau of the MHLW since 2003, whereas the Items for Further Study (40 items) have been suggested by the Minister's Health Science Council to put under observation in order to cope with various emerging and future issues on water quality management.

Drinking Water Quality Standards
 Tap water quality must meet the DWQSs based on the Water Works Law. Thirty

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items are set from the viewpoint of human health, and twenty items are set from other reasons including user needs on water quality and control level at purification plants. The Water Works Law requires the water suppliers to monitor the tap water quality regularly to make sure that the water meets the standards. The DWQSs basically include items that are detected or can possibly be detected in purified water at levels of 10% of the health-based value or higher.

Complementary Items

The Complementary Items for Water Quality Management are items that the MHLW requests water suppliers to monitor. Fifteen items (including the total of 101 agricultural chemicals) are set from the viewpoint of human health and twelve items are set from other reasons including user needs on water quality and control level at purification plants

Items for Further Study

The Items for Further Study are items of which health-based value are provisional, or items of which detect level and frequency in purified water are not clear. Further studies are needed to collect more information and knowledge on these items.

2.2 The state of the water quality in Japan

The present DWQSs and Complementary items went into effect on April 2004. Since then, water suppliers have monitored these items and the results show that water suppliers have to pay attention to the items which follow.

· DWQSs

Lead is sometimes detected in purified water at higher level than the standard value. This is caused by lead water pipes which still have been used in private buildings or houses.

Nitrate and Nitrite are detected in purified water at level of higher than the standard value in a few points. Many private drinking water wells are at risk and would need precaution against contamination.

Bromate is sometimes detected in purified water at higher level than the standard value. The major causes for the formation are impurities included in Sodium hypochlorite. In addition, formation in the ozone treatment system is also to be noted.

Complementary Items

Chlorate is detected in purified water at 10% level of the health-based value in many points. And it is detected at higher level than the health-based value in a few places. It has been reported that chlorate may be formed in oxidation of Sodium hypochlorite, being used as disinfectants, more rapidly at warmer temperatures.

2.3 Addition of chlorate to the DWQSs

Considering frequent detections of high level of chlorate, the MHLW took an action to the Health Science Council, held on Aug 4, 2006, to add chlorate to the DWQSs. It was agreed by the Council to forward to the Food Safety Commission, which was established in July 2003 to undertake risk assessment under the Food Safety Basic Law to respond to the growth of national concern about food. The Commission is independent from management organizations such as the MHLW. The Commission conducts risk assessment on food in a scientific, independent, and fair manner. Hence, the MHLW have been requested to inquire the Commission to conduct risk assessment when the MHLW wishes to make any changes on the DWQSs. According to this rule, the MHLW submitted the draft for deliberation to the Commission on Aug 31, 2006 in order to conduct risk assessment to add chlorate to the DWQSs. After receiving the Commission's report, the draft will be disclosed by the MHLW for public comments for one month. After checking public comments, the MHLW will finalize the standard. The proposed standard value is 0.6mg/L, which is decided from the viewpoint of human health, as it causes damage to the oxidation of blood cells.

3. Recent water quality incidents

3.1 The state of the occurrence of water quality incidents

Water suppliers in Japan always make efforts to supply potable water under the proper water quality management. However, a few water quality incidents take place every year. In 2006, more than ten incidents which lead to cutting off the water supply happened. When the MHLW receives the report of the incidents, it takes measures to prevent recurrence of the accident. For example, when an incident happened as a result of inappropriate coagulation management, The MHLW would issue a letter to all water suppliers in Japan in order to remind of the importance of appropriate use of coagulation chemicals. When it happened because of contamination of water source, the letter would focus on observation of water source.

3.2 Infectious diseases caused by drinking water

A few infectious diseases caused by drinking water happened in 2006. In Fukushima Pref., a small-scale water supply service supplied water without chlorination and 71 persons who drunk the water showed the symptoms of diarrhea, stomachache, or fever. The facility was not inspected appropriately. As a result, the deposition of sodium hypochlorite clogged the chlorine injecting nozzle. To make matters worse,

measures taken against the accidents was delayed because they disregarded the accident when they recognized that chlorine was not detected in the water. The inspection of untreated water of the facility and feces of the patients proved that the bacteria which caused the symptoms were *Campylobacter*.

The table shows the infectious diseases caused by drinking water in Japan. Many of them occurred because of the inappropriate management or defects of disinfection, therefore, taking proper management is essential in small-scale water services. Now the information of virus is so limited that further studies are necessary to gain more information and knowledge.

Table: Infectious diseases caused by drinking water in Japan

WH	IEN	WHERE	ORIGIN	PATHOGEN	FACILITIES	EATER	PATIENT
1999	July	Nagano	spring	enterohaemorrhagic E. coli O157	home	unknown	30
2000	Feb.	Kyoto	well	enteropathogenic E. coli O126	restaurant	unknown	50
2001	June	Nagano	spring	enterotoxigenic E.coli O169	accomodations	310	181
2002	Oct.	Akita	spring, swamp	Campylobacter jejuni	home	unknown	13
	Mar.	Niigata	well	Noroviruses, Clostridium perfringens, Staphylococcus aureus, Campylobacter, E. coli	restaurant	227	151
	June	Ishikawa	well	Norovirus	restaurant	522	76
2003	July	Chiba	small water supply system (water cooler)	Rotavirus group A	school	86	47
	July	Oita (water cooler) Kotavirus group A school enterohaemorrhagic E. coli (verotoxin-producing) home	home	4	3		
	Sep.	Ehime			school	525	69
	Mar.	Hiroshima	well	Genus Escherichia	home	17	15
2004	Aug.	Ishikawa	small water supply system	Campylobacter jejuni, Campylobacter coli	accomodations	78	52
	Mar.	Akita	small water supply system	Norovirus	home	unknown	29
	June	Yamanashi	small water supply system	Campylobacter jejuni, Campylobacter coli	home	unknown	76
2005	Jyly	Oita	small water supply system	Plesiomonas shigelloides	accomodations	280	190
	Jyly	Oita	well	enterotoxigenic E.coli O168	campsite	348	273
	Aug.	Nagano	spring	enteroaggregative E.coli O55	accomodations	81	43
	Aug.	Kochi	well	unknown	home	28	16
2006	Aug.	Fukushima	spring	Campylobacter jejuni	home	unknown	71
2000	Sep.	Miyagi	well?	Clostridium botulinum type A	home	9	1

4. Measures to unregulated substances

Although the Water Works Law does not require regular monitoring on unregulated substances, unless listed in the DWQSs, observation of water source should be done wider perspective. With this in mind, the MHLW has been investigating unregulated substances in collaboration with research institutes and water laboratories of large water suppliers. It is also necessary to take measures immediately when unregulated substances are detected in tap water, as they might be caused by disorder of treatment facilities or some other important reasons. In other case, agricultural chemicals should also be monitored even if they were prohibited from marketing: it was the case in groundwater in 2006, and the water supplier had to stop taking water from the groundwater and strengthened the watching for water source.

In 2006, perchlorate, one of the unregulated substances, was detected by researchers' investigation in Tone River, which flew down through Kanto Plains. Although no body paid any attention to perchlorate by that time, the MHLW took measures and requested researchers to keep investigation on perchlorate and advocated investigating its level in wide-ranging area.

5. Conclusion

Water suppliers in Japan always supply potable water, which we can drink directly from taps without any cares or any special treatment. But recent researches reported that the number of people who drink tap water directly is decreasing. This may have been caused by a discontent on the tastes of tap water or popularity of bottled mineral water due to its convenience. Under this situation, in order to improve the popularity of tap water and improve the reliability of consumers on safety and reliability of drinking water, the MHLW will continue further efforts in cooperation with all water suppliers to take measures for appropriate water quality management, such as preventive measure against water quality incidents, encouragement to introduce advanced water-treatment facilities, and valuable information exchange on water quality management.

Overview on Drinking Water Quality Management in Japan

Mayuko HATTORI Water Supply Division Health Service Bureau Ministry of Health, Labour and Welfare

1. Introduction

2. Revision of the DWQSs

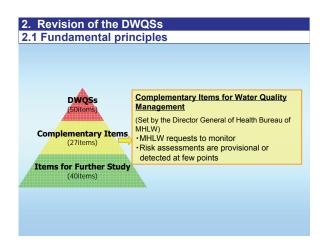
2. Revision of the DWQSs 2.1 Fundamental principles Drinking Water Quality Standards (Based on The Water Works Law) The Water Works Law requires the water suppliers to monitor Detected in purified water at 10% of the health based value or higher Items for Further Study (40ltems)

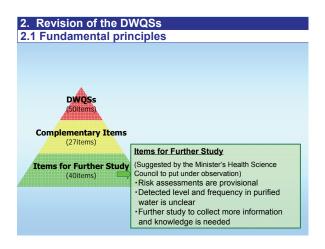
Overview on Drinking Water Quality Management in Japan

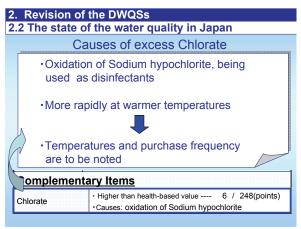
- 1. Introduction
- 2. Revision of the DWQSs (Drinking Water Quality Standards)
- 3. Recent water quality incidents
- 4. Measures to unregulated substances

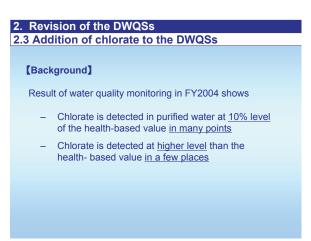
State of Water Quality in Japan Source water quality has been improved The overall situation is good Current state depends on continuous efforts Further safety expected Rising Concern about tasty water

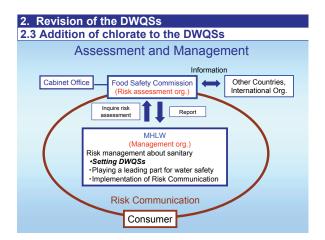




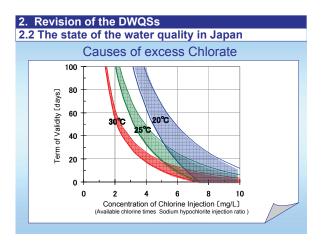








2. Revision of the DWQSs 2.2 The state of the water quality in Japan Results of water-quality monitoring **Drinking Water Quality Standards** ·Higher than standard ---- 6 / 2,886 (points) Lead Causes: lead water pipes Higher than standard ---- 1 / 4.158 (points) Nitrate and Nitrite Private drinking water wells need precaution · Higher than standard ---- 18 / 5,695 (points) Bromate Causes: impurities in Sodium hypochlorite also formed in Ozone treatment system **Complementary Items** Higher than health-based value --- 6 / 248(points) Chlorate · Causes: oxidation of Sodium hypochlorite



2. Revision of the DWQSs 2.3 Addition of chlorate to the DWQSs [Action] Aug 4, 2006 MHLW took action to the Health Science Council to add chlorate to DWQSs It was agreed by the Council to forward to the Food Safety Commission Aug 31, 2006 MHLW submitted the draft for deliberation to the Commission

2. Revision of the DWQSs 2.3 Addition of chlorate to the DWQSs After receiving the Commission's reports, the draft will be disclosed by the MHLW for public comments MHLW will finalize the standard Chlorate causes damage to the oxidation of blood cells Proposed standard value is 0.6mg/L

3. Recent water quality incidents

3. Recent water quality incidents 3.1 The state of the occurrence 30 25 organic matter 20 ■ turbidity 51% 15 □ odor □pH 10 ■ others Pollutants (FY2004) In 2006, more than ten incidents leading to cutting off the water supply



3. Recent water quality incidents3.2 Infectious diseases caused by drinking water

A few infectious diseases happened in 2006

One Case at small-scale water supply service

- Aug 17-25, 2006
- Supplied water without chlorination
- 71 persons showed the symptoms of diarrhea, stomachache, or fever
- This facility was not inspected appropriately
- The bacteria is Campylobacter

MHLW issued a letter to all water suppliers to remind of the importance of appropriate management on chlorination

3. Recent water quality incidents

3.2 Infectious diseases caused by drinking water

Infectious diseases in Japan (2004-2006)

Wi	IEN	WHERE	ORIGIN	PATHOGEN	FACILITIES	EATER	PATIENT
	Mar.	Hiroshima	well	Genus Escherichia	home	17	15
2004	Aug.	Ishikawa	small water supply system	Campylobacter jejuni, Campylobacter coli	accomodations	78	52
	Mar.	Akita	small water supply system	Norovirus	home	unknown	29
	June	rine Yamanashi small water supply system Campylobacter jejuni, Campylobacter coli	home	unknown	76		
2005	Jyly	Oita	small water supply system	Plesiomonas shigelloides	accomodations	280	190
	Jyly	Oita	well	enterotoxigenic E.coli O168	campsite	348	273
	Aug.	Nagano	spring	enteroaggregative E.coli 055	accomodations	81	43
	Aug.	Kochi	well	unknown	home	28	16
2006	Aug.	Fukushima	spring	Campylobacter jejuni	home	unknown	71
2006	Sep.	Miyagi	well?	Clostridium botulinum type A	home	9	1

3. Recent water quality incidents

3.2 Infectious diseases caused by drinking water

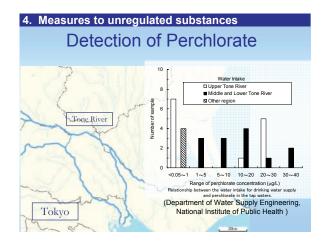
Measures to incidents

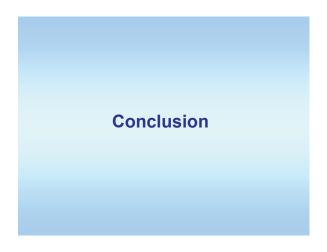
- ◆Many of incidents happened by inappropriate or poor management
- ◆Appropriate management in small -scale water service
 - ◆Information of Virus in drinking water is limited
 - ◆Further study and knowledge

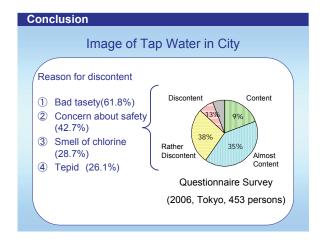
4. Measures to unregulated substances

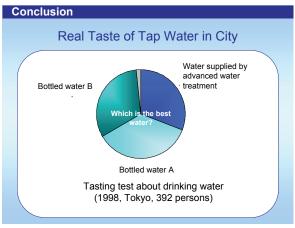
4. Measures to unregulated substances

- ◆ Investigate into unregulated substances
- ◆ Research unknown substances
- ◆ Gather information on toxicity and knowledge









Conclusion

In order to improve the popularity of tap water and improve the reliability of consumers on safety and reliability of drinking water,

the MHLW will continue further efforts in cooperation with all water suppliers to take measures for appropriate water quality management.

Thank you

Strategy on Wastewater Control in Japan for 21st Century

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²Director for Sewerage Engineering and Development, Sewerage Planning Division, Sewerage and Wastewater Management Department, City and Regional Development Bureau, Ministry of Land Infrastructure and Transport

Abstract: When we stepped into the 21st century, we noticed so many changes in various fields, such as meteorological change in global scale, soaring price of crude oil, frequent draughts and floods, overt heat-island phenomena in big city areas, falling birthrate and rapidly aging population. These changes are not temporary mutations, but are transformations based on a long-term trend that we cannot ignore for planning and re-visioning of the future state of the wastewater systems. Starting from these understanding of present state of circumstances, new concept for the role of wastewater system is formed as a national strategy to be key infrastructure for recycling society, namely "The Road toward Recycling Society." This paper describes the new concept of The Road toward Recycling Society along with its implementing policy.

Keywords: Recycle, the 21st century, policy for wastewater system, improvement of systems

Introduction

When we have perspectives of the 21st century, we can predict great changes in Japan that will emerge in many fields. We must change our living systems preparing for the coming future. Our systems consist of many sub-systems. Wastewater system is one of them, but important one to keep our society in healthy and comfortable one. This means that we need to have a new concept adapting our society to future situations. For setting the new concept and policy both of the wastewater systems and the wastewater works, a special committee was convened

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and carried out intense discussions for about one year, and announced their conclusion in a report titled as Wastewater System Vision 2100. The subtitle of this report is "From Wastewater System to The Road toward Recycling Society as 100-years strategy". This paper describes about this new strategy and new concept of The Road toward Recycling Society.

A new concept for wastewater system adapting to the 21st century

Among the various future changes, some of the serious ones that we will face in the latter part of the 21st century may be the climate changes that will be caused by greenhouse-gas effect and the shortage of natural resources such as fossil oil and natural gas. These changes will be caused as the consequence of our lifestyle in the late 20th century of mass production and thus mass waste-production. In these several years we already suffered from abnormal climate that caused terrific flooding, unusual hot summers and abnormally heavy snowfalls. Another precursor of the future problem is the historically high oil price of these days. When these difficulties become extreme situations, our lives itself will be threatened by the problems. In view of this, we must adapt our society to sustainable one for future prosperity.

Other problems that we will also face in relatively near future in Japan are social problems that will be caused by decrease of population. Although the diminution of the population was predicted and well recognized in relatively long ago, it was a great shock for Japan in last year that periodic census showed actual reduction of the population. This reduction is due to the small number of birth rate of these days that is less than the death rate. On the other hand the life expectancy in Japan is high number. Consequence of these conditions introduces aging society and structural changes in industrial fields and economic aspects. In the aging society government will have limited resources for affording new infrastructure than our generations, and thereby we need to prepare for the future in early stages.

Along with the changes in the future of the natural environment and society, we are also questioned about the direction of future society. In these respects, wastewater system also must change for the establishment of bright future. We need to have a clear image of wastewater systems as new functions and new roles in the 21st Century as a key infrastructure for better world, thinking out of conventional images of the systems. For these view points, the vision for 21st century of the systems should work to bring out three goals: beautiful environment,

safe community and vigorous society. To realize these three goals, how our wastewater systems contribute to new era becomes crucial point. Contemplating these conditions, the new concept as the 21st century of wastewater systems has been emerged as "*The Road toward Recycling Society*" for the new strategy of the central government.

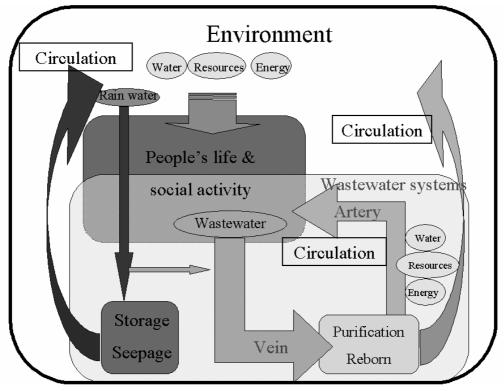


Figure 1. Schematic image of wastewater system's role in the 21st century society Wastewater system is a key infrastructure to sustain limited resource society.

Besides above-mentioned future problems, we have already some problems straggling to solve in our working fields. Some of them are categorized in water problems and others are facility management. One of the examples of water problem is the quick run-off of storm water and dried up in the dry seasons in waterways. These cause frequent flooding and less amenity environments. These phenomena are caused partly because of the reduction of impermeable area in our communities. Another water problem is instability of water resources, such as big cities cannot secure their water resources within their water basins. These are not sustainable situations in terms of water resources. A typical example of facility managing problem is increasing aging facilities. These cause not only high demand of rehabilitation works and thereby high requirement of budget, but also increment of road corruptions caused by corroded sewers. The new policy is also

accounting these present problems into them.

What is The Road toward Recycling Society?

The term of *The Road toward Recycling Society* implies not only the venous system but also the arterial system including heart, which works as key organs for circulation of necessary materials and waste transportations of humans; in another word *The Road toward Recycling Society* suggest that the wastewater systems become key facilities for hydrologic circulations and resource cycles. This concept aims to change the 20th-century-type wastewater systems for new ones, and also seeks for new functions and images of the systems for 21st century. More specifically from the viewpoint of the healthy circulation of resources, discussion in the committee about the systems extended to basic question about what is wastewater system and what kind of substances we should collect with the systems and should not collect or how to recover and reuse from the collected substances, and how to create healthy recycling systems in our society. Based on these rethinking works, following three key sub-concepts were presented to achieve the main image or metaphor of *The Road toward Recycling Society*:

- Creation of New Water Passage,
- Creation of New Resource Passage and
- Revitalization of the Systems.

The first sub-concept, *Creation of new water Passage*, intends to create new water-networks and passages for exploiting manifold function of water from wastewater work filed. The second sub-concept, *Creation of new resource Passage*, plans on active working to recover resources, such as bio-solid or nutrients, and followed to supply recovered resources. This sub-concept also includes exploiting land site of wastewater work to create new energy, ---solar power, wind turbine, and micro-hydro-power generation--- to depart from dependence on oil. The third sub-concept, *Revitalization of the Systems*, is different from previous two concepts in supporting them, but has more active meaning to refresh existing facility and to meet the social requirements for the wastewater works.

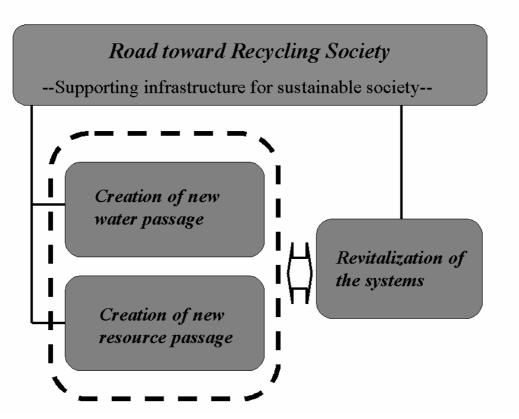


Figure 2. Relation between main concept and three sub-concepts

The Creation of new water Passage and its policy development

The *Creation of new water passage* implies to recover health water cycle in basin area by improving wastewater systems. This will be attained with evolving following three core-ideas:

- -Recycle and reuse stored rainwater, purified wastewater and incoming ground water into the systems thoroughly,
 - -Optimize facility location based on aiming on water reuse and
 - -Redesign facility structure fitting for water reusing.

Healthy water cycle will be realized through encouraging infiltration of storm water to the ground along with reusing of stored storm-water and treated-wastewater. Storm-water infiltration can be realized with storm -water system designing based on infiltration first not draining first. Along with infiltration first policy, introduction of storm-water storage facilities to systems stimulate increment of reusing of water. Direct reuse of treated wastewater also should be inspired with advanced treatment.

Storm-water utilization and treated-wastewater recycle may require deferent configuration and location of the facilities from existing ones. Although conventional decision way for the location and capacity of treatment plant is based on how effectively we can collect wastewater to a plant, the location and capacity should be decided according to the demand of water. In this new way, the location and capacity may be greatly different from existing plants. Same idea also should be applied to storm water systems. The viewpoint of how effectively we can make recycling systems facilitates reorganization and rehabilitation of water networks.

The structure of the storm water systems also may be changed greatly when we introduce the new concept into designing of detail structures. For example, storm water drains becomes open channels instead of pipe systems along with applying percolating structure and ecologically friendly configurations, in another terms near natural systems and nature friendly systems.

The Passage for Resources and its policy development

The *Passage for Resources* aims resource recovery through wastewater works and thus supply recovered resources to communities. Introducing this scheme aims less release of global worming gas from the wastewater systems by promoting energy saving in the systems and boosting for using greenhouse-gas-free energy to local communities such as biomass energy.

This will be realized following three ideas:

- -Realize self-supporting in energy use for treatment systems,
- -Become a top runner of new-energy application by wastewater works and
- -Supply energy & resources actively to local communities from wastewater works.

These three ideas need to be accounted in more specifically. The first idea, realization of self-supporting in energy usage for treatment systems, aims in promotion of energy saving, producing new energy in the systems, and trying independence from outer energy supply for facility operations. The second idea, becoming top runner for new energy, proposes wastewater works to be a top runner of new-energy user and producer. The third idea, supplying energy & resources that are recovered from wastewater works to local community, intend to become energy and resource center through wastewater works.

The Revitalization of the Systems and its policy development

The Revitalization of the Systems proposes effective maintenance of existing facilities and improvement of the systems to support the two other sub-concepts, Creation of new water Passage and Creation of new resource Passage. Basic policies for realizing this concept are extended into following three ideas:

- -Transform maintenance policy from reactive to preventive type,
- -Improve facilities to meet social demands including multi purpose usages and
- -Integrate new facility constructions and maintenance works into asset management.

For these purposes following three working category is considered in actual fields: works for safety, works for exploiting of facilities and works for improvement of functions. The works for safety suggest proactive measures for accident due to poor maintenance works such as road corruptions caused by corroded pipes, anti-earthquake measures, and contribution to local community for providing port of distress. The works for exploiting of facilities means promotion of multipurpose usage of existing facilities. The works for improvement of functions implies not only simply improving of facilities but also active management in accordance with overall review of system plans including to meet new concept for Road toward Recycling Society.

Conclusion

The 21st century is an era that we will face many difficulties in terms of shortage of resources and climate changes. To cope with these situations we need new concept and policy for our wastewater systems to abate these impacts. As the new concept for 21st century wastewater systems, *The Road toward Recycling Society* is proposed through one-year committee discussions. The new concept is dividend into three sub-concepts that are *Passage of Water, Passage for Resources* and *Revitalization of the Systems*. Each sub-concept contains specific polices to promote actual works. We have just started evolving wastewater works based on this new concept, thereby the actual promotion is small at this moment but have a great expectation in a future to be a key infrastructure of recycling society.

References

Ministry of Land Infrastructure and Transport: Report on Wastewater System Vision 2100; The Road toward Recycling Society. September 2005.

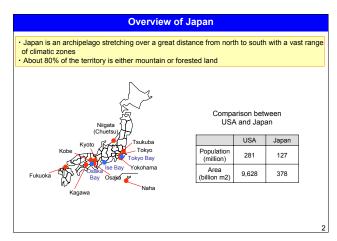
Strategy on Wastewater Control in Japan for 21st Century

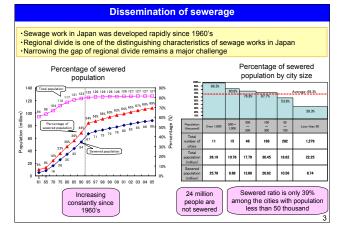
Motoi NASU

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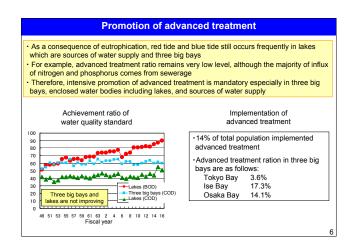


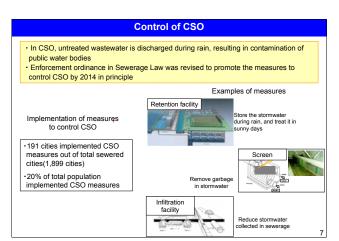




Prevention of inundation Recently, heavy rain that exceeds over the presumption of sewerage plan occurs frequently in urban area of Japan, causing the inundation and death accidents in underground facilities. In order to protect lives and urban system, various measures are taken in sewerage facilities such as publication of hazardous maps, management of retention facilities, remote control of sewerage facilities, etc. Damages by inundation in urban area Increase in occurrence of heavy rain Increase in occurrence of heavy rain Time/year Water-covered roads (Tokyo, 2004) Water-covered roads (Tokyo, 2004)

Recovery against Seismic Damages Since there is a lot of active fault located in Japan, the potential for large-scale earthquake For the sewerage facilities built before 1998, more than 80% is not earthquake resistant Measures to secure the minimum function of sewerage at the incident of large-scale earthquake is promoted urgently and intensively Damages to sewage facilities Examples of measures at Niigata-Chuetsu earthquake in 2004 Improvement of resistance to earthquake in sewer pipes especially under the main Leakage of wastewater Improvement of resistance to earthquake in pumping station and STP ·Preparation of toilet directly connected to Protrusion of manhole Development of pipe network to connect each STP





Utilization of resources

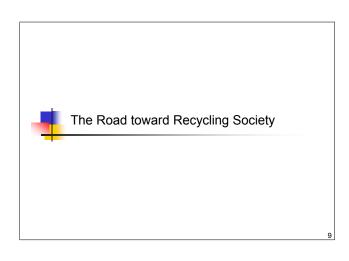
- Amount of water treated in sewerage is about 14 billion m³, and it can be used as important source of water for landscape use, flush toilets, etc (reclaimed water: 0.19 billion m³ (1.4%)) Increasing amount of sewage sludge is utilized as fertilizer and construction materials conventionally (recycled sewage sludge: 2.17 million DS+t (67%)). Recently, focusing on the characteristics of carbon neutrality, conversion to bio-gas and
- sludge fuel is promoted as countermeasure to global warming

Utilization of advanced treated wastewater for landscape use in Tadotsu, Kagawa Prefecture

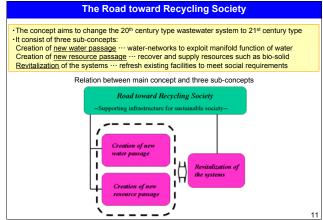
Energy use as bio-gas in Yokohama

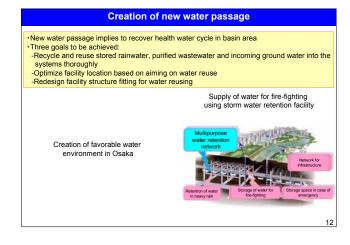
Bio-gas used as fuel for CNG vehicles in Kobe

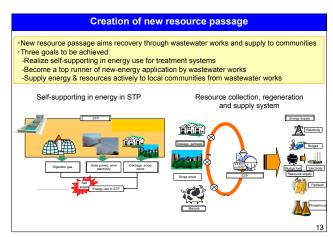
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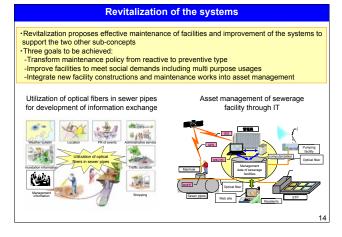


New concept for wastewater system Climate change and the shortage of natural resources will be the serious challenge in 21st -Japan is also facing the decrease of population and related social problems -Under these conditions, new concept for the role of wastewater system "The Road toward Recycling Society" was formed in "Wastewater System Vision 2100" established in Sept. 2005 Schematic image of wastewater system's role in the 21st century society Environment Circulation











Overview of Drinking Water Quality Management

Dr. Audrey LEVINE¹
National Program Director for Drinking Water, USEPA
Dr. James A. GOODRICH²
Water Supply and Water Resources Division Director, USEPA

1. Introduction

The provision and management of drinking water is based upon the multi-barrier concept; that is, (1) selecting the best available source and protecting it from contamination, (2) using water treatment to control contaminants, and (3) preventing water quality deterioration in the distribution systems. An added component is now the prevention, detection, and decontamination of deliberate attacks on drinking water infrastructure. Although such practices have resulted in the virtual elimination of traditional waterborne threats such as cholera and typhoid, public health concerns remain.

2. Problem Overview

The continued occurrence of waterborne disease outbreaks demonstrate that the safety of drinking water can still be threatened by pathogenic microorganisms if treatment is inadequate or the distribution system is compromised. New concerns have also been raised about emerging pollutants of concern with natural (arsenic) and man-made (endocrine disrupting chemicals) substances. The disinfection process itself leads to the formation of a number of potentially toxic organic and inorganic chemical by-products. Human subpopulations such as infants, children, pregnant women, and those with weakened immune systems are also of concern.

3. Program Description

The Safe Drinking Water Act (SDWA) requires EPA to set national drinking water standards to ensure the safety of water consumed by the millions of people who consume water from public water systems. The SDWA regulatory requirements require research on disinfection by-products, the Arsenic Rule, the Groundwater Rule, the Long Term 2 Enhanced Surface Water Treatment Rule, as well as future unregulated waterborne pathogens and chemicals on the Contaminant Candidate List (CCL). Source water protection, as well as maintaining the quality of drinking water in distribution systems is also priorities of the SDWA. Research is also associated with a subset of the contaminants subject to the Six-Year Review where regulations can be modified based upon new information. The most recent change was

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the reduction of the Arsenic MCL from 50 ug/L to 10/ug/L which involves nearly 4,000 small systems. The EPA Office of Research & Development (ORD) has established an integrated, multidisciplinary research program that is closely linked to Office of Water's regulatory activities. The ORD program also works closely with the EPA Regions helping to implement the regulations. Recently, the Drinking Water Multi-Year plan has undergone revisions that will carry the research program through the next several years. A major change in the plan is the increased emphasis on aging infrastructure and source water protection. This also includes research on maintaining water quality in the distribution system and real-time monitoring. Another aspect of the new plan is the web-based Treatability Data Base that will be a repository on control of contaminants in drinking water. It will be interactive and portions of it will be available in 2007. There will ultimately be hundreds of contaminants.

The Drinking Water Research Program also includes efforts from other national laboratories and centers: The National Exposure Research Laboratory (NERL), the National Health and Environmental Effects Research Laboratory, the National Center for Environmental Assessment, the National Center for Environmental Research, the National Center for Computational Toxicology, and the National Homeland Security Research Center.

Sustainable Water Resources

Challenges

- · Population growth
- Urbanization
- · Water scarcity
- · Climate change



Drinking Water Challenges

- · More stringent regulations
- Emerging contaminants
- Water security
- · Aging infrastructure
- Coordinating regulations



Ongoing Drinking Water Research











Arsenic Removal Demonstration **Program**

- \$20 million targeted to a two year program (\$20M EPA; \$12M Congress) Small systems, full-scale, long-term (1 year) evaluation studies
- Focused on commercially-ready technologies or engineering app Three phases with the third beginning in 2006

Round 1: 12 Sites / 9 States
Iron media
Iron-based media
Anion exchange
Modified activated alumina
Iron-removal system
Iron-addition process

Oxidation / filtration
Iron Coagulation / filtration
Reverse osmosis
Anion exchange
Process modification
Dissolved air flotation / filtration

Emerging Research Areas

- · Perchlorate
- EDCs
- · Cyanobacteria toxins
- Nanotechnology



Perchlorate Research

- EPA Funded a series of projects through AwwaRF
 Ion Exchange
 Biological treatment
 Membranes
 Tailored GAC

 - Electrochemical

- New research
 Small-system cost modeling for perchlorate
 - Ion exchange brine treatment with biological systems

 - systems

 Adsorbents for multiple contaminants: arsenic & perchlorate

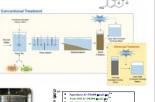
 Biological treatment of EDR concentrate streams with wastewater augmentation

 Biotreatment of perchlorate post treatment need Effect of nitrate competition on ion exchange treatment of perchlorate



EDC Treatment Research

· Bench-scale conventional, PAC, GAC, and oxidation research for estrogens, androgens, and progesterone







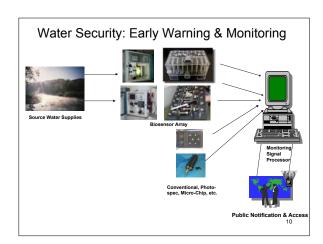


Cyanobacteria Research

Microcystis aeruginosa bloom



Cyanobacteria Research Filter Gallery



Toxicity Monitor Research

- "Canary in the coal mine"
- Only an organism in its own environment can integrate all factors that contribute to stress









11

Clam Monitor - Biosentinel





12

Coordinating Regulations

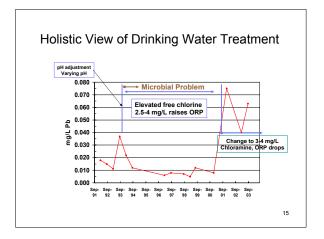
- Simultaneous compliance for drinking water regulation
- · Complementing CWA with the SDWA

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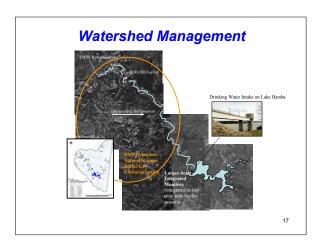
Lead Corrosion in Distribution Systems



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EPA's Source Tracking Research

- Development of animalspecific molecular assays
- · TMDL preparation
- Evaluation of Best Management Practices



21

Activity of Microbes in Water Distribution Systems

Problem: Traditional culture-based methods significantly underestimate density/diversity

Goal: DNA-based and RNA-based clone libraries to characterize non-culturable microbial communities and active populations in water distribution systems.



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Outreach

- Presentations, publications, multimedia
- · EPA workshops
- Brochures, posters, etc.
- Collaborations
- Website: http://www.epa.gov/ORD/NRMRL/wswrd/



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Key Products for Water Utilities

24

Treatability Database

- Project

 Repository of referenced information on control of contaminants in drinking water

 Interactive database on EPA website in 2007

Contaminants

- Regulated
- Unregulated

Long-Term Commitment

- Expanding to hundreds of contaminantsUpdated over time

Potentially the largest single compilation of referenced drinking water treatment data in one place

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Progress and Challenges in Wastewater Treatment in the United States With Focus on the Ohio Valley and the Ohio River

Alan H. Vicory Jr. P.E., DEE Executive Director and Chief Engineer Ohio River Valley Water Sanitation Commission (ORSANCO)

1. Introduction

As a highly developed and industrialized nation, the United States has accomplished great strides in the abatement of water pollution resulting from the installation of facilities to capture and process municipal and industrial wastewater flows. However, the U.S.'s efforts did not substantively begin until after major industrial development, which occurred in the late 19th century/early 20th century. Thus, driving initial national efforts was the poor state of water quality in many areas and its associated impacts on public health, as well as the recognition that restoration of water quality was necessary for the public's well being and for continuing economic development.

2. The beginnings – 1948 to 1972

As a national commitment to the development of sewage treatment works, the origin United States' effort can be considered the passage of the Federal Water Pollution Control Act of 1948. In that legislation, the United States Congress did not call for a regulatory approach, but encouraged the states to improve water quality, largely through grants or loans for the construction of facilities. Through a series of amendments to the 1948 legislation, the last being enacted in 1970, provisions were added that expanded the federal government's statutory authority, including adding federal enforcement authority in certain situations (e.g. navigable waters) and conditioning receipt of federal monies on the states setting water quality standards.

In the 1950's and 1960's, while progress in establishing water quality objectives and installation of municipal and industrial wastewater treatment was less than was desired by Congress, there occurred however some notable programs. In the Ohio Valley Region, and under the leadership of the Ohio River Valley Water Sanitation Commission (ORSANCO), intensive studies were undertaken to determine appropriate criteria for key water quality pollutants (e.g. fecal Coliform), best available treatment technologies were determined for categories of waste discharging industries, and municipalities were provided technical assistance to facilitate construction of facilities. This "Clean Streams Campaign" resulted in ORSANCO being awarded the American Society of Civil Engineer's *Outstanding Civil Engineering Achievement Award* in 1963 for "the most effective large-scale water pollution abatement program ever undertaken in the Western Hemisphere."(1) By that time, over \$1 Billion had been dedicated towards wastewater treatment, with the population along the Ohio River with at least primary treatment either in place or under construction rising from less than one percent to 98.5 percent. Correspondingly, 86% of industries had installed facilities. (2)

3. The 1972 Clean Water Act and Amendments – Providing the Requirements and Funding for Secondary Treatment for Municipalities and Requiring Best Available Technology Treatment for Industry

Responding to growing public concern with the condition of the nations waters, combined with a general dissatisfaction with the pace of construction of facilities, the U.S Congress enacted the 1972 Clean Water Act and set new baselines for treatment of point sources of wastewater. Aided by federal grants totaling over \$61 Billion which provided for up to 75 % of the cost for installation of municipal publicly owned treatment works (POTWs), at a minimum level of secondary treatment, the population served and number of installed facilities providing that level of treatment or greater grew rapidly as illustrated by the following statistics for 1968 and 1998:

- 1968 U. S. population served by less than secondary treatment 39% U. S. population receiving greater than secondary treatment 0.3 million 14,051 POTWs; serving 140 million people; 73% providing at least secondary treatment
- 1996 U. S. population served by less than secondary treatment 9% U. S. population receiving greater than secondary treatment 164 million 16, 024 POTWs; serving 190 million people; 86% providing at least secondary treatment (3)

USEPA's pending latest survey shows the number of POTWs as 15,583 (4)

Over the 1968-1996 period, effluent BOD(5) releases were reduced by 45% while influent levels almost doubled. Correspondingly, water quality across the U.S. improved dramatically, particularly in the Eastern region, which, in turn has spurred growth in recreation and revitalization of urban waterfronts.

Along the Ohio River, comparative levels of dissolved oxygen under drought conditions have increased and biological surveys such as has been conducted by ORSANCO have documented the return of some pollution intolerant species, such as Sauger, and shown a steady increase in numerical indices, such as the Modified Index of Well Being.

However, as of 2000, 39%, 45% and 51% respectively of the rivers, lakes and estuaries in the U.S are considered still polluted. Among the leading causes of impairment are bacteria, nutrients, metals (primarily mercury) and siltation, with sewage treatment plants as one primary source. (5)

4. Reduction in Federal Funding Support and the Current Infrastructure Gap Beginning in the mid 1980's the federal government began implementation of a policy shift to reduce its direct financial commitment to development of wastewater infrastructure. Most notably, the program of grants was phased out and, in its place, capitalization grants have been provided to State loan agencies which are supplemented with state derived funds to provide reduced interest loans to public agencies. Over \$20 Billion has thus far been made available to States but the amounts appropriate annually

by Congress has going down, with the most recent allocation being \$0.9 Billion (Fiscal year 2006). Comparatively, if the amount of Federal funding in the several years following enactment of the 1072 Clean Water were expressed in today's dollars, the amount would be upwards of \$25 Billion!

While estimates differ, a mid-point of the estimates prepared by the U.S. Congressional Budget Office sets wastewater capital needs at \$340 Billion over the next 20 years. Among the needs for funding is the correction of combined sewer overflows, replacement refurbishment or expansion of facilities constructed in the 1970's and installation of technologies to address such issues as excess nutrients in receiving waters. Thus, a monumental challenge is presented for new sources of funding and employment of strategies to prolong the life of existing assets.

5. Today's Wastewater Utility Agenda; Some Key Challenges

With the exception of some rural areas, installation of wastewater treatment in the U.S. has been accomplished to achieve pollutant removal levels of at least 85%. Severe pollution conditions in waterways no longer occur, but problems remain that pose significant challenges, particularly to municipal utilities. Most notably, it is estimated that over \$50 Billion will be needed for the correction of discharges from combined sewer overflows (CSOs). Many facilities, constructed in the 1970s and 1980s are reaching their design life and capacities and must be expanded or modernized. However, without federal assistance funding, revenue from users must be significantly increased. This is a particular problem in older cities which have lost population, industry, and the tax base which comes with it. In the metropolitan area of Cincinnati, Ohio, a metroplex of just over 1 million population, the cost to correct CSO will approach \$3Billion and result of increases in user fees estimated to be 300% over the coming two decades..

Wastewater utilities are now and in the future will likely be receiving requirements for reducing the presence of nutrients in their discharges. In some areas, such as in the Chesapeake Bay Watershed, very stringent limits are being applied, but other regions of the country can expect to be eventually subject to similar requirements (e.g. Mississippi River Basin). In other areas, wastewater utilities will be required to address such pollutants as mercury and dioxin. These pollutants have resulted in fish consumption advisories and sources will be assigned limits on loadings designed to achieve water quality requirements.

These and other challenges are causing employment of new planning, management and operational techniques to extend the life of physical facilities and achieve more efficient operation. These initiatives include "asset management", "environmental systems approaches" and "capacity, management, operations and maintenance" (CMOM) programs.

Also emerging in the U.S. is the use of trading programs to achieve, on a watershed basis, prescribed overall loadings of a given pollutant. Among the trading programs that have been/are being established are those to meet reductions in nutrient loadings to the Long

Island Sound and the Chesapeake Bay. Participation in these programs will impact the construction of wastewater facilities.

Wastewater utilities in the U.S. are also being impacted by implementation of watershed-based approaches for achieving water quality objectives. Among specific developments are use of "watershed discharge permits" where facilities are bundled and authorized to discharge under a single issued permit. Also, wastewater utilities are actively cooperating with other interests in the watershed to forge partnerships or address common interests. Examples are working with sources of non-point pollution to develop cooperative initiatives and water supply utilities to assure protection of their source waters.

Finally, resulting from the events of September 11, 2001, security issues have come to the forefront. As many POTWs employ the use of chlorine as a disinfectant, some have abandoned use of Chlorine in favor of less dangerous chemicals, such as sodium hypochlorite, and facility perimeter barriers have been strengthened. This will be a continued trend.

Summary

Wastewater treatment in the U.S., substantially developed in the final three decades of the last century, has resulted in major water quality improvements. However widespread and significant water quality problems remain for which wastewater utilities will bear a heavy cost burden to address.

New management techniques are being deployed to improve planning and efficiency of operation, but many facilities have reached their design life and/or capacity.

Among the most significant current/emerging issues are reduction of impacts of sewer overflows and control of nutrients. Creative approached are being developed, including use of trading programs.

However, wastewater utilities are one component in the context of watershed-based water quality management. As such, the future of wastewater treatment in the U.S. will involve cooperation and partnerships with other interests to achieve water quality goals.

Reference

- (1) Statement of William Wisely, Executive Secretary, American Society of Civil Engineers, May, 1963
- (2) Annual Report for 1963, Ohio River Valley Water Sanitation Commission
- (3) "Progress in Water Quality" An Evaluation of the National Investment in Municipal Wastewater Treatment, USEPA, June 2000
- (4) Mr. Bob Bastian, USEPA, Email Communication, November 6, 2006
- (5) National Water Quality Inventory, 2000, USEPA

Progress and Challenges in Wastewater Treatment in the U.S.A. With Focus on the Ohio Valley and the Ohio River Alan H. Vicory Executive Director and Chief Engineer ORSANCO



Water Pollution Control Act of 1948

- Act amended numerous times which
- Nationally, results not as hoped by Congress

The Ohio River Basing

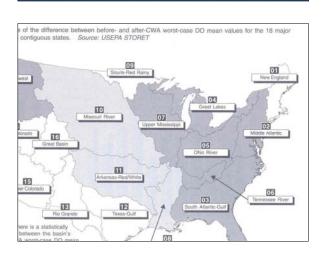
The "Clean Streams Program" for the Ohio Valley

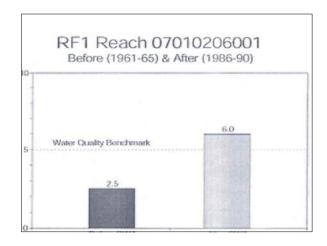
- Spearheaded by the Ohio River Valley Water Sanitation Commission (ORSANCO)
- A public awareness effort
- ORSANCO developed stream quality objectives

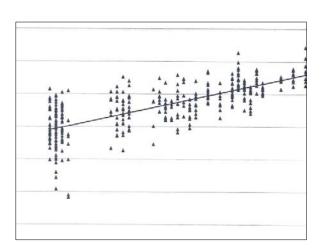
1972 Clean Water Act

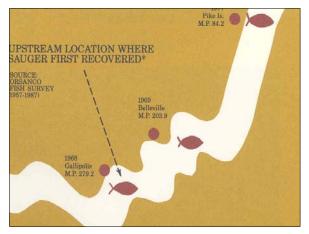
- Change of philosophy: requires a minimum of secondary treatment across the land (i.e. technology based requirement)
- From water quality perspective, requires restoration of chemical, physical and biological
- Requires permits to discharge Places federal government in ultimate control
- Federal funding assistance up to 75% for planning/design/construction

Development of Sewage Works in the U.S. 1968 Population receiving greater than secondary treatment









Water quality has improved, however, as of 2000, 39% of U.S. rivers, 45% of U.S lakes and 51% of U.S. estuaries are still considered polluted

And, The U.S. Government, beginning in the 1980s, began a trend of disinvestment in sewerage infrastructure

75% support funding was terminated

Funds are now being provided to States to capitalize revolving Funds to provide low interest loans

Current Estimate of Wastewater Capital Needs

\$340 Billion

Today's Wastewater Utility Challenges

- Correction of combined sewer overflows (CSOs) - \$50 Billion
- Refurbishment/expansion/replacement of plants built in the 1970s
- Affordability in cities that have lost population and industry

Today's Challenges (continued)

- Reduction of Nutrients, PCBs, Dioxin and Mercury in Effluent
- Better Internal Management
 - Asset Management
 - Environmental Systems Approaches
 - Capacity, Management , Operations and Maintenance (CMOM)

Today's Challenges (continued)

- More proactive engagement outside the fence line as watershed management approaches needed to achieve water quality goals.
 - Trading to address nutrients
 - Protection of "source water" of drinking water utilities.
 - Public education on risk vs. cost

If, in the U.S., There is not Continued (Accelerated?) Investment in Water Pollution Control, the Gains in Water Quality Achieved Over the Past 35 Years Could Be Lost

Wastewater Treatment in the U.S. Summary

- Great progress in wastewater services provided and receiving water quality
- Federal support made it happen but utilities are now on their own
- MAJOR capitol needs exist for many utilities to control CSOs.
- Awareness and concern rising regarding failure to attend to infrastructure needs
- There is a "New World" for wastewater utilities

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Application of "Water Safety Plan" to drinking water quality management in Japan

Shoichi KUNIKANE*

Department of Water Supply Engineering, National Institute of Public Health (NIPH)

Introduction

"Water Safety Plan (WSP)", a highlight in the third edition of WHO Guidelines for Drinking-water Quality [WHO, 2004], is a very important tool to achieve health-based targets. WSP requires the systematic management of drinking water quality from a source to consumer taps. In this paper, Japan's approaches to WSP incorporation in drinking water quality management are described.

Japan approaches to WSP incorporation in drinking water quality management

Activities for the introduction and application of WSP to the drinking water quality management in Japan include a research study on WSP application in municipal water supplies and the development of guidelines on WSP application. Key steps in developing a WSP are shown in Figure 1 for reference.

Research study on WSP application in municipal water supplies

A research study, with its objective of exemplifying the way of WSP introduction to municipal water supplies in Japan and funded by a grant of MHLW, started in FY2004. Five water supplies, such as Tokyo, Yokohama, Osaka, Osaka (bulk water supply) and Kobe, are going to reformulate their drinking water quality management programs applying the concept of WSP. The study originally started on a trial basis, but it actually contributes to streamlining and upgrading their current programs of drinking water quality management. Tokyo Metropolitan Water Supply and Osaka Municipal Water Supply are going to obtain or have obtained ISO 9001 certifications regarding to their water treatment and/or distribution systems along with WSP application.

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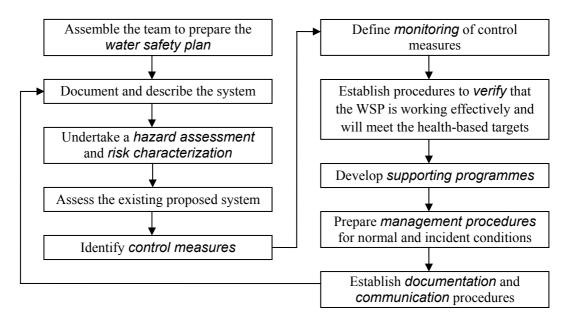


Figure 1 Overview of the key steps in developing a Water Safety Plan (WSP)

Development of guidelines on WSP application

A committee for the development of guidelines on WSP introduction was organized in Japan Water Works Association (JWWA) under the financial support of MHLW in FY2005. A few trials of WSP application to small drinking water supplies are being implemented. There exist more than eight thousand small water supplies, with a population served of 101-5,000 persons, in Japan at present. Their water quality management is rather poor compared with municipal water supplies, and its improvement is of vital importance for preventing waterborne disease outbreaks caused by drinking water contamination. Most of them lack manpower, technology and financial resources. Therefore, small water suppliers will become the main audience of the guidelines on WSP application. Their WSP should be simple, user-friendly and easy to improve. Draft guidelines will be prepared until March 2007.

WSP dissemination to developing countries through international cooperation

NIPH has been serving as the coordinator of Operation and Maintenance Network (OMN) Group since several years ago. OMN is a NGO established in 1990 under WHO for the purpose of improving the operation and maintenance of water supply and sanitation facilities especially in developing countries through the exchange of experiences, knowledge and information. The main activities of OMN include training tool development, convening workshops/seminars and information exchange through the web. Recently, OMN is contributing to the improvement of drinking water quality management through WSP dissemination to developing countries in Asia

collaborating with WHO, JICWELS (Japan International Corporation of Welfare Services) and other institutions as written below.

- JICWELS workshop on WSP and other topics, Hue, Vietnam, June 2005; Collaboration with OMN and WHO/WPRO
- JICWELS seminar on water supply management (WSP and other topics), Tokyo, January 2006; Collaboration with ONM, WHO/WPRO and NZ
- WHO-OMN workshop for PPWSA (Phnom Penh Water Supply Authority) on water supply management (WSP and other topics), Phnom Penh, Cambodia, October 2006

Conclusions

There is no doubt that WSP is essential for ensuring drinking water safety. Hazard identification seems a key component of WSP. Catchment management should be paid more attention to by drinking water suppliers in order to achieve drinking water safety. The way of WSP application may vary according to the situations of individual water supply.

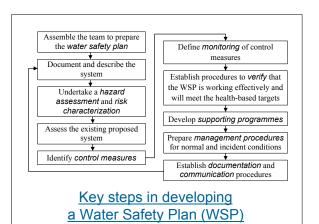
Reference

World Health Organization: Guidelines for Drinking-water Quality, 3rd Edition, Vol.1: Recommendations, 2004

Application of "Water Safety Plan" to drinking water quality management in Japan

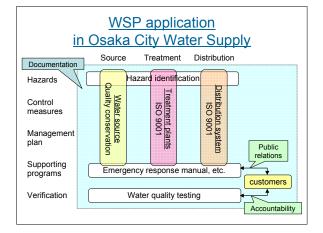
US-Japan Governmental Conference 22-24 January 2007, Okinawa

Shoichi Kunikane Department of Water Supply Engineering National Institute of Public Health (NIPH)



WSP: Japan's approaches

- Introduction into drinking water supplies in Japan
 - ➤A research study on WSP application in municipal water supplies
 - ➤ Development of guidelines on WSP application
- Dissemination to developing countries through international cooperation



Water Safety Plan

(WHO Guidelines for Drinking-water Quality, 3rd Ed.)

- A management tool
- Uses a comprehensive risk assessment and risk management approach encompassing all steps in water supply
- From water source (catchment) to consumer

Objectives

- Minimize contamination of source water
- Remove contamination through treatment
- Prevent re-contamination during storage, distribution and handling of drinking-water

WSP application in the world

- "Bonn Charter" (IWA, 2004)
- Incorporation in the regulatory framework in New Zealand and United Kingdom
- Trials in Germany
- Use in international cooperation by the US
- Application in many developing countries

A research study on WSP application

- ➤ Research period of FY2004-2006 (for three years)
- > Funded by a grant of MHLW
- Case studies on WSP application to drinking water quality management in municipal water supplies; Tokyo, Yokohama, Osaka and Kobe
- ➤ Contribution to streamlining and upgrading their current drinking water quality management programs

<u>Development of guidelines on</u> <u>WSP application</u>

- ➤ Guideline development in FY2005-2007 (for three years)
- ➤ Provision of a fund by MHLW
- ➤ Organization of a committee for guideline development in JWWA
- > Small water suppliers as main audience
- ➤ Guidelines being simple, user-friendly and easy to improve
- ➤ Reference to New Zealand's approach

Small water supplies in Japan

Population served	Systems	Proportion (%)
>4,000	465	5.5
3,000-4,000	344	4.1
2,000-3,000	528	6.3
1,000-2,000	1,116	13.2
500-1,000	1,435	17.0
<500	4,540	53.9
Total	8,428	100.0

Population served of less than 1,000 persons: Approx. 6,000 systems

Note: 1) Data as of FY2003.

 The population served by a "small water supply" is nominally 101 to 5,000 according to its definition.

Treatment Flow-Diagram Raw Water Water Treatment Control Point Sheet Sheet Sheet - Hazard analysis Identification of Identification of critical control points control measures Need of Need of Improvement Need Sheet - Development of an improvement plan - Determination of a tentative management plan (Draft) WSP worksheets for small water supplies

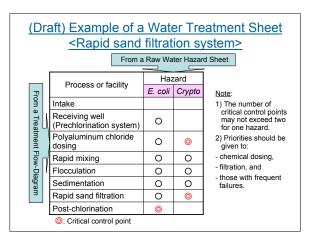
(Draft) Example of a Critical Control Point Sheet E. coli Those given a sign of referred to in a Improvem Post-chlorination PAC dosing Rapid sand filtration a Water Pump Control parameter Residual chlorine Control limit 0.5-0.8mg/l <0.1unit No disorder Treatment Sheet Calibration Weekly Monthly Weekly Improvement Monitoring/ Monitoring Recording 0 Alarming 0 Recording 0 Factors of deviation and Insufficient Pump failure Eluctuation of " should be It Need Shee its preventive measures <Examples> dose → Dose increase → Inspection/ raw water pH – Maintenance pH adjustment Remedial actions when the limit is Treated water reservoir Water transmission interruption and reservoir cleaning Sheet Distribution Additional chlorination (Not applicable) exceeded

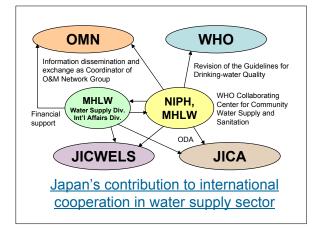
WSP dissemination to developing countries

- JICWELS Workshop on WSP and other topics, Hue, Vietnam, June 2005; Collaboration with OMN and WHO/WPRO
- JICWELS Seminar on Water Supply Management (WSP and other topics), Tokyo, January 2006; Collaboration with ONM, WHO/WPRO and NZ
- WHO-OMN Workshop for PPWSA on Water Supply Management (WSP and other topics), Phnom Penh, Cambodia, October 2006

Importance of WSP to small water supplies

- Inadequate facility maintenance
- Necessity of limited source prioritization
- Insufficient operation manuals
- Inadequate record keeping
- Necessity of existing system improvement
- Need of operator's awareness raising





Conclusions

- ■WSP is essential for ensuring drinking water safety.
- Hazard identification is a key of WSP.
- Catchment management should be paid more attention to by drinking water suppliers.
- The way of WSP application may vary according to the situations.



Risk Assessment and Management of Water Supply System - Infrastructure Initiative for the 21st Century

Dr. James A. GOODRICH¹
Water Supply and Water Resources Division, USEPA
Daniel J. MURRAY²
Water Supply and Water Resources Division, USEPA

1. Introduction

Both drinking water and wastewater infrastructure are critical to providing essential services to not only protect public health and the environment, but is essential to a strong economy. There has been a significant investment in water infrastructure in the United States. There are over 16,000 wastewater plants serving 190 million people utilizing over 600,000 miles (965,000 km) of sewers. Drinking water is provided by nearly 160,000 large and small drinking water systems serving 264 million people via 1,000,000 miles (1,609,000 km) distribution pipes.

2. Problem Overview

The current problem in the United States is that the water infrastructure is aging and spending has not been adequate to repair, replace, or rehabilitate drinking water distribution systems and wastewater collection systems. The American Society of Civil Engineers Report Card in 2005 rated both the drinking water and wastewater infrastructure as "D-." It was stated that there is a risk in reversing the public health, environmental and economic gains of the past three decade if the infrastructure is allowed to continue deteriorating. Sanitary sewer overflows caused by broken pipes are thought to be responsible for releasing as much as 10 billion gallons of raw sewage yearly. The difference between projected needs and required spending to improve the water infrastructure ranges from \$ 0 to over \$13 billion per year for drinking water and \$ 3 billion to over \$ 26 billion for wastewater collection systems. The U.S. EPA has responded to this problem as part of its Sustainable Infrastructure Strategy. This strategy is based upon **Four Pillars**:

- better management,
- water efficiency
- full cost pricing, and
- watershed approach

•

There are also cross-cutting themes to be found under each Pillar:

- innovation
- partnerships
- technology
- research

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3. Program Description

The purpose of the "Innovation and Research for Water Infrastructure for the 21st Century" research program is to generate innovative technologies for the most cost effective:

- Operation, maintenance, and replacement of aging and failing drinking water and wastewater systems and
- Design of new drinking water and wastewater systems.

This research initiative will focus on both the drinking water distribution system and wastewater collection system integrity. The research focus areas are:

- Condition Assessment
 - Gravity Sewers
 - Pressure Pipes (Distribution Systems and Force Mains)
- System Rehabilitation
 - Gravity Sewers
 - Pressure Pipes
- Advanced Concepts (Design & Management)
 - Distribution, Collection and Water Reuse Systems
 - Treatment Systems

The Wastewater Collection Systems research program goal is to develop and demonstrate innovative technologies for:

- · Improved inspection and condition assessment
- · Cost-effective rehabilitation and replacement
- Sewerage system designs, e.g., real-time control, watershed approach
- Improved performance and service life extension

The Drinking Water Distribution System research program goal is to develop and demonstrate innovative technologies for:

- · Improved inspection and condition assessment
- · Cost-effective rehabilitation and replacement
- Sewerage system designs, e.g., real-time control, watershed approach
- Improved performance and service life extension

The program will consist of a wide variety of projects and institutional approaches. The research projects will include: (1) full scale, long term demonstration assessments, (2) state of the technology evaluations, (3) applied research (pilot scale), and (4) basic research that includes proof of concept and bench scale projects. Another aspect of this research program is the development of "Centers of Excellence." These Centers will be competitively selected among academic institutions or consortiums among several universities that will establish nationally and internationally recognized expertise to work collaboratively with the U.S. EPA and key stakeholders.

It is the goal of the "Innovation and Research for Water Infrastructure for the 21st Century" research program to reduce the amount of treated drinking water lost, extend the service life of installed infrastructure, reduce sewer overflows, reduce high risk water main breaks, reduce the amount of untreated wastewater entering surface waters, and optimize the operation, design, and cost efficiency of the infrastructure, thus improving public health, protecting the environment, and improving the economy.

Risk Assessment and Management of Water Supply Systems - Infrastructure Initiative for the 21st Century

James A. Goodrich and Daniel J. Murray Division/NRMRL/ORD/USEPA

4th U.S. – Japan Governmental Conference on Drinking Water Quality Management and

Innovation and Research for Water Infrastructure for the 21st Century

Background

U.S. water infrastructure is critical for providing essential services

- Protect public health and the environment
- Support our economy

Significant investment in water infrastructure

- Over 16,000 POTWs, serving 190 million people
- About 54,000 community water systems, serving 264 million people
- 600.000 miles wastewater sewers
- 1 000 000 miles water distribution lines

Innovation and Research for Water Infrastructure for the 21st Century

The "Gap"

The difference between projected needs and spending trends (\$ billion per year)

	Drinking Water	Wastewater	Total
Congressional Budget Office	0-8.3	3.2-11.1	3.2-19.4
Water Infrastructure Network	9.4	9.2	18.6
EPA Gap Analysis Report	2.3-13.2	1.6-13.5	3.9-26.7

Innovation and Research for Water Infrastructure for the 21st Century

Research Initiative

- · Wastewater Collection Systems
- Drinking Water Distribution Systems Research

Innovation and Research for Water Infrastructure for the 21st Century

Purpose

Generate innovative technologies for more cost effective:

- · Operation, maintenance, and replacement of aging and failing drinking water and wastewater systems
- · Design of new drinking water and wastewater systems.

Innovation and Research for Water Infrastructure for the 21st Century

Current Problem

American Society of Civil Engineers 2005 Infrastructure Report Card

- "D-" for drinking water "...New solutions are needed...(we) risk reversing the public health, environmental and economic gains of the past three decades."
 "D-" for wastewater "...Sanitary sewer overflows, caused by blocked or broken pipes, result in the release of as much as 10 billion gallons of raw sewage yearly"
- U.S. Conference of Mayors 2005 National City Water
- "aging water resources infrastructure" rated top priority

Innovation and Research for Water Infrastructure for the 21st Century

Sustainable Infrastructure Initiative

- Responding to the 2002 "Gap" Report
- Water Infrastructure Gap Forum in 2003
- Sustainable Infrastructure Strategy
 - Four Pillars: better management, water efficiency, full cost pricing, watershed approach
 - Cross Cutting Themes: innovation, partnerships, technology, research

Innovation and Research for Water Infrastructure for the 21st Century

Wastewater Collection Systems





Innovation and Research for Water Infrastructure for the 21st Century

Wastewater Collection Systems

Develop and demonstrate innovative technologies for:

- Improved inspection and condition assessment
- · Cost-effective rehabilitation and replacement
- Sewerage system designs, e.g., real-time control, watershed approach
- · Improved performance and service life extension

Innovation and Research for Water Infrastructure for the 21st Century

Drinking Water Distribution Systems

Develop and demonstrate innovative technologies for:

- · Leak detection/location
- · Assessment of high risk mains
- · Cost-effective rehabilitation and replacement
- Distribution system designs, e.g., dual systems with wastewater/stormwater reuse

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types

- Technology Demonstration Programs
- "State of the Technology" Assessments
- · Applied Research Decision Support
- · Basic Research Advanced Designs
- · "Center of Excellence"

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- · Technology Demonstration Programs
 - Emerging and innovative inspection technologies and rehabilitation technologies
 - Innovative sanitary sewer and collection system designs
 - Wastewater separation/reuse/dual system designs

Building a scientific foundation for sound environmental decisions

Innovation and Research for Water Infrastructure for the 21st Century

Drinking Water Distribution Systems



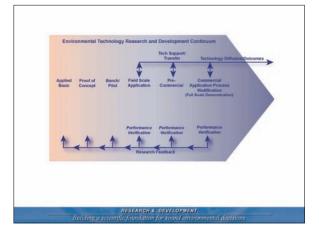
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Innovation and Research for Water Infrastructure for the 21st Century

Research Focus Areas

- · Condition Assessment
 - Gravity Sewers
 - Pressure Pipes (Distribution Systems and Force Mains)
- · System Rehabilitation
 - Gravity Sewers
 - Pressure Pipes
- Advanced Concepts (Design & Management)
 - Distribution, Collection and Water Reuse Systems
 - Treatment Systems

Building a scientific foundation for sound environmental decisions



Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- "State of the Technology" Assessments
 - Optimization of internal camera inspections
 - Emerging inspection and rehabilitation technologies
 - Innovative sewer and collection/distribution system designs
 - Understanding forensics of sewer/water main degradation and failure

Building a scientific foundation for sound environmental decisions

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- · Applied Research
 - Cross-sector application of advanced and remote sensing techniques
 - Evaluation and improvement of decision support systems
 - Improvement of repair and rehabilitation materials

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- · "Center of Excellence"
 - Competitively awarded, academic research center
 - Collaboration among several universities
 - Establish nationally recognized expertise
 - Cooperative research program with EPA and key stakeholders

Innovation and Research for Water Infrastructure for the 21st Century

Possible Goals/Outcomes

- Closing the "gap"...reducing life-cycle costs
- · Extending service life of installed infrastructure
- Reducing sewer overflows, back-ups, failures
- Reducing I&I and plant WWF bypasses
- · Reducing high risk water main breaks
- Improving condition assessment and decision-making capabilities
- · Reducing potable water leakage & intrusion potential
- · Use of performance/cost data for decision support
- Incentives for adoption of innovative technologies

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- Basic Research
 - Exploration of advanced techniques (molecular and isotope tracers) for condition assessment
 - Development of new and innovative pipe and system design approaches
 - Center-based, academic research

Innovation and Research for Water Infrastructure for the 21st Century

Program & Project Types (cont'd)

- · Cross-Cutting Areas
 - Cost, cost-effectiveness, cost-benefit, and lifecycle costing;
 - Performance and outcome measurement;
 - Technology baseline development;
 - Decision-support systems;
 - Systems modeling; and
 - Integrated management systems.

Overview of Current In-Building Water Supply System Management in Japan - Introduction of a Manual for Safety Management of these Systems - Tetsuo Hayakawa*

Professor, Department of Environmental Health, Azabu University, Japan

1. Introduction

In 2005, WHO published Water Safety Plans (WSP) with the subtitle – Managing drinking water quality, from catchment to consumer.¹ According to the WSP and other documents, to assure drinking water safety, several issues should be considered. These include:

- 1) Source water pollution prevention;
- 2) Treatment prior to distribution;
- 3) Protection during distribution;
- 4) Safe storage and distribution within buildings.

Of these, 1), 2), 3) can be regarded to function as barriers, where activities are designed to minimize the likelihood of contaminants entering the water supply or reduce or eliminate contaminants already present in the supply.

With the multiple barriers approach, each barrier provides an incremental reduction in the risk of water becoming unsafe.

If there is a failure at one point, the other barriers continue to provide protection.

In Japan 1) to 3) are controlled by the water supplier (public sectors) in common with other countries , and therefore the regulator can specify compliance requirements to the water supplier. As a result, it is not so difficult to keep safe management in these respects. However 4) may be outside the responsibility of the water supplier, and may thus be implemented by building managers. In addition as this is the final step, failure is not permitted.

So in-building water supply should be considered as a critical step to supply safe drinking water to the consumer.

In-building water supply systems with water tanks have been controlled by the Water Works Law in Japan since 1977. Since then owners of systems and/or building

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¹ Water Safety Plans, WHO/SDE/WSH/05.06 ,2005

managers have tried to manage them more safely. To keep these systems - over one million – safe, it is required that the owner should manage them safely. However, as owners normally do not have enough knowledge on the maintenance of such systems, a maintenance manual on in-building water supply systems for owners with a little knowledge on this issue is desirable.

2. Overview

2-1 Current status of In-Building Water Supply Systems with Water Storage Tanks in Japan

2-1-1 Tank volume Over 10 m³

Regulated by Water Works Law article 34-2;

The owner of the system is responsible for safety management of the system;

Technical maintenance protocol required including;

Regular Inspection (at least once a year);

Regular Tank cleaning (at least once a year);

Pollution control procedure should be introduced if necessary.

Table -1 Status of Inspection of Water storage tanks (Data; MLHW) (Water Storage Tanks over 10m³)

	1999	2000	2001	2002	2003	2004
Number of	184,401	190,150	194,278	196,381	201,809	206,451
tanks						
Number of	157,781	162,186	165,034	165,408	167,497	166,839
inspected						
tanks						
Ratio (%)	85.6	85.3	84.9	84.2	83.0	80.8

Table-2 Status of non-compliance

	1999	2000	2001	2002	2003	2004
Number of	65,318	68,386	70,816	68,598	62,431	47,625
non-complying						
tanks						
Ratio (%)	41.9	42.2	42.9	41.5	37.3	36.2

2-1-2 Tank volume less than 10m³

Not regulated by Water Works Law;

Some Local Governments control them by local regulations.

Table-3 Current Situation of small scale In-Building Water Supply System Management (Tank Volume; Less than 10m³)

	2000	2001	2002	2003	2004
Number of	745,414	754,319	768,426	890,470	907,055
tanks					
Number of	24,381	24,657	25,156	31,159	26,411
inspected					
tanks					
Number of	12,918	12,060	11,047	14,041	9,498
non-complying					
tanks					
Ratio (%)	53.0	48.9	43.9	45.0	36.0

As shown in these tables , the ratio of non-compliance remains at a high level despite the existing regulations. In my study, some 10,000 systems that were found to have non-complying tanks as a result of the previous year's inspection are surveyed. Of these systems, some 50% have not been improved in regard to the previous year's non-compliance.

2-2 Examples of non-compliance

Examples of non-complying tanks are as followings:

- 1 Sewage flow into water tank from sewage tank;
- 2 Animal Carcasses are found in water tanks;
- 3 Because of decay of water tanks' manholes, rainwater or sewage may flow into water tanks

This is caused by poor design of plumbing system, incorrect installation, alterations and inadequate maintenance.

Fortunately the ratio of such severe violations is very low at 0.2%; however we should try to improve this situation. There are two main measures for improvement. One is to change a tank system to direct connection. Whilst this may be effective, in some cases it may require a whole system alteration for high pressure supply. Another is to improve

the maintenance level of tank supply systems. In this case it is important to improve the building owners and/or managers' knowledge.

This study focused on preparing an in-building water supply system maintenance manual for building managers.

3. Introduction of the Maintenance Manual

The manual consists of the following articles:

1 Maintenance protocol

A building owner/manager is advised to prepare the maintenance protocol including:

- 1) Maintenance target;
- 2) Regular inspection of a whole system and each component;
- 3) Regular cleaning;
- 4) Emergency stop water supply;
- 5) Keeping documents on maintenance;
- 6) Cost for maintenance.
- 2 Selection of Water Tank Cleaning and Inspection Firm
- 1) Free available information of water tank cleaning and inspection firms;
- 2) Cleaning and inspection in the presence of building manager;
- 3) Hearing of the results of cleaning/inspection;
- 4) Receiving an improvement plan;
- 5) Combination of building manager, relevant firms, water supplier and government.

Other issues which should be considered together with the implementation of the maintenance manual are:

- 1) To introduce a recognition system of buildings with good maintenance; this may raise the value of the building.
- 2) To strengthen the relationship between building managers, cleaning/inspection firms, plumbers, water suppliers and government.

It is hoped that many owners/managers of in-buildings water supply systems and relevant specialists can become familiar with this manual in the near future. As a result maintenance levels of in-building water supply systems would be improved and then a step towards the goal of Safe Drinking Water Supply to All will be achieved.

Overview of Current In-Building Water Supply System Management in Japan

-Introduction of a Manual for Safety Management of these Systems -

Tetsuo Hayakawa Professor, Environmental Health College, Azabu University, Japan

Water Safety Plan

Risk Management and Assessment From Catchment to Consumer

Three Components

- 1) System assessment
- 2) Risk Management
- 3) Maintenance Protocol



WHO Guidelines for Drinking –water Quality 3rd,Ed. (Sept. 2000)

The Multiple Barriers Approach

Issues 1), 2), 3) can be regarded to function as barriers, where activities are designed to minimize the likelihood of contaminants entering the water supply or reduce or eliminate contaminants already present in the supply.

Each barrier provides an incremental reduction in the risk of water becoming unsafe.

Current status of In-Building Water Supply Systems with Water Storage Tanks in Japan

Tank volume Over 10 m³

- 1) Regulated by Water Works Law article 34-2
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- 2) Technical maintenance protocol required including;
- Regular Inspection (at least once a year);
- •Regular Tank cleaning (at least once a year);
- ·Pollution control procedure should be introduced if necessary

1. Introduction

In 2005

WHO published Water Safety Plans (WSP) with subtitle – Managing drinking water quality from catchment to consumer.[1] According to the WSP and other documents, to assure drinkingwater safety, several issues should be considered, for example,

[1] Water Safety Plans, WHO/SDE/WSH/05.06 ,2005

Issues should be considered

According to the WSP and other documents, Issues to assure drinking water safety:

- 1) Source water pollution prevention:
- 2) Treatment prior to distribution;
- 3) Protection during distribution;
- 4) Safe storage and distribution within buildings.

A critical step to supply safe drinking water

- In Japan 1) to 3) are controlled by the water supplier (públic sectors)
- It is not so difficult to keep safe management.
- 4) may be outside the responsibility of the water supplier, and may thus be implemented by building managers
- This is final step, failure is not permitted.
- So In-building Water Supply should be considered as a critical step to supply safe drinking water to the consumer.

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157.781 162.186 165.034 165.408 167.497 166.839 Ratio (%)

85 6 85.3 84.9 84.2 83.0 80.8

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Ratio (%)

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Tank volume less than 10m³

 Not regulated by Water Works Law;
 Some Local Governments control them by local regulations.

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2000 2001 2002 2003 2004 Number of tanks 754,319 768,426 890,470 907,055 745.414 Number of inspected tanks 24,381 24,657 25,156 31,159 26,411 Number of non-complying tanks 12,918 12,060 11,047 14,041 9,498 Ratio(%) 48.9 53.0 43.9 45.0 36.0

Examples of non-compliance

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- 1 Sewage flow into water tank from sewage tank
- 2 Animal Carcasses are found in water tanks;
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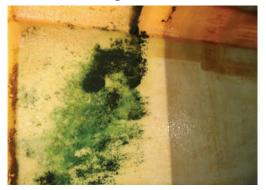
EX. 1 Cross connection



EX.3 Decay of a ROOF



EX. 2 Algae in a Tank



Two main measures for improvement

- 1) To change a tank system to direct connection, this may be effective in some cases it may require whole system alteration for high pressure supply
- 2) To improve maintenance level of tank supply systems

it is important to improve building owners and/or managers' knowledge.

Water Tanks on Roofs in Okinawa





Introduction of the Maintenance Manual

1 Maintenance protocol

A building owner/manager is advised to prepare the maintenance protocol including

- 1) Maintenance target
- 2) Regular inspection of a whole system and each components
- 3) Regular cleaning
- 4) Emergency stop water supply
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Other issues together with implementation of maintenance manual

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Water Tanks in Shingapore





2 Selection of Water Tank Cleaning and Inspection Firm

- 1) Free available information of water tank cleaning and inspection firms;
- 2) Cleaning and inspection in the presence of building manager;
- 3) Hearing of the results of cleaning/inspection;
- 4) Receiving an improvement plan;
- 5) Combination of building manager, relevant firms, water supplier and government.

(参考) 横浜市給水管理適合施設表示制度

○目的: 設置者の管理意識を高め、 安全で衛生的な受水槽水を確保する 平成6年6月から実施 当初(市が認定) ⇒平成16年度に表示制度に改正 ⇒検査機関(協定)に移行 ○管理の良好な施設が自ら表示できる。 〇給水管理のより・有効期限シールの交付 〇施設利用者に見える場所に掲示



表示プレート

How to deal with aging sewers? - Statistical Life Data Analysis of Sewer-

Yosuke MATSUMIYA*, Chizato MIYAUCHI, Kazuya FUJIU National Institute for Land and Infrastructure Management, MLIT

1. Introduction

Japan has invested over 80 trillion yen in wastewater infrastructure. Sewer length has reached above 380,000 km. Some 2000 wastewater treatment plants are under operation. In recent years, sewer cave-ins have been reported in increasing numbers. It brings safety concerns among stakeholders. Preventive maintenance and asset management are being cried out. In this paper, statistical life data analysis of sewer is presented. It enables local governments, which are wastewater operators, to project future investment needs for sewer rehabilitation and replacement.

2. Method

Statistical life data analysis was conducted with 2-parameter Weibull distribution. Weibull functions are shown in Table 1 for sewers at the age of t.

Table 1 Weibull Distribution

definition		Weibull Function
death rate	$\lambda_{(t)} = \frac{f}{R}_{(t)}^{(t)}$	$= \frac{b}{a} \cdot (\frac{t}{a})$
probalility density on death	$f_{(t)} = \frac{\partial F_{(t)}}{\partial t_{(t)}} = -\frac{\partial R_{(t)}}{\partial t_{(t)}}$	$= \frac{b}{a} \cdot \left(\frac{t}{a}\right) \qquad \cdot e \qquad \left(\frac{t}{a}\right) \qquad b$
cumulative distribution on survival	R = 1 - F (t)	$= e^{-\left(\frac{t}{a}\right)}$
cumulative distribution on death	F = 1 - R (t)	$= 1 - e^{-\left(\frac{t}{a}\right) b}$

In the case of sewers, death is defined by having them rehabilitated or replaced. Rehabilitated or replaced sewers get 50 year of useful life newly in the account book. To know the death rate, a questionnaire survey was conducted to all the local

governments with sewer systems on August 2006. The questions were how many kilometers of sewers survived and died during FY 2005 by age and material. The surveyed materials were concrete, clay, and PVC, which are the majority.

3. Result & Discussion

As of FY 2005 end, entire sewer length was 383,031 km. Out of this, 342,290 km, 89% of the total was analyzed, whose ages were identified and which agreed with any of the three materials. Coefficient **a** and **b** resulted in 99.30 and 3.048

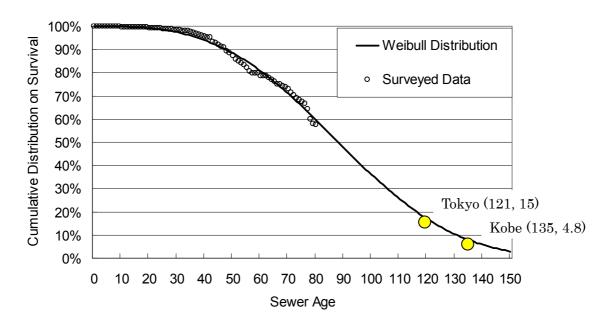


Figure 1 Survival Curve

To know the applicability of the curve to the more aged sewers, the oldest brick sewer data from two municipalities, Tokyo and Kobe were plotted. They are close to the approximation line. This analysis ignores specific factors influencing lives of sewers such as quality of the works, sewer standard of the times and how well or badly each sewer has been maintained. However, the curve is considered effective to project overall future investment needs if future investment decision is made similarly to the one in FY 2005.

Reference

Weibull distribution, http://en.wikipedia.org/wiki/Weibull distribution

*1 Asahi, Tsukuba City, 305-0804, JAPAN Email: matsumiya-y92ta@nilim.go.jp

Jan. 22, 2007 20 min

How to deal with aging sewers?



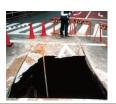
Yosuke MATSUMIYA **Wastewater System Division** National Institute for Land & Infrastructure Management (NILIM) MLIT, Japan

Contents

- 1. Current Issues
- 2. Proposed Sewer Management
- 3. Survival Curve
- 4. NILIM Research Projects **Underway**

Cave-Ins Looming

- Number is increasing (5,000 cases/yr)
- Big cities account for majority
- Some of their sewers are over 50 yrs
- 50 is expected life time for depreciation.





Contents

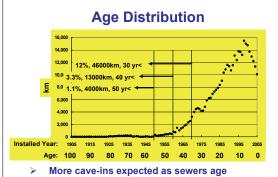
- 1. Current Issues
- 2. Proposed Sewer Management
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Mission

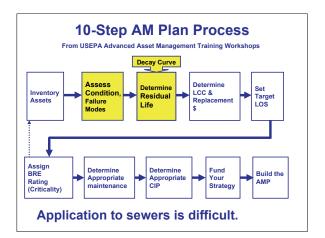
- >Sustainable Sewer Service
- > Effective & Efficient Management
- > Help LGs to do Asset Management

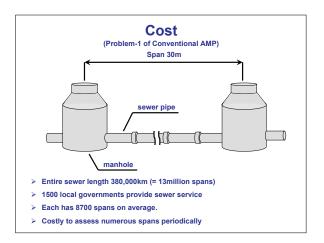
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- > Feared traffic problems
- > AM necessary!





Effectiveness

(Problem-2 of Conventional AMP)

- Sewers get damaged by unexpected external force.
- Construction works of other utility pipes are typical.
- Service not interrupted instantly by severe damage.
- Later, damaged sewers cause cave-ins.
- Assessments before damage cannot predict life.

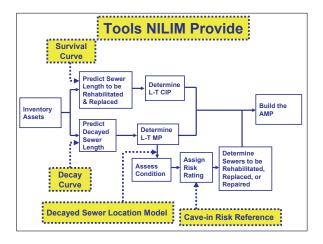
Technical difficulty

(Problem-3 of Conventional AMP)

- Most sewers are small & needs CCTV.
- Picture qualities of now, past, future different. Comparing between different times is misleading.
- Interpretation tend to differ from person to person.
- Time series analysis is questionable



> Frequency (CCTV + eye) is once/over 30 years.



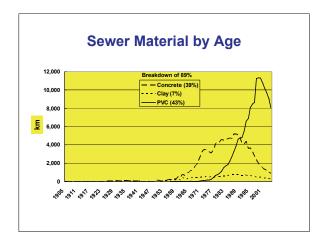
Proposal on Process Predict Sewer Length to be Rehabilitated & Replaced Determine L-T CIP Build the Inventory Assets Length Assign Assess Replaced, or

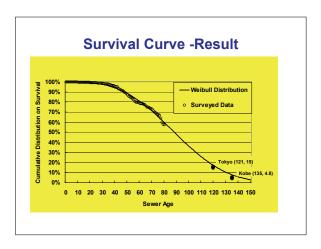
Contents Proposed Sewer Management 3. Survival Curve 4. NILIM Research Projects Underway

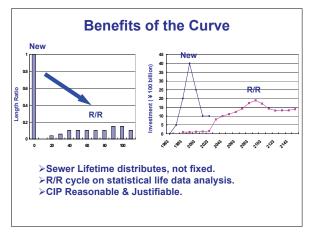
Survival Curve - Method

- Similar to Human Life Expectancy Calculation
- Unique approach as far as we know
- Data
 - **Questionnaire Survey to All**
 - Death & Survival Lengths during FY 2005 Concrete, Clay & PVC chosen

 - Death means getting rehabilitated/replaced
 - R/R sewers get 50 year of new life
- - 2-parameter Weibull Distribution
 - 342,290 km, 89% of all, 383,031km, analyzed

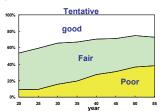






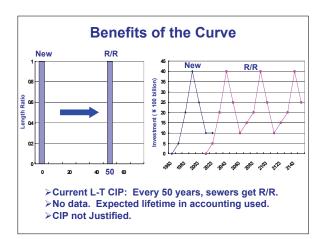


- \succ DC useful for LTMP. Now collecting data from LGs.
- > Assessment protocols differ among LGs.
- > Data integration for application to most situations.
- > Analyzing integration possibility.
- Applying different protocols to same CCTV pictures.



Cave-In Risk

- Floods, back-ups, odors are risks too.
- > Focus on cave-ins as it is life threatening.
- Damaged sewers neglected by budget lack
- Need to prioritize which sewers addressed first
- > Prioritization based on criticality/risk
- Our research helpful for LGs.



Contents

- 1. Current Issues
- 2. Proposed Sewer Management
- 3. Survival Curve
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Decayed Sewer Location Model

- > Sewer spans numerous. Assessment needs efficiency.
- > Where to assess important.
- Model to predict where decayed sewer exists
- > Statistical model with regression analysis employed.
- > Dependent variable: results of condition assessment.
- > Independent variables: age, diameter, material, etc
- > Problem: inventory and condition stored separately.
- AM is not pervasive.
- > Problem-2: integration of different protocol data.

(Condition) = f (Inventory Data; Age, Diameter, Material...)

Loading Test for Aged Sewers Cave-in Risk Reference -1





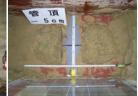
An aged sewer being removed for replacement

- > Currently, collecting aged sewers
- > Appearance & remaining strength will be studied

Experiment on Soil Infiltration

Cave-in Risk Reference -2





- > Low chances for ruptured sewers to cause cave-ins
- > High chances for dislocation/openings to cave-ins
- > Soil infiltration leads to cave-ins
- ➤ Intended to know the possibility of cave-ins
 ➤ Parameters: Backfill soil, openings, groundwater level

Thank you!

For better sewer management

- Long term planning

 - Downsizing policy restricts LTP.
 LTP needed to spend wisely.
 10 to 20 planning norm US, Australia, New Zealand.
- Risk Based Management
 Risk not considered schematically, but with intuition.
 - > Sewer mains and laterals might be handled equally.
 - Avoid catastrophes while allowing inconveniences. Thanks to USEPA trainings course & Mr. Albee.

Management of Aging Wastewater Infrastructure -- Challenges and Strategies --

Jerry N. Johnson, General Manager District of Columbia Water and Sewer Authority Washington, D.C.

Overview of the Aging Situation

For many years, water and sewer systems in core cities in the U.S. have suffered from deferred and under-funded programs for upkeep and improvements. Many systems, especially in the eastern U.S., date from the middle 1800s, and an acute backlog of needs to maintain basic services and meet new regulatory mandates has developed.

The U.S. Environmental Protection Agency (EPA) has estimated that water and sewer systems in the U.S. will require funding upwards of \$500 billion above current spending levels over the next 20 years to improve the aging infrastructure. Core cities in the U.S. cannot, on their own, finance these needs from existing revenues based on rates and taxes.

Lawmakers, on the other hand, seem to have not recognized the urgent situation facing the core cities and instead have focused on programs that provide federal financial assistance to the more visible public projects in the areas of roads, bridges and airports. Moreover, lawmakers and regulators continue to mandate more stringent environmental controls which require massive water and sewer projects to achieve compliance. When these mandates are added to the already severely strained financial structures of core cities, the burden becomes critical and in some cases results in population and industry moving out of the cities to avoid high utility costs among other factors. This leaves these municipalities with a smaller revenue base to fund a fast-growing investment need.

U.S. cities need to marshal their resources to educate elected officials and the general public to the situation and the need for a comprehensive national program that reinvests in critical infrastructure. Washington, D.C. is typical of a core city having to deal with an aged water and sewer infrastructure, and the problems of deferred upkeep and new environmental mandates. The following discussion shows how the D.C. Water and Sewer Authority is addressing the funding needs and existing infrastructure conditions, and highlights our efforts to shift from past practices and meet new demands.

A population shift and shrinking rate base

Infrastructure systems in this country have followed population growth in cities across the nation. Over the years, populations continue to increase in numbers and shift in location. For example, the U.S. Census Bureau projects its 2000 population count of 231 million to increase to 325 million by 2020. Moreover, this growth continues to move outward from the core cities, leaving many older cities with a declining population, a shrinking rate base and the costly maintenance of an aging and failing infrastructure. The problems are not just financial; they are also managerial and technical.

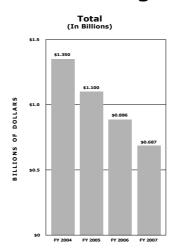
Federal funding support continues to decline

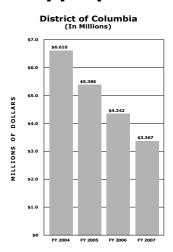
Since 1987, the Clean Water State Revolving Fund (CWSRF) has been the primary source of federal funding for wastewater infrastructure – including the repair and replacement of pipes, pumps and treatment plants. However, federal support for clean water projects such as these has continued a steady decline.

Total federal funds for the CWSRF have declined from \$1.35 billion in fiscal year 2004 to \$687.6 million in fiscal year 2007 or 50%.

Over the same period, the CWSRF funding allocation for the District of Columbia has declined 50% from \$6.6 million to \$3.4 million.

Funding Levels in Clean Water State Revolving Fund Appropriations





Long-term, dedicated funding needed

Studies by U.S. Environmental Protection Agency (EPA), Congress and the General Accounting Office (GAO) have estimated a water and wastewater funding gap of \$300 – \$500 billion over the next 20 years between the nation's needs and what is actually spent on aging infrastructure. The District of Columbia Water and Sewer Authority has joined elected officials, wastewater service providers, state environmental and health administrators, engineers and environmentalists in advocating the establishment of a trust fund to guarantee basic services and compliance with environmental standards over the long-term. (Similar trust funds have been formed to dedicate revenue sources for other critical infrastructure such as highways and airports.)

Wastewater infrastructure in the nation's capital

An examination of the financing and management of America's wastewater utilities shows major trends toward (1) addressing wet weather issues, driven by regulations, and (2) undertaking major replacements, driven by aging infrastructure. Facing these challenges in the nation's capital is the District of Columbia Water and Sewer Authority (WASA), one of the largest such utilities on the East Coast – with a 725 square mile service area. Incorporated in 1996 as a regional utility, WASA distributes drinking water to a population of 500,000 in the District of Columbia and provides wastewater treatment

for more than two one half million persons in the District and for suburban counties in Maryland and Virginia.

WASA operates and maintains 1300 miles of sanitary and combined sewers, 500 miles of storm sewers, nine sanitary pumping stations, 15 stormwater pumping stations, and 53 outfalls. The collection system includes more than 900 flow control structures such as diversion and overflow facilities, weirs, siphons, inflatable dams, and tide gates. Sewage flows mainly by gravity, however, there are some pressurized forced mains and pumping stations. The pumping stations were constructed from 1905 through around 1960. Parts of the sewer system date back to the 1800's and are comprised of various materials including vitrified clay pipe, reinforced concrete, ductile iron, brick arch, and some PVC pipe.

The District's wastewater treatment facility, originally constructed in 1938, sits on a 150-acre site on the Potomac River. Blue Plains is the largest advanced wastewater treatment facility of its type with a rated annual average capacity of 370 million gallons per day and a peak wet weather capacity of 1.076 billion gallons per day. While other metropolitan areas have facilities with larger capacities, none of these provide the high level of treatment that Blue Plains does with its nitrification, de-nitrification and filtration processes. Consistent with the high level of treatment provided, the plant's operating permit contains the most stringent effluent discharge requirements of any plant of its size. However, all of this comes at a cost and since 1997, WASA has invested more than \$300 million in a critical overhaul of the plant – targeting the repair and replacement of every process unit, from grit chambers and screening to nitrogen removal and final filtration. As a result, Blue Plains has evolved from a facility with significant reliability and odor issues ten years ago, to one that is nationally recognized for its high quality effluent and biosolids management program.

Financing the District's aging wastewater infrastructure

WASA has implemented a 10-year, \$2.1 billion Capital Improvement Program (CIP) to address the needs of its aging water and sewer infrastructure that had been deferred for decades. In the last 10 years, WASA has invested more than \$1.2 billion in capital improvements for sanitary and stormwater projects, combined sewer overflow control, and wastewater treatment plant upgrades. These investments, along with prudent financial policies implemented by its Board of Directors, have earned WASA a double-A category bond rating, resulting in reducing debt service costs associated with financing the CIP. Rate revenue, with steady, predictable annual increases, continues to be the major source of funding for maintaining and improving the water and sewer infrastructure.

Regulatory challenges

Wet weather discharges A third of the District is served by a combined sewer system. Built in the 1870s, this system carries both sanitary sewage and stormwater in a single pipe. During wet weather, or rainstorms, the capacity of these sewers is overwhelmed and a mixture of untreated wastewater and stormwater will overflow into local rivers and streams. Combined sewer overflows (CSOs) impact nearly 1100 cities in this country. Federal "wet weather" policies require combined-sewer communities to

reduce these overflows to meet water quality standards through a combination of short-term control measures and the implementation of long-term control plans. This mandate represents a \$2.1 billion cost burden for WASA customers, who must fund a federal court-ordered short-term plan to reduce CSOs by 40 percent and a Long-Term Control Plan to obtain an overall 96 percent reduction over the next 20 years. Compliance with "wet weather" mandates has created a severe financial plight for urban areas and the federal government must come forward with increased financial assistance to construct these massive CSO control projects. Without greater federal participation, the burden of these mandates falls unfairly on ratepayers in older core cities, like the District, where costs sometime far exceed the affordability index of the community. Moreover, a recent federal court ruling redefining discharges from CSOs may substantially impact WASA's ability and the cost to move forward on its mandated long-term plan to control CSOs.

Nitrogen reduction Blue Plains is the single, largest point source of discharge entering the Chesapeake Bay. As a condition of its federal discharge permit, WASA operates under the limitations of the Chesapeake Bay Agreement goal of a 40 percent reduction in nitrogen discharges. The District was the only one of five Agreement signatories (EPA and Bay states) to reach the 2000 goal. In 2004, the nitrogen load was reduced by 56 percent, far exceeding the goal. However, EPA is modifying WASA's discharge permit with new limits for "enhanced" nitrogen removal, requiring WASA to spend upwards of \$800 million to \$1 billion to meet these limits.

Strategies for managing aging wastewater infrastructure

Sewer Assessment Program Management challenges for the District's sewers relate largely to the age of the system. It is extensive and will take many years to assess its condition. To begin the process, WASA has commissioned a five-year Sewer System Assessment Program with multiple contracts and plans for internal inspections over the next decade. The assessment begins with high priority sewers, such as outfalls, siphons, stream crossings, major interceptors and sewers under buildings.

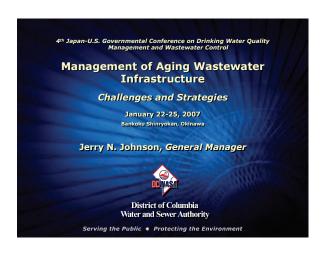
Products of the assessment program include hydraulic modeling, capacity analyses, location mapping integrating GIS, condition assessment and a facilities plan and schedule for improvements and ongoing inspections. Meanwhile, WASA is addressing immediate sewer problems and failures with TV/video inspections, cleaning and lining and other technologies that includes trenchless repair.

Asset management In America, the wastewater industry has embraced the concept of asset management as a major tool in managing the operations and costs associated with aging infrastructure. At WASA, the implementation of its Asset Management Program represents a significant leap in automation and business process improvements for infrastructure management and maintenance lifecycles. From receiving a customer complaint to its ultimate resolution, the system supports work orders, job planning, operating condition monitoring, proactive and scheduled maintenance activities, and is integrated with WASA's inventory system. Among the benefits of an Asset Management System, is its impact on changing the operating culture from "break down" maintenance to predictive and planned maintenance. Eventually the system will tie into WASA's purchasing and financial systems for capital replacement and associated cost management.

Human resource management WASA, like most utilities, is faced with a critical shortage of personnel in positions that require a unique skill set, and there are at least three other utilities within 30 miles with which WASA has to compete for employees. The average age of workers in the U.S. wastewater utility industry is 45; the average age at WASA is 47 years old, with an average of 14 years service. More than half of the middle management staff has been with WASA since its inception in 1996, and in some cases for more than 20 years. Many of WASA's employees are eligible to retire and that will cause a significant loss of operational and managerial knowledge. WASA is preparing for this type of turnover in two ways. WASA is using a Knowledge Capture concept for key processes to gather and document the tacit institutional knowledge that exists with individual employees rather than in the standard operating manuals. Succession Planning focuses on the senior and executive levels in the organization and ensures that the right people with the right competencies, experience and training are positioned for operations and business continuity. Additional strategies employed by WASA include "double-filling" certain key positions, rotating engineering and internship programs, and entry level training opportunities.

Summary

The District of Columbia is one of many core cities in America burdened with the need, cost and requirements to maintain, replace and upgrade aging plant and underground wastewater infrastructure. Aging systems, costly upgrades, regulatory demands and shifting populations are a challenge for communities across the country. Thirty years ago, the federal share for wastewater infrastructure construction was 75 percent. Today it has fallen below five percent. EPA estimates that, if the nation's infrastructure needs are not addressed in the next 10 years, 35 years of water quality gains will be lost. The experience in the nation's capital reflects conditions and challenges in like communities across America. As the District and other core city stakeholders advocate the establishment of a federal clean water trust fund, annual rate increases continue. In the meantime, long term facility planning, the use of strategies and tools such as legislative advocacy, asset management systems, succession planning and public education are keys to meeting the service, regulatory, and financial challenges facing America's aging water and sewer infrastructure.







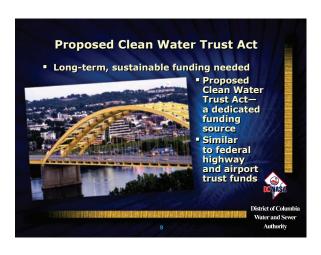




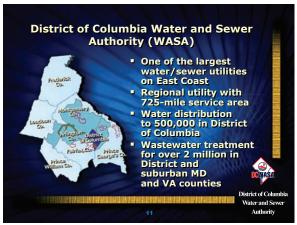


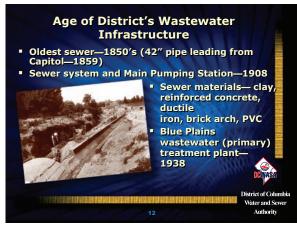






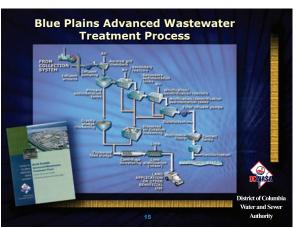




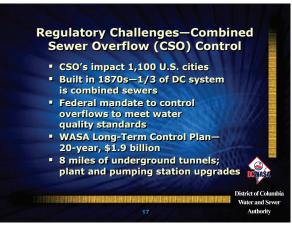














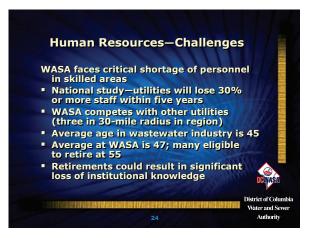










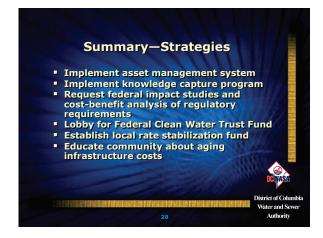












Watershed Management in Drinking Water for Emergency:

A Case of Lake Biwa - Yodo River System

Takashi SASAKI* & Daiji NAGASHIO**
Yodo River Water Quality Committee

1. Background

Lake Biwa - Yodo River water system is located in the middle west part of Japan and supports urban life and activities as one of the main water source for 14 million consumers in the Kansai area (Fig. 1). The water system is characterized by urbanization and developed industry in upstream area, at the same time, much use of domestic water in downstream area. This means the water is being reused so highly from upstream to downstream that there exist many kinds of risk factors to water safety.

Drinking water supply utilities taking water from the river organize "Yodo River Water Quality Committee" for integrated source water quality management to cope quickly and systematically with source accidents. This paper describes outline of the Committee and its source monitoring for emergency.

2. Outline of Yodo River Water Quality Committee

Fig. 2 shows yearly changes in raw water quality at Kunijima water treatment plant (WTP) of Osaka City, one of the largest utilities. Since the quality rapidly deteriorated due to increased domestic and industrial wastewaters in 1960s, downstream utilities were forced to take countermeasures for these problems. The utilities concluded that cooperative approach for integrated source quality management was the best way and established Yodo River Water Quality Committee in 1965, which is currently composed of ten utilities (Osaka Prefectural -, Osaka Municipal -, Moriguchi City -, Neyagawa City -, Hirakata City -, Suita City -, Amagasaki City -, Itami City -, Nishinomiya City - waterworks and Hanshin Water Supply Authority) (Pic. 1). Since then, the Committee has engaged in various activities for resource conservation including;

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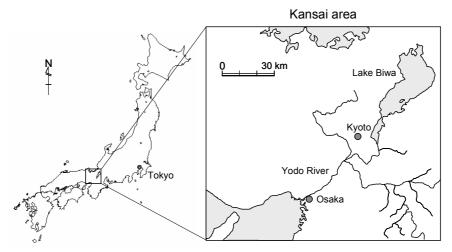


Fig. 1 Outline of Lake Biwa - Yodo River water system

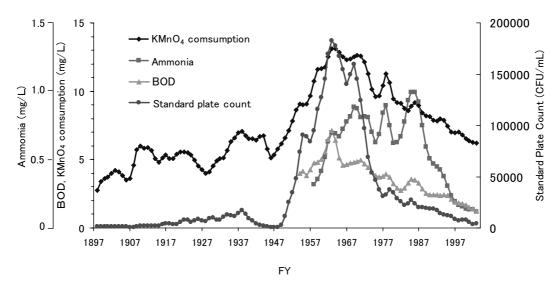


Fig. 2 Yearly changes in water quality of Yodo River



Pic. 1 Board Meeting of Yodo River Water Quality Committee

- ·Regular monitoring of source quality
- ·Research and investigation for source quality management
- ·Advocating activities for pollution control
- · Awareness raising for resource conservation
- · Establishment of information networks for emergency control

3. Water Source Monitoring for Emergency

(1) Information Networks for Emergency Control

In case of source accident, river administrator provides the Committee with information reported from the finder. Then the Committee informs all the members of the accident according to emergency information networks rules (Fig. 3).

Fig. 4 shows changes in the number of source accidents. The number has been increasing since 1990 after brief decline at around 1980. Severe accidents which directly affect waterworks has been decreasing, on the other hand, the ratio of oil spill accidents has been increasing in recent years. The Committee has periodically appealed to administrative bodies to supervise the causative facilities, and achieved successful results.

An oil spill accident in October 2003 provides a good example. The accident occurred at one of tributaries of Yodo River and affected downstream utilities. One of WTPs was forced to stop water intake for four hours and six of WTPs had to reduce water intake, absorb oil, or use powdered activated carbon to cope with the spilled oil. Quick circulation of information followed by proper response to the accident prevented finished water from being contaminated. After that, four affected utilities claimed compensation from the causative facility that the Committee identified.

(2) Organizing Watershed Data

Differences in the arrival time of contaminants from accident spot to intake points are useful when accidents happen. The Committee developed "Arrival time display system in Yodo River" based on observed time considering the effect of river shape and estuary barrage. The Committee also created factories' database in the basin named "Environmental map" (Fig. 5) containing their locations and harmful chemicals used to quickly respond to source accidents. The map can numerically display contamination risk by harmful chemicals in the whole area utilizing the stored data.

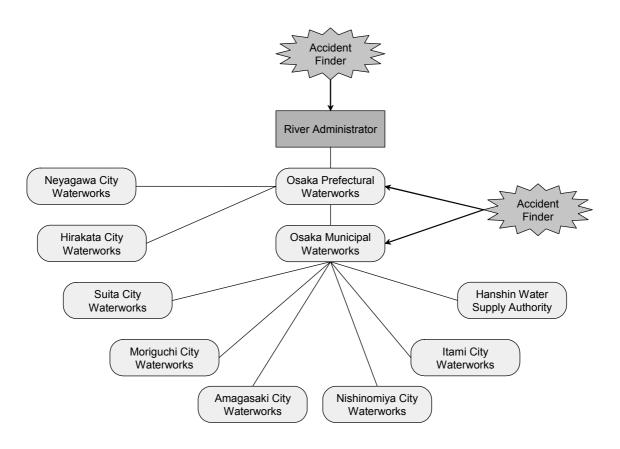


Fig. 3 Information networks for emergency control

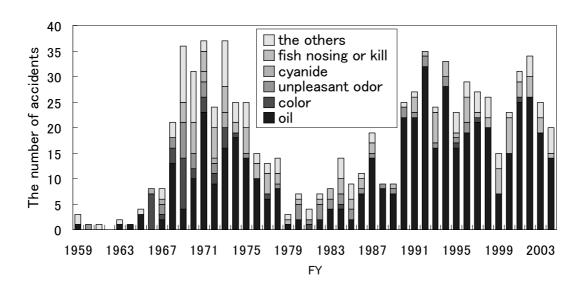


Fig. 4 The number of water source accidents in Lake Biwa – Yodo River water system

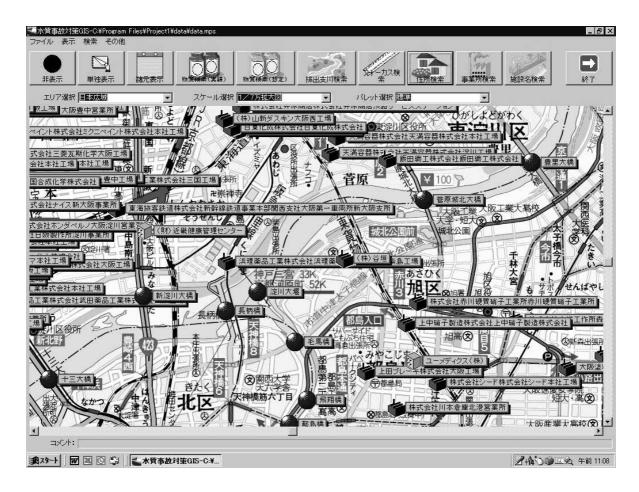


Fig. 5 Part of environmental map in Yodo River basin

4. Summary

Delay in the response to accidents in the source may cause serious damages in the social life, since the systems of waterworks being consisted of series of facilities from source to consumers' tap and the systems are not free from vulnerability. In order to ensure water safety, it is important to detect source accidents as quickly as possible and then respond to them properly. The Yodo River Water Quality Committee, a group of downstream water utilities of Yodo River being exposed to the high risk of accidents, jointly monitors water source and engages in resource conservation activities. These efforts have been successfully assuring safety of drinking water so far.

There are other efforts in regard to watershed management. Review Panel on Water Cycle Dysfunction Risk in Emergency, a panel established by government ministries, is discussing cross-sectoral measures to avoid or reduce water quality risk in case of earthquake, whose target area includes Yodo River basin. In addition, Kansai Waterworks Association consisted of eight major utilities in the Kansai area has jointly been studying on "Kansai version of Water Safety Plan". The developing process will include scientific evaluation on risk factors about their characteristics and risk levels. The goal is to contribute to planning of source quality management and drinking water treatment.

Watershed Management in **Drinking Water for Emergency:**

A Case of Lake Biwa - Yodo River System

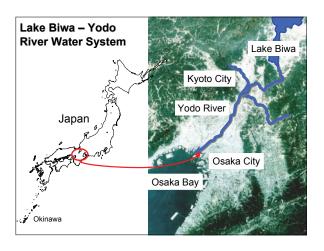
Yodo River Water Quality Committee Takashi SASAKI, Daiji NAGASHIO

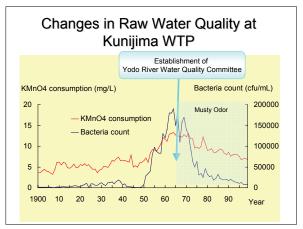


Establishment of Yodo River Water Quality Committee

- · Why organized?
 - Urbanization and industrial development in upstream area
 - Deterioration of water quality in Yodo River
- · When established?
 - 1965
- · What purpose?
 - Cooperative approach for integrated source water quality management







Members

Total Capacity (plan)
7.2 million m³/d
Served population

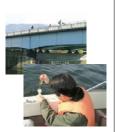
11 million

- Osaka Prefectural -
- Osaka Municipal -
- Moriguchi City -
- Neyagawa City -
- Hirakata City -
- Suita City
- Amagasaki City -
- Itami City -
- Nishinomiya City Waterworks
- Hanshin Water Supply Authority



Regular Monitoring of Source Quality

- Monthly monitoring conducted with cooperative system
- · 20 Monitoring points
- · Over 160 of monitoring Items
- Results summarized as annual reports



Advocating Activities for Pollution Control Request National government Ministry of - Health, Labour and Welfare - Agriculture, Forestry and Fisheries - Economy, Trade and Industry - Land, Infrastructure and Transport - the Environment Cosaka prefecture Kyoto prefecture and city Other 6 administrative bodies

Water Source Monitoring for Emergency

- · Information-sharing
 - Monitoring of source quality
 - Source accident
 - Research and investigation
 - Risk factors
- · Control of pollutant source
 - Advocating activities
 - Awareness raising

The Number of Water Source Accidents in Lake Biwa - Yodo River Water System 40 1959 1963 1967 1971 1975 1979 1983 1987 1991 1995 1999 2003

Research and Investigation

 Several working groups for special task urgently needed

Assignment

- ➤ Musty odor at Lake Biwa
- ➤ Precursors of trihalomethanes and agricultural chemicals in the water source
- > Development of useful tools for quick response to water source accidents

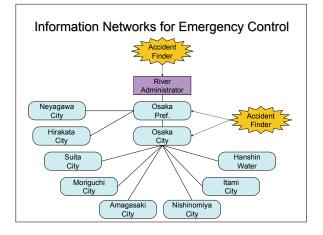
Awareness Raising for Water Resource Conservation

 Posters and brochures



 Annual lecture meeting





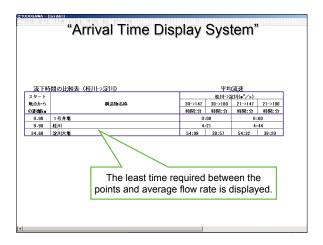
Case with Oil Spill Accident

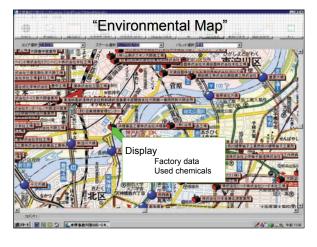
- Diesel oil spill from a gas station to a tributary stream
- · 6 WTPs suffered damage
 - Oil removal, PAC, increase of ozone dose, reduction of water intake
 - One WTP stopped taking water for 4 hours.
- · No contamination of finished water
- · Identification of causative facility
- · Claim for compensation

"Arrival Time Display System" and "Environmental Map" in Yodo River

 To respond to source accidents quickly and properly

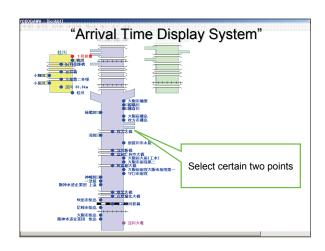






Summary

- It is important to detect resource accidents as quickly as possible and respond to them properly.
- Yodo River Water Quality Committee jointly monitors water source and engages in resource conservation activities.
- · To assure safety of drinking water



"Environmental Map" Information system combining factory database and GIS Number of factory data 6,500 25 cities, wards and counties in the Area on the system Yodo River water system Type of industry 31 types 15 items (address, chemicals used, Data item volume of discharge etc.) Software Exclusive Mapping Soft (ProAtlas) Reference to the factories' information, output of the file Additional function Address, chemicals used and point Search function of discharge

Effects of Cooperative Activities

- Reduction in cost concerning water conservation
- Prompt countermeasure for unexpected pollution
- Powerful advocating activities to national and local government

Other Efforts of Watershed Management in Drinking Water

- Review Panel on Water Cycle Dysfunction Risk in Emergency
 - Established by government ministries
 - To avoid or reduce water quality risk in case of earthquake
- · Kansai version of Water Safety Plan
 - Kansai Waterworks Association (8 major utilities)
 - To contribute to planning of source quality management and drinking water treatment

Climate Change and Water Resources: A Primer for Municipal Water Providers

David Yates & Kathleen Miller National Center for Atmospheric Research

1. Introduction

A recent collaboration between the AWWA Research Foundation (AwwaRF) and the National Center for Atmospheric Research (NCAR) has led to a new publication "Climate Change and Water Resources: A Primer for Municipal Water Providers" (Miller and Yates 2006). This document tries to dispel some of the misunderstandings about climate change – showing that it is neither an impending catastrophe nor a myth that can be safely ignored. Generally, the Primer 1) summarizes the scientific evidence regarding both natural climate changes and those caused by human activity; 2) describes the hydrologic impacts of climate change and potential consequences for water utilities 3) discusses the nature and sources of uncertainties in these projections and 4) provides guidance on planning and adaptation strategies. In particular, the Primer explains how a warmer climate will intensify the global hydrologic cycle, leading to increases in global average annual precipitation, heavier rainfall events, and possibly longer dry spells. Warmer temperatures will cause snowpacks to melt earlier – shifting seasonal streamflow timing, while changes in storm tracks may leave some regions much drier than now, and others wetter. In addition, water quality will be affected by changes in runoff processes and watershed characteristics, including wildfire impacts.

2. Overview

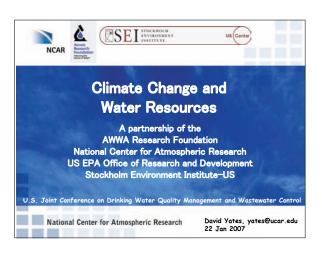
There is a great deal of misunderstanding surrounding the subject of climate change, often leading to profound confusion regarding its potential impacts on natural resource systems and human wellbeing. Well-intentioned, but misguided attempts by the popular press and movie industry to call attention to the prospect of climate change have left much of the public with the impression that the Earth's climate system is either poised at the brink of cataclysmic change or that global climate change is a myth that they can safely ignore. Neither of those extreme views provides useful guidance to anyone attempting to make informed decisions about the management of climate-sensitive resources.

Here, we will attempt to dispel some of the confusion by summarizing the best available scientific evidence on climate change – including both natural changes and changes that may be caused by human activities. In particular, this primer will focus on what is known about the implications of climate change for the water cycle and the availability and quality of water resources. The goals of this primer are to 1) introduce water utility managers to the science of climate change; 2) suggest the types of impacts it can have on water resources, and 3) provide guidance on planning and adaptation strategies. This guidance primarily reflects the activities of forward-looking utilities that have begun to plan and prepare for these changes, with some additional insights gained from the research community.

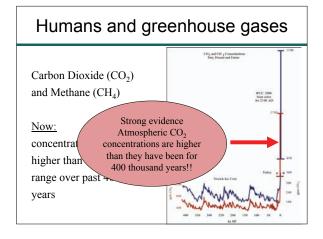
Water industry professionals are keenly aware of the fact that climate variability affects the availability and quality of water resources and that runoff or temperature extremes can affect their operations. Unanticipated extremes, such as an unprecedented drought, are likely to pose particularly severe problems. Prudent management focuses on anticipating and

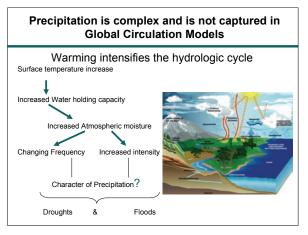
mitigating the potential adverse impacts of such natural variability. To plan efficiently, it is important to understand how and why climate may change in the future and how that may affect the resources upon which the water utility industry depends.

Will climate change have significant impacts in the near future on water availability, water quality and the ability of water utilities to meet the needs of their customers at desired levels of reliability and affordability? If so, what types of impacts could occur? What should utilities be doing to assess and prepare for the resulting risks and opportunities? Is this an issue that requires attention now, or will climate change occur so far in the future that water utilities can safely ignore it and concentrate on more pressing concerns? These are the types of questions addressed in the Primer and will be discussed during the presentation.



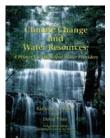






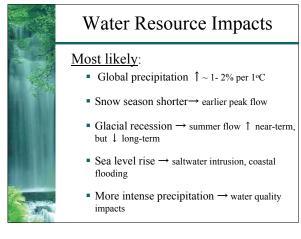
$Collaborative\ Project-Urban\ Water\ Utilities:$

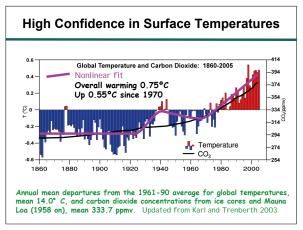
impacts and response options



GOALS:

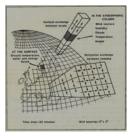
- Dispel confusion about climate change
- Assess vulnerabilities to climatic trends; future projections
 - Glacier & snowpack reductions;
 - Sea-level rise; runoff changes
 - Temperatures are highly likely to increases in most places
 - Precipitation changes are uncertain
- Learn from extreme events:
 - Wildfires; droughts; floods
- Advance adaptation strategies
- http://www.isse.ucar.edu/h2o_primer.jsp







Coupled Models of the Ocean, Atmosphere, Cryosphere, and Land



- Global Climate Models
- Good at estimating just that, the Global Climate
- Not as good at estimating regional climate change
- We need orders of magnitude greater computing power!!!

Natural forcings do not account for observed 20th century warming after 1970 Global Average Temperature Observations (Natural) volc+solar (Anthropogenic + Natural) volc+solar+ghg+so4 0.6 0.7 0.8 0.9 Observations (Natural) volc+solar+ghg+so4 0.6 0.7 1900 1920 1940 1960 1980 2000 Meehl et al. 2004: J. Climate.

AwwaRF's Climate Change Research Program

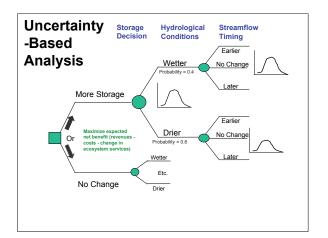
- Partnership with the National Center for Atmospheric Research
- Recognition in the CC community for the need to develop adaptation strategies
 - Long residence time of CO₂ commits us to some change
 - Water Resource Sector needs innovate to deal with climate change (and variability)

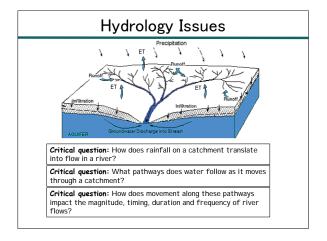
Methods of Assessment Top down: Emissions Climate Water Assessment of impacts & adaptation options Utility impacts Change in Resource Vulnerabilities Bottom up:

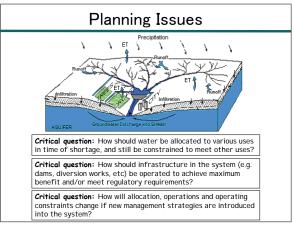
Scenario vs. Decision Analysis

- Scenario analysis answers questions like:
 - What is the best adaptation plan for a given climate change scenario?
- Decision analysis answers this type of question:
 - What is the best adaptation plan given a range of possible future climate change scenarios?

Scenario-Based Analysis Climate Change Study of the American River Watershed Earlier Streamflows Hydropower generation revenues increase No Change Hydropower generation revenues decrease This only tells us what to do if we are certain about the future. The reality is that we are uncertain.







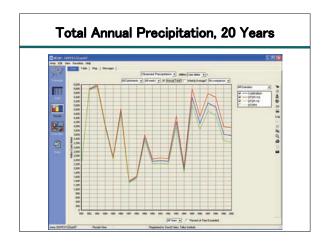
WEAP Example

- American River Basin, Northern California
- Simplified Climate Change Scenarios impose a warming and precipitation trend over 20-year period
 - +ΔT 2°C
 - ± 10% change in precipitation over 20 year period

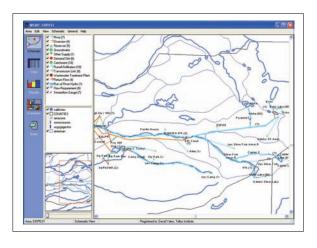


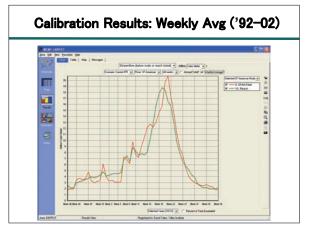


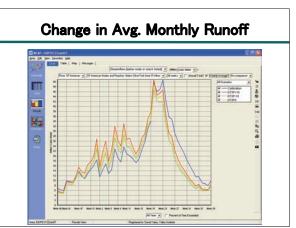
South Fork American Today To

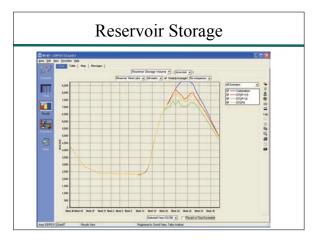












WEAP Requirements/Features

- Windows 95 or later (Borland Delphi, not ported to Linux)
- Imports from/exports to Excel and Word (not required).
- Uses standard ArcView GIS "shape" files. ArcView is not required.
- Available for download at http://www.weap21.org
- User Interface can accommodate other languages (currently)
 - Korean, Chinese, Portuguese, Spanish, English

ESTABLISHMENT OF GUIDELINES FOR THE REUSE OF TREATED WASTEWATER

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Wastewater and Sludge Management Division, Water Quality Control Department, National Institute for Land and Infrastructure Management (NILIM), Ministry of Land, Infrastructure and Transport (MLIT)

Abstract: The Committee on Reclaimed Wastewater Quality Criteria (Chairman: Dr. Mitsumi Kaneko, Visiting Professor of Ritsumeikan University) established new criteria and considerations for the reuse of treated wastewater such as for toilet flushing, sprinkling, landscape use and recreational use. Hygienic safety, appearance, user acceptance, and risk of facility malfunction were discussed. The new criteria and considerations were published as the Guidelines for the Reuse of Treated Wastewater from the Ministry of Land, Infrastructure and Transport of Japan. In the guidelines, new criteria were established for *Escherichia coli* (ND/100 mL) instead of for coliform groups as in the former guidelines with the exception of reuse as water for landscape use. Facility standards were also established, including required treatment methods and turbidity as the index used for ensuring effective treatment. Measures against loss of residual chlorine, cross connection, and accidental intake were also established as considerations for treated wastewater reuse.

Keywords: reclaimed wastewater quality standard, treated wastewater reuse.

Introduction

Japan's average annual rainfall is approximately 1,700 mm, which is twice the world average, but because of its small land area and large population, the annual per capita water resource is about 3,300 m³, less than half the world average of 7,800 m³. Only 905 m³ (almost the same as in Egypt) is available in the Kanto district where Tokyo is located. Furthermore, the amount of precipitation has fluctuated greatly in recent years. For these reasons, more importance is now placed on managing water resources in Japan (MLIT, 2005a).

In response to the severe water shortage of 1978, Japan began reusing treated wastewater as an important water resource in urban areas, starting with reuse for toilet flushing in Fukuoka City in 1980. Since then, treated wastewater has also been used for snow melting, environmental and industrial use, sprinkling and so on. However, only 200 million m³ per year of treated wastewater from 246 wastewater treatment plants (WTPs) is reused outside the plants, which is less than 2% of the 1.4 billion m³ of effluent from 1,924 plants in FY 2003 (JSWA, 2005). It is expected that such applications will increase in the future from the viewpoint of saving water resources in

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urban areas, which will in turn increase the importance of appropriately reusing treated wastewater.

On the other hand, since several incidents of human health damage by pathogenic microbes have recently occurred in Japan, people have become more interested in the hygienic safety of water. Therefore, measures against these new problems must be taken if we are to promote the reuse of treated wastewater. In addition, it is necessary to maintain an appropriate color, clearness, and less odor to ensure that the public feels comfortable using the reclaimed wastewater, as well as protecting against facility malfunctions such as corrosion and blocking of pipes.

For the above reasons, the Sewerage and Wastewater Management Department, Ministry of Land, Infrastructure and Transport and the Water Quality Control Department, National Institute for Land and Infrastructure Management formed the Committee on Reclaimed Wastewater Quality Criteria (Chairman: Dr. Mitsumi Kaneko, Visiting Professor of Ritsumeikan University) with the objective of establishing new guidelines for the reuse of treated wastewater. The Ministry of Land, Infrastructure and Transport instituted the new criteria and considerations proposed by the committee as the Guidelines for the Reuse of Treated Wastewater (MLIT, 2005b) and announced it in April 2005. This report presents an outline of the guidelines.

Scope of application

Due to the numerous types of use applications for treated wastewater, we limited our study to those based on the actual conditions of treated wastewater reuse in Japan. Therefore, the guidelines take into consideration the reuse of wastewater for toilet flushing, sprinkling, landscape use (untouchable) and recreational use (touchable). These use applications pertain to a large number of unspecified persons and the reclaimed wastewater was distributed directly from WTPs. Sprinkling refers to watering for trees, plants and lawns or for road flushing. Landscape and recreational use refers to environmental water.

For the time being, we decided that reuse as large-scale waterfalls or fountains would be considered recreational use, because of the potential generation of mist.

Status of complaints and problems concerning treated wastewater reuse in Japan

The new guidelines were established from three points of view: hygienic safety, appearance and acceptance, and risk of facility malfunction. Details concerning appearance and acceptance, and facility malfunction are based on a study concerning

complaints and problems on actual treated wastewater reuse in Japan. The study is outlined below.

Methods

Questionnaires were sent out to WTPs that distributed reclaimed wastewater outside their plants in FY 2002 as water for toilet flushing, sprinkling, landscape use, and recreational use. The results of this research provided us with the details about complaints and problems regarding treated wastewater reuse in the past.

Results

We obtained the following information as a result of the study.

Appearance and acceptance

- Appearance of reclaimed wastewater
 - Reclaimed wastewater is generally inferior to drinking water in color, clearness and odor, so these problems must be considered. There were complaints about the appearance of toilet flushing water but few complaints about other uses, most likely because people had more opportunity to observe the toilet flushing water.
- Growth of periphytic algae where treated wastewater is applied to landscape use and recreational use
 - Reclaimed wastewater generally contains more nutrients, such as nitrogen and phosphorus, than drinking water. Nutrients accelerate the propagation of periphytic algae, which leads to complaints from facility users.
- Chironomid in toilet flushing water
 - There were a number of complaints concerning the growth and propagation of Chironomid in the reservoir tank for toilet flushing water after being distributed from the WTP. On the other hand, there were few complaints about this problem in water for landscape use and recreational use because Chironomid scatters easily and is not as prominent in these applications.

Facility malfunction

Problems concerning corrosion and leaking of pipes and other equipment were reported. The corrosion may be caused by direct contact between the reclaimed wastewater and exposed iron or between different kinds of metals. Attention must be paid to corrosion in the case of highly corrosive reclaimed wastewater with significant amounts of chlorine ion, sulfate ion, or residual chlorine.

Problems with water supply due to the blockage of drains or pipe bends were also reported. Blockage of pipes may occur when the dissolved iron from corrosion is oxidized by residual chlorine or dissolved oxygen and accumulates at the bend or at narrow areas of the pipes. Measures have already been taken against these problems and they have now been solved (Fukuoka City, 1999; 2000).

Guidelines for the reuse of treated wastewater

The guidelines are divided into criteria for wastewater reuse and considerations for wastewater reuse. They were established from three points of view: hygienic safety, appearance and acceptance, and risk of facility malfunction. The outline of the guidelines is as follows.

Three points of view in establishing the guidelines

Hygienic safety

In establishing the guidelines, consideration was given to measures against bacteria for which chlorine was comparatively effective, and measures against protozoa that had comparative chlorine tolerance. Measures against viruses could not be considered due to numerous problems concerning the virus detection methods.

Appearance and acceptance

The three points listed below were taken into consideration for establishing the guidelines. The second and third points were included only in the considerations for wastewater reuse, not in the criteria part, because different types of facilities cause different conditions for the second point, and the effects of measures have not yet been clarified for the third point.

- Appearance of reclaimed wastewater (color, clearness, odor)
- Growth of periphytic algae in facility water for landscape and recreational use
- Chironomid (imago/larva) in toilet flushing water

Facility malfunction

Measures against corrosion and blockage of pipes and other equipment were taken into consideration for establishing the guidelines.

New criteria for treated wastewater reuse

The new criteria established for the reuse of treated wastewater are shown in Table 1. The grounds for the new criteria are indicated as follows.

E. coli and coliform groups

The following criteria were selected from the viewpoint of measures against bacteria.

E. coli N.D./100 mL was set as a new criterion instead of the number of coliform groups. The number of coliform groups, which includes bacteria that propagates in soil, is not necessarily suitable as the index for indicating contamination by excrement. Furthermore, *E. coli* N.D./100 mL was set as the quality criteria for drinking water in Japan in 2003 based on establishing a quick and easy culture method.

The number of coliform groups set as effluent quality criteria was established as a provisional criterion for landscape use, where handling is not permitted, and the former criteria for treated wastewater reuse (coliform groups 1,000 CFU / 100 mL) was adopted on a provisional basis.

Facility standards (Required treatment methods and turbidity as control parameter)

The facility standards were established from the viewpoint of measures against facility malfunction and measures against protozoa for hygienic safety.

Designated treatment methods and turbidity conditions were set from the viewpoint of protecting against blockage for toilet flushing, sprinkling and landscape use, for which there is little possibility of accidental intake. Sand filtration or an equivalent treatment method was set as a required facility standard. Turbidity was also set as the control parameter to ensure effective treatment of the sand filtration. Turbidity of less than 2 mg-kaolin equivalent/L was set as the target value based on research results demonstrating that the turbidity of treated wastewater from a properly operated filtration system barely exceeded 2 mg-kaolin equivalent/L.

Chemical precipitation followed by sand filtration or an equivalent treatment method was set as a required facility standard to efficiently remove protozoa from recreational-use water for which there is a risk of accidental intake. Turbidity of less than 2 mg-kaolin equivalent/L was set as the value to be observed at all times.

Additional treatment, restricted use or halting the distribution of treated wastewater may be required in certain cases if hygienic safety is at risk due to a group infection outbreak caused by protozoa within the basin of the WTP.

pН

The pH level of 5.8–8.6 was set as an effluent quality criterion. It was established from the viewpoint of preventing corrosion in pipes and other equipment. In addition, it was recommended that corrosion-resistant structure and materials for pipes and other equipment be adopted.

Appearance, Color, and Odor

Appearance, color and odor were established from the viewpoint of appeal and acceptance. These criteria are the same as the former criteria. The target value of the color in the former criteria was set based on the results of user questionnaires in which almost all users accepted a color of 40 units under the premise of not handling the water, and a color of 10 units under the premise of handling (JSWA, 1981; MOC *et al.*, 1990). However, it is preferable that the values be set based on the wishes of regional users.

Residual chlorine

In terms of controlling bacterial growth in the distribution process, chlorine disinfection with long-term effects was regarded as the basic disinfection method and the concentration of residual chlorine was set as the target value. The concentration of residual chlorine set as the drinking water quality criteria in Japan (free: more than 0.1 mg/L or combined: more than 0.4 mg/L) was applied to the criteria for treated wastewater reuse. This was also based on research results indicating that bacteria hardly developed in the distribution process under conditions of values greater than 0.1 mg/L for free residual chlorine or 0.4 mg/L for combined residual chlorine.

Table 1 New criteria for the reuse of treated wastewater in Japan

	Location relevant to standards	Toilet flushing water	Sprinkling water	Water for landscape use	Water for recreational use
E. coli	Outlet of	N.D./100 mL	N.D./100 mL	≤1000 CFU	N.D./100 mL
	reclaimed			/100 mL as	
	treatment			coliform	
	facilities			groups ¹⁾	
Appearance		Not unpleasant			
Turbidity		$\leq 2^{(2)3)}$			$\leq 2^{3)}$
Color				≤ 40 units	≤ 10 units
Odor		Not unpleasant			
рН		5.8 – 8.6			
Residual	Admin.	≥ free: 0.1 mg/L	≥ free: 0.1 mg/L		≥ free: 0.1 mg/L
chlorine	boundary	or	or		or
		combined:	combined:		combined:
		0.4 mg/L ²⁾	$0.4 \text{ mg/L}^{2)4)}$		0.4 mg/L ²⁾⁴⁾

		Chemical
Treatment	Sand filtration or equivalent	precipitation +
		sand filtration
		or equivalent

- 1) Provisional value
- 2) Control target value
- 3) Unit: mg-kaolin equivalent/L
- 4) Not applicable for cases in which long-term effects of disinfection is unnecessary

For sprinkling and recreational use of treated wastewater, a value was not applied for cases in which long-term effects of disinfection are not required, for example, when the retention time from the WTP to the place of use is short.

A value was not set for landscape use because handling is not permitted in its use and treatment other than chlorine disinfection may be adopted from the viewpoint of ecosystem preservation.

Considerations for treated wastewater reuse

The main considerations for treated wastewater reuse are given below.

Measures against loss of residual chlorine

- Decrease, as much as possible, in ammonia nitrogen that easily consumes residual chlorine using secondary treatment and reclamation treatment.
- Construction of distribution networks so as to shorten the retention time. For example, the selection of pipes with suitable diameter and the avoidance of a dead end by looping of pipes. Also, pipes should be of a material not easily oxidized by residual chlorine.
- Consideration given to additional chlorine disinfection in places where residual chlorine is significantly decreased.
- Confirmation of suitable volume for the reservoir tank in facilities where reclaimed wastewater is used, and cleaning of the tank to control the consumption of residual chlorine.

Measures against cross connection

- Indication of treated wastewater by placing signs on pipes and other equipment or color-coding them in order to clearly distinguish the ones using reclaimed wastewater. An example of color-coding is given as Photo 1.
- Inspection for cross connections before starting the distribution of reclaimed wastewater. The sewerage administration departments must confirm that there is no cross connection. One example of inspection is opening and shutting the main

valves for the reclaimed wastewater and the drinking water after coloring the reclaimed wastewater.

Measures against accidental intake

- Posting of notices to users that reclaimed wastewater is used. Especially in the
 case of landscape use, accidental intake must be prevented by displaying explicit
 warnings against drinking.
- Regarding sprinkling, accidental intake of the mist can be prevented, for example, by sprinkling at a time when there are few people in the area.



Photo 1 Example of distinction by color-coding the pipes (Yellow is reclaimed wastewater, blue is drinking water)

Conclusion – Amendment of the Sewerage Law

The new criteria and considerations were published as the Guidelines for the Reuse of Treated Wastewater from the Ministry of Land, Infrastructure and Transport of Japan. The guidelines were used as a reference for the amendment of the Sewerage Law.

The objective of the Sewerage Law (enacted in 1958) is to develop sewerage systems, and thereby contribute to sound urban development and enhancement of public sanitation, and contribute to water quality control of public water bodies.

The last amendment of the Sewerage Law in October 2005 (enforced in April 2006) newly added the criteria for hygienic safety of recreational water in order to preserve the

living environment and protect human health. Specifically, under the structural standards for sewerage system facilities stipulated by the Sewerage Law, in principle, shielding and fences are installed and other measures taken to prevent entry to the facilities, but it is also stipulated that their installation is unnecessary under specified conditions. One such condition is that the recreational water that is used satisfies quality standards for final effluent, contains *E. coli* N.D./100 mL, and has turbidity of less than 2 mg-kaolin equivalent/L.

New structural standards not only encourage the suitable reuse of treated wastewater, but will also encourage the recovery of good quality waterside spaces in urban areas.

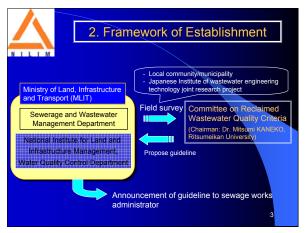
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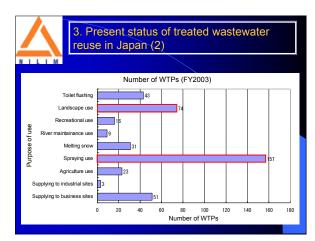
The new criteria and considerations for treated wastewater reuse described in this paper were proposed by the Committee on Reclaimed Wastewater Quality Criteria. We express our deep appreciation to the members of the committee who put extensive effort into developing and proposing the guidelines.

References

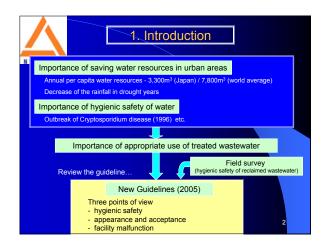
- Fukuoka City (1999). Syuugou-juutaku-niokeru Saiseisui-riyou-nitsuite (Teigen) (in Japanese) (Suggestions on Treated Wastewater Reuse in Apartment Houses), Consultation on Treated Wastewater Reuse in Apartment Houses, Fukuoka City, Fukuoka, Japan.
- Fukuoka City (2000). Syuugou-juutaku-niokeru Saiseisui-riyou-setsubi-kijun-ni-tsuite (Teigen) (in Japanese) (Suggestions on Equipment Criteria for Treated Wastewater Reuse in Apartment Houses), Study Conference on Equipment Criteria for Treated Wastewater Reuse, Fukuoka City, Fukuoka, Japan.
- JSWA (Japan Sewage Works Association) (1981). Gesuisyorisui Junkan-riyou Gijutsushishin-(an) (in Japanese) (Technical Guidelines on the Reuse of Treated Wastewater Proposal). JSWA, Tokyo, Japan.
- JSWA (Japan Sewage Works Association) (2005). Heisei-15-nendo-ban Gesuidou Toukei (in Japanese) (Statistics on Sewage Works, fiscal 2003 edition), JSWA, Tokyo, Japan.
- MLIT (Water Resources Department, Land and Water Bureau, Ministry of Land, Infrastructure and Transport, Japan) (2005a). *Heisei-16-nendo-ban Nippon-no Mizushigen (in Japanese) (Water Resources in Japan, fiscal 2004 edition)*, MLIT, Tokyo, Japan.
- MLIT (Ministry of Land, Infrastructure and Transport, Japan) (2005b). Gesui-syorisui-no Sairiyou Suishitsukijun-tou manyuaru (in Japanese) (Guidelines for the Reuse of Treated Wastewater), MLIT, Japan.
- MOC (Ministry of Construction, Japan) and TCAWT (Technical Conference on Advanced Wastewater Treatment) (1990). Gesuisyorisui-no Syuukei Shinsui Riyou Suishitsu-kentou-manyuaru-(an) (in Japanese) (Manual on Setting Up of Water Quality Target for Treated Wastewater Reuse such as for Landscape and Recreational Use Proposal), MOC and TCAWT, Japan

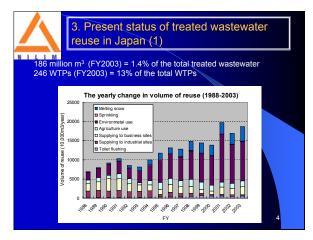


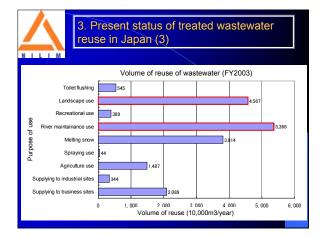




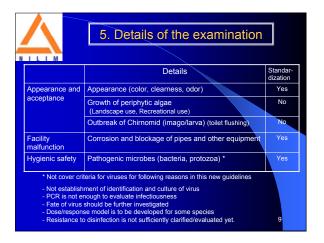




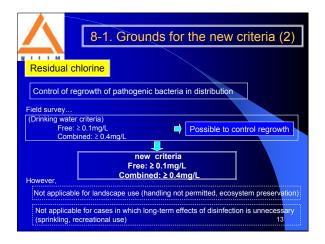




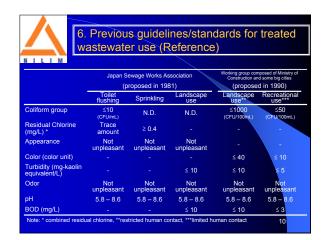


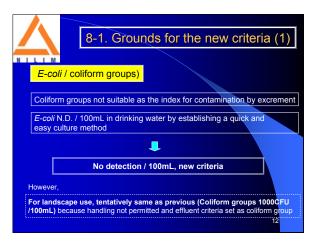










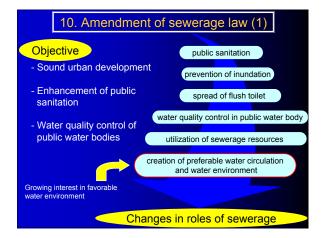




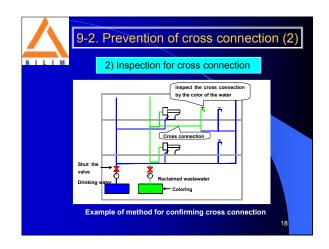




















Promotion of Treated Wastewater Reuse in Okinawa —In search of local community without water shortage—

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1. Introduction

Okinawa Prefecture (OP), isolated island, has been historically suffering from water shortage by severe condition due to geographical feature and topography. Water rationing was repeated like an annual event, and especially, at the time of water shortage in 1987, it was performed over about one year, and it had a great influence on Okinawan's life. For this reason, many dams have been built on the mountains in the northern part of Okinawa main island, but the construction site of dam is restricted due to small OP's area. Therefore, they regarded seawater as new water resources, and constructed Desalination Plant in 1997. The Plant has played an important role as precious water sources for OP that has been suffering from water shortage.

People pay attention to Okinawa sightseeing. Because, TV programs dealing with Okinawa have been frequently broadcast recently. "Kyushu and Okinawa Summit" held in 2000 was successful. Therefore, tourist business has been in good condition for the reason that the number of tourist breaks through 5 millions. Moreover, while population decrease is indicated nationally, the population of OP is increasing in number. Therefore, it is expected that water demand will continue.

Although one hundred percent of sludge (145t/day) generated within prefecture plants was recycled for green farmland-return, treated water (270,000m3/day) was almost discharged to the sea. They have been expecting that the water is used effectively in OP that has been suffering from water shortage. Therefore, OP reuses treated wastewater which occurs constantly in urban environment as precious water resources. I introduce Sewerage Business of Recycled Water Use (SBRWU) implemented by OP to you.

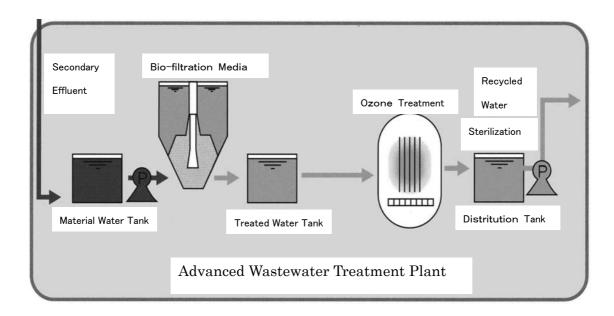
2. Sewerage Business of Recycled Water Use

SBRWU treats secondary disposal water discharged from Naha Sewage Treatment Plant (STP) highly, and supplies the water to Naha New Urban District (NNUD) mainly for flushing toilets and sprinkling in the parks.

Redevelopment enterprise was planned to utilize vast area of 4.4% of Naha-City and good location of NNUD which used to be U.S. Forces housing area. At present, a large-sized commercial store, a public facility, and a large-sized apartment are under construction at NNUD.

2.1 Advanced Wastewater Treatment Plant

Advanced Wastewater Treatment Plant (AWTP) was built in Naha STP in 2002. The flow of advanced processing is as follows:



2.2 Technical problems

A few technical problems have been caused over 4 years after supply. One of them is to secure residual chlorine 0.4 mg/litter or more. At the beginning of the supply, it was difficult to keep the density, because the water remained for a long time in the pipe for small-volume use. However, it was solved by releasing the water at the end of the pipe and by changing the current of water and by adjustment of the infusion quantity of sodium hypochlolite at AWTP.

2.3 Supply achievement

The Number of Supply Places and Water Use per Day is the following figure:

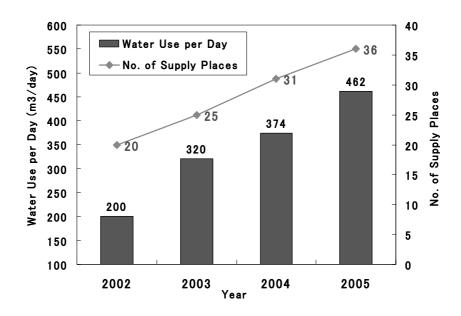


Fig. The Number of Supply Places and Water Use per Day

According to the figure, after supply, between 2002 and 2005 fiscal year, supply places increased from 20 to 36. Amount of water consumption per day also increased steadily from 200 to 462 cubic meters. Naha Water Resources Effective Use Promotion Outline created by Naha City, which encourages citizens to use recycled water. OP is also going to examine whether the demand can be increased further.

3. Conclusion

If water shortage happens in OP, a local newspaper begins to indicate the number of water rate of dams. Moreover, the number is also indicated on Okinawa Prefectural Enterprise Bureau Homepage, to which Okinawans pay attention. Fortunately, water rationing has never happened by hard work of the persons in charge of water works and sewage works since March, 1994. But, reservation of water resources is an important subject for our island prefecture. As stated in the introduction, it is expected that the water demand of OP will has been increasing.

STP plays a part of constantly-available dam in urban environment. It is the best to treat secondary effluent and to utilize it. We think that SBRWU is very important when water condition is considered in OP that has been suffering from water shortage, and that it is indispensable to promote and spread "Recycled Water Use without water shortage" from now on.

References

Okinawa Prefecture Sewerage Management Office, Department of Civil Engineering and Construction, Maintenance Management Annual Report, 2004

Yoshimitu KUWAE, Sewerage Business of Recycled Water Use in Okinawa, Journal of Japan Sewage Works Association, 2006/No.525, Vol.43

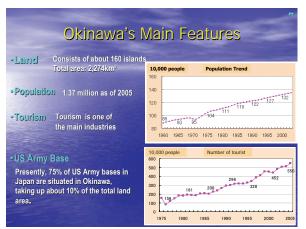
Okinawa Prefecture Enterprise Bureau, Water in Okinawa, 2005

Department of Planning, Statistics Data Reading Room in Okinawa Prefecture, Statistics Division Home Page

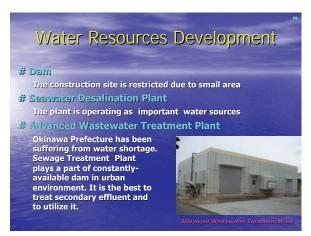
Urban Renaissance Agency of Japan, Naha New Urban District

Home Page of Meteorological Agency of Japan, Meteorological Information

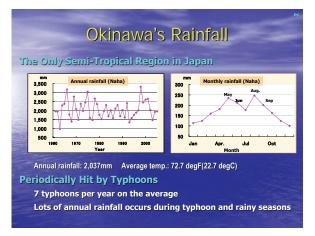


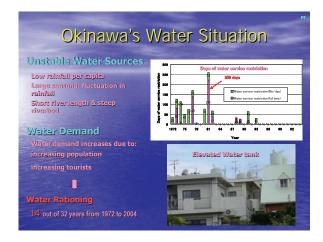




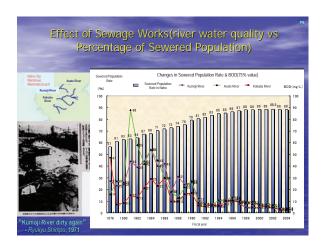






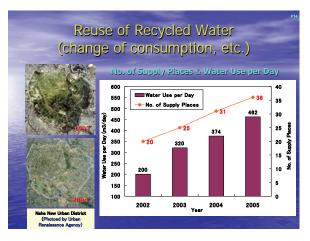


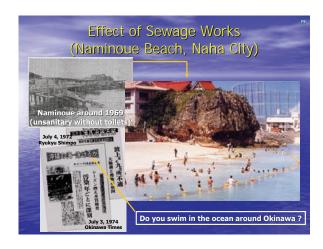






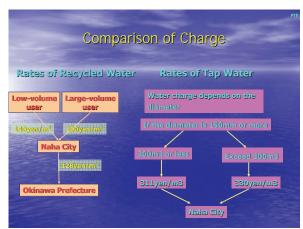


















An Overview of Water Recycling in the United States

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Water Environment Research Foundation
Board of Directors (Vice Chair)

1. Introduction

Water recycling is a growing practice in many regions of the world. Countries and regions in which water reuse is on the rise include the United States (U.S.), Western Europe, Australia, and Israel. In the U.S., the practice of recycling water is a large and growing industry. An estimated 3.4 billion gallons per day (bgd) (13 million m³/d) is reused in the U.S. However, this is but a small fraction of the total volume of wastewater generated. According to the U.S. Environmental Protection Agency's (EPA) 2000 Watershed Needs Survey, a total of 34.9 bgd (132 million m³/d) of municipal wastewater effluent is produced. Thus, the proportion currently reused amounts to only 9.7%, suggesting that future potential for recycling treated wastewater is enormous.

2. Discussion

There are a number of factors that drive water reuse in the U.S., including that recycled water is a drought-resistant and reliable local supply, the increasing demand for water as the population grows, preservation of limited potable water supplies for drinking, that recycled water is a method for wastewater disposal, the economic feasibility of recycled water projects with well-established technology, and that recycled water is an integrated part of public policy particularly in states with limited water supplies.

Recycled water use on a volume basis is growing at an estimated 15% per year in the U.S. All evidence suggests that water recycling will play an expanded role in water management in the 21st century, not only in the semi-arid western states and "sunbelt" states, but perhaps in all 50 states. At a compound annual growth rate of 15%, the volume of recycled water would amount to 12 bgd (45 million m³/d) by the year 2015.

The early applications of water reuse were for irrigation of landscaping; this is no longer the case, however. Other applications include industrial reuse, irrigation of edible and non-edible agricultural crops, commercial uses such as toilet flushing in high-rise office buildings, groundwater recharge, and indirect potable reuse. Industrial reuse applications include use in cooling towers and for boiler feedwater. In Sonoma and Monterey Counties in California, lettuce, artichokes, strawberries, and grapes are irrigated with recycled water. There are several well known examples of indirect potable reuse around the world, including a facility in Orange County, California.

Water recycling represents a viable, long-term solution to the challenges presented by growing demands for water. Recycled water has numerous benefits, including a local, dependable water supply that is drought-resistant and under local control, reduction of treated wastewater discharge to sensitive or impaired surface waters, reduction of imported water and avoided costs associated with importing water, environmental benefits, and that it represents a sustainable water resource.

Recycled water regulations vary across the U.S. from state to state. There are no national standards. In general, the highest treatment is required for the highest use to ensure adequate level of protection of public heath. California has the most stringent

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regulations (Title 22 as set by the Department of Health Services) in the U.S. In Title 22, Chapter 4, of the California Code of Regulations, bacteriological water quality standards are established based on the expected degree of public contact with recycled water.

The technologies used most frequently in California for treatment prior to groundwater recharge are microfiltration (MF), reverse osmosis (RO), and ultraviolet disinfection (UV). Many California experts believe that in the future, virtually all wastewater treatment plants, especially those that discharge into the Bay-Delta surface waters, will feature filtration of some type. Groundwater recharge requires that a municipal utility purify water to a higher quality than most natural water resources. Clear, treated wastewater is subjected to three purification processes in order to produce clean water that is allowed to filter through the ground by natural filtration processes (e.g., the path that rainwater takes) into deep aquifers in an underground basin, where it will be extracted by wells for drinking water after mixing with exiting groundwater supplies for at least a year. The first of these three purification processes is MF, which uses a low-pressure membrane that takes small suspended particles and other materials out of the water. MF efficiently prepares water for the RO process.

Technologies employed to treat recycled water in the U.S. depend almost entirely on the application, which is called "highest treatment for highest use." For example, if the primary application is irrigation or cooling tower water, sand or dual media filtration after secondary treatment is sufficient to achieve a state's water quality criteria. If, on the other hand, the intended application is indirect potable reuse, sophisticated technologies such as MF, RO, and UV disinfection must be employed to ensure chemical and microbiological safety of the recycled water. Although membranes are not required for all applications of water reuse, it is becoming the technology of choice as the pricing becomes more competitive.

The cost for a water agency to implement recycled water projects vary across the U.S. from minimal to over \$2,000 per acre-ft (\$1,5/m³). Variable factors include proximity to users, federal and state funding availability, subsidies offered, and retrofit users or new development. Projects are more cost effective where there is a large user located in close proximity to the source of recycled water, as compared to projects where an extensive distribution system is needed to reach a number of smaller users. Federal and state funding can help offset project costs. For example, some types of federal funding can offset up to 75% of project costs. Some water wholesalers offer subsidies to water retailers to encourage implementation of recycled water projects in order to offset demand for imported potable water supplies. The Metropolitan Water District of southern California offers the West Basin Municipal Water District \$250 per acre-ft (\$0.2/m³) for recycled water produced. Another variable involves whether a new development is mandated to use recycled water. In this case, the water agency can often negotiate with the developer to pay for a substantial portion of the recycled water project costs. With retrofit customers, a large industrial user may have more incentive and capital available to help jointly fund a recycled water project than smaller, irrigation users.

Some of the principal issues, barriers, and impediments to widespread water reuse include the need for further public education, lack of available funding, better documentation of the economics of water reuse, consistent regulations that enable protection of public health, and the need for additional research.

As for public perception and acceptance, while non-potable reuse applications (e.g., landscape irrigation) are generally acceptable, as reuse moves toward indirect potable

reuse, the reaction from the public – usually in the form of negative publicity in the media – becomes more negative. More focus and consideration should be given to the psychological factors that lead to the public's resistance to indirect potable reuse.

A survey of municipalities in California several years ago revealed that the major constraint to water recycling is lack of funds. Although many larger municipalities have constructed recycled water projects, smaller utilities have not, often due to lack of funding support from Federal and/or state governments.

There is the need for additional research on water recycling issues, including development of innovative and emerging technologies that could lower projects costs, testing and monitoring methods, and emerging issues relating to public and environmental heath such as the emergence of endocrine disrupting compounds and pharmaceutically active compounds.

3. Conclusion

Water recycling already represents an important water supply in many areas of the world. Reuse is growing in importance in the U.S., Australia, Europe and other regions. Its potential is largely untapped, however, due to a number of barriers. Water reuse should not be viewed as simply the reuse of wastewater effluents. Rather, water reuse should be viewed as one of several alternative sources of new water, all of which will be important tools in the toolkit of the water manager of the 21st century.

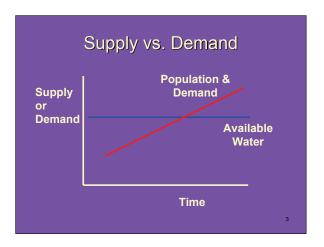
Both water professionals and the consuming public will need to view water differently in the 21st century. It is incumbent upon the consuming public that they develop more trust in the ability of water utilities to treat any poor quality (impaired) water to drinking water or higher standard. Similarly, water professionals must earn that trust. Water will finally be recognized for its inherent great value in the 21st century as demand grows and readily available and inexpensive supplies remain at virtually the same level. The water community should strive to convey the value of water through a variety of means, including education of the public and elected officials.

References

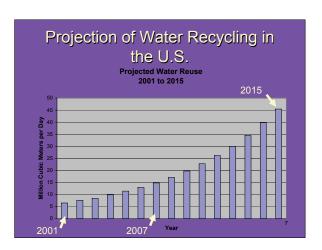
Miller, G. Wade, "Integrated Concepts in Water Reuse: Managing Global Water Needs," 2005

Talley, Pick, Presentation at the American Water Works Association Annual Conference in San Antonio, TX, June 14, 2006

Overview of Water Recycling in the United States Japan-U.S. Conference on Drinking Water Quality and Wastewater Control January 22, 2007

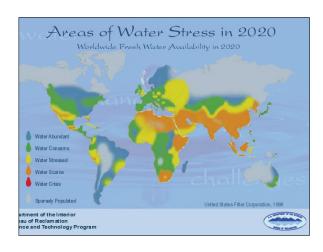


Factors Driving Water Recycling in the U.S. Drought-resistant/reliable supply Population growth/increasing demand for water Preserving limited potable water supplies for drinking Wastewater disposal Ecosystem and environmental protection Economically feasible Well-established technology Public policy and integrated water planning

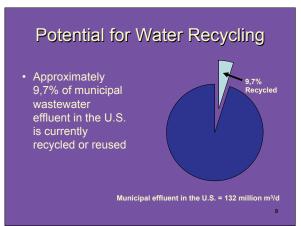


Outline

- Background global water supply
- · Water recycling in the U.S.
 - Driving factors
 - Projected increase
 - Applications
 - Benefits
 - Regulations
 - Treatment technologies
 - Costs
 - Areas of increased emphasis needed













Applications of Recycled Water

- Landscape irrigation
- · Agricultural irrigation
- · Industrial and commercial
- Non-potable urban uses (toilet flushing in high-rise commercial buildings)



- Groundwater recharge
- · Potable water supply augmentation

Benefits of Recycled Water

- Local, dependable water supply
- Drought-resistant
- · Reduces wastewater discharge to surface
- Reduces uses of imported water
- · Benefits the environment
- · Sustainable supply

Recycled Water Regulations

- Regulations vary across the U.S.
- · No national standards in the U.S.
- In general, highest treatment required for highest use
- · California has the most stringent regulations (Title 22), as set by the Department of Health Services

Treatment Technologies for Recycled Water

- · Conventional treatment

 - Media (sand) filtration
 Chlorination or ultraviolet (UV) disinfection
- Advanced treatment
 - Microfiltration and reverse osmosis (RO) membranes
 Membrane bioreactor

 - UV disinfection
- Membranes are becoming the technology of choice around the world as the best available technology for water purification

Good News: RO Technology Costs Fall \$/m³ 1.5 0.5 1950 1960 1970 1980 1990 2000 AWWARF Study, 2001



Areas of Increased Emphasis **Needed for Water Reuse**

- Further public education
- Funding assistance from federal and state governments
- · Better documentation of economics
- · Consistent regulations that enable protection of public
- · Additional research



Thank You

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Costs of Recycled Water Projects

- · Costs for a water agency to implement recycled water projects vary across the U.S. (minimal to over \$1,5/m³)
- Variable factors:
 - Proximity to users
 - Federal and state funding availability
 - Subsidies offered
 - Retrofit or new development

Conclusion

- · Water recycling is growing in the U.S.
- Water recycling is also increasing in Australia, Europe and other regions of the
- · Opportunities for water recycling are numerous in the future as population and demand increase

Title 22 Regulations

Treatment Level	Treatment Required	Total Coliform (MPN) Limit	Turbidity Limit
Disinfected Tertiary (Unrestricted Use)	Filtration & chlorine disinfection or other forms of disinfection to inactivate 99.999% virus	Median <= 2.2 per 100 mL (7 days), Max <= 23 per 100 mL (30 days), Max <=240 per 100 mL	Conventional filtration (2 NTU avg, <= 5 NTU 5% of time, <= 10 NTU max) Membrane (<= 0.2 NTU 5% of time, <= 0.5 NTU max)
Disinfected Secondary 2.2 (Restricted Use)	Secondary, oxidized, disinfected	Median <= 2.2 per 100 mL (7 days), Max <= 23 per 100 mL (30 days)	None
Disinfected Secondary 23 (Restricted Use)	Secondary, oxidized, disinfected	Median <= 23 per 100 mL (7 days), Max <= 240 per 100 mL (30 days)	None

What is learned from water-related outbreak of cryptosporidiosis
- Sign phenomenon and Oocyst monitoring -

Takuro ENDO and Shinji IZUMIYAMA

Department of Parasitology, National Institute of Infectious Diseases

The WHO's definition of a water- or a foodborne outbreak is when two or more persons experience a similar illness after ingestion of the same type of food or water from the same source and when the epidemiological evidence implicates the food or the water as the source of the illness (Schmidt, 1995). A useful definition of a waterborne outbreak, for the purposes of active surveillance, is when more cases than would be expected are clustered, geographically and in time.

Table 1. Reported outbreak cases and their causal events.

	-1			
Area		Causal Events	Date	
Bradford	(GB)	Amount of tapwater consumed	1992.10 - 12	
Milwaukee	(US)	Treatment failure (high turbidity)	1993.03 - 04	
Ogose	(JPN)	Amount of tapwater consumed (elevation of temperature)	1994.05 - 06	
London	(GB)	Oocyst detected (Active surveillance)	1999.04 - 05	
Battlefords	(Can)	Treatment failure (high turbidity)	2001.03 - 04	

From this view point, we have re-examined the outbreak reports published elsewhere (Table 1), and tentatively summarized as follows:

- 1) A small increase in the diarrhea (cryptosporidiosis) cases preceded almost exclusively the large-scale outbreak of the disease in the community (Fig. 1a-c), suggesting that, prior to the disease in outbreak, leakage of a small number of oocysts in tapwater has lasted on the order longer than a month.
- 2) It is most plausible that leakage is attributable to the increase in the number of oocysts in the source water to a level that can not be removed thoroughly by the treatment process. (This supports the idea that waterborne outbreak of infectious diseases occurs when failure in,

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- or accidental defect(s) of, the treatment system happen to occurs under the conditions where there has been relatively heavy contamination of source water with the oocysts.)
- 3) Sudden temperature shift, and thus elevated intake of unboiled tapwater, can also be another type of variable to cause the outbreak.
- 4) It was demonstrated that this sign phenomenon (a small number of diarrhea cases associated with a water supply) was not detectable against the general background of infection by the health-based monitoring, and could only be detected by the post-outbreak investigation.

However, there is still hope to detect the sign phenomenon by monitoring oocysts in source water. By doing so, pre-warning system can be established for large-scale outbreak of cryptosporidiosis.

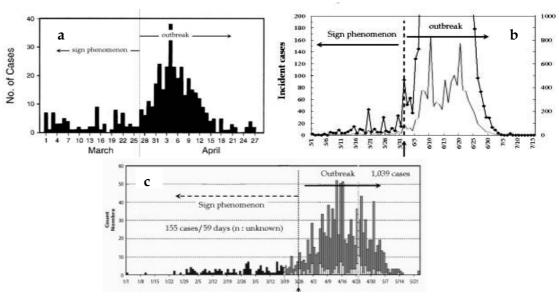


Fig. 1. Sign phenomena of the waterborne outbreak of cryptosporidiosis. Small increase in the diarrhea (cryptosporidiosis) cases in the community preceded the large-scale waterborne outbreaks. Number of onset of illness within a: Milwaukee, b: Ogose and c: Battlefords health service areas.

The calculated number of oocysts in tapwater during pre-outbreak period was something around ~ 0.02 oocysts/L which is far from the detection limit of the routine test for *Cryptosporidium*. In the source water, however, 10 to 1,000 times of the concentration of the oocysts will be expected depending on the particle removal efficacy of the treatment

process (Table 2). Given that a 2.7 log removal ($\pm 1/500$) is assured by the overall treatment process, the number of oocyst in source water is ~ 10 oocysts/L. Considering that the new sign phenomenon (or high load of oocysts in source water) is not a transient event but lasts for several weeks as reported in many post-outbreak survey reports, and that isolation of oocyst from 200 ~ 1,000 mL of source water is not time consuming, it is, therefore, feasible to incorporate the *Cryptosporidium* monitoring in source water into the routine monitoring work at intervals of every one or two weeks.

In this presentation, we are going to discuss a new monitoring system, such as using DNA amplification method, for detecting oocyst to prevent large-scale waterborne outbreak of cryptosporidiosis.

Table 2. Number of oocysts estimated in source and tap water during pre-outbreak period.

	Amount of	Number of oocyst estimated (/L)				
Outbreak Cases	tapwater consumed	in tapwater	in source water with varying removal rate of the treatment plant			
	daily		1-log	2-log	3-log	
Milwaukee, US -	200 ml	0.1	1.0	10	100	
- Willwaukee, US	1,000ml	0.02	0.2	2	20	
North Battlefords,	200 ml	0.05	0.5	5	50	
Canada	1,000ml	0.01	0.1	1	10	
Ogoso Jaman	20ml	0.5	5.0	50	500	
Ogose, Japan	1,000 ml	0.01	0.1	1	10	

What is learned from water-related outbreak of cryptosporidiosis

- Sign phenomenon and Oocyst monitoring -

Takuro ENDO and Shinji IZUMIYAMA

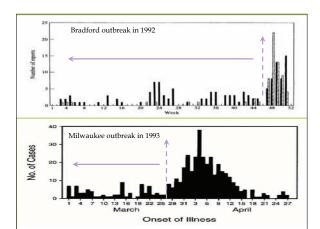
Department of Parasitology, National Institute of Infectious Diseases

Table. Reported outbreak cases and their causal events.

Area		Causal Event(s)	Date	
Bradford	(GB)	Amount of tapwater consumed	1992.10 - 12	
Milwaukee	(US)	Treatment failure (high turbidity)	1993.03 - 04	
Ogose	(JPN)	Amount of tapwater consumed (elevation of temperature)	1996.05 - 06	
Battlefords	(Can)	Treatment failure (high turbidity)	2001.03 - 04	

In general, waterborne outbreak of infectious disease occurs when failure in, or inadequate design of, the treatment system happen to occur under the conditions where there is relatively heavy contamination of source water with a pathogen.

Sudden temperature shift, and thus elevated intake of unboiled tapwater, can also be another type of variable to cause the outbreak.



Summary of Ogose Outbreak Case

Among 11,619 responders, 215 reported having had diarrhea during pre-outbreak period from May 1 to May 28, 1996 with average daily infection rate of 0.066%.

$$P_d = 1 - e^{-rx_d}$$
 \Longrightarrow $x_d = -\frac{\ln(1 - P_d)}{r}$ (Haas et al. 1996)

where P_d is a daily infection rate, x_d is number of infectious oocyst ingested, and r (=0.09) is the probability of infection from ingesting a single infectious oocyst.

The number of oocysts in tapwater was estimated to be 0.012, 0.04 or 0.4 oocysts/L, given the amount of unboiled tapwater consumed daily was 600ml (3 cups of water), 200ml or 20ml, respectively.

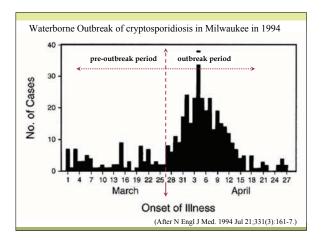
It is generally said that a useful definition of a waterborne outbreak, for the purposes of active surveillance, is when more cases than would be expected are clustered, geographically and in time.

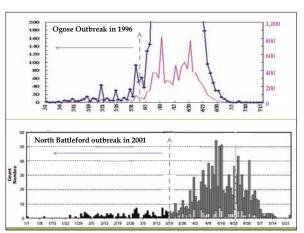


A small number of diarrhea cases associated with a water supply is hardly detectable against the general background of infection by the health-based monitoring, and could only be detected by the post-outbreak investigation.



Need a new sign phenomenon of the disease in outbreak





Summary of Milwaukee Outbreak Case

Of 1,663 responders, 81 reported having had diarrhea during pre-outbreak period between March 1 and March 26,1994.

The average daily infection rate was 0.0019.

Number of oocyst consumed was estimated to be 0.02 per person per day. $\,$

The number of oocysts in the tapwater was estimated to be 0.02 or 0.1 oocysts/L, given the amount of unboiled tapwater consumed daily was 1,000 or 200ml, respectively.

Summary of Battlefords Outbreak Case

A total 155 residents reported having had diarrhea during pre-outbreak period between January 23 and March 25, 2001.

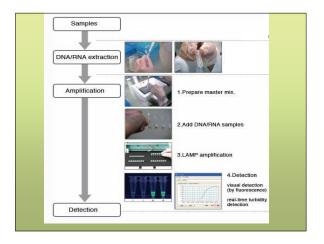
The average daily infection rate was 0.0011.

Number of oocyst consumed was estimated to be 0.012 per person per day.

The number of oocysts in the tapwater was estimated to be 0.01 or 0.05 oocysts/L, given the amount of unboiled tapwater consumed daily was 1,000 or 200ml per day, respectively.

In general, it is said that waterborne outbreak of infectious disease occurs when failure in, or inadequate design of, the treatment system happen to occurs under the conditions where there is relatively heavy contamination of source water with a pathogen.

- According to the case reports, small increase in the diarrhea (cryptosporidiosis) cases in the community preceded the outbreak of the disease. (⇒ sign phenomenon)
- 2. The estimated number of oocysts in tapwater during preoutbreak period was $\sim 0.02 oocyst/L.$
- 3. Leakage of small number of the oocysts into the finished water, and thus causes cryptosporidiosis, is attributable to a high load of oocysts in the source water.
- 4. Given that a 2.7 log removal (1/500) is assured by the treatment process, the number of oocyst in source water is ~ 10 oocysts/L. (⇒ new sign phenomenon)
- 5. Leakage of oocyst in tapwater (+ high load of oocyst in source water) lasts on the order longer than a month.

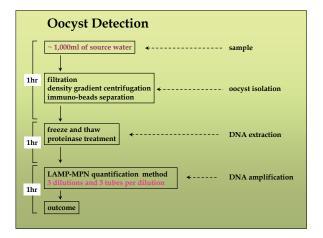


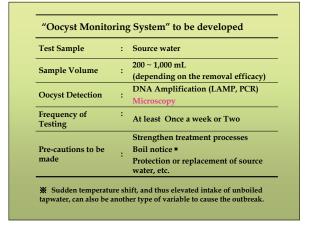
ACKNOWLEDGEMENTS

This research was supported by a grant-in-aid of Ministry of Health Labor and Welfare [H16-Shinkou-16, and H17-Kenkou-066].

Number of oocysts estimated in source and treated water during pre-outbreak period

	Number of oocyst estimated (/L)						
Outbreak Cases	Amount of tapwater consumed daily	Tapwater	Source water with varying removal rate of the treatment plant				
			1-log	2-log	3-log		
NC1 1 TIC	1,000 ml	0.02	0.2	2	20		
Milwaukee, US	200ml	0.10	1.0	10	100		
North Battleford,	1,000 ml	0.01	0.1	1	10		
Canada	200ml	0.05	0.5	5	50		
	1,000 ml	0.01	0.1	1	10		
Ogose, Japan	20ml	0.4	4.0	40	400		





Pharmaceuticals in the Environment – A Review of PhRMA Initiatives

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Pharmaceutical Research and Manufacturers of America²

1. Introduction

When patients consume pharmaceuticals, there may be some active pharmaceutical ingredient (API) that is not completely metabolised and is excreted by the patient. These small quantities of material are then transported to wastewater treatment systems where most of them are removed but some are discharged to receiving streams.

Recently, as a result of advances in analytical techniques, it has become possible to show that pharmaceuticals can be measured in wastewater, surface water (rivers and streams) and drinking water at low concentrations. There is substantial public concern about the possibility of health or environmental effects, compounded by debate about the effects of endocrine modulating chemicals and worries about resistance to antibiotics.

There is ongoing scientific work to establish the extent of the issues. PhRMA has been actively involved in industry efforts to develop models that can then be used to identify potential environmental exposures from pharmaceutical products entering the environment through patient use. When used with appropriate effects information, these exposure assessments may be used to assess potential risk to human health and the environment from trace levels of pharmaceuticals in drinking and surface waters. In addition, PhRMA has been proactively involved in efforts to develop: the science needed to understand and manage the technical aspects; the methodologies to better define the environmental fate characteristics of pharmaceuticals and the appropriate end-points for impacts on aquatic life and ecosystems; and the strategies needed to appropriately manage the issue. However, the state-of-the-art for this issue is developing rapidly, and considerable additional work needs to be done to ensure that this issue is understood, managed, and properly

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² From work by Virginia Cunningham, Glaxo Smith Kline

communicated to internal and external stakeholders, including employees, contractors, suppliers, customers, investors, governmental agencies, NGOs, and the public.

2. Background

The widespread detection of pharmaceuticals in environmental samples as a result of improved analytical capabilities and focused field surveys has led to concern over the potential risks associated with releases of pharmaceuticals into the environment. This concern has been driven by surface water sampling programs in the US, Europe and elsewhere that have all shown the presence of many different classes of pharmaceuticals. The high polarity and low volatility of most pharmaceuticals means that they are likely to be transported to and by the water compartment. The research published to date describes the sampling and analysis of surface water, groundwater, drinking water, and sewage treatment plant (STP) effluent, and the detection of pharmaceutical active ingredients and their degradation products, usually at concentrations much less than 1 µg/L. The pharmaceuticals reported in surface water include hormones (e.g., synthetic and natural estrogens), antibiotics, blood lipid regulators, non-steroid analgesics and anti-inflammatory agents, beta-blockers, antiepileptics, antineoplastics, tranquilizers, and diagnostic contrast media. Although some pharmaceuticals are unlikely to be a risk to the aquatic environment because of low concentrations combined with low toxicity, other pharmaceuticals such as natural and synthetic sex hormones may pose potentially significant risks.

Attention has focused on pharmaceuticals used in both veterinary and human medicine; however the environmental exposure scenarios are quite different for these modes of entry. A comprehensive discussion of the issue of veterinary medicines in the environment, which may be introduced to the environment through a variety of direct and indirect, point and diffuse sources, is provided in Boxall *et al.*. In contrast, exposure of aquatic wildlife to human pharmaceuticals is most likely to occur from sewage treatment plant (STP) point source discharges and this exposure may therefore be at continuous, low concentrations. Despite this, most published aquatic toxicity data and risk assessments for pharmaceuticals are based on short-term acute studies. Concerns over the possible environmental effects of low level continuous aquatic exposure to human pharmaceuticals have led to significant revisions in European new drug regulatory submission requirements, where chronic aquatic toxicity tests have been adopted in the most recent environmental risk assessment guidance document for human pharmaceuticals produced by the European Medicines Agency in support of Directive 2001/83/EC.

3. Occurrence in the Environment

In the late 1980s, new, highly sensitive analytical methods for organic chemicals with polar and nonpolar properties were developed. These new analytical methods could detect and quantitate organic chemicals, including pharmaceuticals, at concentrations ranging from 1-100 nanograms/litre (ng/L). Some pharmaceutical chemicals can now be identified and quantified at sub-ng/L concentrations, i.e., down to 100 parts per quadrillion (to 0.1 ng/L).

Efforts to improve the sensitivity of analytical methods for trace analytes in water will continue. As an example of the sensitivity of analytical methods for trace organics in water, the currently approved analytical method for 2,3,7,8-tetrachloro-p-dioxin can detect this chemical at less than 1 picogram/litre (pg/L) - 1000 times lower than 1 ng/L, nearly approaching the molecular level. As the sensitivity of analytical methods increases, it is likely that additional chemicals will be identified in ambient waters and that chemicals already found may prove to be more widespread.

4. Behavior in the Environment

Aquatic transport and transformation processes in the environment include sorption, ionization, volatilization, hydrolysis, oxidation-reduction, photolysis, biological transformation-degradation and precipitation-dissolution. These processes occur continuously in the environment and influence the presence and bioavailability of pharmaceuticals in aquatic ecosystems. Response of drugs to any of these pathways for partitioning, degradation or change in the environment could reduce their concentrations in the environment or remove them entirely and thereby reduce their potential to impact human health and aquatic life. Pharmaceutical compounds that are marketed in large quantities and are soluble or slightly soluble yet resistant to degradation through biological or chemical processes have the greatest potential to reach steady-state levels in the environment and be detected in surface and ground waters and potable water supplies.

5. Understanding the Risk to Human Health - Modeling as One Approach

The potential risk to human health associated with low levels of pharmaceuticals in the environment is a function of exposure and hazard. One way to assess this risk is to create a model to predict human exposure and evaluate the hazard present. However, models are merely predictive and are only as good as the input data and assumptions

used. Models can be constructed, using the principles discussed above, to estimate the human health risk associated with pharmaceuticals in the environment.

Screening models can be used to evaluate large numbers of compounds, employing conservative assumptions and readily available data, in order to identify those compounds with the greatest potential risk. A PhRMA-sponsored risk assessment for 26 APIs has been published. Other assessments have been published as well.

Detailed deterministic or probabilistic models can then be used to provide more definitive risk estimates for those compounds, and/or classes of compounds, identified in the screening analysis. Deterministic models are used to simulate site-specific conditions in a particular area, while probabilistic models are used to estimate the percentage of the population exposed to various levels of risk.

A. Hazard

There is no universally accepted methodology to measure the human health hazard associated with low levels of pharmaceuticals in the environment. One approach could be to use the therapeutic dose with a safety factor of 1000. Another approach is to use EPA's Reference Dose (RfD) methodology. The RfD is the amount of a chemical that a person, including sensitive subgroups, can be exposed to on a daily basis without causing adverse health effects over a lifetime. The RfD is derived from the no observed adverse effect level (NOAEL) by consistent application of generally order-of-magnitude uncertainty factors.

One methodology developed and reported by pharmaceutical industry scientists is a model to establish human health predicted no effects levels (PNECs). Typically during the research and development of pharmaceuticals, a risk/benefit analysis is used by regulatory authorities to evaluate the safety of pharmaceuticals for the patient population. A certain amount of risk, e.g., side effects, is recognized as acceptable to receive the therapeutic benefits. This contrasts with the case where no benefit is presumed to be received by the exposed individual, such as the incidental exposure to pharmaceuticals through drinking water or fish consumption. The potentially exposed population is presumed to include healthy adults as well as susceptible sub-populations (e.g., children, the elderly, and infirm) in which the pharmacologic effect is considered undesirable. The database for a compound normally contains several toxic endpoints from which a point of departure should be determined to calculate the most restrictive reference value (or allowable daily intake - ADI). The point of departure for determining an ADI for chemicals is often either the highest dose resulting in no observed effects (no observed effect level or NOEL) or in no observed adverse effects (no observed adverse effect level or NOAEL) for a given toxic endpoint. For many APIs, however, a point of departure

is the lowest dose resulting in an observable effect (lowest observed effect level or LOEL) or in an observable adverse effect (lowest observed adverse effect level or LOAEL). For an API, the therapeutic effect usually occurs at a dose considerably below those expected to result in toxicity.

B. Exposure

Human exposure to environmental concentrations of pharmaceuticals is believed to be primarily through ingestion of drinking water and, for compounds that bioaccumulate, through ingestion of meat or fish.

The concentration of drug substances in drinking water depends on the following factors:

- the quantity of drug substance consumed by a given population;
- the extent to which the drug is metabolised in the body;
- available dilution in public sewer systems and in receiving waters;
- removal and partitioning in STPs and receiving waters; and,
- · degree of removal by drinking water treatment technologies.

Drug sales data available from IMS Health can provide the total mass of individual drug substances across all product lines. Since IMS data are not readily available except through commercial license agreements, many published studies use prescription sales data to characterize drug sales. However, it is difficult to estimate the mass of drugs sold from prescription data, because of the many different drug products and since the number of scripts typically does not include drugs dispensed in hospitals or nursing homes. Furthermore, there are several reasons why drug sales data may not translate into accurate drug use data: (1) drugs may be discarded in toilets or household trash (a small amount); (2) average sales data may not reflect geographic or seasonal variability in consumption; and, (3) only a portion of the drug substance may be delivered to the body, e.g., transdermal dosage forms.

After ingestion, human drugs undergo Phase I metabolism, which includes oxidation, reduction or hydrolysis; followed by Phase II metabolism, which involves conjugation (e.g., addition of glucuronic acid, sulphate, acetic acid or amino acid). Depending upon the drug, these processes can yield various proportions of unchanged drug substance, active or inactive metabolites, or conjugates. There is evidence that conjugates can be converted back to the parent drug or metabolite through bacterial hydrolysis in a STP. The reduction in pharmacological activity following metabolism

can range from zero to essentially 100 percent depending on the drug.

Drug substances excreted into the public sewer are diluted by the available wastewater flow. The average total STP influent flow in the US is 121.4 billion liters per day, which is used to estimate the expected introductory concentration for FDA. Regional and seasonal variability in STP flow is expected as a result of differences in water consumption per capita, industrial water use, weather conditions, etc. STP effluent is further diluted by the receiving water – a factor of 1:10 is often used to account for dilution in the environment. As described in Section 2, a number of degradation and partitioning mechanisms can act on drug substances in both an STP and the environment.

Conservative estimates of environmental concentrations of a drug substance can be calculated from the total mass of drug substance sold and the available dilution from STP and receiving water flow as described above. These estimates can be refined by considering metabolism and the various STP and environmental degradation and partitioning mechanisms.

C. Characterizing Risk

The estimation of potential impact of human pharmaceuticals to human health from environmental exposures typically uses two concepts: the predicted environmental concentration (PEC) and the predicted no effect concentration (PNEC). The PEC element is based on the physical, chemical and biological fate properties of the molecule, as well as hydrological information on STP effluent flows and surface water flows. The PNEC element estimates concentrations at which potential effects on human health might occur. In general, if the PEC is less than the PNEC (PEC/PNEC < 1) the risk is deemed acceptable. This approach to environmental risk assessment is called the risk characterization ratio method.

7. Modeling as One Approach Understanding the Risk to the Environment

As with the risk to human health, the potential risk to the environment presented by the presence of pharmaceuticals is a function of hazard and exposure.

A. Potential for and Evaluation of Acute Hazards

Pharmaceutical companies sometimes conduct acute toxicity studies to support environmental assessments that are filed with NDA and MAA applications or to support internal programs. Acute toxicity to aquatic receptors is usually assessed by evaluation of several common species including typically a fish (usually fathead minnows, bluegills or rainbow trout), an invertebrate (usually a daphnid such as Daphnia magna) and an algal species. These acute toxicity studies last up to 96 hours. The endpoints measured may include growth and/or growth rate (algae), immobilisation (Daphnia), and morbidity and/or mortality (fish) and are often expressed as a concentration that elicits an effect in a specified percentage of the test group. For substances that may be expected to partition into soils or sediments, studies in terrestrial species, such as earthworms, may be conducted.

Generally speaking, there is little potential for an acute environmental hazard to exist from the presence of pharmaceuticals that find their way into the environment through use by humans because the levels are so low. As for the potential for an acute environmental hazard to be presented from pharmaceutical manufacturing, there are regulatory and industry practices in place that minimise the risk. Environmental agencies have in place permitting programs that control acutely toxic manufacturing discharges.

B. Potential for and Evaluation of Chronic Hazards

There are several methods that are currently approved by regulatory agencies for the conduct of chronic aquatic toxicity studies. The most commonly used are the Daphnia 21-day toxicity study and the prolonged toxicity study in fish. Currently, such studies are conducted relatively infrequently due to the relatively low introduction concentrations of drug substances into the environment, the tendency for many drugs to be metabolized to relatively more water-soluble and less active metabolites, and because they are primarily produced by batch vs. continuous manufacturing operations. There is however, considerable interest in the development of improved methods for aquatic toxicity assessments of chronic effects. In addition, the EMEA Guidelines for environmental risk assessments for new pharmaceuticals now requires a base set of chronic ecotoxicity studies in lieu of the previously required acute studies.

C. Characterizing Risk

The estimation of potential impact of human pharmaceuticals to aquatic life mirrors the procedure used for human health risk characterization: the predicted environmental concentration (PEC) and the predicted no effect concentration (PNEC). Here, the PNEC element estimates concentrations at which potential effects on aquatic life might

occur. In general, if the PEC is less than the PNEC (PEC/PNEC < 1) the risk is deemed acceptable. This approach to environmental risk assessment is called the risk characterization ratio method.

C. Links

EMEA *Guideline on the environmental risk assessment of medicinal products for human use*; The European Agency for the Evaluation of Medicinal Products, London, England, June 2006 Doc. Ref. EMEA/CHMP/SWP/4447/00 http://www.emea.eu.int/pdfs/human/swp/444700en.pdf

FDA-CDER. Guidance for industry - environmental assessment of human drugs and biologics applications, FDA Center for Drug Evaluation and Research, Rockville, MD, USA (CMC6 Revision 1), 1998, http://www.fda.gov/cder/guidance/index.html)

The Swedish Association of the Pharmaceutical Industry (LIF) (http://www.fass.se)

Pharmaceuticals and Personal Care Products (PPCPs) as Environmental Pollutants http://www.epa.gov/esd/chemistry/pharma/

Monograph, Toward a Green Pharmacy (US EPA)
http://www.epa.gov/esd/chemistry/pharma/images/green1.pdf

Antibiotic Resistance (US FDA)

http://www.fda.gov/oc/opacom/hottopics/anti_resist.html

Endocrine Disruption (WHO)

http://www.who.int/pcs/emerg site/edc/global edc TOC.htm

US PhRMA Position on Pharmaceuticals in the Environment http://www.phrma.org/mediaroom/press/releases///13.03.2002.366.cfm

PhRMA PhATE Model: Screening Analysis of Human Pharmaceuticals in US Surface Waters

http://pubs.acs.org/cgi-bin/article.cgi/esthag/2004/38/i03/pdf/es034430b.pdf

Human pharmaceuticals in US surface waters: A human health risk assessment http://dx.doi.org/doi:10.1016/j.yrtph.2005.05.005

D. Selected Bibliography

- Alder *et al.* 2004. A.C. Alder, C.S. McArdell, E.M. Golet, H.P.E Kohler, E. Molnar and N. Anh Pham Thi *et al.*, Environmental exposure of antibiotics in wastewaters, sewage sludges and surface waters in Switzerland. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 55–66.
- Anderson *et al.* 2004. Anderson, P.D.; D'Aco, V.J.; Shanahan, P.; Chapra, S.C.; Buzby, M.E.; Cunningham, V.L.; DuPlessie, B.M.; Hayes, E.P.; Mastrocco, F.J.; Parke, N.J.; Rader, J.C.; Samuelian, J.H.; Schwab, B.W. (2004). Screening analysis of human pharmaceutical compounds in U.S. surface waters. *Environ. Sci. Technol.* 38, 838-849.
- Ashton *et al.* 2004. D. Ashton, M. Hilton and K.V. Thomas, Investigating the environmental transport of human pharmaceuticals to streams in the United Kingdom, *Sci Total Environ* **333** (2004), pp. 167–184.
- Ayscough *et al.*, 2002. N.J. Ayscough, J. Fawell, G. Franklin and W. Young, Review of Human Pharmaceuticals in the Environment, *R&D Technical Report P390*, Environment Agency, Bristol, UK (2002).
- Bound and Voulvoulis, 2004. J.P. Bound and N. Voulvoulis, Pharmaceuticals in the aquatic environment a comparison of risk assessment strategies, *Chemosphere* **56** (2004), pp. 1143–1155.
- <u>Boxall et al. 2000</u>. A.B.A Boxall, D. Oakes, P. Ripley and C.D. Watts, The application of predictive models in the environmental risk assessment of ECONOR©, Chemosphere **40** (2000), pp. 775–781
- <u>Boxall et al. 2003</u> A.B.A Boxall, D.W. Kolpin, B. Halling-Sørensen and J. Tolls, Are veterinary medicines causing environmental risks?, *Environ Sci Technol* **37** (2003), pp. 286–294.
- Boxall *et al.* 2004. A.B.A. Boxall, L.A. Fogg, P.A. Blackwell, P. Kay, E.J. Pemberton and A. Croxford, Veterinary medicines in the environment, *Rev Environ Contam Toxicol* **180** (2004), pp. 1–91.

- Brain *et al.* 2004. R.A. Brain, D.J. Johnson, S.M. Richards, H. Sanderson, P.K. Sibley and K.R. Solomon, Effects of 25 pharmaceutical compounds to *Lemna gibba* using a seven-day static-renewal test, *Environ Toxicol Chem* **23** (2004), pp. 371–382.
- Brain *et al.* 2004. R.A. Brain, D.J. Johnson, S.M. Richards, M.L. Hanson, H. Sanderson and M.W. Lam *et al.*, Microcosm evaluation of the effects of an eight pharmaceutical mixture to the aquatic macrophytes *Lemna gibba* and *Myriophyllum sibiricum*, *Aquat Toxicol* **70** (2004), pp. 23–40.
- Breton and Boxall, 2003. R. Breton and A. Boxall, Pharmaceuticals and personal care products in the environment: regulatory drivers and research needs, *QSAR Comb Sci* **22** (2003), pp. 399–409.
- Buser *et al.* 1998. H.R. Buser, M.D. Müller and N. Theobald, Occurrence of the pharmaceutical drug clofibric acid and the herbicide mecoprop in various Swiss lakes and in the North Sea, *Environ Sci Technol* **32** (1998), pp. 188–192.
- Calamari *et al.*, 2003. D. Calamari, E. Zuccato, S. Castiglioni, R. Bagnati and R. Fanelli, Strategic survey of therapeutic drugs in the Rivers Po and Lambro in Northern Italy, *Environ Sci Technol* **37** (2003), pp. 1241–1248.
- Christensen, F.M. (1998) *Pharmaceuticals in the environment A Human Risk?*, Reg. Toxicol. & Pharmacol., 28, 212-221.
- <u>Cleuvers, 2003</u> M. Cleuvers, Aquatic ecotoxicity of pharmaceuticals including the assessment of combination effects, *Toxicol Lett* **142** (2003), pp. 185–194
- Colburn *et al.* 1996. Colborn, T.; Dumanoski, D.; Myers, J.P. *Our Stolen Future*, Dutton, Peguin Books (NY) 1996 (ISBN 0-525-93982-2).
- Crane *et al.* 2006. Crane, M.; Watts, C.; Boucard, T. Chronic aquatic environmental risks from exposure to human pharmaceuticals, (2006). *Sci. Tot. Environ.* **367**, 23-41
- Cunningham *et al.* 2006. Cunningham, V.L.; Buzby, M.; Hutchinson, T.; Mastrocco, F.; Parke, N.; Roden, N. (2006). Effects of Human Pharmaceuticals on Aquatic Life: Next Steps, *Environ. Sci. Technol.***40**, 3457-3462
- Cunningham et al. 2004. V.L. Cunningham, D.J.C Constable and R.E. Hannah, Environmental risk assessment of paroxetine, *Environ Sci Technol* **38** (2004), pp. 3351–3359.
- <u>Daughton and Termes, 1999</u> C.G. Daughton and C.G. Ternes, Pharmaceuticals and personal care products in the environment: agents of subtle change?, *Environ*

- Health Perspect 107 (1999), pp. 907-938.
- Daughton, 2001. C.G. Daughton, Pharmaceuticals in the environment: overarching issues and overview. In: C.G. Daughton and T. Jones-Lepp, Editors, *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues, Symposium Series* vol. 791, American Chemical Society, Washington, DC, USA (2001), pp. 2–38.
- Daughton, 2003. C.G. Daughton, Cradle-to-grave stewardship of drugs for minimizing their environmental disposition while promoting human health. I. Rationale for and avenues toward a green pharmacy, *Environ Health Perspect* **111** (2003), pp. 757–774.
- Desbrow *et al.* 1998 C. Desbrow, E.J. Routledge, G.C. Brighty, J.P. Sumpter and M. Waldock, Identification of estrogenic chemicals in STW effluent: 1. Chemical fractionation and in vitro biological screening, *Environ Sci Technol* **32** (1998), pp. 1549–1558.
- <u>Drewes et al. 2002</u> J.E. Drewes, T. Heberer and K. Reddersen, Fate of pharmaceuticals during indirect potable reuse, *Water Sci Technol* **46** (2002), pp. 73–80.
- EC 2001. Directive 2001/83/EC of the European Parliament and of the Council of 6 November 2001 on the Community Code Relating to Medicinal Products for Human Use, European Union, Brussels, Belgium (2001).
- EC 2003. Technical Guidance Document on Risk Assessment. Part, I.I, European Commission, Brussels, Belgium (2003).
- Emmanuel *et al.* 2005. E. Emmanuel, Y. Perrodin, G. Keck, J.-M. Blanchard and P. Vermande, Ecotoxicological risk assessment of hospital wastewater: a proposed framework for raw effluents discharging into urban sewer network, *J Hazard Mat* **A117** (2005), pp. 1–11
- Environment Agency, 2003. Environment Agency, Position Statement: Human Pharmaceuticals and their Impact on the Aquatic Environment, Environment Agency of England and Wales, Bristol, UK (2003) Final draft 11 August.
- FDA-CDER, 1996. FDA-CDER, Retrospective review of ecotoxicity data submitted in environmental assessments, FDA Center for Drug Evaluation and Research,

- Rockville, MD, USA (1996) (Docket No. 96N-0057).
- Fent et al. 2005. Fent, K.; Weston, A. A.; Caminada, D. Aquatic Toxicology (2006), **76**,122-159
- Ferrari *et al.* 2004. B. Ferrari, R. Mons, B. Vollat, B. Frayse, N. Paxéus and R. Lo Guidice *et al.*, Environmental risk assessment of six human pharmaceuticals: are the current environmental risk assessment procedures sufficient for the protection of the aquatic environment?, *Environ Toxicol Chem* **23** (2004), pp. 1344–1354.
- Focazio *et al.* 2004. M.J. Focazio, D.W. Kolpin and E.T. Furlong, Occurrence of human pharmaceuticals in water resources of the United States: a review. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 91–105.
- Halling-Sorensen *et al.* 1998. Halling-Sorensen, B.; Nielsen, S.; Lanzky, P.F.; Ingerslev, F.; Holten Lutzhoft, H.C.; Jorgensen, S.E. Occurrence, fate and effects of pharmaceutical substances in the environment a review. *Chemosphere* **1998**, 36, 357-393
- Heberer *et al.* 2002 T. Heberer, K. Reddersen and A. Mechlinski, From municipal sewage to drinking water: fate and removal of pharmaceuticals residues in the aquatic environment in urban areas, *Water Sci Technol* **46** (2002), pp. 81–86.
- Heberer, 2002. T. Heberer, Occurrence, fate, and removal of pharmaceutical residues in the aquatic environment: a review of recent research data, *Toxicol Lett* **131** (2002), pp. 5–17
- Henschel *et al.* 1997 K.P. Henschel, A. Wenzel, M. Diedrich and A. Fliedner, Environmental hazard assessment of pharmaceuticals, *Reg Toxicol Pharmacol* **25** (1997), pp. 220–225.
- Jones *et al.* 2002 O.A.H Jones, N. Voulvoulis and J.N. Lester, Aquatic environmental assessment of the top 25 English prescription pharmaceuticals, *Water Res* **36** (2002), pp. 5013–5022.
- Jørgensen and Halling-Sørensen, 2000. S.E. Jørgensen and B. Halling-Sørensen, Drugs in the environment, *Chemosphere* **40** (2000), pp. 691–699.
- Kolpin et al., 2002. D.W. Kolpin, E.T. Furlong, M.T. Meyer, E.M. Thurman, S.D. Zaugg and L.B. Barber et al., Pharmaceuticals, hormones, and other organic wastewater contaminants in US streams 1999–2000: a national reconnaissance, *Environ Sci Technol* 36 (2002), pp. 1202–1211.

- Kümmerer 2004. Kümmerer, K., Ed. *Pharmaceuticals in the Environment, 2nd ed.*; Springer-Verlag, New York, 2004
- Metcalfe *et al.* 2003. C.D. Metcalfe, X.S. Miao, B.G. Koenig and J. Struger, Distribution of acidic and neutral drugs in surface waters near sewage treatment plants in the lower Great Lakes, Canada, *Environ Toxicol Chem* **22** (2003), pp. 2881–2889.
- Metcalfe *et al.* 2004. C. Metcalfe, X.S. Miao, W. Hua, R. Letcher and M. Servos, Pharmaceuticals in the Canadian Environment. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 67–90.
- Meylan and Howard, 1998 W.M. Meylan and P.H. Howard, User's guide for the ECOSAR class program, Syracuse Research; Syracuse, New York, US (1998).
- Mons, M.N. 2003. *Pharmaceuticals and drinking water supply in the Netherlands*, Kiwa N.V. Water Research.
- Nash *et al.* 2004. J.P. Nash, D.E. Kime, L.T.M Van der Ven, P.W. Wester, F. Brion and G. Maack *et al.*, Long-term exposure to environmental concentrations of the pharmaceutical ethynylestradiol causes reproductive failure in fish, *Environ Health Perspect* **112** (2004), pp. 1725–1733.
- Sanderson *et al.* 2003. H. Sanderson, D.J. Johnson, C.J. Wilson, R.A. Brain and K.R. Solomon, Probabilistic hazard assessment of environmentally occurring pharmaceuticals toxicity to fish, daphnids and algae by ECOSAR screening, *Toxicol Lett* **144** (2003), pp. 383–395.
- Sanderson *et al.* 2004. H. Sanderson, R.A. Brain, D.J. Johnson, C.J. Wilson and K.R. Solomon, Toxicity classification and evaluation of four pharmaceuticals classes: antibiotics, antineoplastics, cardiovascular, and sex hormones, *Toxicology* **203** (2004), pp. 27–40.
- Sanderson *et al.* 2004. H. Sanderson, D.J. Johnson, T. Reitsma, R.A. Brain, C.J. Wilson and K.R. Solomon, Ranking and prioritization of environmental risks of pharmaceuticals in surface waters, *Regul Toxicol Pharmacol* **39** (2004), pp. 158–183.
- Schulman, et al. 2002. A human health risk assessment of pharmaceuticals in the aquatic environment, Human & Ecological Risk Assessment, 8 (4), pp. 657-680.
- Schwab et al. 2005. Schwab, B.W.; Hayes, E.P.; Fiori, J.M.; Mastrocco, F.J.; Roden,

- N.M.; Cragin, D.; Meyerhoff, R.; D'Aco, V.J.; Anderson, P.D. (2005). Human pharmaceuticals in U.S. surface water: A human health risk assessment, *Regulatory Toxicology and Pharmacology*, **42**, 296-312.
- Steger-Hartmann *et al.*1999. T. Steger-Hartmann, R. Länge and H. Schweinfurth, Environmental risk assessment for the widely used iodinated X-ray contrast agent iopromide (ultravist), *Ecotoxicol Environ Saf* **42** (1999), pp. 274–281.
- Steger-Hartmann *et al.* 2002. T. Steger-Hartmann, R. Länge, H. Schweinfurth, M. Tschampel and I. Rehmann, Investigations into the environmental fate and effects of iopromide (ultravist), a widely used iodinated X-ray contrast medium, *Water Res* **36** (2002), pp. 266–274.
- Stuer-Lauridsen *et al.* 2000. F. Stuer-Lauridsen, M. Birkved, L.P. Hansen, H.C. Holten Lützhøft and B. Halling-Sørensen, Environmental risk assessment of human pharmaceuticals in Denmark after normal use, *Chemosphere* **40** (2000), pp. 783–793.
- Ternes 1998. Ternes, T.A. Occurrence of drugs in German sewage treatment plants and rivers. *Water Res.* **1998**, *32*, 3245-3260
- Thomas and Hilton, 2003. K.V. Thomas and M. Hilton, Targeted monitoring programme for pharmaceuticals in the aquatic environment. R&D Technical Report P6-012/6, Environment Agency, Bristol, UK (2003).
- Webb, 2004. S.F. Webb, A data-based perspective on the environmental risk assessment of human pharmaceuticals II aquatic risk characterisation. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 345–361.
- Webb, 2004. S.F. Webb, A data-based perspective on the environmental risk assessment of human pharmaceuticals I collation of available ecotoxicity data. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 317–343.
- Webb, et al. 2003. Indirect human exposure to pharmaceuticals via drinking water, Toxicology Letters, 142, 157-167.
- Williams 2005. Williams, R.T., Ed. Science for Assessing the Impacts of Human Pharmaceuticals on Aquatic Ecosystems; SETAC Press, Pensacola, FL 2005
- Zuccato *et al.* 2004. E. Zuccato, S. Castiglioni, R. Fanelli, R. Bagnati, G. Reitano and D. Calamari, Risks related to the discharge of pharmaceuticals in the environment:

further research is needed. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 431–437.

Zuccato *et al.* 2004. E. Zuccato, S. Castiglioni, R. Fanelli, R. Bagnati and D. Calamari, Pharmaceuticals in the environment: changes in the presence and concentrations of pharmaceuticals for human use in Italy. In: K. Kümmerer, Editor, *Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks* (Second Edition), Springer, Berlin, Germany (2004), pp. 45–53.

Pharmaceuticals in the Environment – A Review of PhRMA Initiatives

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Merck & Co., Inc.
Pharmaceutical Research and Manufacturers of America

Prepared for 4th Japan – U.S. Governmental Conference on Drinking Water Quality Management and Wastewater Control

P/RMA

PhRMA Perspective

- · A science-based approach:
 - is required to understand and address concerns resulting from presence of pharmaceutical compounds in the environment
 - will identify gaps in existing knowledge that require further investigation regarding the potential for impacts

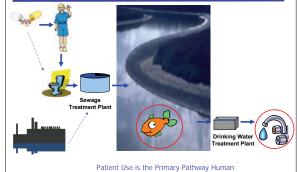
-PhRMA-

Characteristics of Pharmaceuticals

- Pharmaceuticals are often ionic, which influences their environmental fate.
- Ionic, hydrophilic behavior is not typical of chemicals usually evaluated for environmental fate and effects.
 - Many environmental models developed for non-ionic chemicals are not applicable to ionic, multifunctional compounds; their use
 - may lead to incorrect interpretations of test results
 - may lead to improper classifications

-P/RMA

Pharmaceuticals in the Environment



Pharmaceutical Compounds Enter the Environment

Issue

- Pharmaceutical products are being detected in the environment
- Concern has been expressed that human health and aquatic life impacts might result from environmental exposure to pharmaceutical compounds

PhRMA

Benefits of a Science Based Approach to PIE

- Provide confidence to the industry, communities and governments that safety of pharmaceuticals in the environment is well understood
- Identify any issues requiring further investigation regarding existence and significance of potential impacts

PhRMA-

Characteristics of Pharmaceuticals

- · Pharmaceuticals enter the environment continuously.
- Sources are geographically diffuse and may be influenced by regional use patterns.
- Compounds in the environment may be parent, metabolites or conjugates.
- Compounds may be present in mixtures with other pharmaceuticals, organic and inorganic pollutants, etc.
- Science challenges exist, e.g., testing methods, mixtures, chronic eco-toxicity endpoints

P/RMA

A Science-based Approach: A step-wise progression

- Understand the potential for exposure
- Assess potential impacts to man
- Assess potential impacts to environmental species

P/rRMA

The PhATE Model™

Needs:

- Evaluate potential distribution of pharmaceutical compounds in the environment
- Assess the significance of reported concentrations to humans and aquatic life

Action:

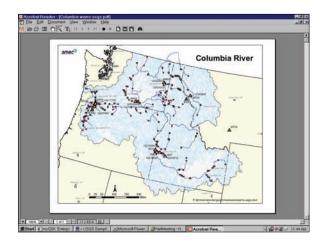
 Develop tool to estimate concentrations of pharmaceutical compounds in the environment

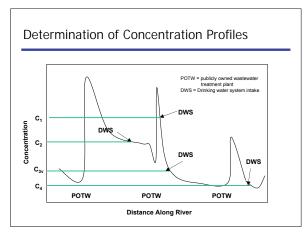


PhATE™ Model Development (2001)

- Model predicts concentrations of pharmaceuticals in the environment due to patient use
- Model was developed by PhRMA PIE Task Force and AMEC Earth and Environmental
- · Third party reviewers:
 - Dr. Josh Cohen, Harvard School of Public Health
 - Dr. Steve Chapra, Tufts University



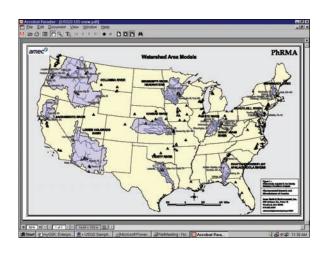


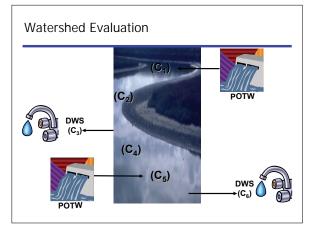


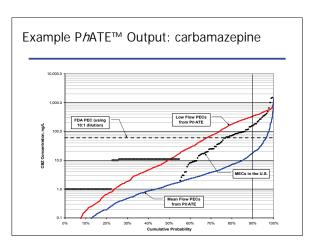
P*h*ATE™ Model Development (2001)

- Watershed (drainage basin of receiving waterbody)
 - a geographic area in which water, sediments and dissolved materials drain to a common outlet
- Approach allows better understanding of the cumulative impact of human activities
- Many regions moving toward watershed based water quality management

P/RMA-







Model-related publications

· USGS Paper:

-Kolpin, et al., Pharmaceuticals, Hormones, & Other Wastewater Conta U.S. Streams, 1999-2000: A National Reco 36, 1202-1211. aissance, Environ. Sci. Technol.. 2002

PhATE™ Papers:

-Cunningham, V.L. The PhATE™ Model: Estimating the Distribution of Pharmaceuticals in the Environment, Southwest Hydrology, November/December 2003,

-Anderson, P.D.; D'Aco, V.J.; Shanahan, P.; Chapra, S.C.; Buzby, M.E.; Cunningham, V.L.; DuPlessie, B.M.; Hayes, E.P.; Mastrocco, F.J.; Parke, N.J.; Rader, J.C.; Samuellan, J.H.; Schwab, B.W. Screening analysis of human pharmaceutical compounds in U.S. surface waters. *Environ. Sci. Technol.* 2004, **38**, 838-849.

-Cunningham, V. L.; Constable, D. J.; Hannah, R. E. Environmental Risk Assessment of Paroxetine, Environ. Sci. Technol. 2004, **38**, 3351-3359.

of Human Pharmaceuticals on Aquatic Life: Next Steps, Environ. Sci. Technol. 2006, 40, 3456 - 3462

P/RMA

A Science-based Approach: A step-wise progression

- · Understand the potential for exposure
- · Assess potential impacts to man
- · Assess potential impacts to environmental species

PhRMA-

Human Health Screening Analysis

- · Analysis included 26 USGS human health pharmaceuticals
 - Non-steroidal analgesics, non-steroidal anti-infla
 - Opiate analgesic
 - Bronchodilator
 - H2 receptor antagonists
 - Antimicrobial, antibiotics, antibacterial
 - Calcium blocker, ACE inhibitor, anti-hypertensives
 - Serotonin uptake inhibitors, anti-depressive
 - Hypoglycemic

 - Anti-coagulantCardiac glycoside
 - Anti-hyperlipidemic
- Compounds studied excluded hormones which are being evaluated separately due to the complexity of that evaluation

PhRMA

Human Health Screening Analysis

- Identified measured environmental concentrations for compounds reported in published articles (MEC)
- Used PhATE™ in screening mode to predict concentrations in environment

- Developed predicted no effect concentrations (PNEC)
 - Considered drinking water and fish consumption exposure pathways
- Evaluated MEC/PNEC and PEC/PNEC ratios

P/RMA

Human Risk Assessment

Conclusion:

"Results of this human health assessment indicate that no appreciable human health risk exists from the presence of these trace residues in surface water and drinking water.

Schwab, B. W., et al. Human pharmaceuticals in US surface waters: A human health risk assessment, Reg. Tox. Pharmacol. 2005, 42, 296-312

PhRMA

Other Human Health Publications

- Christensen, F.M. (1998) **Pharmaceuticals in the environment A Human Risk?,** Reg. Toxicol. & Pharmacol., 28, 212-221.
- Schulman, et al., (2002) A human health risk assessment of pharmaceuticals in the aquatic environment, Human & Ecological Risk Assessment, 8 (4), pp. 657-680.
- Mons, M.N., (2003) **Pharmaceuticals and drinking water supply in the Netherlands**. Kiwa N.V. Water Research.
- Webb, et al., (2003) **Indirect human exposure to pharmaceuticals via drinking water**, Toxicology Letters, 142, 157-167.

All concluded that environmental exposure to human pharmaceuticals poses little human health risk. PhRMA

A Science-based Approach: A step-wise progression

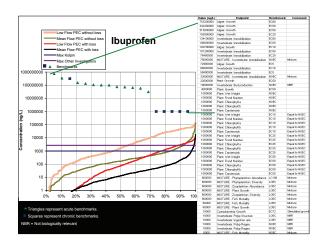
- · Understand the potential for exposure
- Assess potential impacts to man
- · Assess potential impacts to environmental species

P/BMA

Aquatic Life Data Base - PhACT™

- · Includes English language, peer-reviewed literature
 - chronic and acute effects to aquatic organisms
 - fate and transport and treatment removal
- · Bibliographic information entered for 1028 articles
 - 610 chronic and acute effects
 - 618 fate and transport / treatment
- Status
 - data from 583 articles have been entered
 - data from remaining 445 articles will be entered by 2007
 - data from 30-40 new articles entered each quarter

PhRMA-



Summary

- The industry is committed to assessing the significance of pharmaceuticals in the environment using science- based approaches.
- The human risk assessment concluded that, for the compounds investigated to date, no appreciable risk to human health exists.
- The industry is evaluating published data on aquatic life impacts and formulating an approach to assess the potential for impacts to ecosystems.
- The industry is committed to collaborating with other stakeholders

P/RMA-



Other PhRMA PIE Publications

- Till (2005) The detection of pharmaceutical compounds in surface water is a matter of significant interest to the pharmaceutical industry. Sci. Tot. Environ. In press.
- Till (2005) Pharmaceutical data do not elude researchers. *Environ. Sci. Technol.* (Oct 1 2005, p 292a)
- Carbamazepine risk assessment (SETAC presentations, Nov. 2005, May 2006)
- Cunningham et al. Human Health and Environmental Risk Assessment of Carbamazepine in Surface Waters of North America and Europe, submitted for review
- Analgesics case study (SETAC poster, Nov, 2005); manuscript in preparation
- Do pharmaceuticals in surface waters pose a risk to human health? In submission process
- Environmental risk assessment of EE2 in EU and US manuscripts in preparation
- Landfill Disposal of Medicines as a Potential Surface Water Pathway WEF presentation, August 2007, manuscript in preparation



Contributors

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 - Aquatic Life Working Group
 - Human Health Working Group
 - · Environmental Assessment Working Group
 - · Unused Medicines Working Group
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- · Paul Anderson and Beth DuPlessie, AMEC
- · Lial Tischler, Tischler & Kocurek

PARMA

Management of Chemical Substances in Biosolids

Hiromasa Yamashita^{*}, Masaaki Ozaki Recycling Team, Material and Geotechnical Engineering Research Group, Public

Works Research Institute

1. Introduction

Thousands of chemical substances are used in industrial factories, agriculture/aquaculture farms, hospitals and households. Some or most of them are discharged into sewage and flow into wastewater treatment plants.

Chemical substances recognized as environmental pollution recently and not legally regulated for environmental protection, such as endocrine disruptors (EDs), pharmaceuticals and personal care products (PPCPs), are of great concerns for their occurrence and fate in wastewater treatment process because it often happens that sewage is the primary pathway of those substances entering into the environment.

Hydrophobic chemical substances tend to be partitioned in biosolids. When they remained unchanged or retained chemical activity, utilization (especially land application) of those biosolids may cause adverse effect on human health and environment by exposure.

(In FY2002 the total amount of sewage sludge generated was 2,105 kt of dry solids (DS) and around 14% of this amount (293 kt-DS) was recycled for agricultural use.)

2. Objectives

Our research aims to understand the occurrence of chemical substances in biosolids and their fate in biosolids treatment/utilization process. We will develop management method of chemical substances in biosolids, if necessary.

3. Research methods and results

We studied the occurrence and the fate of three categories of chemical substances in biosolids. The categories and research results are as follows;

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(1) Endocrine disrupting chemicals (EDs)

Nonylphenols (NPs), nonylphenol ethoxylates (NPnEOs) and nonylphenol polyethoxycarboxylates (NPnECs) were analyzed by LC/MS/MS.

Biosolids composts from 17 cities in Japan contained detectable level of NPs, NPnEOs and NPnECs.

Anaerobically digested sludge composts contained high concentration of NPs.

NP1-2EO and NP1-2EC were the major contributor to the NPnEOs and NPnECs in composts, respectively.

Ethoxylates chains of NPnEOs and NPnECs were shortened in biosolids composts NPs biodegradation decreased under high temperature condition(70 $^{\circ}$ C)

High temperature operation may suppress the NP degrading microbial activities in the composting plant.

Degradation pathways of NP2EO-NP2EC- (NP1EC)-degradation or NP1EO-NP1EC-degradation played major roles in the aerobic degradation of NPnEOs and NPnECs that remained in biosolids.

(2) Estrogens

Estrone (E1), 17- β estradiol(E2), estriol (E3), ethynylestradiol (EE2) and their conjugates (both glucronated and sulfated) were analyzed by LC/MS/MS.

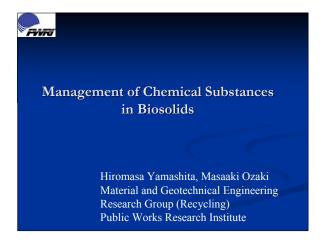
Biosolids composts from 17 cities in Japan contained almost no detectable level of Estrogens.

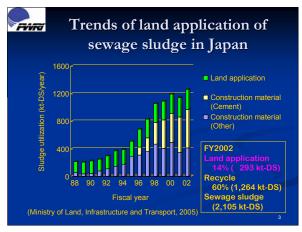
(3) Pharmaceuticals and Personal Care Products (PPCPs)

We conducted a screening research based on several statistics of PPCPs production, use and discharge in Japan to develop a priority PPCPs list in biosolids. We have also developed measurement methods of important PPCPs in biosolids and have been conducting field survey to understand the occurrence and the fate of them.

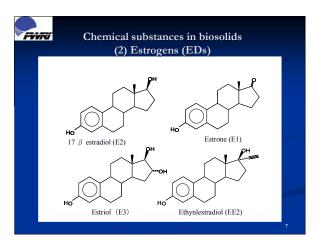
4. Conclusions

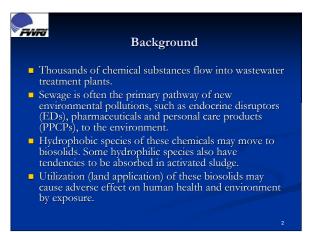
Most of endocrine disrupting chemicals in biosolids were degraded when composted for land application. But they were found in some biosolids composts and need to be studied for effective degradation methods in biosolids utilization/treatment process. PPCPs research is currently in progress and the necessity of development of management methods in biosolids will be discussed in the future.

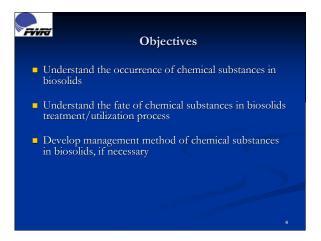


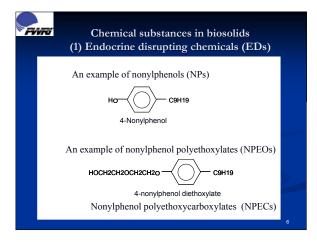


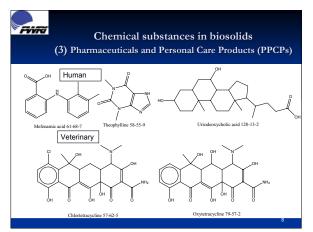


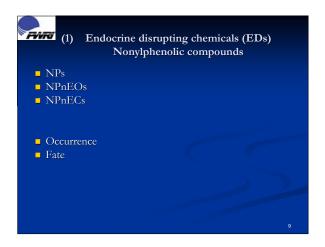


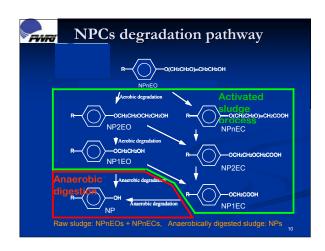


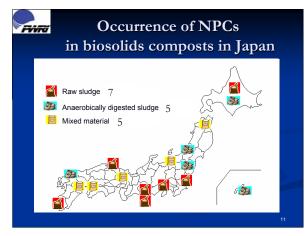


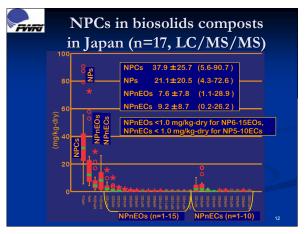


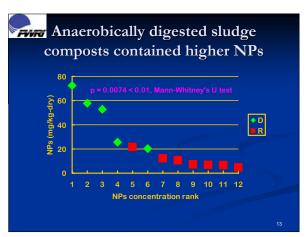


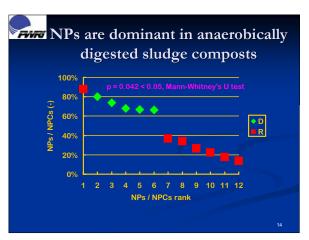


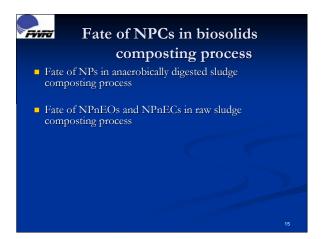


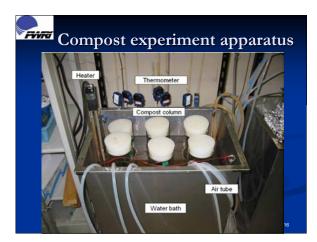


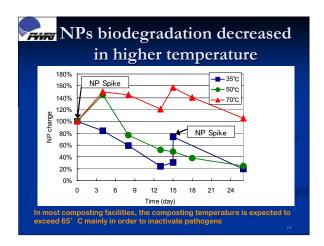


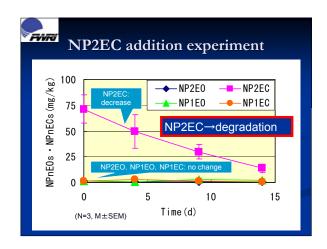


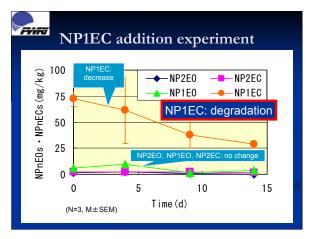


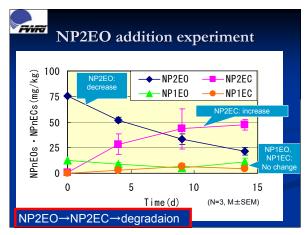


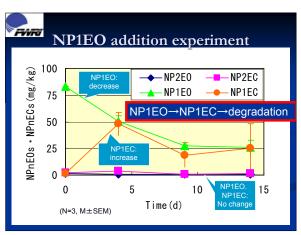


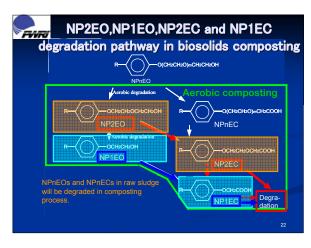


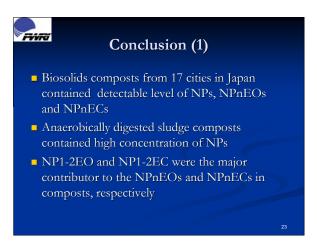


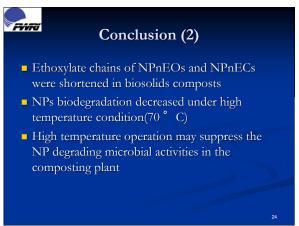


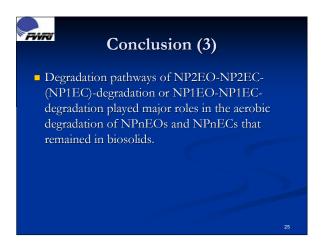


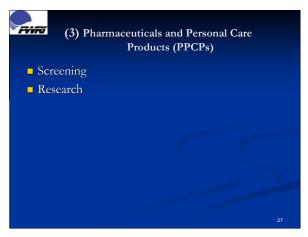


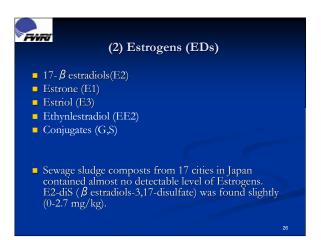












Occurrence of Pharmaceuticals and Personal Care Products in Wastewater Systems

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1. Introduction

Recently, there has been a growing public concern about the emergence of environmental pollution of water sources from pharmaceuticals and personal care products (PPCPs). Considering the route PPCPs take to reach water environment, wastewater treatment plants (WWTPs) may facilitate their initial entry. If PPCPs are not properly treated during the wastewater treatment process, they can contaminate water environment, including drinking water sources.

Considering the current level of knowledge regarding this problem, it is necessary to clarify the fates of PPCPs in WWTPs to identify appropriate treatment methods. In our research, we analyzed the presence of PPCPs in several WWTPs to clarify the concentrations and fates of PPCPs along the units of wastewater treatment.

In addition, toxic effects of antibiotics on aquatic organisms were evaluated with ecotoxicity tests, and ecological risk of the antibiotics was evaluated by comparison between concentrations in water environment and ecotoxicity results.

2. Survey Sites and Methods

Surveys were conducted in four or six WWTPs employing conventional activated sludge process, depending on the type of the PPCPs. Twenty four-hour water flow proportional composite samples were collected from several sampling locations in each WWTP.

The target PPCPs were four anti-inflammatories (aspirin, ketoprofen, ibuprofen, naproxen), a phenolic antiseptic (triclosan), three amide pharmaceuticals (crotamiton, diethyltoluamide, carbamazepine) and two antibiotics (levofloxacin, clarithromycin). They were analyzed with GC/MS or LS/MS/MS after sample extraction and purification according to the methods by Nakada,N. et al.(2006) and Yasojima, M. et al.(2006). Ecotoxicity was evaluated with the tests using bacterium, alga and crustacean.

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3. Occurrence and Fate of PPCPs

The PPCP concentrations in the influent were of the order of hundreds ng/L, except for carbamazepine of the order of tens ng/L. Almost all of the PPCPs existed in the dissolved form except for triclosan and antibiotics, which might be the reason for no remarkable decrease after the primary sedimentation tank.

During the biological treatment, two anti-inflammatories (aspirin and ibuprofen) and triclosan were effectively removed, while the remaining anti-inflammatories (ketoprofen and naproxen), diethyltoluamide and antibiotics showed around 50% reduction, and crotamiton and carbamazepine was hardly removed.

The fates of PPCPs were evaluated by calculating the mass balance of PPCPs in the WWTPs. Ibuprofen was significantly removed and degraded by the activated sludge in the aeration tank (Figure 1), while triclosan was removed by the adsorption to the activated sludge and the accumulation in the sludge was observed (Figure 2). Antibiotics was removed mainly by the adsorption to the activated sludge, and accumulation in the sludge was observed.

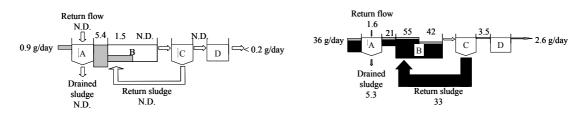


Figure 1 Mass balance of ibuprofen in WWTP

Figure 2 Mass balance of triclosan in WWTP

4. Ecotoxicity of Antibiotics

Microtox test using marine fluorescent bacterium and Daphnia immobilization test showed that levofloxacin (LVFX) and clarithromycin (CAM) have no acute toxicity on bacterium. Meanwhile, algal growth inhibition test revealed that LVFX and CAM have a toxicity to microalga, but the phytotoxicity of CAM was about 100 fold higher than that of LVFX.

Comparison of the concentration in aquatic environment and PNEC indicates that CAM discharged into aquatic environment may affect algae if dilution rate is low.

Reference

Nakada,N. et al.(2006) Pharmaceutical chemicals and endocrine disrupters in municipal wastewater in Tokyo and their removal during activated sludge treatment, Water Research 40, 3297-3303

Yasojima, M. et al.(2006) Occurrence of levofloxacin, clarithromysin and azithromycin in wastewater treatment plant in Japan, Wat. Sci. & Tech., 53(11), 227-233

Occurrence of Pharmaceuticals and Personal Care Products in Wastewater Systems

Yutaka SUZUKI*, Koya KOMORI*, Arata HARADA*, Norihide NAKADA* and Makoto YASOJIMA**

*Water Quality Research Team Water Environment Research Group Public Works Research Institute **Towa Kagaku Corporation



- In our research, we conducted surveys in several WWTPs to clarify the concentrations and fates of PPCPs along the units of wastewater treatment.
- In addition, toxic effects of PPCPs on aquatic organisms were evaluated with ecotoxicity tests.

PPCPs grouping by structural characteristics

 Anti-inflammatory drugs: Aspirin, Ibuprofen, Fenoprofen, Naproxen, Mefenamic Acid, Ketoprofen

Having carboxl group (-COOH)

Group A

· Phenolic antiseptic: Triclosan

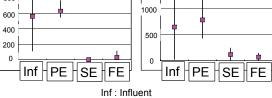
Having Phenol

Group B

· Amide pharmaceuticals:

Crotamiton (relieve itching)
Carbamazepine (Antiepileptic)

Group C

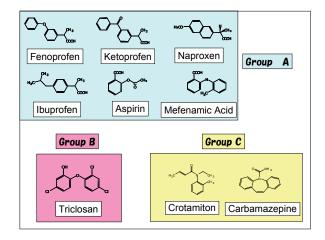


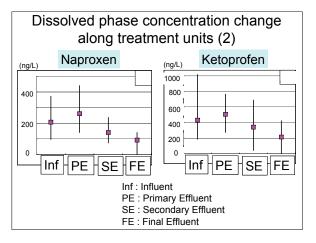
PE : Primary Effluent SE : Secondary Effluent FE : Final Effluent

1. Introduction

- Growing public concern about the environment pollution of pharmaceuticals and personal care products (PPCPs)
- -From existing research, wastewater treatment plants (WWTPs) may facilitate the initial entry of PPCPs to water environment
- -It is important to clarify the occurrence and fates of PPCPs in WWTPs to evaluate both the effect of treated wastewater on water environment and the performance of WWTPs to remove PPCPs

2. Occurrence and Fate of PPCPs (Anti-inflammatory Drugs, etc.) in WWTPs Final Secondary Primary effluent Influent Effluent Chlorine Primary Final Sedimentation Sedimentation Aeration Tank Treatment method: Conventional activated sludge process Treatment capacity: 22,500~700,000 m³/d Number of plants surveyed: 4 Sampling: Composite sample taken every 2 hours

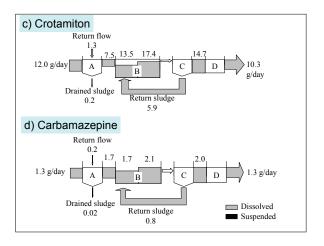


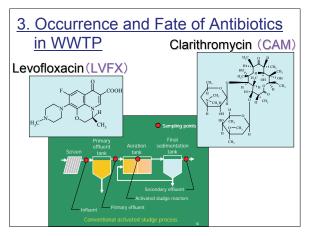


Dissolved phase concentration change along treatment units (3) Carbamazepine Crotamiton (ng/L) (ng/L) 100 80 1000 60 40 500 20 0 0 Inf Inf | PE | SE | FE PE SEHFE Inf · Influent PE : Primary Effluent SE: Secondary Effluent FE: Final Effluent

From the survey of 4 WWTPs,

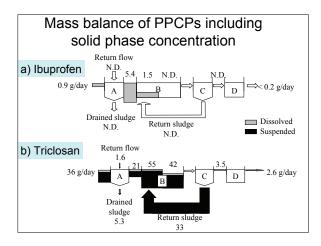
- -PPCPs (anti-inflammatory drugs, etc) concentraion in dissolved phase in influent ranged from hundreds to one thousand ng/L except for Carbamazepine
- -PPCPs could be classified into three groups by the removal ratio in WWTPs





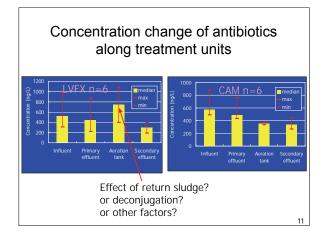
Average PPCP removal ratio in WWTPs

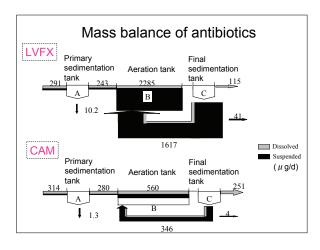
PPCPs		Removal ratio (%)
Aspirin	Anti-inflammatory	96
Ibuprofen	Anti-inflammatory	95
Triclosan	Antiseptic	90
Naproxen	Anti-inflammatory	55
Ketoprofen	Anti-inflammatory	50
Crotamiton	relieve itching	20
Carbamazepine	Antiepileptic	-25
Mefenamic acid	Anti-inflammatory	-240



From the mass balance survey in a WWTP,

- -Almost of all of the PPCPs existed in the dissolved phase, except for Triclosan which mostly existed in solid phase.
- -lbuprofen was decomposed in the biological treatment process effectively
- -Triclosan was removed by the adsorption to the activetaed sludge, and was accumulated in the activated sludge in a high concentration.
- Crotamiton and Carbamazepine was hardly changed in the process





4. Effect of PPCPs on Aquatic Organisms

Ecotoxicity tests (acute toxicity) applied

- Bacterium: Microtox test
- Alga: Algal growth inhibition test
- Crustacean: Daphnia acute immobilization test



Comparison between EC50 and the concentration of wastewater

	EC50	Influent	Final
	(a)	(b)	effluent (c)
Triclosan (μ g/L)	400	1	0.1
(b or c)/a		1/400	1/4000
Clarithromycin (μ g/L)	11	0.6	0.4
(b or c)/a		1/18	1/28

Conclusion

- The concentration of most PPCPs in influent ranged from hundreds to one thousand ng/L
- Several patterns of PPCP removal in the treatment process were observed;
 - a) effectively decomposed by activated sludge
 - b) adsorbed to activated sludge
 - c) hardly changed
- Some PPCPs showed ecotoxicity, but the concentration of the order of mg/L
- Antibiotic in treated wastewater might be evaluated to have toxic effect on Alga

From the survey of antibiotics,

- -Antibiotics concentration in the influent ranged from hundreds to one thousand ng/L, and the removal ratio in WWTPs was around 50%
- -LVFX was removed by the adsorption to the activated sludge, and was accumulated in the activated sludge in a high concentration
- -CAM accumulation in the sludge was small, which might indicate biodegradation by the activated sludge

Results of Ecotoxicity tests (mg/L)							
PPCPs	Microtox test		Algal growth inhibition test	Daphnia acute immobilization test			
	EC50		EC50	EC50			
	5min	15min	96hour	24hour	48hour		
Aspirin	N.E.	N.E.	/	N.E.	N.E.		
Triclosan	0.6	0.6	/	0.4	0.4		
Crotamiton	57.6	N.E.	/	N.E.	N.E.		
Levofloxacin	N.E.	N.E.	1.435	N.E.	N.E.		
Clarithromycin	N.E.	N.E.	0.011	N.E.	N.E.		

N.E.: No Effect

From the ecotoxicity tests,

- Antiseptic agent (Triclosan) showed toxicity on Bacterium and Crustacean
- Antibiotics showed inhibition to Algal growth
- The toxic effect concentration was in the order of mg/L except for Clarithromycin
- Clarithromycin in treated wastewater might be evaluated to have toxic effect on Alga if NOEC is obtained

Occurrence, Treatment, and Toxicological Relevance of Endocrine Disruptors and Pharmaceuticals in Drinking Water

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1. Introduction

Over the past decade a great amount of interest has arisen regarding the occurrence and fate of trace organic contaminants in the aquatic environment. Of particular concern are human hormones and pharmaceuticals, many of which are ubiquitous contaminants in conventional municipal wastewater treatment plant effluents when measured with ng/L detection limits. As analytical procedures and bioassay techniques become more readily available and increasingly sensitive, additional new contaminants will be discovered. The presence or absence of any chemical in commerce in a wastewater effluent is essentially a function of the analytical detection capability. This poses a unique challenge for water treatment processes intent on the removal of organic contaminants, as complete removal is merely a reflection of an analytical reporting limit. The projects described here sought to was designed to investigate the attenuation of a group of structurally diverse emerging contaminants in a variety of commonly utilized conventional and advanced water treatment processes and to determine the concentration of these compounds in drinking water that would be expected to invoke toxicological responses in humans.

This study shows that the majority of emerging contaminants can be readily removed using ozone or UV-advanced oxidation. However, some compounds are recalcitrant and difficult to oxidize using commonly employed oxidant doses. Magnetic ion-exchange (MIEX ®) provided minimal contaminant removal; however, contaminants that were negatively charged at ambient pH were well removed. Activated carbon, both in powdered and granular forms, was effective for contaminant absorption. Carbon type, contact time, and dose or regeneration are influential parameters in removal efficacy by activated carbon. No single treatment process was capable of removing all contaminants consistently to less than the analytical method reporting limits employed. Moreover, each treatment process provided advantages and disadvantages that will be discussed in this chapter. A multi-barrier approach would

provide the most comprehensive removal strategy for organic contaminant treatment.

The human health relevance of pharmaceuticals detected in full scale drinking water facilities in the US was investigated. A series of toxicological endpoints were evaluated, and the most sensitive endpoint chosen as a point of departure. In some cases, the most sensitive endpoint was not the therapeutic effect of the pharmaceutical. For all pharmaceuticals investigated, the drinking water equivalent level (DWEL) of concern was in µg/L, or larger, concentrations. Therefore, there appears to be no human health relevance at the levels detected in drinking water. A further component of this study sought to investigate endocrine disrupting impacts of select EDCs. The EDC component also included an investigation into the estrogenicity of common food items as compared to drinking and reuse water. The concentrations of selected chemicals to induce EDC effects occurred at concentrations far above those found in US drinking waters. Moreover, the concentrations of these chemicals in food/beverage items were often orders of magnitude greater than those find in water. Using an in vitro bioassay, it was determined that the estrogenicity of soy sauce, green tea, and milk were orders of magnitude greater than estrogenicity of water (even wastewater). It is unlikely the endocrine disruptive effects from trace organic chemicals are relevance in US drinking waters.

2. Overview

2.1 History

In 1965 Stumm-Zollinger and Fair of Harvard University published the first known report indicating that steroid hormones are not completely eliminated by wastewater treatment (Stumm-Zollinger and Fair 1965). In an article published in 1970, Tabak and Bunch investigated the fate of human hormones during wastewater treatment and stated "since they (hormones) are physiologically active in very small amounts, it is important to determine to what extent the steroids are biodegraded" (Tabak and Bunch 1970). As early as the 1940s, scientists were aware that certain chemicals had the ability to mimic endogenous estrogens and androgens (Schueler 1946; Sluczewski and Roth 1948). In 1977, researchers from the University of Kansas published the first known report specifically addressing the discharge of pharmaceuticals from a wastewater treatment plant (Hignite and Azarnoff 1977). Despite these early findings, the issue of steroids and pharmaceuticals in wastewater outfalls did not gain significant attention until the 1990s, when the occurrence of natural and synthetic steroid hormones in wastewater was linked to reproductive impacts in fish living downstream of outfalls (Purdom, Hardiman et al. 1994; Desbrow, Routledge et al. 1998; Routledge, Sheahan et al. 1998).

Since the initial link between trace contaminants (sub-µg/L) in wastewater

effluents and ecological impacts in receiving waters, many studies have focused on the occurrence of these contaminants (Halling-Sorensen, Nielsen et al. 1998; Ternes, Hirsch et al. 1998; Daughton and Ternes 1999; Snyder, Keith et al. 1999; Metcalfe, Koenig et al. 2000; Ternes and Hirsch 2000; Snyder, Kelly et al. 2001; Kolpin, Furlong et al. 2002; Vanderford, Pearson et al. 2003). As a result, pharmaceuticals and steroid hormones have been detected in many water bodies around the world (Kolpin, Furlong et al. 2002; Cargouet, Perdiz et al. 2004; Petrovic, Eljarrat et al. 2004). One major contributor of such widespread contamination is municipal wastewater discharge, which impacts surface water quality by contaminating receiving water bodies with chemicals not completely removed by current treatment processes. Indirect potable water reuse, either planned or unplanned, can occur when wastewater treatment plant discharge comprises a significant portion of the receiving stream's total flow. In some cases, effluent dominated surface waters are used as source waters for drinking water treatment facilities. Global water sustainability depends in part upon effective reuse of water. In particular, the reuse of municipal wastewater for irrigation and augmentation of potable water supplies is critical. Public perception and concern regarding trace hormones and pharmaceuticals is creating resistance to reuse projects. necessary to obtain accurate information on the attenuation or elimination of these contaminants from wastewater, the impact of wastewater discharge on surface water or groundwater supplies, and the removal efficiency of the remaining contaminants by drinking water treatment processes.

A significant number of articles have investigated the fate of trace hormones and pharmaceuticals in water treatment processes (Ternes, Kreckel et al. 1999; Ternes, Stumpf et al. 1999; Snyder, Westerhoff et al. 2003; Huber, Korhonen et al. 2005; Westerhoff, Yoon et al. 2005; Snyder, Adham et al. 2006; Snyder, Wert et al. 2006; Yoon, Westerhoff et al. 2006). The ability of a particular treatment process to remove organic contaminants depends mostly on the structure and concentration of the contaminant. In addition, the operational parameters of the process (e.g., oxidant dose and contact time) will also determine the degree of attenuation of a particular contaminant.

3. Results

The results from US drinking water testing for select EDCs and pharmaceuticals are shown in Table 1. The insect repellant N,N diethyl-*m*-toluamide (DEET), the suspected endocrine disrupting herbicide atrazine, and the anti-anxiety pharmaceutical meprobamate were the top three occurring contaminants, respectively, in this study. In raw waters, the profile was quite different. The greatest impact in most water treatment systems occurs during disinfection. Disinfection with ozone provided, by far, the greatest removal of contaminants, followed by free chlorine,

chloramine, and UV, respectively (Tables 2-5). In full scale plants, removal by disinfection was quite comparable to that predicted in bench and pilot scale testing. Removal by activated carbon and membranes can be highly efficient depending upon the operation parameters (Snyder, Adham et al. 2006); however, these processes are far less common in US drinking water treatment facilities. While ozone was found to be highly-efficient oxidizing selected contaminants in both drinking and reuse waters (Snyder, Wert et al. 2006), the formation of oxidation products must be considered.

The human health consideration of selected trace contaminants was evaluated. Table 6 provides the DWEL values for some of the contaminants considered. Using the MCF-7 *in vitro* bioassay, it was demonstrated that estrogenicity of recommended serving sizes of soy sauce, green tea, and cows milk provided far greater estrogenicity than did any wastewater or drinking water. These data show that using an *in vitro* measure of estrogenicity may not be suitable for extrapolation to health risk. Oxidation by ozone and chlorine readily degraded any observed estrogenicity, and subsequent byproducts were no longer estrogenic.

4. Conclusions

Trace levels of hormones and pharmaceuticals are ubiquitous contaminants of municipal wastewater effluents. The detection of these chemicals is a direct function of analytical detection limits. Therefore, more and more trace contaminants will continue to be discovered. Water treatment processes have various levels of efficacy in the attenuation of these contaminants. In drinking water, oxidation provides a cost-effective means for disinfection and simultaneous contaminant removal. Those compounds which are resilient to oxidation are often detected in finished US drinking waters. However, the concentration at which these occur is extremely small, and far below the concentrations that would be expected to be of human health concern. In an evaluation of estrogenicity as a class of toxicity, the estrogenicity of common food items is far beyond that of any wastewater or drinking water evaluated. The relative risk factors of common exposure to EDCs through foods and beverages appears to be far greater than the exposure through drinking water. More research is needed to adequately address human health relevance of EDCs and pharmaceuticals, but it is likely that most drinking waters do not provide a substantial exposure and the concentrations expected to have human health detriment.

5. References

Cargouet, M., D. Perdiz, et al. (2004). "Assessment of river contamination by estrogenic compounds in Paris area (France)." <u>Science Of The Total Environment</u> **324**(1-3):

55-66.

- Daughton, C. G. and T. A. Ternes (1999). "Pharmaceuticals and Personal Care Products in the Environment: Agents of Subtle Change?" Environmental Health Perspectives 107(6): 907-938.
- Desbrow, C., E. J. Routledge, et al. (1998). "Identification of Estrogenic Chemicals in STW Effleunt. 1. Chemical Fractionation and in Vitro Biological Screening."

 <u>Environmental Science & Technology</u> **32**(11): 1549-1558.
- Halling-Sorensen, B., S. N. Nielsen, et al. (1998). "Occurrence, Fate and Effects of Pharmaceutical Substances in the Environment A Review." <u>Chemosphere</u> **36**(2): 357-393.
- Hignite, C. and D. L. Azarnoff (1977). "Drugs and drug metabolites as environmental contaminants: chlorophenoxyisobutyrate and salicylic acid in sewage water effluent." <u>Life Sciences</u> **20**(2): 337-341.
- Huber, M. M., S. Korhonen, et al. (2005). "Oxidation of pharmaceuticals during water treatment with chlorine dioxide." <u>Water Research Water Research</u> **39**: 3607-3617.
- Kolpin, D. W., E. T. Furlong, et al. (2002). "Pharmaceuticals, Hormones, and Other Organic Waste Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance."
 Environmental Science & Technology 36(6): 1202-1211.
- Metcalfe, C. D., B. Koenig, et al. (2000). <u>Drugs in sewage treatment plant effluents in Canada</u>. ACS National Meeting, American Chemcial Society.
- Petrovic, M., E. Eljarrat, et al. (2004). "Endocrine disrupting compounds and other emerging contaminants in the environment: A survey on new monitoring strategies and occurrence data." <u>Analytical and Bioanalytical Chemistry</u> **378**(3): 549-562.
- Purdom, C. E., P. A. Hardiman, et al. (1994). "Estrogenic effects of effluents from sewage treament works." <u>Chemistry and Ecology</u> **8**: 275-285.
- Routledge, E. J., D. Sheahan, et al. (1998). "Identification of estrogenic chemicals in STW effluent. 2. In vivo responses in trout and roach." Environmental Toxicology and Chemistry 32(11): 1559-1565.
- Schueler, F. W. (1946). "Sex-hormonal action and chemical constitution." <u>Science</u> **103**: 221-223.
- Sluczewski, A. and P. Roth (1948). "Effects of androgenic and estrogenic compounds on the experimental metamorphoses of amphibians." <u>Gynecology and obstetrics</u> **47**: 164-176.
- Snyder, S. A., S. Adham, et al. (2006). "Role of Membranes and Activated Carbon in the Removal of Endocrine Disruptors and Pharmaceuticals." <u>Desalination</u> **202**: 156-181.
- Snyder, S. A., T. L. Keith, et al. (1999). "Analytical methods for detection of selected estrogenic compounds in aqueous mixtures." <u>Environmental Science & Technology</u> **33**(16): 2814-2820.

- Snyder, S. A., K. L. Kelly, et al. (2001). Pharmaceuticals and personal care products in the waters of Lake Mead, Nevada. <u>Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues</u>. C. G. Daughton and T. L. Jones-Lepp. Washington, D.C., American Chemical Society. <u>Symposium Series 791:</u> 116-140.
- Snyder, S. A., E. C. Wert, et al. (2006). "Ozone oxidation of endocrine disruptors and pharmaceuticals in surface water and wastewater." <u>Ozone Science & Engineering</u> **28**: 445-460.
- Snyder, S. A., P. Westerhoff, et al. (2003). "Pharmaceuticals, Personal Care Products, and Endocrine Disruptors in Water: Implications for the Water Industry." <u>Environmental Engineering Science</u> **20**(5): 449-469.
- Stumm-Zollinger, E. and G. M. Fair (1965). "Biodegradation of steroid hormones." <u>Journal of the Water Pollution Control Federation</u> 37: 1506-1510.
- Tabak, H. H. and R. L. Bunch (1970). "Steroid hormones as water pollutants. I. Metabolism of natural and synthetic ovulation-inhibiting hormones by microorganisms of activated sludge and primary settled sewage." <u>Dev. Ind. Microbiol.</u> 11: 367-376.
- Ternes, T. A. and R. Hirsch (2000). "Occurrence and behavior of x-ray contrast media in sewage facilities and the aquatic environment." <u>Environmental Science & Technology</u> **34**: 2741-2748.
- Ternes, T. A., R. Hirsch, et al. (1998). "Methods for the determination of neutral drugs as well as betablockers and β₂-sympathomimetics in aqueous matrices using GC/MS and LC/MS/MS." <u>Fresenius' Journal of Analytical Chemistry</u> **362**: 329-340.
- Ternes, T. A., P. Kreckel, et al. (1999). "Behaviour and occurrence of estrogens in municipal sewage treatment plants II. Aerobic batch experiments with activated sludge." <u>The Science of the Total Environment</u> **225**: 91-99.
- Ternes, T. A., M. Stumpf, et al. (1999). "Behavior and occurrence of estrogens in municipal sewage treatment plants I. Investigations in Germany, Canada and Brazil." The Science of the Total Environment 225: 81-90.
- Vanderford, B. J., R. A. Pearson, et al. (2003). "Analysis of Endocrine Disruptors, Pharmaceuticals, and Personal Care Products in Water Using Liquid Chromatography/Tandem Mass Spectrometry." <u>Analytical Chemistry</u> **75**(22): 6265-6274.
- Westerhoff, P., Y. Yoon, et al. (2005). "Fate of endocrine-disruptor, pharmaceutical, and personal care product chemicals during simulated drinking water treatment processes" Environmental Science & Technology 39(17): 6649-6663.
- Yoon, Y., P. Westerhoff, et al. (2006). "Removal endocrine disrupting compounds and pharmaceuticals by nanofiltration and ultrafiltration membranes." <u>Desalination</u> **202**: 16-23.

Table 1. Occurrence of EDCs and Pharmaceuticals in 20 US Drinking Waters

Compound	Hits	% Freq	Min (ng/L)	Max (ng/L)	Median (ng/L)	Ave (ng/L)
DEET	18	90	2.1	30	5.1	8.2
Atrazine	15	75	1.4	430	29	74
Meprobamate	15	75	1.6	13	3.8	6.1
Dilantin	14	70	1.1	6.7	2.3	2.7
Ibuprofen	13	65	1	32	3.8	7.9
Iopromide	13	65	1.1	31	6.5	8.5
Caffeine	12	60	2.6	83	23	25
Carbamazepine	11	55	1.1	5.7	2.8	2.8
TCEP	7	35	3	19	5.5	10.1
Gemfibrozil	5	25	1.3	6.5	4.2	3.9
Metalochlor	4	20	14	160	86	86
Estrone	2	10	1.1	2.3	1.7	1.7
Progesterone	2	10	1.1	1.1	1.1	1.1
Erythromycin	1	5	1.3	1.3	1.3	1.3
Musk Ketone	1	5	17	17	17	17
Naproxen	1	5	8	8	8	8.0
Sulfamethoxazole	1	5	20	20	20	20
Triclosan	1	5	43	43	43	43
Trimethoprim	1	5	1.3	1.3	1.3	1.3

Table 2. Summary of Removal by Ozone Disinfection

24 Minutes Contact Time					
> 80% Removal	50-80% Removal	20-50% Removal	< 20% Removal		
Acetaminophen	DEET	Atrazine	TCEP		
Androstenedione	Diazepam	Iopromide			
Caffeine	Dilantin	Meprobamate			
Carbamazepine	Ibuprofen				
Diclofenac					
Erythromycin					
Estradiol					
Estriol					
Estrone					
Ethynylestradiol					
Fluoxetine					
Gemfibrozil					
Hydrocodone					
Naproxen					
Oxybenzone					
Pentoxifylline					
Progesterone					
Sulfamethoxazole					
Triclosan					
Trimethoprim					
Testosterone					

Table 3. Summary of Removal by Free Chlorine

Chlorine	Chlorine Dose = 3 mg/L, Contact Time = 24 hours, pH=7.9-8.5					
> 80% Removal	50-80% Removal	20-50% Removal	< 20% Removal			
Acetaminophen	Gemfibrozil	Diazepam	Androstenedione			
Benzo(a)pyrene		Galaxolide	Atrazine			
Diclofenac		Pentoxifylline	Caffeine			
Erythromycin			Carbamazepine			
Estradiol			DDT			
Estriol			DEET			
Estrone			Dilantin			
Ethynylestradiol			Fluorene			
Hydrocodone			Fluoxetine			
Musk Ketone			g-BHC			
Naproxen			Ibuprofen			
Oxybenzone			Iopromide			
Sulfamethoxazole			Meprobamate			
Triclosan			Metolachlor			
Trimethoprim			Progesterone			
			TCEP			
			Testosterone			

Table 4. Summary of Removal by Chloramine

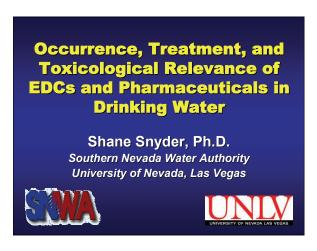
	Chloramine Dose = 3 mg	/L, Contact Time = 24 ho	ours
> 80% Removal	50-80% Removal	20-50% Removal	< 20% Removal
Acetaminophen	Benzo(a)pyrene	Hydrocodone	Androstenedione
Estradiol	Diclofenac	Galaxolide	Atrazine
Estriol	Oxybenzone		Caffeine
Estrone			Carbamazepine
Ethynylestradiol			DDT
Triclosan			DEET
			Diazepam
			Dilantin
			Erythromycin
			Fluorene
			Fluoxetine
			g-BHC
			Gemfibrozil
			Ibuprofen
			Iopromide
			Meprobamate
			Metolachlor
			Musk Ketone
			Naproxen
			Pentoxifylline
			Progesterone
			Sulfamethoxazole
			TCEP
			Testosterone
			Trimethoprim

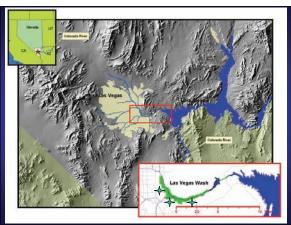
Table 5. Summary of Removal by UV disinfection (40 mJ/cm²)

> 80% Removal	50-80% Removal	20-50% Removal	< 20% Removal
	Diclofenac	Acetaminophen	Androstenedione
	Sulfamethoxazole		Atrazine
	Triclosan		Caffeine
			Carbamazepine
			DEET
			Diazepam
			Dilantin
			Erythromycin-H ₂ O
			Estradiol
			Estriol
			Estrone
			Ethynylestradiol
			Fluoxetine
			Gemfibrozil
			Hydrocodone
			Ibuprofen
			Iopromide
			Meprobamate
			Naproxen
			Oxybenzone
			Pentoxifylline
			Progesterone
			TCEP
			Testosterone
			Trimethoprim

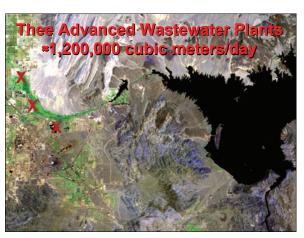
Table 6. Human Health Evaluation of Select Contaminants

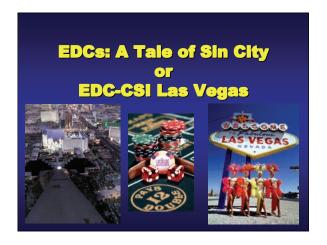
Drug	Composite Safety Factor	DWEL (ng/L)	Max Finished Water Conc. (ng/L)	Margin of Safety
Atenolol	300	81,000	20	4,100
Atorvastatin			<0.25	380,000
o-hydroxy atorvastatin	1,000	96,000	<0.50	190,000
o-hydroxy atorvastatin			<0.50	190,000
Carbamazepine	3,000	330,000	18	18,000
Diazepam	1,000	4,800	<0.25	19,000
Diclofenac	300	66,000	<0.25	260,000
Enalapril	300	33,000	<0.25	130,000
Fluoxetine	1,000	36,000	<0.50	66,000
Gemfibrozil	1,000	450,000	2.1	210,000
Meprobamate	1,000	480,000	43	11,000
Naproxen	300	330,000	<0.50	960,000
Phenytoin	1,000	2,400,000	15	160,000
Risperidone	1,000	780	0.34	2,300
Simvastatin	3,000	57,000	<0.25	230,000
Simvastatin hydroxy acid			<0.25	230,000
Sulfamethoxazole	300	3,900,000	3	1,300,000
Triclosan	1,000	29,000	1.2	24,000
Trimethoprim	300	1,100,000	<0.25	4,400,000



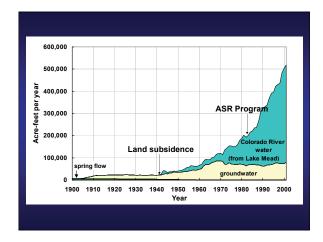


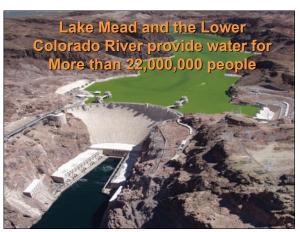


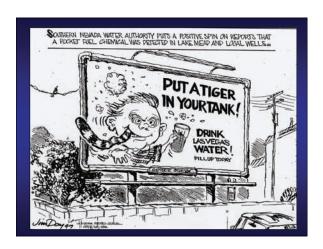


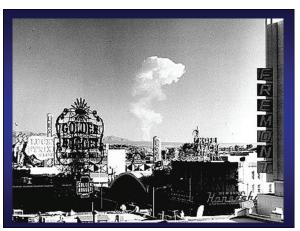




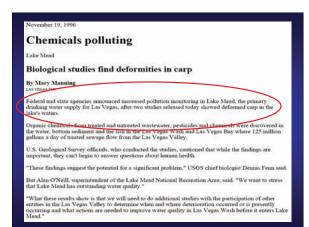


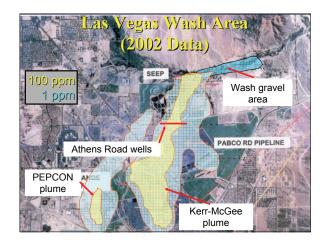
















REVIEW-JOURNAL review-Journal.com November 20, 1996 Copyright © Las Vegas Review-Journal Park Service to step up water monitoring at Lake Mead Keith Rogers Park service to monitor Lake Mead water more Despite a study's findings about Lake Mead pollution, the drinking water is safe, the water authority says. By Keith Rogers Review-Journal

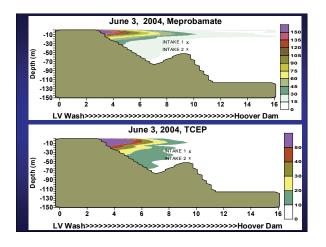
The National Park Service said Tuesday it will increase monitoring of **Lake Mead**'s water quality in the wake of a new federal study that claims a potential link between pollution and problems with carp reproductive systems.

'We're concerned. We all feel we need to find out more,' said Bill Dickinson, assistant superintendent at Lake Mead National Recreation Area.



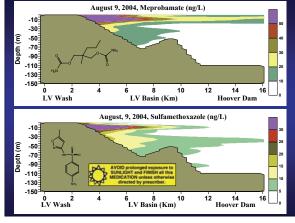


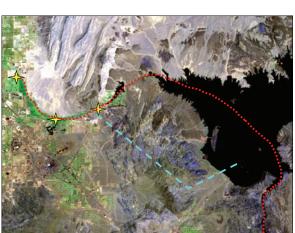


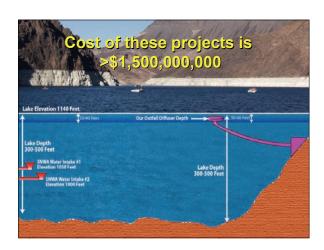










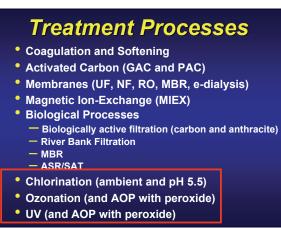


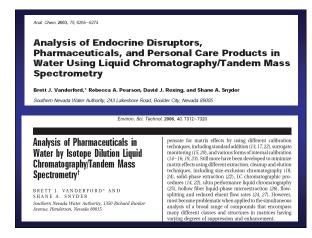


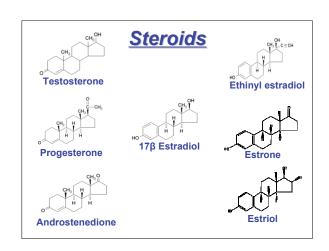
The US Fish & Wildlife Service is requesting a flow-through fish exposure study to compare our current wastewater to wastewater after advanced treatment processes (i.e., membranes, ozone, UV-AOP)

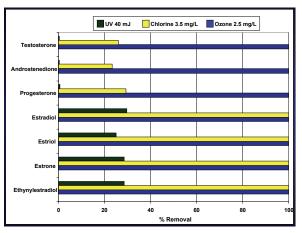


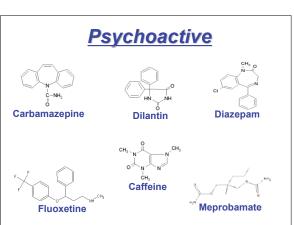


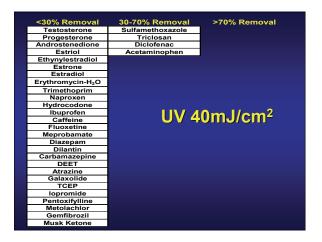




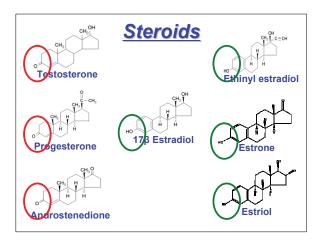


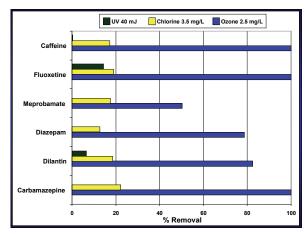


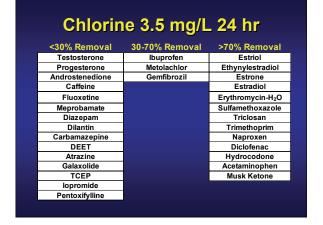


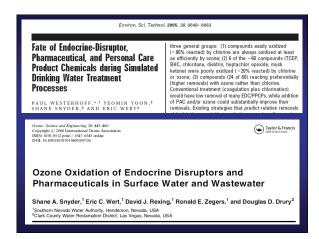


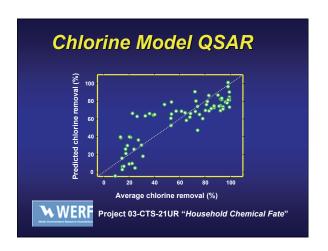
<30% Removal	30-70% Removal	>70% Removal
Musk Ketone	Meprobamate	Testosterone
TCEP	Atrazine	Progesterone
	lopromide	Androstenedione
		Estriol
		Ethynylestradiol
		Estrone
		Estradiol
Ozone 2.	5 ma/l	Erythromycin-H2O
O20116 2.	o ilig/L	Sulfamethoxazole
	9	Triclosan
		Trimethoprim
		Naproxen
		Diclofenac
		Ibuprofen
		Hydrocodone
		Acetaminophen
		Carbamazepine
		Dilantin
		Diazepam
		Caffeine
		Fluoxetine
		DEET
		Metolachlor
		Galaxolide
		Pentoxifylline
		Gemfibrozil

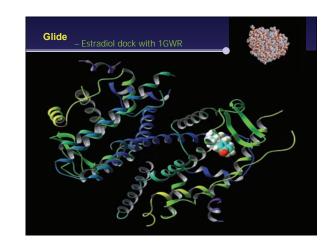






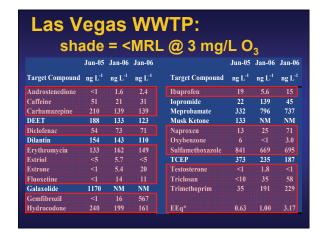




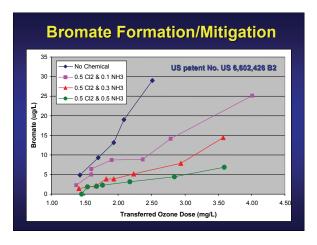


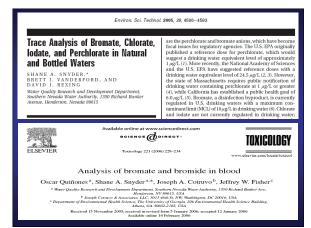


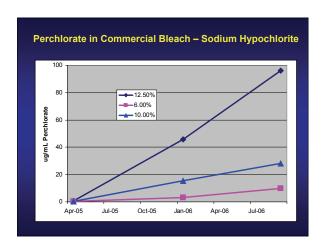
	Jun-05	Jan-06	Jan-06		Jun-05	Jan-06	Jan-0
Target Compound	ngL^4	$ngL^{\text{-}1}$	$ngL^{\text{-}1}$	Target Compound	$ngL^{\text{-}1}$	$ngL^{\text{-}1}$	ng L
Androstenedione	<1	1.6	2.4	Ibuprofen	19	5.6	15
Caffeine	51	21	31	Iopromide	22	139	45
Carbamazepine	210	139	139	Meprobamate	332	796	737
DEET	188	133	123	Musk Ketone	133	NM	NM
Diclofenac	54	73	71	Naproxen	13	25	71
Dilantin	154	143	110	Oxybenzone		<1	3.0
Erythromycin	133	162	149	Sulfamethoxazole	841	669	695
Estriol	<5	5.7	<5	TCEP	373	235	187
Estrone	<1	5.4	20	Testosterone	<1	1.8	<1
Fluoxetine	<1	14	11	Triclosan	<10	35	58
Galaxolide	1170	NM	NM	Trimethoprim	35	191	229
Gemfibrozil	<1	16	567				
Hydrocodone	240	199	161	EEq*	0.63	1.00	3.17





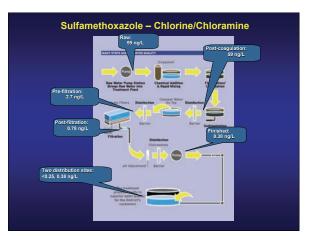




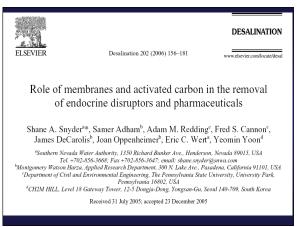


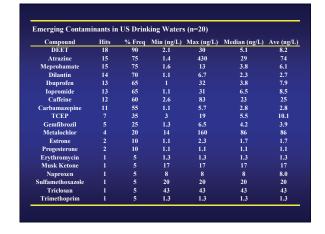


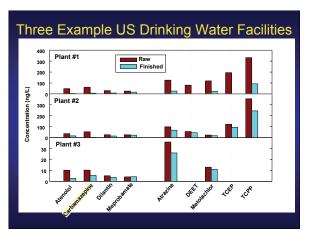




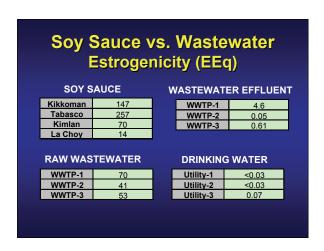




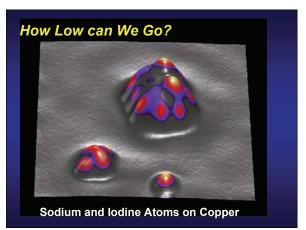


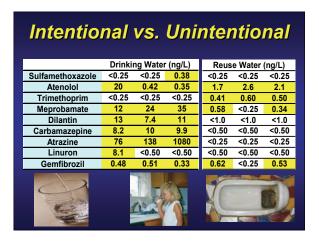


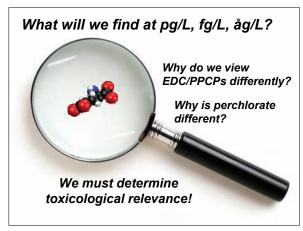
Relevance to Human Health (mg/kg-d) 0.8 (LOAEL) Developmental, human 0.0027 3,000 0.011 200 (LOAEL) Developmental, rat 1 (LOAEL) 0.16 1,000 4 (NOAEL) 0.65 0.0022 0.3 (LOAEL) Developmental, babooi Developmental, rat 7.5 (LOAEL) 0.0012 92 (NOAEL) Reproductive, rat 15 1,000 0.015 No data No data 20 (NOAEL) Developmental, rat 0.011 0.16 (LOAEL) Reproductive, rat 0.026 1,000 0.000026 0.011 250 (NOAEL) Reproductive, rat 0.13













Conclusions • EDCs and Pharmaceuticals are ubiquitous • Removal related to structure (and dose) — Chlorine good for phenolics, less effective for ketones — Ozone more effective than chlorine — UV ineffective at disinfection doses • Effective with high-energy UV & AOP using peroxide • Ozone eliminates in vitro estrogenicity • Surface water under influence of conventional WWTPs will have more trace contaminants than IPR system

Take Home Thoughts...

- Non-detect ≠ Safe
- Safe ≠ Non-detect
- Non-detect ≠ Zero
- · Consider public perception
- · Consider public dollars
 - The public will pay for monitoring programs
 - The public will pay for additional treatment
- · There is NO silver bullet
 - Oxidation = Byproducts
 - Membranes = Brines
 - Activated Carbon = Disposal/Regeneration
 - ALL processes use energy = air quality issues





- > Leaders in sustainability
- > Model City for conservation
- > Model City for research
- Explore cutting-edge conservation practices
- International destination "water tourism/science"
- Establish collaborations globally









Occurrence and Control of Disinfection By-products in Drinking Water

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Department of Urban Management,

Graduate School of Engineering, Kyoto University

1,2 Research Group on DBPs in Drinking Water MHLW Research Grants

1. Introduction

Disinfection by-products, DBPs are one of major group of chemicals in the water quality standard items. The results of DBP survey for the Standard Items of approximately 6000 sites in the fiscal year 2004 showed some incompliance of DBPs, especially on these three items;

-Bromate (exceeded 0.010 mg/l) 20 cases -Total THM (0.10 mg/l) 1 case -Bromodichloromethane 4 cases

In addition, the results of DBP survey for the Monitoring Items of 2031 water supply bodies in the fiscal year 2004, some DBPs exceeded their target values as described below. Among them, chlorate exhibits higher concentration close to and above its target value.

-Dichloroacetonitrile 2 cases
-Chloral hydrate 3 cases
-Chlorate (0.6 mg/l) 6 cases
-Residual Chlorine 101 cases
(exceeded 1.0 mg/l for aesthetic reasons)

2. Bromate, Chlorate, and Perchlorate control in Hypochlorite Solution¹⁾

Bromate exhibits highest portion of calculated risk of DBPs as a carcinogen. Bromate concentration has been decreased according to the control of ozonation condition. However, bromate has been detected at certain concentrations in hypochlorite solutions used in water treatment systems. Chlorate has found increased especially after duration of storage at higher temperature. Perchlorate is recently found to show the same trend. Fig.1 shows the existence of perchlorate in sodium hypochlorite

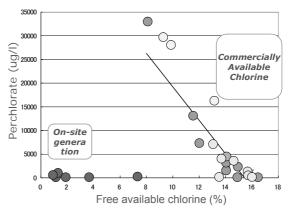


Fig.1 Perchlorate concentration in stored hypochlorite solution

solutions and on-site generation process.

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Since chlorate and chlorite exhibit oxidative damage to red blood cells and perchlorate is known to interfere with iodine uptake by the thyroid gland, control of these chemicals should be taken into consideration in managing hypochlorite solution.

3. Perchlorate Pollution in Water Source of the Tokyo Metropolitan Area

Perchlorate is used in rocket propellants and also in various oxidative materials. In 2005, the United States Environmental Protection Agency (USEPA) has established 0.7 µg/kg/day of the reference dose (RfD) for perchlorate and announced 24.5 µg/L of its drinking water equivalent level (DWEL). The river and tap waters in the Tone River Basin located in the east area in Japan were contaminated by perchlorate, mainly due to

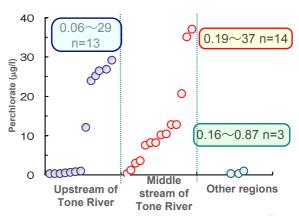


Fig.2 Perchlorate in drinking water²⁾

industrial discharges²⁾. Estimation of perchlorate load to upstream of the Tone River was calculated from the perchlorate concentration and the river flow assuming constant discharge and river flow as follows;

- -From the upstream of the Tone River: 95 to 100 kg/day
- -From a river flow into the Tone River: 40 to 78 kg/day
- -Estimated total load to the Tone River: 110 to 170 kg/day

Water of the Tone River is introduced to many water treatment plants and distributed to Tokyo metropolitan area. Estimated population affected by this water is over 20 million. In addition, this water is used for irrigation and food production. Although iodine uptake of normal Japanese diet is higher than in other countries, it is necessary to estimate total exposure of perchlorate.

4. Exposure Assessment of Volatile DBPs³⁾

Since exposure to DBPs is not limited to drinking water, respiratory exposure to DBPs is examined in several houses in Kyoto area. Personal air sampler with absorbent was employed to accumulate DBPs in bath room, kitchen, living room, and others, for the time spending in each room, in typical Japanese houses. The total exposure through respiratory route and dermal

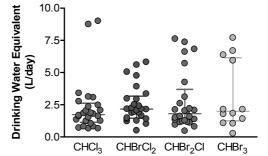


Fig.3 Exposure to THMs from respiratory and dermal route (adult)

route was calculated. In some cases, respiratory route exhibits maximum 8 times higher. Fig.3 shows the concentration calculated from equivalent to almost 2 times in average and maximum 9 times higher than in estimated exposure through drinking water.

5. Occurrence of NDMA

Nitrosodimethylamine, NDMA, one of nitro-DBPs was also found in water purification process. Other halogenated acetonitriles should be examined.

6. Bromide in water source

Bromide is one of precursors of brominated DBPs, such as bromate, brominated trihalomethanes and brominated haloacetic acids. Discharge of bromide into the Lake Biwa and the Yodo River was examined and contribution of artificial discharge is estimated. Source of bromide was calculated; 28% from sewerage (daily use and service industry), 34% from natural sources and rest 38% from direct discharge such as industrial and agricultural water. Since discharge from daily use is mainly from foods, bromide control in source water seems difficult.

7. Future direction

Human exposure to DBPs is not restricted through drinking water, but also via inhalation of indoor air, dermal exposure and cooked foods. Thus the total exposure should be considered when allocating theoretical exposure of DBPs from water. In addition, ionic and hydrophilic compounds are being found in water, such as carcinogenic bromate, toxic nitro compounds and hormone inhibiting perchlorate.

- 1) Asami M., Kosaka K., Kunikane S., Bromate, Chlorate, Chlorite and Perchlorate in Sodium Hypochlorite Solution Used for Water Supply, 2nd IWA-ASPIRE Conference and Exhibition 2007 (Submitted)
- 2) Kosaka K., Asami M., Matsuoka, Y., Kamoshita K., Kunikane S., Determination of perchlorate in the Tone River Basin using IC/MS/MS, *Journal of Environmental Instrumentation Control and Automation*, 2006.10, 11(2/3), 215~218.
- 3) Ken T., Muto T., Yanagibashi Y., Itoh S.. Echigo S., Ohkouchi Y. and Jinno H.: Exposure assessment of trihalomethanes in households for estimating allocation to drinking water, Proceedings of The 15th Joint KKNN Symposium on Environmental Engineering, 21-24 June, Kyoto, Japan, 2006.6.

Occurrence and Control of **Disinfection By-products** in Drinking Water

Management and Wastewater Control
Bankoku Shinryokan, Okinawa, January 25-28, 2007

Mari ASAMI

National Institute of Public Health

Sadahiko ITOH

Kvoto University (Research Group on DBPs in Drinking Water **MHLW Research Grants)**

Occurrence of DBPs

Standard Items (App. 6000 sites, 2004 FY)

- Bromate (exceeded 0.010 mg/l) 20cases
- Total THM (0.10 mg/l) 1 case 4 cases
- Bromodichloromethane

Monitoring Items

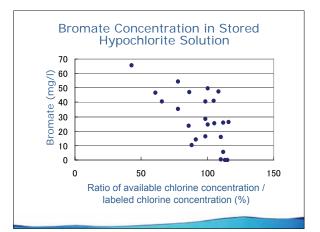
(2031 water supply bodies, 2004 FY)

· Dichloro acetonitrile 2 cases · Chloral hydrate 3 cases · Chlorate (0.6 mg/l) 6 cases · Residual Chlorine 101 cases

(exceeded 1.0 mg/l for aesthetic reasons)

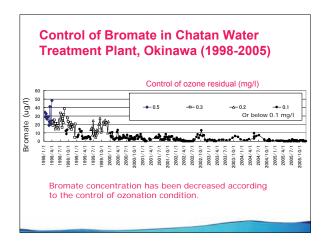
Bromate Concentration in Sodium Hypochlorite Solution

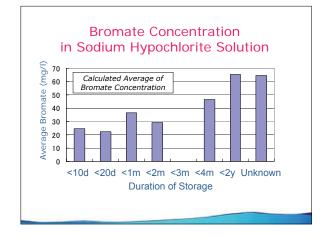
- Bromate is a group B2 carcinogen in IARC
- Currently listed in the drinking water quality standard in Japan.
- In April 2004, bromate was detected at a concentration of 0.168 mg/l in chlorinated drinking water in Hokkaido.
- 16.8 times higher than its standard value.
- Bromate in a sodium hypochlorite solution was detected at a concentration of 668 mg/l.

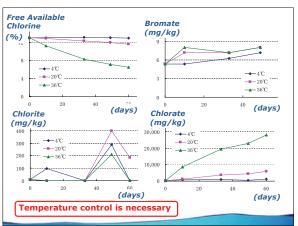


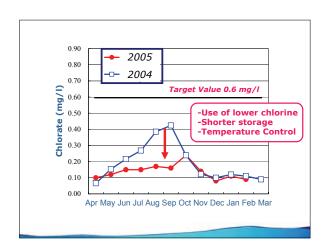
Contents

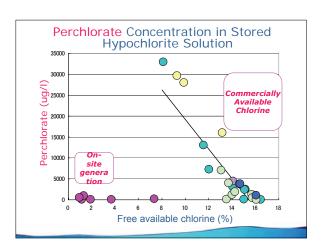
- 1 Occurrence of Disinfection By-products
- 2 Control of Bromate, Chlorate and **Perchlorate**
- 3 Perchlorate in Water Source
- 4 Exposure Assessment of Volatile DBPs
- 5 NDMA
- 6 Control of Halogen in Water Source

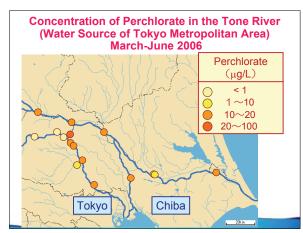


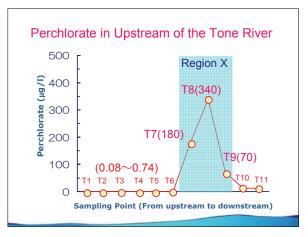


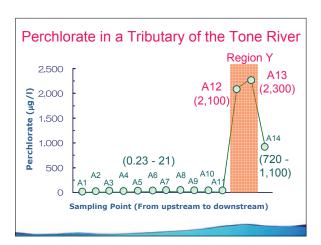


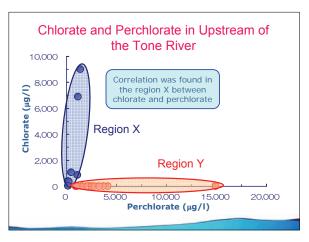


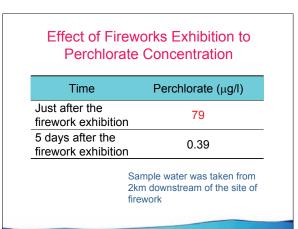


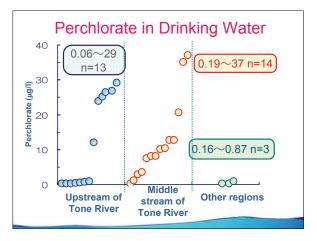






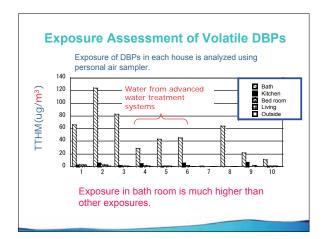


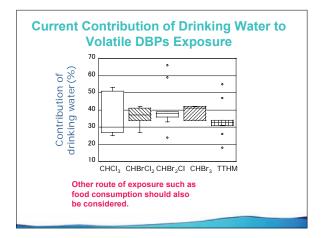


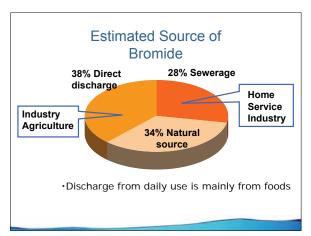


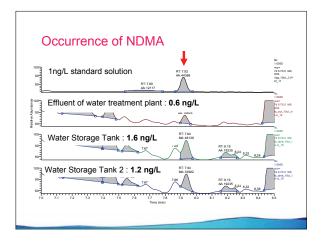
Load of Perchlorate and Population affected • Estimation of perchlorate load to upstream of the Calculated from the perchlorate concentration and the river flow assuming constant discharge and river flow • From the Upstream of the Tone River: 95 to 100 kg/day

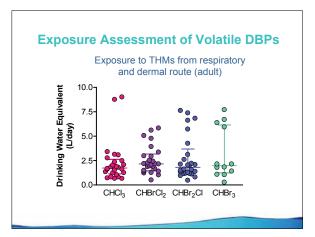
- From a river flow into the Tone River: 40 to 78 kg/day
- Estimated total load to the Tone River : 110~170 kg/day
- Estimated population
 - Water of the Tone river is introduced to many water treatment plants and distributed to Tokyo metropolitan area
 - Estimated population affected by this water is over 20 million.
 - In addition, this water is used for irrigation and food production.

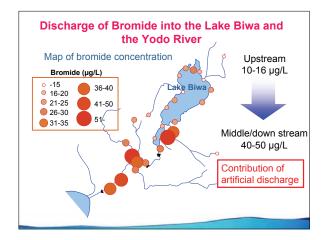


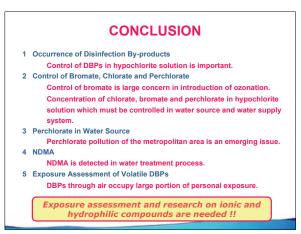












Measures for recovery against seismic damage to wastewater systems

TANAKA Shuji

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1. Introduction

Beginning with the Kushiro Offshore Earthquake in 1993, earthquakes have frequently damaged sewage treatment systems. The Hyogo-ken Nanbu Earthquake of January 1995 and the Niigata-ken Chuetsu Earthquake of October 2004 inflicted particularly severe damage on wastewater systems, either shutting down their treatment systems or severely damaging their pipelines. As the Hyogo-ken Nanbu Earthquake and the Niigata-ken Chuetsu Earthquake caused such serious damage to people's homes and to the social infrastructure, residents were forced to spend long periods of time evacuated from their homes. Damage to sewage treatment systems by these two earthquakes halted their operations, causing polluted water to flow directly into public bodies of water. This report describes (1) the characteristics of the damage caused by these two earthquakes, (2) measures taken until their wastewater systems were restored, (3) methods of providing support until the restoration of their functions halted by earthquake damage, and (4) the toilet problem.

2. Scale of the Hyogo-ken Nanbu Earthquake and the Niigata-ken Chuetsu Earthquake and the characteristics of the damages

The Hyogo-ken Nanbu Earthquake, a magnitude 7.2 earthquake with maximum seismic intensity of 7, occurred early in the early morning on January 17, 1995. It inflicted extremely severe damage, killing 6,308 people, injuring 43,177, and totally destroying 100,302 homes. Damage to sewage systems by this earthquake effected the treatment operation at 8 plants and damaged an additional 43 treatment plants. It also damaged 56 pumping stations and a total of 162 km of pipelines.

The Niigata-ken Chuetsu Earthquake, a magnitude 7.8 earthquake with maximum seismic intensity of 7, occurred in the evening on October 23, 2004, killing 59 people, injuring 4,805, and totally destroying 3,175 homes. And the quake caused landslides and soil-collapse introducing damages on roads and railways throughout the effected region. In 2004 prior to this quake, large-scale flooding occurred in the Niigata Prefecture region on July 13, and abnormally heavy rainfall followed during the summer and autumn as a record number of 10 typhoons crossed the Japanese Archipelago. Therefore, where the topography was originally vulnerable to sliding, the rain loosened the ground, so that when this earthquake occurred, it caused soil to collapse at many locations. In addition to

sewage systems, it damaged lifelines such as electric power lines, gas mains, water mains, telephone lines, and the cell phone and internet infrastructures. And because telephone calls were made to Niigata Prefecture from throughout Japan, communication systems were congested, restricting ingoing communications. And communication cables and detour roads through the mountains were also damaged, isolating some municipalities from outside information. Cell phone systems that had been considered to be highly disaster resistant since the Hyogo-ken Nanbu Earthquake Disaster, were unusable over a wide area as relay stations stopped it's functioning so they could no longer handle calls. This occurred typically near the epicenter, relay station equipment was damaged and the power was cut off and batteries installed and charged to maintain the functions of relay stations during emergences were usable for only one day due to the flood of incoming phone calls. Damage to sewage treatment plants by this earthquake shut down 1 treatment plant and damaged 6 others. It damaged 6 pumping stations, obstructing the water supply functions of 2 of these. A total of 152.1km of pipeline were damaged, and problems were found at the locations of 2,506 manholes.

Damage to sewers differed greatly between the Hyogo-ken Nanbu Earthquake and the Niigata-ken Chuetsu Earthquake. The Hyogo-ken Nanbu Earthquake caused permanent strain of the ground that shifted pipelines and its earthquake motion caused cracking, but a large part of the damage by the Niigata-ken Chuetsu Earthquake was lifting up of pipes and manholes by liquefaction of backfill soil around pipelines. The lifting up of manholes blocked traffic. Damage to the sewers caused problem for draining from homes.



Photo1. A lift-uped manhole in Niigata-ken Chuetsu Earthquake

3. Restoration of the damage

In Kobe City that was the largest city to suffer severe damage during the Hyogo-ken Nanbu Earthquake, as the office building servicing for the Sewage Works Bureau was heavily damaged including data storage area, they had to the recovering works of the systems without major data

assistance in the initial phase. As a result, even though there had been pipeline data in digital conditions, it was unusable after quake due to under knocked off building, so that even if information about damage to complex pipeline networks coming to the restoration work center, they could not assess the degree of impact. Fortunately, a consultant company had stored copies of the original data. Besides luckily the City of Nagoya had adopted the same system, it was possible to use the Nagoya City System to print out the required data needed to perform the restoration works.

Even though the wastewater system had been damaged, it had to be quickly restored so it could resume its role as a lifeline. But it is not easy to identify the exact damaged locations in wastewater systems. It is often possible to visually confirm the state of damages to sewage treatment plants, but it is actually difficult to find out damages of sewers without interior inspections with TV cameras. Clarifying the state of damage and considering countermeasures is the first action that must be taken. It is, therefore, important to be able to mobilize a certain number of responsible employees. After the Hyogo-ken Nanbu Earthquake, it was not easy to gather staff, because of the extremely large scale of the damage it caused. Table 1 shows how the staff gathered.

Table 1. Staff gathering conditions after Hyogo-ken Naubu Earthquake

City name	Staff number	within 1 ho	our	Within 6 h	ours	Within 12h	nours	Within 24 ho	ours	Within 3 d	lays
Koube	-	-		-		-		-		-	
Ashiya	65	9	14%	23	35%	25	38%	27	42%	35	54%
Nishinimoya	191	-		-		-		124	65%	176	92%
Takarazuka	70	2	3%	50	71%	51	73%	52	74%	66	94%
Amagasaki	234	3	1%	74	32%	84	36%	84	36%	102	44%
Kawanishi	66	-		57	86%	-		-		-	
Itami	54	41	76%	41	76%	41	76%	47	87%	49	91%
Akashi	147	5	3%	117	80%	123	84%	123	84%	142	97%
Toyonaka	127	5	4%	84	66%	90	71%	90	71%	124	98%

The Higashi-nada Treatment Plant in Kobe City was damaged extremely by the earthquake, which not only cut off feeding wastewater to the treatment plant from its pumping station, but also damaged its main treatment system so it no longer functioned. Other treatment plants were also damaged, but on regarding the degree of damages and impact to environment, restoration of the Higashi-nada Treatment Plant was an extremely important. As the route linking this treatment plant with its pumping station was intersected with a canal, this canal can be used as a temporary settlement pond with enclosing sheet piles, preventing serious deterioration of the quality of the water in surrounding bodies of water. This measure was taken for 100 days.

A major cause of damage to the treatment systems in the Higashi-nada Plant was the destruction of piles caused by lateral flow triggered by liquefaction of the sandy ground in a reclaimed land area. To identify this cause required a great deal of time-consuming work, but once its results were obtained, measures to restore the systems were taken.

The Niigata-ken Chuetsu Earthquake shut down the Horinouchi Treatment Plant of a river basin sewerage system in Niigata Prefecture, allowing polluted water flowing into the plant to overflow, inundating with incoming wastewater around the plant. This was caused by damage to the inlet, but the treatment systems were also severely damaged as well. As emergency measures, a temporary settlement pond and a disinfection plant were installed to prevent the discharge of untreated polluted water to nearby river.



Photo2.A temporary settlement pond and a disinfection plant in Horinouchi Treatment Plant

4. Problems providing assistance

Following the Hyogo-ken Nanbu Earthquake, assistance with restoration activities was provided to severely damage regions, mainly from large cities. Aware of the need for fundamental initiatives as a result of this experience, the Japan Sewage Works Association prepared Rules for assistance dealing with damage to sewage systems. Based on these rules, systems to provide support were established by dividing the country into six blocks. For ordinance-designated cities, another rule requiring mutual support by these cities was enacted.

When the later Niigata-ken Chuetsu Earthquake occurred, it was learned that when a municipality struck by a disaster requested assistance under this rule, supported bodies bore a specified cost burden including travel expenses and overtime pay for their employees, resulting in delayed requests for assistance from municipalities concerned about the payment of these costs. In fact, supporting organizations carried out the cost burden, so that finally wide area support was provided. Based on such experiences, the present support rules have been revised.

Under the present assistance procedure, a municipality with earthquake damage requests assistance within its block. When it is difficult for only the block to respond, the block requests assistance from the national government that responds by establishing a liaison office for seismic damage recovery.

This office assists the city where the disaster has occurred by coordinating efforts among the NILIM, Japan Sewage Works Agency, ordinance-designated cities, and related industries.

5. Toilet problems

The availability of toilets is a problem that appears immediately after earthquake damage has occurred. It is a tragedy when existing toilets cannot be used normally at evacuation sites where large numbers of people have gathered. Toilets are unusable in cases where water needed to flush them cannot be obtained or when the wastewater system is damaged so that it cannot remove human excreta from the toilets. In such cases, temporary toilets are installed, but if enough temporary toilets cannot be obtained, serious sanitary problems occur at the same time as the residents who have been impacted by the disaster are forced to endure even heavier mental and physical burdens.

After the Hyogo-ken Nanbu Earthquake, people whose homes were knocked down or burned down, whose supplies of electricity, water, etc. were cut off, or who could not remain in their homes because of fear of aftershocks, gathered at evacuation sites. Records show that at the peak point six days after the earthquake on January 23, 1995, there were 316,678 evacuees at 1,153 evacuation sites. People were evacuated to places like schools, gymnasiums, and parks.

There are toilets in public facilities of these kinds, but because the numbers of toilets were not set premised on their evacuee capacity and it was impossible to obtain water to flush them, they quickly became unusable after being used a few times. It is reported that because they could not handle the demand for toilet use, they were soon plugged with large quantities of excreta. Temporary toilets were installed beginning on January 18 the day after the earthquake, and on January 19, only 230, a number far from adequate, could be obtained. According to a survey carried out on January 24, the problem was still unresolved, as temporary toilets had only been installed at 2,488 locations, that was 45% of the locations they were needed. Later, temporary toilets were supplied that was owned by construction companies, providing 1 toilet for every 60 people at the evacuation sites. Even though enough number of temporally toilets were supplied with roads into the disaster region continuing to be seriously congested, it was not easy to transport temporary toilets from outside the region. In parks and athletic fields at schools, holes were excavated on the ground and used as emergency toilets, but they were unusable within a few days due to limited capacity.

When a disaster has occurred, food and water are considered to be priority, but ensuring sanitary toilet facilities were an even more important issue. Since then, a variety of emergency toilets have been developed, but toilets made using manholes have been very popular.

Based on experience gained from the Hyogo-ken Nanbu Earthquake, the following concept of handling excreta during disasters has been established. The top priority is taking advance measures to ensure that flush toilets can be used. Substitute measures are taken to cover the period until these flush toilets are usable. One thing that is essential to guarantee that flush toilets can be used is ensuring a supply of toilet water. This can be done by using water in pools at evacuation sites, using treated wastewater, using stored rainwater, and transporting water from the ocean, marshes, or rivers. At evacuation sites, water supply and water drainage systems must be seismically retrofitted in advance.

At the same time as the required numbers of conventional temporary toilets are provided, full scale preparations are being taken to use sewage system facilities to introduce new temporary toilets as full-scale disaster measures. Special manhole covers are introduced at the same time as manholes and covers are installed in parks and other evacuation sites where they can be used immediately when a disaster occurs, so that temporary toilets linked to sewage systems and manholes can be easily converted to toilets.

When the Niigata-ken Chuetsu Earthquake occurred, fortunately, with the cooperation of the construction companies, it was possible to supply a sufficient number of temporary toilets relatively quickly, so toilets were not a serious problem. But it has been reported that problems remained; the removal of the temporary toilets for example.

6. Conclusion

Earthquake damage to sewage systems directly links to toilet problems, causing serious problems following earthquakes. Large earthquakes that have occurred during the past ten years have provided considerable knowledge and experience including the characteristics of their damage, restoration methods, methods of gaining support from the surroundings, and toilet measures. While still not completed, measures to protect sewage systems from earthquake are progressing based on lessons learned in this way. It is predicted that a large earthquake will strike Tokyo in the future, requiring the development and improvement of technologies to perform seismic retrofitting and to take post-earthquake measures.

Measures for recovery against seismic damages to wastewater systems

TANAKA Shuji

Director, Water Quality Control Department, National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure and Transport

Typical damages to STPs:

- Damages in influent channel to STPs
- Damages to treatment plant structures
- Shutdown of operations
- Leakage or discharge of untreated wastewater to public water bodies

Lessons from Higasinada introduced quick actions to Horinouchi • Higasinada STP (1995)

- - Three weeks for starting temporary sedimentation
- Horinouchi STP (2004)
 - One week for starting temporary sedimentation
 - Experience teaches:
 - Quick assistance of JS to recovery works
 - Manual books for EQ damaging recovery after Hyougo EQ

Typical damages to sewers

- Hyougo-ken Nanbu EQ:
 - Difficulty of finding of damages in sewers
 - Cracks caused by shaking of manholes and permanent strains of grounds
 - Relatively small damage-ratio: Ave.1.7%, Max.9.7%
- Niigata-ken Chuetu EQ:
 - Surfaced up of manholes and lifted up of sewers
 - Sinking of ground surfaces six months later
 - High damage-ratio: Ave. 4.6%, Max. 21.7%

Hyougo-ken Nanbu Earthquake and Niigata-ken Chuetu Earthquake

	Hyougo-ken Naubu	Niigata-ken Chuetu
Occurrence	January 17, 1995	October 23, 2004
Magnitude	7.2	6.8
Maximum accelation gal	818	1715
Loss of lives	6,308	59
Injured people	43,177	4,805
Damaged houses	436,414	121,613
Operatinal problemed STPs	8	1
Damaged STPs	51	6
Damaged PSs	56	6
Damaged sewers km	162	152

Measures against damages and shutdowns of operations of STPs

- · Quick visual checks of damaging conditions
- · Planning for recovery works
- · Prevention of raw wastewater discharge;
 - Quick construction of temporary sedimentation ponds and disinfection facilities
- Repair or rehabilitation of some facilities
- Resuming of operations

· Restriction of discharge to sewers

Preparation for future; Long term measures for STPs

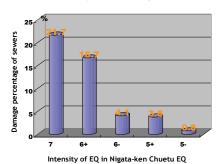
- Seismic proofing of existing facilities
- · Reduction of damages as planning solutions
 - Networking of STPs
 - Multiple trunk-sewers
- STPs; high reliable evacuation centers

Typical damage types in Niigata-ken Chuetu EQ



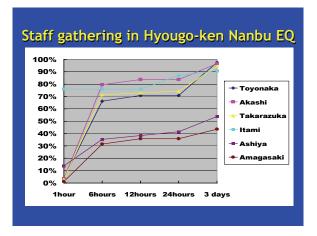
Liquefaction of backfilled sand caused floating up of manholes and sewers (マンホールの浮上がり) (マンホールの浮上がり) (埋戻し部の地盤次下) 管渠の浮上がり

Intensity and damage ratio



Problem in recovery works

- · Shortage of manpower and experiences:
 - Sewage work staff was inputted to rescue works or water works recoveries
 - Difficulty of full-staff gathering
 - No experience of quake disaster
- Functional incompetence of telecommunication means:
 - Telephone, facsimile, and mobile were dysfunctional
 High traffics of signals or damages of infrastructure



Assistance providing from outside

- No detail information to central government offices
- Dispatch of an advance research party:
 Selected member from HQ of MLIT, NILIM ,PWRI, & JS
- Setting of emergency headquarter office in disaster area:
 - Coordination among central government offices, prefecture offices, local governments, and related aggregate cooperations
- Recovery-work assistances;
 - damage surveys and recovery work preparations
- Contract based sewer-inspection worker gathering from all
- Rules for assistance advocated by Japan Sewage Works Association—after Hyougo EQ:
 - Six block systems
 - Cost payment by requester side-----?



Conclusions

- · Quick assistance is the key to quick recovery;
 - Lesson from Hyougo-ken Nanbu EQ worked to recover from damages in Niigata-ken Chuetu EQ
 - Emergency HQ office in disaster site worked effectively
- Measures against STPs shutdown;
 - Construction of temporally sedimentation tanks and disinfections for prevention of epidemic
 - Restriction of discharge to sewer systems (is
- Deferent type of damages to sewers in Niigata-ken Chuetu EQ;
 - High ratio of damage in 6+ intensity and over - Sewer damage blocked toilet use
- Wastewater systems are the first priority lifelines

MEASURES AGAINST EMERGENCIES: LESSONS FROM HURRICANE KATRINA REGARDING SEWAGE WORKS

James H. Clark¹ Black & Veatch

1. Introduction

After Hurricane Katrina cut its destructive swath across Louisiana, Mississippi, and Alabama, the Water Environment Federation (WEF) assembled a response team to conduct an official assessment of the wastewater system damage. WEF, together with Black & Veatch and select utilities, provided the technical and financial basis for this assessment. The team worked with the US Environmental Protection Agency, state regulatory agencies, and WEF member associations in the three impacted states to facilitate planning and execution of the study. Findings, conclusions, and recommendations from the assessment provide good information on steps to take to lessen the impact of and expedite the mitigation efforts for future disasters.

2. Overview

Hurricane Katrina brought a tidal surge of 15-to-25 feet, which inundated the entire coastline of Mississippi, a large portion of Louisiana, and the western coast line of Alabama. Homes and businesses were destroyed across hundreds of square miles. The hurricane also devastated wastewater utilities, with some treatment systems suffering catastrophic damage. Compounding the problem, affected utilities in the surge area lost 25 to 80 percent of their population rate base, undermining their ability to generate sufficient revenue to meet operating costs and bond payments.

The area assessed by the study team was defined as the regions in Louisiana, Mississippi, and Alabama that experienced any of the following types of damage from Katrina: (1) ocean surge, (2) flood, and (3) winds in excess of 100 miles per hour. Of the 896 wastewater facilities in the three states, 118 were determined to have been located in one of the three damage zones, as shown in Table 1.

Surge	23
Flood	8
Wind	87
Total	118

Table 1 Number of Affected Utilities by Damage Zone

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¹ 800 Wilshire Boulevard, Suite 600, Los Angeles, CA 90017 e-mail:Clarkjh@bv.com

As shown in Table 2, total damages to wastewater utilities from the assessment were estimated to be close to \$1.4 billion: \$1.2 billion for infrastructure damage and an addition \$163 million in needed subsidies to maintain a minimal level of financial solvency. A significant portion of the damage is not expected to be covered under current Federal Emergency Management Agency (FEMA) guidelines.

State	Infra- structure	Financial	Total	%
Alabama	50	1	51	4%
Louisiana	925	146	1,071	78%
Mississippi	231	16	247	18%
Total	1,206	163	1,369	100%

Table 2 – Wastewater Utility Damage Estimate from Hurricane Katrina (US\$Millions)

3. Findings

In general, lessons learned can be categorized as (1) logistical issues that can be anticipated when investigating future disasters and (2) findings related to Katrina's impact on facilities and local resources.

Logistics

A number of issues arose during the planning and implementation of the post-Katrina investigations that have implications for future study efforts. These include:

- Maps. Maps of damage zones were not publicly available even two months after the disaster. Nine months after the disaster, there still were no known publicly available maps that demonstrated the sheer magnitude of the damage.
- Travel. Eight weeks after the storm, hotel rooms, rental cars, and flights were still scarce. The investigators tried to use recreational vehicles (RVs) to access the area, but few were available, and state regulations required a commercial driver's license for RV operators if the RV is to be used for commercial purposes.
- *Tires.* Rental cars sustained significant tire damage from debris and nails covering the road, and new tires were in short supply.
- Access. Hard hit areas were closed to the public, but investigators were able to access these areas when accompanied by utility staff.
- Information. Utility staff had to immediately begin searching for and fixing leaks, as well as inventorying damages, so they were a wealth of information on the impacts of the hurricane, particularly regarding infrastructure damage and implications.

- *Traffic.* Two months after the storm, roads were clogged with construction and relief workers. Traffic into the regions in the morning and leaving the regions in the afternoon was reported to be much higher than normal.
- *Telephones.* Phone lines were disrupted and the "fast busy signal" was common. Eventually, it was usually possible to get through, though some utilities lost all phone service and gave their staff new cell phones.
- Local support. People from the region were essential in overcoming obstacles. In particular, they were highly attuned to communications issues and often provided multiple phone numbers for requested contacts.

Katrina's Impact

Study findings ranged from impact on specific facilities, financial implications, and examples of what works and what doesn't.

- Wastewater treatment plants. Most wastewater treatment plant damage was from storm surge, not wind. Electrical circuitry and power generators were destroyed, and pumps and motors were damaged. Basins filled with grit, but reinforced concrete structures held.
- Collection systems. Storm surge also affected collection systems. There
 was a high level of service connection failures in surge areas, and clean up
 further damaged service connections. Above-ground portions of lift stations
 were heavily damaged, and below-ground portions were impacted by grit
 accumulation. Point repairs were greater in flooded areas, but not as bad
 as expected.
- Human resources. It was discovered that many people won't evacuate, including utility employees. Strong senior management is critical. Wastewater employees made heroic efforts.
- Institutional efforts. Emergency Management Assistance Compacts didn't work well for water/wastewater utilities, and FEMA subcontractors were unfamiliar with assets, creating a greater burden on resource-constrained utilities.
- Solvency issues. "Events of default" will hurt communities more than bond holders. Reserve funds (12-month) will run out in 2007. Bonds are being issued to cover operating expense.
- Long-term financial impact. A significant percentage of the rate base was lost, with population loss in surge areas ranging from 25 to 80 percent. There was a smaller reduction in expenses. Without intervention, some reduction in debt service reserves is expected in 2006 with an inability to fund debt service payments in 2007.

4. Recommendations

Several recommendations evolved from the study:

- Federal government. The federal government should develop greater flexibility in programs, including eligibility and replacement. The fiscal health of utilities should be monitored and relief provided as necessary. The U.S. Environmental Protection Agency (EPA) should be provided a stronger role in disaster response related to water and wastewater agencies.
- State agencies and utilities. These entities should invest wisely and develop state-to-state mutual aid compacts that focus on water and wastewater.
- Wastewater industry. The industry should improve training and best practices on emergency preparedness. The industry should also educate the public on the importance of wastewater in public health.

References

Federal Emergency Management Agency, Katrina Recovery Maps. http://www.fema.gov/hazards/floods/recoverydata/katrina_index.shtm (accessed Jan 2006).

Hunter, Michelle. (2006) Jeff Sheriff's Office Plans for the Worst. *Times-Picayune* 8 June 2006, http://www.nola.com/search/index.ssf?/base/news-2/1149753038307650.xml?nola (Accessed 8 June 2006).

Mississippi Automated Resource Information System, Hurricane Katrina Shapefiles. http://www.maris.state.ms.us/HTM/ Miscellaneous/Hurricane Katrina.htm (accessed Dec 2005).

Peacock, W. G.; Morrow, B. H.; Gladwin, H., Eds. (1997) *Hurricane Andrew: Ethnicity, Gender and the Sociology of Disasters;* Routledge, Chapman & Hall: New York.

Smith, S. K. (1995) Demography of Disaster: Population Estimates after Hurricane Andrew; Bureau of Economic and Business Research, University of Florida at Gainesville.

Smith, S. K.; McCarty, C. (1996) Demographic Effects of Natural Disasters: A Case Study of Hurricane Andrew. *Demography*, **33**, 265–275.

Southern Regional Climate Center. http://www.srcc.lsu.edu/(accessed Dec 2005).

Water Environment Federation, *Assessment of Reconstruction Costs and Debt Management for Wastewater Utilities Affected by Hurricane Katrina*, (April 2006) http://www.wef.org/NR/rdonlyres/DF8D6AED-D72E-49A3-9711-
E956D750E720/0/katrinafinal.pdf



Charitable Teaming Approach

- Water Environment Federation (Report Publishing and Legislative Affairs)
- Black & Veatch (Project Management, Estimating, and Report Development)
- Utility, WEF, and Corporate Volunteers (Field and Phone Survey Support)
- US EPA, DEQs, WEAs
- 25 Impacted Utilities from Louisiana, Mississippi, and Alabama

Project Schedule was Ambitious

Hurricane Katrina August 29 Proposal to WEF October 5 WEF Acceptance October 7 Site Visit Teams Mobilized November 7 Phone Surveys Began December 1 New Orleans Site Visit January 5-6 Draft Report for Peer Review January 17 Report Published April 25

12 Utilities Visited (19 Facilities out of 118 Affected)

- FAIRHOPE, AL
- GULF SHORES, AL
- MOBILE, AL (2)
- BOGALUSA, LA
- COVINGTON, LA
- PLAQUEMINES PARISH, LA (SEVERN TRENT) (5)
- SLIDELL, LA
- WESTWEGO, LA
- HARRISON COUNTY, MS (3)
- HATTIESBURG, MS
- MS GULF COAST REGIONAL WWA, MS
- SEWERAGE & WATER BOARD OF NEW ORLEANS, LA

Purpose of Gulf States Assessment

- Gain better understanding of hurricane-impacted wastewater utilities' needs; communicate these needs to policy-makers and industry
 - Develop high-level assessment of infrastructure damage and cost to repair
 - Develop assessment of impact on financial stability
 - Complete as quickly as possible
 - Use knowledge to educate policy-makers
 - Communicate impacts and needs to industry leaders

Methodology

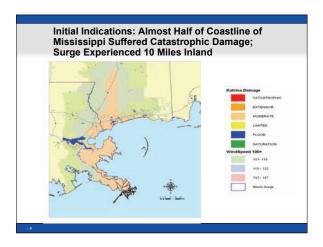
- Map damage zones
 - Storm Surge
 - Flood: Seawater+Freshwater
 - Peak wind gusts >= 100 mph
- Identify wastewater utilities in each damage zone
- Site visits followed by phone surveys across different zones.
- Develop average infrastructure cost estimates for utilities in each damage zone
- Apply costs across all affected utilities based on damage zone location, utility size, treatment methods
- Develop pro forma "Income Statement" for all wastewater utilities in surge zone

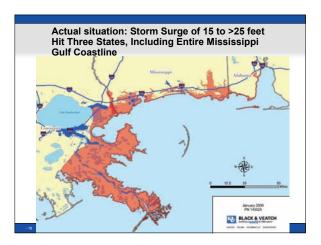
Field Visits Posed Challenges

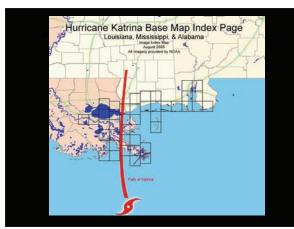
- Three field teams
- Volunteers not covered under Emergency Management Assistance Compacts (EMAC)
- Two months after Katrina:
 - Impacted utilities phone lines down
 - Limited hotel space
 - Rental cars scarce
 - Vaccinations required
 - Rumors abound re conditions
- "Let's take RVs!"
- Development of appropriate survey forms

Initial Expectations

- Catastrophic damage to wastewater treatment plants and collection systems in New Orleans area and parts of Mississippi coast line
- Reduced population in New Orleans, Slidell, perhaps elsewhere will affect utility revenues
- Assumed publicly available maps could be used to plot damage areas

















Estimated 450,000 People's Homes were Destroyed

 25-80% loss of population rate base amongst utilities in surge area





Impacted Population Served

State	Pop. Served in Study Area (Thousands)	Percent of Impacted Pop.	Sur
Alabama	242	14%	19
Louisiana	1,157	64%	79
Mississippi	386	22%	20
Total	1,785	100%	

Most Wastewater Treatment Plant Damage was from Storm Surge, not Wind

- Electrical circuitry destroyed
- Pumps and motors damaged
- Power generators destroyed
- Basins filled with grit
- Reinforced concrete structures held

Collection Systems

- High level of service connection failures in surge area
- Clean up further damaging service connections
- Above ground portion of lift stations heavily damaged; below ground impacted by grit accumulation
- Point repairs greater in flooded areas, but not as bad as expected

Additional Findings

- Many won't evacuate...including utility employees. Plan for it.
- Strong senior management is critical
- Heroic efforts amongst wastewater employees
- Emergency
 Management
 Assistance Compact
 (EMAC) didn't work
 well for
 water/wastewater
 utilities



Additional Findings

- Redundancy in supplies—diesel fuel, rolling stock, records, telemetry
- FEMA sub-contractors unfamiliar with assets, created greater burden on resource-constrained utilities
- Solvency issues
 - "Events of default" will hurt communities more than bond holders
 - 12 month reserve funds will run out in 2007
 - Bonds being issued to cover operating expense
 - "FEMA anticipation notes"

Long-Term Financial Impact

- Significant percentage loss in rate base
 - 25-80% population loss in surge areas
- Smaller reduction in expenses
- Without intervention, some likely to experience reduction in debt service reserves in 2006, inability to fund debt service payments in 2007

Assessment Findings by State (US\$ Millions)

State	Infra- structure	Finan- cial	Total	Percent- age
Alabama	50	1	51	4%
Louisiana	925	146	1,071	78%
Mississippi	231	16	247	18%
Total	1,206	163	1,369	100%

Recommendations

- Develop greater flexibility in grant programs (eligibility and replacement)
 Monitor of utility fiscal health and provide relief as necessary
- Provide stronger role for EPA in disaster response (wrt water/wastewater)

States and Utilities

- Invest wisely
- Develop state-to-state mutual aid compacts that focus on water and wastewater (Water/Wastewater Agency Response Networks)
- Wastewater Industry
 - Improve training, best practices on emergency preparedness
 - Educate the public on the importance of wastewater to public health

Surge Sources

- Satellite images of damages from NOAA: http://ngs.woc.noaa.gov/katrina/KATRINA0000.HTM
- Surge height maps from FEMA: https://www.fema.gov/hazards/floods/recoverydata/katrina_index.shtm
- WEF / B&V Report
 http://www.wef.org/NewsCenter/katrinadamagereport.htm



Risk Assessment and Management of Water Supply Business

Yasumoto MAGARA and Atushi Miyawaki Professor, Graduate School of Public Policy Hokkaido University, Japan

1. Introduction

The water supply coverage ratio in Japan is as high as 97 percent, which means that effectively all citizens have convenient access to hygienically problem-free running water, at any time, anywhere, and without restrictions on quantity. A steady supply of piped water is important not only in the daily lives of citizens, but it also has many other implications. It is significant for the maintenance and improvement of public hygiene and plays a fundamental role in sustaining the fabric of society. If the water supply were interrupted, the adverse effect on society would be drastic. Such an occurrence, therefore, must be prevented at all measures. In particular, water suppliers serving a population of 50,000 or more, making up about 80 percent of the annual water supply, would be severely affected because only few of citizens can access to alternative sources of water. In the case of large cities such as Tokyo, a disturbance in the water supply would also affect areas such as the supply of cooling water for large-capacity computing installations. It would lead to a disruption of financial services and public transport, as well as stoppages in industries and services due to lack of industrial water. Furthermore, living conditions would suffer and the supply of fresh foodstuff would be affected. In short, a severe disruption of ordinary life would result.

The Water Works Law proscribes that in the event the water supplier recognizes that water being supplied may be a risk to human health, the supply must be stopped immediately, and measures must be taken to fully inform all concerned parties of the fact that using the supplied water can be dangerous. The law defines water quality standards and requires the supplier to monitor the presence of chemical substances and possible health risks based on such standards, and to stop the supply according to these criteria. By implementing a thorough risk management system, the supplier must prevent the occurrence of stoppages in the water system. Measures must also be taken to deal with situations where water stoppages occur due to external factors that are beyond the control of the water supplier, such as natural disasters including earthquakes, wind and flood damage, drought, or wide-area power outages. In the event of such stoppages due to non-predictable factors, the focus will be on how quickly the water supply can be restored in order to maintain the requested level of the water services.

Water supplier risks include not only physical aspects such as water supply stoppage, but also aspects that pertain to the sustainability of water services. This includes situations where the principle of full-cost pricing can no longer be adhered to, making the goal of financial self-sufficiency unattainable and leading to a lack of funds for day-to-day operations as well as for facility upgrades and maintenance. Where water supply facilities are managed jointly with companies from the private sector, responsibilities for risk management are often not clearly defined, which can lead to a

degradation of water services that in turn makes customers less willing to pay their water bills.

For the reasons outlined above, we will look at risk management under three aspects: human health related risks, disaster related risks and management related risks.

2. Risk Management of Water Quality Requirements

In August 1996, an outbreak of waterborne cryptosporidiosis occurred in Ogose Town, Saitama Prefecture. Out of a population of 13,000, about 9000 residents were infected, and the water supply was stopped. This was the largest mass incident of drinking water related gastrointestinal infection so far encountered in Japan. The fact that a sewage treatment plant with a discharge outlet had been constructed upstream of the intake point for the water supply was cited as a possible reason. A more direct cause can be seen in the fact that even after the discharge outlet of the sewage treatment plant became active, operation management of the water works purification plant, in particular procedures for coagulation, flocculation and filtration management were not adjusted to reduce the existing emergent risks.

In order to prevent a future occurrence of incidents such as the mass cryptosporidium infection at Ogose, in the same year the Ministry of Health, Labour and Welfare issued a provisional guideline for cryptosporidium control in drinking water. According to this guideline, if a sewage treatment facility, livestock breeding facility or other possible cryptosporidium source exists in the drinking water source area, and when coliform bacteria and anaerobic spore forming bacteria are detected in the source water, the risk of cryptosporidium contamination in the tap water is to be assumed and filtering or other proper measures must be immediately implemented to reduce the risk. In addition, the filtered water must be managed to keep turbidity less than 0.1 units. Accordingly, filter installations were improved or newly constructed at a rapid pace, and membrane filtration techniques were also put into place. No actual outbreak of cryptosporidium infection has occurred since, but cryptosporidium detection in drinking water has in fact led to water supply stoppage in a total of 17 cases.

Although the provisional guideline for *cryptosporidium* control as mentioned above was issued in 1996, the number of water suppliers that have implemented measures based on that guideline amounts to approximately 55 percent, as shown in Table 1. In other words, many water works still do not have appropriate systems in place. One of the reasons for this is to be found in financial limitations. The Ministry of Health, Labour and Welfare therefore has renewed the guideline in 2006 and has recognized the ultra-violet irradiation as a cryptosporidium control measure for water

 ${\it Table-1}\ {\it The\ enhancement\ of\ water\ purification\ plant\ for\ risk\ management\ of\ \it Cryptosporidium$

	Public water supply	Small public water supply	Bulk water supply	Others	Total
Total No. of WPP	1679	3296	158	347	5480
No. of measured WPP	1147	1596	155	178	3076
No. of non-measured WPP	532	1700	3	169	2404
Population served ¹⁾	4011	944	-	49	5005

works with sources other than surface water. This was done in order to promote the implementation of anti-cryptosporidium measures. Whether by filtration or by ultra-violet irradiation, the required efficiency of *cryptosporidium* inactivation is assumed to be 3log.

The number of suppliers that had to stop water intake due to oil spillage or unpredictable events in the water source area, or that had to take measures to strengthen the water purification process such powdered activated carbon application, or that had to temporarily stop the water supply amounts to about 80 - 100 per year, as shown in Figure 1. This represents some 0.5 percent of the total number of water supplier. Frequent causes are oil or organic matter contamination, as well as increased turbidity due to sediment

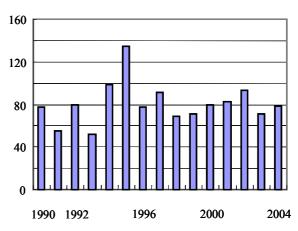


Figure -1 No. of accidental spills in the catchments area

discharge from civil engineering works. Because most rivers in Japan have a rapid water flow, there is often not enough time to stop the water supply before contaminants emerge from the intake area. The capacity of valves and other water discharge facilities designed to discharge contaminated water from the system after they have been transported downstream is often too low. Maintaining water quality in the drinking water source area is the most effective approach, not only with regard to accidents such as chemical spills but also for disinfection byproduct precursors, odor-inducing substances, agricultural fertilizers, etc. Close coordination with water environment administration authorities and water source area management authorities is therefore necessary.

Water stoppages are necessitated on occasion not only by contamination or accidents in the water source area but also by a failure of taking appropriate risk management measures within the water works system. In one example, painting inside a purification plant was done using solvents containing methylene chloride. The sublimated methylene chloride was dissolved again on the water surface of the sedimentation and filtration basins, which led to an unacceptable level of methylene chloride being detected in the drinking water, requiring a water stoppage. In other instances where sodium hypochlorite was used for disinfection purposes, bromate impurities in sodium hypochlorite created by on-site salt electrolyzation exceeded the permissible standard in water works with high chlorine injection rates, and water had to be stopped briefly until substitute sodium hypochlorite could be purchased.

3. Disaster Risk Management

Japan is a country where natural disasters such as typhoons and earthquakes occur with a high frequency. Consequently, there are regulations that require the structure of water works facilities to be able to withstand the influence of such disasters. However, it is usually not possible to fully preclude any disaster related damage. To

reduce the risk of such damage, it is therefore necessary to have measures in place that are aimed at the quick restoration of services in the event of a disaster.

The damage status due to natural disasters is shown in Figure 2. As can be seen, damage occurs every year, and about 12 billion yen in government subsidies was needed in the period from 2000 to 2005. Vast

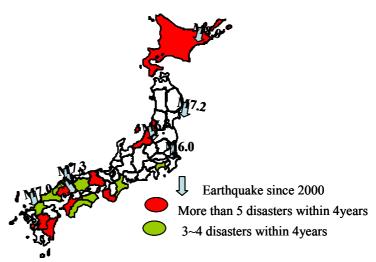


Figure 2 Earthquakes and disasters in recent years

sums are spent for restoring facilities, and water stoppages or restrictions are frequent. This of course affects not only the daily lives of citizens but also causes economic damage through the impact on socio-economic activities.

Damage due to typhoons and localized torrential rains is listed in Table 2. Each year water facilities in about 10 areas are affected, with about 100,000 people nationwide experiencing water stoppages of 30 to 100 days duration. Road collapses causing pipeline rupture are a frequent cause, followed by lightning strikes and power outages that interrupt operations. Damage due to internal problems at water facilities such as operation stops because of an abnormal rise in intake water turbidity is relatively infrequent. However, collapses or cave-ins of roads and road shoulders often occur in locations where this can be predicted. Although these are counted under damage by natural disasters, it should be possible to reduce this kind of damage by fortifying such sections and taking other preventive measures.

In 1995, the Great Hanshin-Awaji Earthquake struck an area inhabited by 20 million people, causing 5,000 deaths and leading to water stoppages of up to nine weeks for 900,000 people. The costs for repairs to water facilities amounted to some 600 billion yen. This caused the Ministry of Health, Labour and Welfare to formulate a plan for the fortification of anti-earthquake measures by water suppliers, and the implementation of these measures is being systematically promoted. Using the prognosis of a large-scale earthquake in an area where about 30 percent of the Japanese

Table -2 Damage of water supply utilities by Typhoons and Heavy Storms

Year	2003	2004	2005	2006
No. of disaster	4	10	13	13
Population affected	59,079	168,057	137,368	7,1089
Total days of stoppage/year	ı	99	72	35

Table-3 Damage of water supply utilities by earthquakes

	A	В	C	D
Date	2000,10,6	2001.3.24	2003.9.26	2004.10.23
Magnitude	M7.3	M6.4	М8	M6.8
Seismic intensity	More 6	Less 6	Less 6	7
Damage ¹⁾	M.P.260, S.P.612	MP213,Wreck of facilities	MP58,Wreck of facilities	MP 806, Wreck of many facilities
No. of house	150	40,269	15887	129,750
Length	5 days	4 days	8 days	25days
Cost for recover ²⁾	20	21	26	650

	E	F	G
Date	2005.3.20	2006.7.23	2006.8.16
Magnitude	M7.0	M6.0	M7.2
Seismic intensity	Less 6	More 5	Less 6
Damage 1)	MP31,SP101 800mm pipe in plant	MP2	MP37,Wreck of facilities
No. of house	None	430	40
Length	Few days/ 2months for plant	4 hours	3 days
Cost for recovery 2)	18	-	7

MP: Transmission /Distribution pipe, SP: Service pipe 2)Million yen

population lives, the Japanese government is calling for the strengthening of earthquake-resistant design in important civil infrastructure sectors including water supply facilities.

An outline of earthquake related damage since 1995 is given in Table 3. Every year, somewhere in Japan there is damage from seismic activity. Increasingly, water facilities are being quake-proofed according to governmental policy. In the event of an earthquake measuring intensity 5 on the Japanese scale, severe damage can be expected for asbestos cement pipes, PVC pipes, and similar non-quake-resistant pipes. When the intensity exceeds 6, water supply trunk pipes will also suffer damage, as will water treatment plants, water supply reservoirs, and other structural facilities. The damage and the costs for restoration therefore can be expected to increase dramatically. Revisions of building standards in 1977 and 1988 have improved the earthquake proofing levels of reinforced concrete structures. Piping facilities also have come to be designed along similar principles, which is why structures and piping constructed in recent years are showing better resistance to earthquake related damage. However, it is desirable that earthquake proofing and updating of older facilities should also be carried out.

Out of the 506 water suppliers serving communities with over 50,000 inhabitants, about 80 percent have implemented earthquake proofing measures in accordance with the government policy. However, among water suppliers serving communities with over 10,000 inhabitants, this figure drops to only 25 percent. On a national average, the implementation of earthquake proofing stands at 20 percent for

Table – 4 Performance Index relating the anti-seismic measures

	A	В	С	D	E	F	G	Н	I	J	K	L	М
Earthquake-resistant treatment facility (%)	-	0	18.6	0	-	60.9	0	0	35.8	0	0	21.9	-
Earthquake-resistant pumping station (%)	72.3	59.3	26.7	30.5	-	53.1	17.6	0	15.7	0.3	0	-	0.7
Earthquake-resistant service reservoir (%)	20.9	12.7	30.2	24.2	34.8	87.3	16.0	0.3	19.6	34.4	67.6	-	9.6
Earthquake-resistant pipeline (%)	16.8	7.1	11.0	9.1	23.0	21.5	3.9	0.1	1.7	1.3	11.6	17.4	7.5
Chemicals stock (day)	24.1	32.0	51.9	27.7	19.8	-	32.4	19.1	35.4	23.9	60.6	30.2	29.7
Fuel stock (day)	1.1	2.7	0.7	0.15	0.6	0.8	1.6	0	0.38	0.7	0	0	0
Non-utility generation facility (%)	54.3	32.9	91.3	100	72.4	100	88.0	61.5	66.7	42.9	-	78.4	55.1

water purification plants, 30 percent for water supply reservoirs, and 14 percent for piping facilities.

The Water Supply Business Guideline issued by the Japan Water Works Association specifies various performance indicators. The rating of 10 major water suppliers regarding earthquake proofing indicators is given in Table 4. Regarding in-house power generating capability and stockpiling of chemicals, which are indicators related with earthquake safety and disaster risk management, there is a considerable difference among water suppliers. In particular, the level of earthquake proofing of water purification plants and pumping stations is very uneven, and there are many water suppliers whose installations do not meet modern quake resistance reinforcement standards. For piping facilities, earthquake proofing by using ductile cast iron pipes with quake resistant joints, steel pipes with welded joints, ductile cast iron pipes with mechanical joints, polyethylene pipes with fused joints, or similar pipes is recommended. However, the upgrading of older cast iron pipes or asbestos cement pipes without quake resistance is not progressing at a great pace. For example, since 1990 there has been a government subsidy plan for upgrading asbestos cement pipes. Consequently, this has progressed as shown in Figure 3, but in 2004, there were still about 16,000 km of such pipes in existence. The cost for upgrading these is estimated at 450 billion yen, which is why progress in this area is slow especially in the case of suppliers whose financial condition is poor.

Because the overall earthquake proofing progress is slow, point measures are being taken to secure the water supply to critical facilities such as hospitals that will act as medical bases in case of disasters. **Pipes** replaced are being quake-proof types, and some businesses also have taken other measures such as locating emergency underground water supply tanks in

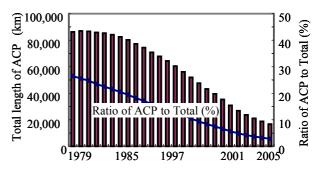


Figure 4 Replacement of ACP

nearby parks, etc.. The biggest risk facing Japanese water suppliers is earthquakes. While consumers are aware of this fact, the crisis awareness of the general populace has not reached a level where an increase in water rates in order to cover the costs for adequate risk management could be easily tolerated.

4. Business Operation Risks Management

Japanese water works are local public enterprises run in effect by local governments, under the management of water works administrators. These represent the local government and operate largely independently, except for making budget adjustments, submitting measures to local councils, having their books examined by audit commissioners, obtaining council approval, and imposing fines. In this sense, the water works are public enterprises whose business accountability is effectively self-supporting.

Normally, water rates are determined according to the multiple costing principle. As seen on a national basis, income from water rates in the year 2004 accounted for about 90 percent of the gross income of water works, which means that self-sustenance is largely achieved. However, 358 water suppliers were posting a net loss, and 383 businesses had carryover losses. The highest items on the outgoing side were costs for construction and renovation of 1128 billion yen, and debt repayments of 720.3 billion yen. Funds were obtained from corporate bonds, other account funds, government and other subsidies as well as accumulated reserves. The effective shortage in financial sourcing amounted to 1.32 billion yen. On the national level and in the short term, business operations of water works therefore can be seen as largely functional, but in the long term, lack of financial resources is likely to affect the upgrading of facilities. This in turn leads to social problems such as the possibility of a degradation of water services due to aging facilities, and the need for steep rises in water rates. The total debt load of national and local government is on the order of 800 trillion yen, which necessarily makes it increasingly difficult for water works to obtain funding and subsidies from other accounts. Implementing risk management principles in the business operations of water works therefore is becoming ever more important.

Under this viewpoint, the Ministry of Health, Labour and Welfare publicized its "Water Works Vision" in 2004, and analyzed the current situation as follows: (1) Many water works have a weak business operation basis. (2) Management of operations is therefore also not fully developed. (3) Technical response to citizens' demands with regard to water services has run out of options. (4) Necessary investments are being put off.

For example, as shown in Figure 5, the drop in the amount of supplied water and the corresponding drop in income from water rates is especially pronounced in the case of small and medium size water works serving areas where the demographics are changing due to aging and depopulation. Lower birth rates and aging are expected to lead to lower population numbers in general, with a figure of 100 million instead of today's 125 million being predicted for 2050. The employment situation at water works is also expected to change, as shown in Figure 6, with about 35 percent of the personnel retiring over the next 15 years. Daily operations may well be affected by the much lower number of employees that is to be expected.

With regard to facilities, piping accounts for some 70 percent of water works assets. Figure 7 shows that from year to year, there is a steady increase in piping

facilities that exceed their statutory useful life of 40 - 60 years. As the revenue from water bills falls, fewer funds are available for the upgrading of equipment and facilities, and as the necessary minimum is not being met, the result is obsolete and aging equipment. Eventually, failures will occur that will impact the stability of water services.

Many social infrastructure including water suppliers services operate according to a management principle that can be called "incrementalism". This is based on the assumption that both the income from water bills as well as the number of personnel will increase every year, and operations can be conducted simply by allocating these increased resources. Proper stock verification is not carried out, while attempting to maximize water services under the assumption that past allocations of increased resources have been appropriate. However, now that decreasing revenue because of a drop in population numbers and in the amount of supplied water have become an unavoidable trend, the efficiency of past allocations must be carefully examined and new structures for allocating funds and manpower must be established. In other words, change towards "decrementalism" is necessary. Services should still be maximized, but this must

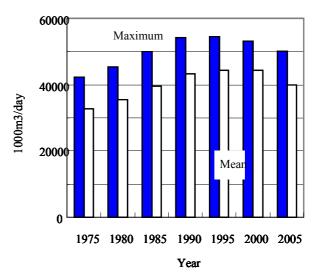


Figure 5 Trends of water supply demands

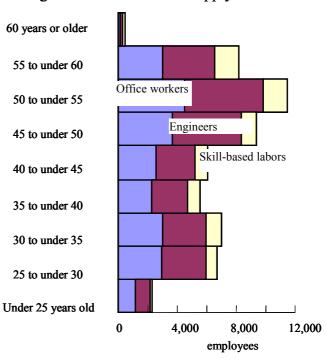


Figure 6 Age distribution of employee

be done while revising the old allocation structure and keeping budget restraints as well as shrinking revenue in mind.

Of course, this means that efficiency must be a priority, but it is even more important to uncover and eliminate hidden inefficiencies. This in turn can be done most successfully by adopting private-sector management policies, i.e. by managing water works according to the mechanisms of the market. Advantages to be expected from this approach are as follows: (1) Provide efficient water services to the public. (2) Promote cost awareness and the desire to devise and implement improvements. (3) Overcome the high cost concept. (4) Consolidate and integrate operations, implement downsizing of facilities, and realize the sustainability of the water supply business.

Because water works are public enterprises run by the local administration,

required funds for upgrading facilities and other activities can come from raising water rates and pursuing the merits of scale by water integration. Small-scale improvements aimed at allowing existing facilities to be used on a long-term basis can help to control the need for large-scale investments and reduce outgoings by cutting down on the interest burden and depreciation costs. However, it is doubtful whether water works that for long time have been accustomed to the decision making local and central patterns of government will be able successfully make the switch to private sector type management based on market mechanisms. In this respect, cooperation between public water works and private-sectors seems more promising approach that should

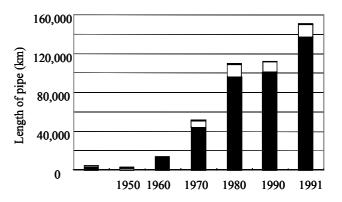


Figure 7 Distribution of aged pipes

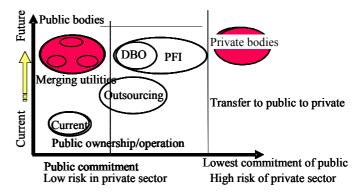


Figure 8 Type of Public and Private Partnership

allow the deliberate adoption of private-sector methods.

Reflecting such environments, revisions of the Water Works Law and the promulgation of the PFI Law have made possible outsourcing to third-party suppliers. At the same time, local governance regulations have been revised to introduce a system of designated administrators for public facilities, and a law allowing the creation of independent administrative corporations has been enacted. These and a number of other regulatory changes have enabled a much more varied interaction between water works and public-sector companies. As shown in Figure 8, such interaction can take various forms, each with different characteristics. How to select an optimum pattern is an important question that must be approached from various angles, taking the service needs and expectations of customers into consideration. Since water works are providers of a public utility, proper risk management allocation between the public and the private sector is mandatory. In this regard, it must be acknowledged that in addition to the traditional stakeholders of a public venture, the investors that effectively enable operation of private-sector companies by providing funds will have to be included in the equation.

If a private-sector company is to partially or wholly provide a public-interest service, a highly developed management structure capable of managing any involved risks is necessary. A principle often adopted in joint undertakings between the public and private sector is that risks should not be borne by a party that is not able to take responsibility. In other words, a party that is capable of taking the responsibility for risks must be found and defined. Rather than information about current cost structures and management principles, a private-sector enterprise looking to enter into a

Table-5 Component of manual of audit to water supplier

	Safety	Stability	Sustainability	Management	Environment
Satisfaction of customer			0		0
Capability of facilities	0		•		0
Competence of Employee		0	•		0
Appraisal of asset	0	0	•	•	•
B/S assessment		0	•	•	0

public-private relationship will need information about the size of possible risks during the intended contract period. This includes data about facility performance and aging status, available manpower resources, type and reliability of compiled management data, accident and failure history, amount and causes of payment arrears, history of warnings or infringements against legal regulations, limitations at the end of operations, and involvement and support by the local administration. In particular, if facilities are to be upgraded with funds raised on the open market, investors will require exact information about the size of possible risks.

In order to assure sustainability, the water works business model will need to be revised from the ground up, including the aspect of joint operations between the public and the private sector. It is necessary to fully examine what management style can be adopted in order to properly manage the water supply business based on the situation in each area from both the managerial and technical perspectives. In order to involve the private sector, it is necessary to evaluate objectively whether business operations carried out by the private sector can achieve its goals, and obtain the agreement of customers.

Therefore, it is also necessary to develop a third party audit system that includes an evaluation of the recommendation for better performance, including the sustainability, of water services. Although the water supply service level is characterized by a sociological, cultural, economical, natural and environmental background, the minimum service level should be able to fulfill the human dignity right in the 25th article of the Japanese government constituent, that is regulated by the Water Works Law. Therefore, the audit system should be composed from the basic point such as protecting public health to the sophisticated point such as aesthetic satisfaction of the water services. And the implementation of the audit to each water service business should be done by a type of de facto standard so as to publish the evaluation and the recommendation as an effective tool to develop consumers' agreements of the stakeholders with its water service business. The audit of the water supplier will be implemented from the view points of safety, stability, management and environment in order to evaluate the satisfaction of customers, capability of facilities, competence of employees, and appraisal of asset and balance sheet assessment, as shown in Table-5. The ISO/TC224, that will be ISO/WD24512, and the Water Supply Business Guidelines issued by the Japan Water Works Association in 2005 will be referred in the manual, because they have been standardized in the performance index.

5. Conclusions

In recent years when most people have access to tap water, their main concern is whether the water supplied is safe to drink and easily available. However, according to the results of on-site inspections of water suppliers nationwide conducted by the Ministry of Health, Labor and Welfare, there are many cases where management of

water supply system is inadequate. In addition, safe water is not yet available to all because of the deterioration in water quality at the source, loss of water quality at connecting points between the public water supply system and private water supply facilities such as the customer's water storage tanks and so on. Significant differences among areas are also present in terms of the availability of drinkable water; specifically, poor taste and odor, the presence of chlorine, color, and turbidity. In order to solve these problems, it is necessary not only to exercise strict control over water quality based on the Waterworks Law but also to implement the risk management from a wider point of view. In order to implement an appropriate risk management it is necessary to identify the goal of environmental management considering the social, natural and economical conditions.

Because of the huge demands of fund for the renovation of exiting facilities that will be terminated the service life, it is necessary to promote public private partnerships for sustainable service of water. In order to evaluate a risk of water utility management it is necessary to develop a de facto standard to audit the water supplier.

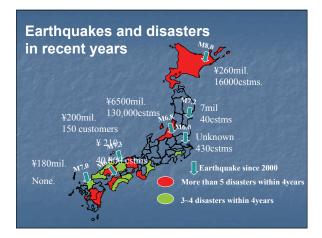
Various globalization movements have been visible recently in the water supply service, including progress in international standardization for water supply and sewage treatment systems in connection with ISO/TC224. Under these circumstances, we can advance international cooperation in water supply services and strengthen our competitiveness by promoting bilateral and multilateral exchanges and adopting an aggressive stance on globalization that will benefit to citizens

References

- 1. Ministry of health, labor and welfares. The Water Works Vision. June 2005
- 2. Japan Water Works Association. Water works management guideline. Oct 2005

Guidelines for the management and assessment of a drinking water supply service Japan-US Governmental conference Bankoku Sinryoukan Okinawa ,2007 Yasumoto MAGARA Professor, Graduate School of Public Policies, Hokkaido University, Japan

Water Utility Management Onsite Inspection report :MHLW Inadequate management Water Quality Management at On-site of customer Risk communication with customer



Great Hansin Earthquake
■ 1995, January 17
 5000 death / 2,000,000 habitants
891,000 without service of piped
water
9 weeks to re-supply of piped
water to damaged customers
60,000 million yen to restore the
facilities
Citizens waiting emergent water supply
in school play ground

Public Water Supply

- Continuous supply is the most important task for water supplier
 - None alternative water source
 - Civil and social activities dependent on water supplied by public water supply
- Risk
 - Water quality
 - Disaste
 - Management

Crypto. Risk management

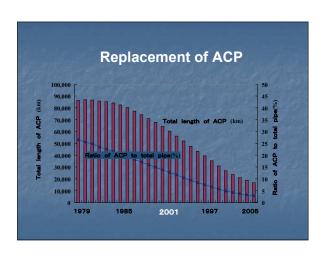
	Public water supply	Small public water supply	Bulk water supply	Others	Total
Total No. of WPP	1679	3296	158	347	5480
No. of measured WPP	1147	1596	155	178	3076
No. of non-measured WPP	532	1700	3	169	2404
Population served1)	4011	944	F-01	49	5005

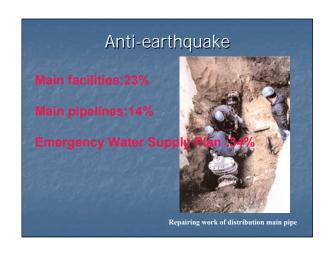
Damage of water supply utilities by Typhoons and Heavy Storms

Year	2003	2004	2005	2006
No. of disaster	4	10	13	13
Population affected	59,079	168,057	137,368	7,108
Total days of stoppage/year	99	99	72	35

The manual of anti-earthquake measures for water services (1996)

- Design standard of water supply facilities
 - Bench mark for physical strength of each unit facilities
- Guidelines for developing the antiearthquake plan
- Guidelines for anti-earthquake construction practice





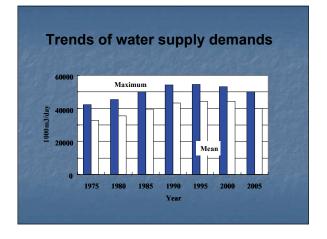
Water supply business management

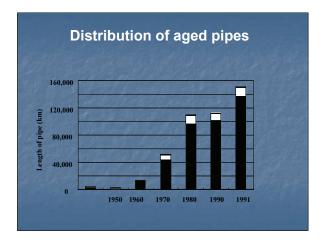
- local public enterprises run in effect by local governments
- water rates are determined according to the multiple costing principle
- The highest items on the outgoing side were costs for construction and renovation of 1128billion yen, and debt repayments of 720.3 billion yen.
- The effective shortage in financial sourcing amounted to 1.3 billion yen
- business operations of water works therefore can be seen as largely functional, but in the long term, lack of financial resources is likely to affect the upgrading of facilities.

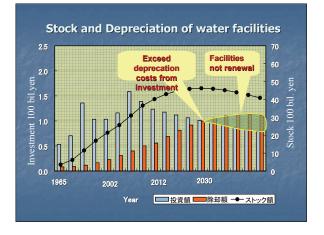
"Water Works Vision"

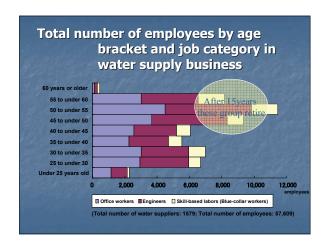
- Many water works have a weak business operation basis.
- (2) Management of operations is therefore also not fully developed.
- (3) Technical response to citizens' demands with regard to water services has run out of options.
- (4) Necessary investments are being put off.

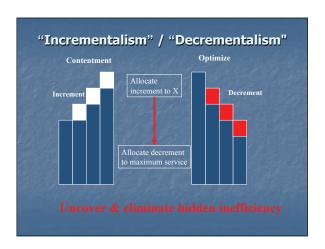
Corrections Page 7, 18lines 11.2 billion 1.120billion Page 7. 21 lines 1.327 billion 1.3 billion











uncover and eliminate hidden inefficiencies

- (1) Provide efficient water services to the public.
- (2) Promote cost awareness and the desire to devise and implement improvements.
- (3) Overcome the high cost concept.
- (4) Consolidate and integrate operations, implement down-sizing of facilities

	anagement Using ns of Collaboration
	stable supply of clear water at low cost hat can greatly satisfy customers
Private companies, etc. Providing expertise, now-how, etc. Provide companies, etc Improve skills to be commissioned by water suppliers Propose various forms of collaboration Provide assistance for technical development regarding efficient maintenance of facilities	management forms from various choices/ Disclosure cicision-making processes and business performance or suppliers or suppliers ead by large-scale water suppliers of facilities, etc. Water suppliers National and local governments Implement and promote collaboration by developing model projects and various guidelinesplers Supervise water suppliers Supervise water suppliers Hopelment and promote collaboration by developing model projects and various guidelinesplers Supervise water suppliers Hopelment and promote collaboration by developing model projects and various guidelinesplers Supervise water suppliers Hopelment and promote collaboration by developing model projects and various guidelinesplers Hopelment and guidelinesplersplers Hopelment and guideline

Guidelines for the management and assessment of a drinking water supply service (JWWA Q 100)

Safety	22
Stability	33
Sustainability	49
Environment	7
Management	24
Globalization	2

Safety of tap Water

PI	Definition	2001 (%)	2002 (%)	2003 (%)	200 4 (%)
Compliance to DWQS	(No. of Exceeding / No. Test)x100	0	0	0	0
Compliance to Must odor	(2-MIB,Geosmin) /(DWQS)x100	67.5	67.5	62.5	100
Replaceme nt of Pb pipes	(No. Pb Plumbing/No. connection)x100	13.0	10.3	7.7	5.8

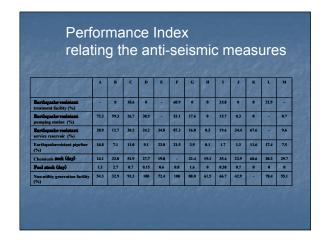
Stability of Services

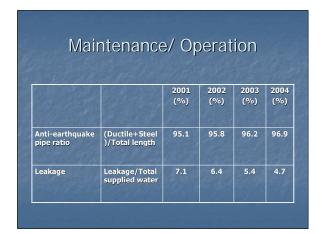
		2001 (%)	2002 (%)	2003 (%)	2004 (%)
Rehabilitation of aged pipe	Length of rehabilitated pipe/Total length	1.4	1.3	1.5	1.3
The accident of water source	No. of accident	18	26	7	6

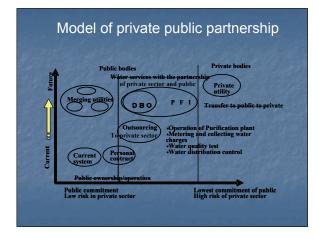
Sustainability of water services

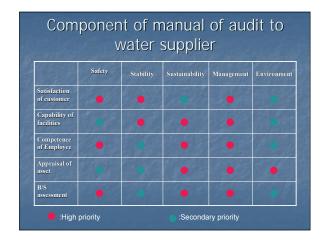
		2001	2002	2003	2004
Income per employees (yen)	(Income/employe es/1000)	63723	65587	68841	71444
Ratio of owned capitals(%)	(Capitals+surplus)/Debt	59.7	61.4	62.8	64.8
Effectiveness of capitals(m3/100 00yen)	Amount of supplied /Capitals	9.1	8.7	8.5	8.4
No. Claims	Claims/ customer	0.2 (‰)	4.6 (‰)	3.9 (‰)	1.0 (‰)



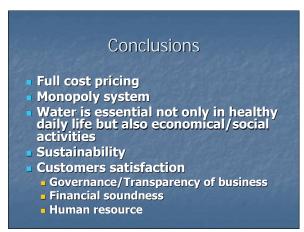












A Strategic Assessment of the Future of Water Utilities

Robert C. RENNER Executive Director AwwaRF

1. Introduction

In order to characterize and respond to future trends, the Awwa Research Foundation (AwwaRF) funded a project entitled, "An Update to the Strategic Assessment of the Future of Water Utilities" in 2004. Efforts focused on the development of Future Trend Papers, future trends grouped into plausible scenarios and the development of future strategies. The project included assembling a group of water utility leaders at a futures workshop.

At the workshop, utility leaders reviewed trend papers, heard futurists, debated over water utility trends, and identified and ranked approximately 19 trends in terms of certainty and desirability. These trends were then grouped into several potential future scenarios.

The expert workshop was designed to gather the wisdom and expertise of the participants by conducting thorough breakout group discussions. The workshop included 35 water professionals from across the U.S. and 6 project team members from McGuire Environmental Consultants, Inc., the principal investigator for the project. The primary objective of the workshop was to develop, through in depth discussions, ten top future trends and formulate strategies to deal with each trend.

2. Top Trends

The top ten trends that were identified are listed below. A summary of each trends potential implications, as well as potential coping strategies, are described in the report.

- 1. Energy
- 2. Drinking Water Industry Employment and Workforce Issues
- 3. Political Environment
- 4. Regulatory Trends
- 5. Population and Demographic Trends
- 6. Total Water Management

- 7. Customer Expectations
- 8. Information Technology
- 9. Utility Finances
- 10, Information Security

A Strategic Assessment of the Future of Water Utilities



Rob Renner

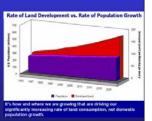
Awwa Research Foundation

A Strategic Assessment of the Future of Water Utilities Top Ten Trends

- 1. Population
- 6. Workforce Issues
- 2. Political Environment
- 7. Technology
- 3. Financial Constraints
- 8. Energy
- 4. Total Water Management
- 9. Increasing Risk
- 5. Customer Expectations
- 10. Regulations

Population: Regional Growth





U.S. Population Projections

2000 - 282,125,000

2030 - 363,584,000b

Political Environment

The political environment is grows complex. There is a surge in NGOs that will play a greater role in public policy decisions. Public participation will play a larger role. Term limits in many communities require greater outreach.

Strategies to address this trend:

- ☐ Develop & maintain state of the art communications.
- ☐ Documentation of financial & capital improvement plans to improve transparency.
- □ Develop communicators & processes
- ☐ Leverage NGOs & relationships

AwwaRF

Mission: Advance the science of water to improve the quality of life

- Centralized research program for drinking water utilities
 - Sponsor research
 - Develop knowledgePromote collaboration
- Agenda is planned and guided by drinking water utilities
- Research covers a broad range of topics including source water, treatment, infrastructure, and management for drinking water utilities

Population Growth

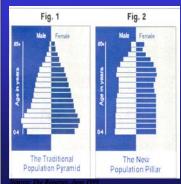
U.S. population steady increase over the past 40 years

Expected to maintain that rate into the next century with the South & West experiencing greatest growth.

Strategies address this trend:

- ☐ Integrated resources planning using scenarios & contingencies.
- □ Become involved in watersheds.
- □ Communicate with consumers.
- ☐ Stake out position on development?

Population: New Demographics



- □ Globally, # of persons >60 yrs is $\sim600M$ in 1999, and projects to $\sim2B$ by 2050.
- □ The # of older persons will be larger than the # of children (0-14) for the first time.
- ☐ People are now living 20 years longer

Finance: Utility Constraints



The challenges of replacing and repairing infrastructure will strain many systems.

Doubling to tripling of rates over next 20 yrs.

Rising rates will require "cost-containment".

Labor unrest potential.

Strategies to address this trend:

- Communication to stakeholders.
- □ Optimize utility efficiency.

Total Water Management

Water utilities will need to increasingly consider broader policy impacts on their water sources.

Strategies to address this trend:

- Documentation of infrastructure & rate needs.
- Communication to stakeholders.
- Optimize utility efficiency.

Total Water Management: Water Use Trends by Category, 1950-2000 Public water use is increasing Source: USGS, March 2004 Impairment is widespread

Customer Expectations Customer service can be improved. Understanding customer needs, desires, and best methods of communication will help ensure there is never a disconnect between the customer and the utility. Strategies to address this trend: ☐ Use state-of -the-art outreach methods to understand & frame interactions ☐ Provide governing bodies consumer info

Workforce Issues There are significant changes occurring in the workforce including retirement, education, increased technology, conflicting generational values, ethnicity and gender. Strategies to address this trend: ☐ Understand generational & workforce differences & needs of employees. Provide workforce flexibility. □ Conduct more training programs. Develop apprenticeship programs.

Total Water Management: Global Warming - Intergovernmental Panel on **Climate Change**

- Projects global temp increase from 1.4 -5.8° C from 1990-2100.
- · Widely varying regional responses,
- Precipitation expected to increase in N. mid-high latitudes
- · Glaciers/ice-caps continue to retreat.
- 3° C melts the 1.8 mile thick Greenland Ice Cap raising - oceans rise by average 7 meters w/in 1000 years (Nature, 2004).



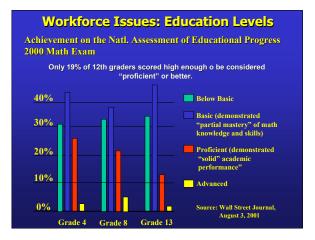
Total Water Management: Alternative Water Sources



- Use of "marginal" supplies (cost & quality) growing
- Membrane costs dropping & energy efficiency improving
- Real & perceived quality issues
- · Water/Growth: chicken or egg?
- 1950 seawater desalting US\$4/kL; now ~US\$0.65/kL
- · Residuals disposal issues grow

Customer Expectations 0.6 **Bottled water sales have** 8.0 risen about 8.0% per year since 1993 2005-0.9 \$9.8B **Projected** SBillion 4.0 3.0 2.0 • 5.1 → 18.2 gal/capita 1985-2000 1984

2000 2003



Workforce Issues: The Brain Drain

More than 40% or U.S. labor Force will reach retirement age by the end of this decade.

More than half of electric utility Workers will be eligible w/in 5 yrs

of workers between 35 and 44 is expected to shrink by 7%



Drinking Water Treatment Technologies

- Multiple drivers pushing new treatment techs.
 - Need to seek additional source water.
 - Impaired/degraded sources
 - Increased demand
 - New/future SDWA regulations.
 - Emerging contaminants.
 - Consumer demands.
- ☐ Major residuals handling issues loom

Increasing Risk Profile

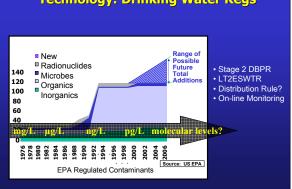


Utility risk issues (e.g. IT, physical security, and litigation) are increasing.

Strategies to address this trend:

- □ Assess internal capability and needs.
- ☐ Outsource functions where appropriate.
- ☐ Develop specific risk management policies.

Technology: Drinking Water Regs



Technology

Technology is rapidly evolving. Its becoming smaller, cheaper and disposable. This trend will continue. On-line monitoring will become the norm.

Energy



Energy and reliability will become a major issue for utilities. Petroleum based energy will give way to other forms within 20-40 years. Alternative fuels will become the norm.

Strategies to address this trend:

- ☐ Develop an energy plan for each utility.
- □ Aggressive energy conservation.
- ☐ Assess backup energy needs & availability.

Regulations



Regulations will continue to challenge water utilities. These regulations will impart fear in the public and are likely to increase sales of bottled water and POU devices.

Strategies to address this trend:

- ☐ Develop clear compliance cost info for stakeholders.
- ☐ Early engagement in regulatory/legislative process.
- ☐ Understand where public stands on issues.
- ☐ Fund and develop alternative regulatory paradigm.

The End Thank You



Modified Watershed-Based Approach to Clean Water - Amendment to Sewerage Law -

Osamu Fujiki*

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Abstract: Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of transferable LRA (Load Reduction Assignment) for nitrogen and phosphorus in the basin of enclosed water bodies. Transferable LRA is somewhat similar to the transferable permit in WQT (Water Quality Trading) employed in the U.S.. The guideline issued by MLIT (Ministry of Land, Infrastructure and Transport) proposes how to determine the baseline LRA, laying an emphasis on the attainment of equity between local entities. Environmental equivalence between before and after the transfer of LRT is expected to be appropriately maintained by evaluating the impacts of every discharged load. "Phased program" of the transfer of LRA and a kind of "LRA Clearinghouse" would be required to explore the opportunities for the transfer of LRA. Draft guideline issued by MLIT proposes the cost allocation that is based on the proportionate relation between transferred LRA and its cost, taking the WQT into consideration. Modifications were made so that the subsidy might not affect the smooth and cost-effective load reduction through the transfer of LRA.

Keywords: watershed-based approach, Comprehensive Basin-wide Plan of Sewerage Systems, water quality trading, load reduction assignment, amendment to Sewerage Law

1. Introduction

Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of transferable LRA (Load Reduction Assignment) for nitrogen and phosphorus in the basins of enclosed water bodies in Japan. The modified watershed-based approach is supposed to play a role equivalent to WQT (Water Quality Trading) which has been applied to quite a few watersheds in the United States¹⁾, where Environmental Protection Agency (EPA) issued Water Quality Trading Policy²⁾ and Water Quality Trading Assessment Handbook³⁾ in 2003 to facilitate the achievement of Total Maximum Daily Load through water quality trading. The aim of this paper is to describe the context of the establishment of this new approach as well as its institutional structures and administrative policies including its comparison with WQT.

2. Difficulties Relating to Advanced Treatment

The water quality has been improved gradually so far in rivers. But most of the enclosed water bodies such as bays and lakes are not getting cleaner in spite of the progress in the population served with sewage treatment (See Figure 1). It is no wonder that those enclosed stagnant water bodies, which are severely polluted through eutrophication, require the reduction in nitrogen or phosphorus inflow by means of advanced treatment of sewerage systems in those basins. In particular, advanced treatments in Tokyo Bay and Osaka Bay basins are considered to be most effective, because almost 90% of population is covered by sewerage and more than half of nitrogen and phosphorus inflows into those water areas through effluent from public WWTP(wastewater treatment plant)s. Therefore, it is no exaggeration to say that the averaged water qualities in Tokyo Bay and Osaka Bay are fundamentally controlled by the water quality of the effluent from public

WWTPs. However the rate of population covered with advanced treatment is very low, 3.6% for Tokyo Bay and 14.1% for Osaka Bay as of the end of fiscal 2003.

The requirements of advanced treatment i.e. effluent water quality that each WWTP is to meet are

usually determined by CBPSS (Comprehensive Basin-wide Plan of Sewerage Systems). CBPSS was legislated in the Sewerage Law as early as 1970. Every prefecture is by law to formulate CBPSSs for ordinance-required water bodies to drive local entities concerned to advance their sewerage construction/improvement projects toward the achievement of EWQS (Environmental Water Quality Standard) in the targeted water bodies (See Figure 2). Although Sewerage construction/improvement programs shall be made and implemented "in accordance with" the relevant CBPSS. CBPSS could not function as strict command-and-control measures and it is often very difficult to guide local entities toward advanced treatment just as is required by CBPSS for the following reasons:

- (1) Sewerage Law postulates that CBPSS should be formulated taking cost-effectiveness into account. Basin-wide cost-effectiveness is theoretically guaranteed on the condition of the equalization of marginal reduction costs across all the WWTPs in the basin. However prefectures formulating CBPSS cannot determine the marginal reduction costs beforehand in reality.
- (2) The expression "in accordance with" does not necessarily imply "coinciding with" juristically. Therefore it is not perceived as illegal for local entities to postpone, for some reasons, the initiation of advanced treatment that CBPSS requires. In other words, command-and-control method cannot be easily applied on the basis of CBPSS.
- (3) Generally speaking, local entities tend to be unwilling to forward the program of advanced treatment in pursuit of downstream benefit alone. Meanwhile, there is often no sufficient reasonable persuasiveness other than downstream benefit to make local entities carry out programmed advanced treatment.

Taking heavily polluted lakes and bays into consideration, some kind of modified approach was obviously needed to promote the advanced treatment in Japan.

3. Preliminary Discussions

Economic, engineering and political studies as well as administrative experiences have revealed that traditional "command-and-control" measures are not enough to ad-

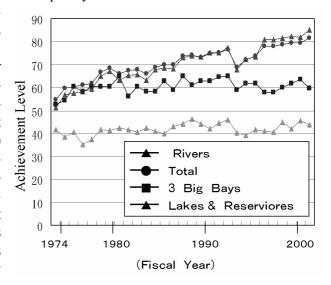
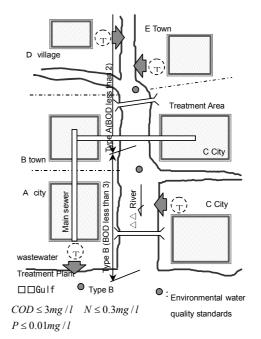


Figure 1: Achievement of Environmental Water Quality Standard

Notes:

- 1.BOD used for rivers, and COD used for lakes/reservoirs, and sea/coastal areas.
- 2.Achievement level (%)=(no. of water bodies achieving / no.of designated water bodies) × 100

Source: Ministry of Environment



Fuigure 2 : Schematic Diagram of CBPSS

dress the externality-related issues such as the promotion of advanced treatment for clean waters whose basin comprises many municipalities. Economic instruments are considered to be cost-effective alternatives, which should be applied solely or together with command-and-control method^{4),5)}. As for the economic instruments for water pollution control, typical examples are

WQT in the US and effluent charge system which is very popular in European countries. Case study for Tokyo Bay and comparative studies focusing on these two methods from the viewpoint of applicability to sewerage works were conducted preliminarily^{6),7)}.

In the case study of WQT focusing on Tokyo Bay, constituents of pollutant were COD, total nitrogen and total phosphorus. By means of computer simulation, transferable permit of each constituent was separately traded among 75 WWTPs in the basin. The total cost abatement rate of water quality trading throughout the basin is estimated to be 31% as shown in Table 1.

Table 1: Total Cost of Advanced Treatment (million yen/year) ^{6),}					
Baseline Permit	After Trading	Cost Abatement Rate			
65,916	45,792	31%			

(simulated for WWTPs in Tokyo Bay basin)

Figure 3 is the schematic diagram of two types of economic instruments, i.e. effluent charge system and WQT. Herein, only the excess load reduction by advanced treatment beyond baseline load (initial permit) is transferable in WQT and let effluent charge system be combined with subsidy where the collected charges are distributed to WWTPs for their advanced treatment By means of theoretical comparison between effluent charge system and WQT, the following conclusions are obtained⁷:

(1) The mathematics for both the effluent charge system and WQT suggests an equivalent cost-effectiveness in meeting a predetermined target of load reduction. Effluent charge system equivalent to a WQT could be theoretically designed from the result of WQT.

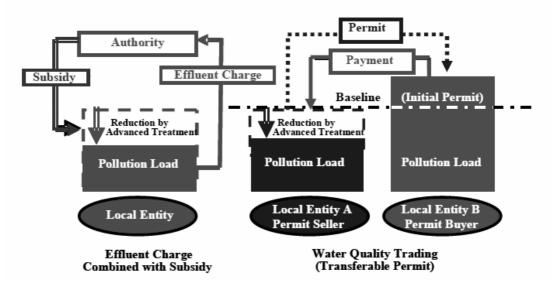


Figure 3: Schematic Diagram of Two Types of Economic Instruments

- (2) WQT could be easily designed on the basis of the total sum of permits which is the predetermined target of the policy, while effluent charge system cannot be designed directly from the target.
- (3) Equality of unit net cost (= cost for advanced treatment subsidy or revenue by selling permit + expenditure for buying permit) is assumed to be an indicator of the equity between WWTPs and the equality could be evaluated by the standard deviation of the unit net costs (net costs per unit volume of effluent). Smaller value of the standard deviation might well be perceived as stronger

equity. According to the comparison of the standard deviations of unit net cost, effluent charge system is estimated to be superior to WQT in terms of equity.

(4) Some local governments might have stronger motive for advanced treatment for their own benefits other than the clean water in targeted water areas. Local conditions like this are more likely to be reflected in the advanced treatment in effluent charge system than in WQT. In other words, effluent charge system is more favourable for local entities that want to forward advanced treatment for their own benefits than WQT.

In course of the energetic arguments for and against employing new economic incentives and scientific discussions about the design of the legislation, it was pointed out that effluent charge system has quite a bit advantage over WQT as shown above. However, the modified approach seems to have been favoured by policy makers mainly because of its plain structure that could be designed easily on the basis of predetermined target as well as of the general public resistance to charging/taxation.

4. Modified Approach

Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of LRA for nitrogen and phosphorus in the basin of enclosed water bodies. Transferable LRA is somewhat similar to transferable permit in WQT employed in the While WQT is founded upon U.S.. NPDES (National Pollution Discharge Elimination System), LRA is a concept in CBPSS and therefore only applied to the advanced treatment of WWTPs. It has become possible that local entities cooperate with each other in advanced treatment of nitrogen and phosphorus through transferring LRA in CBPSS. The outline of the amendment to Sewerage Law is as follows:

A. Determination of the Baseline LRA

(1) Prefecture shall determine the baseline LRA for nitrogen and/or phosphorus contained in the effluent of relevant WWTPs in the CBPSS which targets on enclosed water bodies where EWQS of nitrogen and/or phosphorus is set. Baseline LRA is the LRA initially assigned to WWTPs before initiating LRA transfer according to

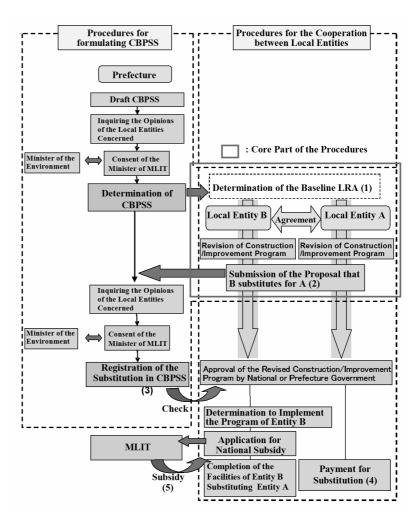


Figure 4: Procedures for Cooperation between Local Entities Relating to Advanced Treatment of Nitrogen and Phosphorus

(1) (5) are correspondent to the underlined heads in this paper.

the procedures for cooperation between local entities.

B. Cooperation for Advanced Treatment between Local Entities

(2) Proposal of Substitution

Local entity can submit to the prefecture a proposal that it will substitutively fulfil the LRA assigned to the other entity's WWTP, after reaching the agreement with the local entity to be substituted for.

(3) Registration in CBPSS

The prefecture that has received the proposal of substitution can register the information of the substitution including the estimated cost and its sharing in the CBPSS.

(4) Payment for Substitution

The local entity that substitutively fulfils the LRA assigned for the other entity's WWTP can, as the legal effect of the registration in CBPSS, make the entity to be substituted for pay the cost for the substitution including the cost of construction, improvement, rehabilitation, repair, maintenance and control.

(5) Subsidy Rate

As to the construction or improvement of the facilities which is carried out for the purpose of the substitution, the subsidy rate for the WWTP whose LRA is substitutively fulfilled is applied. the calculation of subsidy, the cost specified for the other WWTP is basically derived from the ratio of LRA transferred from the other WWTP to all the LRA to be fulfilled by the facilities (See chapter 8).

Legally, there is no concept of the permit for discharging pollutant, much less the concept of transferable permit in Japan. After juristic studies, the concepts of LRA and substituting for another local entity in terms of LRA were introduced to substantially establish the transferable permit for discharging pollutant, i.e. transferable LRA on the basis of CBPSS. Being substituted for by the other local entity on LRA is defined in Sewerage Law as a way to fulfil the duty of the baseline LRA registered in the CBPSS.

Transferable LRA is obviously supposed to play a role equivalent to transferable permit in WQT. shows the equivalence between the

Modified Approach in Water Quality Trading CBPSS (Japan) (U.S.A.) Transferable LRA (Load Transferable Permit for Reduction Assignment) **Discharging Pollutant** Substituting for the Other Local Entity on LRA Selling Transferable Permit (Undertaking the LRA Transferred from the Other Local Entity) Being Substituted for by the Other Local Entity on LRA **Buying Transferable Permit** (Transferring Its Own LRA to the Other Local Entity)

Figure 5: Equivalence between Modified Approach and WQT

modified approach in Japan and WOT in the U.S..

Modified approach with transferable LRA is expected to substantially abate aforementioned difficulties to guide local entities toward advanced treatment, because local entities, which can take the choice of substituting for the other local entities or being substituted for by the other local entities on LRA, will be able to conform to the CBPSS more easily as a whole.

Incidentally, enough attention has to be paid to the fact that "transferable LRA" is not juristically established concept, yet the term and the concept are used often in this paper for the sake of convenience. Figure 4 could be useful for the juristic interpretation.

5. Determination of Baseline LRA

Emphasis should be laid on the attainment of equity between local entities in successful determination of the baselines LRA. In other words, it is important that no entity has a feeling of unfair advantage toward the baseline LRA.

According to the guideline⁸⁾ issued by MLIT (Ministry of Land, Infrastructure and Transport), LRA is determined for every WWTP concerned as follows:

$$LRA(kg/day) = \frac{(C_r - C_t) \times Q_t}{1.000}$$

where

 C_r : Water Quality of Reference (mg/L)

C_t: Average Water Quality Required in the Target Year (mg/L)

 Q_t : Average Daily Flow Rate of the Effluent in the Target Year (m³/day)

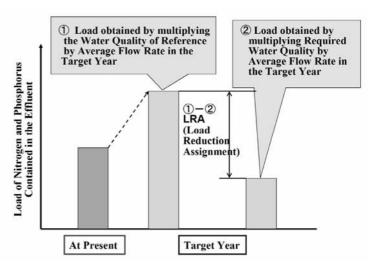


Figure 6: Procedures to Determine Baseline LRA

Water quality of reference C_r is set by taking the present water quality re-

quirement into account. Attention has to be paid to the relation : $C_r \ge C_t$, and therefore each LRA is non-negative.

Average water quality required in the target year C_t is determined so that the municipal wastewater treatment including the increase in the population served with public sewerage might make the relevant waters fulfil their EWQSs together with the other water quality control measures. Concrete method to determine C_t for every WWTP is described as follows:

(a) Set a value for \overline{C}_t common to all the WWTPs at higher level at first. Then decrease the value gradually until it fulfils all the EWQSs in the water areas in target year by means of computer simulation with appropriate boundary conditions e.g. the other countermeasures against pollution.

 \overline{C}_t can be set in this way at nearly maximum value to fulfil the EWQSs.

(b) As for C_t for each WWTP, relevant local entity i determines the values of $C_{t,i,j}$ for its WWTP j, $(j=1 \square n_i)$ so that they may satisfy the equation:

$$\sum_{j=1}^{n_i} C_{t,i,j} \times Q_{t,i,j} \le \overline{C}_t \times \sum_{j=1}^{n_i} Q_{t,i,j}$$

where the local entity i has n_i WWTPs.

But local entity *i* can take the other alternatives, if all the local entities concerned accept it.

(c) When some specific WWTPs dominate exclusively over the water quality at EWQS points in limited areas, then the average water qualities required in the target year for the WWTPs concerned could be determined separately from the rest on the condition that all the other local entities consent to it. In this case, \overline{C}_t is calculated so that it may fulfil all the EWQSs except those of the water areas dominated by the specific WWTPs. The method to determine C_t for WWTPs except those specific ones is same as (b).

The manner mentioned above follows the precedent of basic idea in formulating CBPSS

6. Equivalence in Transfer of LRA

There must be environmental equivalence between before and after the transfer of LRA. In other wards, positive impact of the pollution load abatement in the WWTP undertaking the LRA of another WWTP must exceed or at least cancel the negative impact of the load increase in the WWTP transferring its LRA to the other WWTP.

The relation between the load in the effluent discharged from a point source and its load reaching the point of EWQS is described as:

$$L_r = \alpha \times \beta \times L_o$$

 L_a : Pollution load that is discharged from a point source

 L_r : Pollution load that is discharged from a point source and reaches the point of EWQS.

 α : Runoff coefficient of the pollutant from the discharge point to the receiving point of stream

 β : Runoff coefficient of the pollutant from the receiving point of stream to the point of EWQS

As is described in 3), a pound of phosphorus discharged into a river can "disappear" as it travels down a river through uptake by aquatic plants, settling out, and/or water diversion for agricultural or other users. The coefficient α is supposed to be 1.0 as to WWTPs, because most of the WWTPs discharge their effluents directly into rivers, seas and lakes.

There are quite a few data about β for nitrogen and phosphorus, but most of them are obtained in the fieldwork in dry weather. It is often observed that nitrogen and phosphorus loads in wet weather amount to so much as those in dry weather, while in dry weather the aquatic plants and the depositions/sediments on river beds, which have trapped and kept nitrogen and phosphorus in dry

weather, are supposed to be washed out into the enclosed water bodies concerned. Therefore, the effect of deposit in the streams might be neglected from long-term point of view.

The impact of denitrification in riverbeds is generally estimated to be small enough, compared with the other factors. Concerning the diversion for agricultural use, paddy field use in particular, the impact seems to vary too greatly to be taken into account in the transfer of LRA. Thus, the runoff coefficient

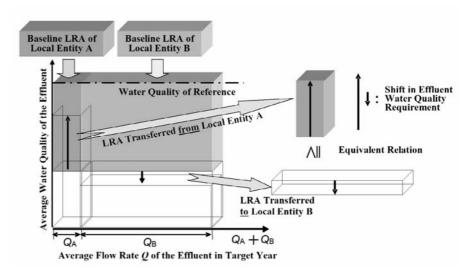


Figure 7: Required Equivalence in Transfer of LRA

 β of nitrogen or phosphorus from the receiving point of stream to the receiving point of the enclosed water body concerned (not to the point of EWQS) may be basically presupposed to be 1.0, except that some specific factors are recognized to give too big impacts to neglect.

Figure 7 is a schematic diagram showing the required equivalent relation between before and after the transfer of LRA. This relation can be written as:

$$Q_{A} \times (C_{1,A} - C_{0,A}) \le Q_{B} \times (C_{0,B} - C_{1,B})$$

where

 Q_A : Average Flow Rate of WWTP A Transferring Its Own LRA to WWTP B

 $Q_{\rm B}$: Average Flow Rate of WWTP B Undertaking the LRA Transferred from WWTP A

 $C_{0,A}$, $C_{0,B}$: Effluent Water Quality Requirements of WWTPs A and B before the Transfer of LRA

 $C_{1,A}$, $C_{1,B}$: Effluent Water Quality Requirements of WWTPs A and B after the Transfer of LRA

Hot Spot" is also a delicate issue in the modified approach just as in WQT. Some potential transfer of LRA that could result in a general water quality improvement in a broad area may also result in acute, localized impacts³⁾.

Since all the proposals submitted by the local entities involved in transfers of LRA is legally checked by the prefecture, the formulator of CBPSS, before being approved as shown in Figure 4, the equivalence is expected to be appropriately maintained by evaluating the impacts of every discharged load and avoiding the transfer of LRA that creates "Hot Spot".

7. Flexible Transfer of LRA

In most cases, WWTPs cannot fulfil their own LRA shortly. The facilities of advanced treatment are constructed in conjunction with reconstruction or extension project of WWTP and those projects are carried out step by step in the long term. If only the WWTP already fulfilling its own LRA were allowed to undertake the LRA transferred from the other WWTP, then the transfer of LRA would not occur because of the shortage of undertakers of LRA.

In order to facilitate the transfer of LRA in a watershed, more flexible processes are proposed⁹⁾ as shown in Figure 8. The WWTP can undertake the LRA transferred from the other WWTP by means of its facilities of advanced treatment, even if the WWTP fulfils only a part of its own LRA. It is recognized as being needed to register the "phased program" of the transfer of LRA in the legal construction/improvement program to promote the smooth and cost-effective load reduction in a watershed. Furthermore, a kind of "LRA Clearinghouse", where aligning the needs and offers to transfer LRA are conducted on the basis of the phased programs, would be required to explore the opportunities for the transfer of LRA between WWTPs.

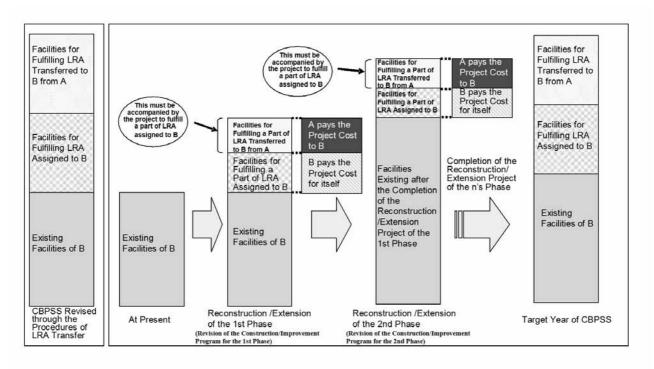


Figure 8 : Phased Program of the WWTP (B) Undertaking the LRA Transferred from Another WWTP(A)

8. Cost Allocation

As is described in chapter 4, the local entity that substitutively fulfils the LRA assigned for the other entity's WWTP can, as the legal effect of the registration in CBPSS, make the entity to be substituted for pay the cost for the substitution including the cost of construction, improvement, rehabilitation, repair, maintenance and control. Following the examples shown in Figure 7 and Figure 8, WWTP B (or local entity B) fulfils the LRA transferred from WWTP A (or local entity A) together with the baseline LRA assigned to B itself. In this case, how should A and B share the cost for the advanced treatment that is conducted by B? Draft guideline issued by MLIT proposes the following method (See Figure 9)⁹⁾:

- (a) Specify the facilities of B and the total project cost C_T for cooperative project of A and B relating to the advanced treatment of N(nitrogen) and/or P(phosphorus).
- (b) Divide the specified facilities into 2 parts: part for the removal of N and the part for the removal of P. Then the project cost C_T is also divided into 2 parts: the costs C_N and C_P related to the facilities for the removal of N and P, respectively.
- (c) Cost allocation for the cooperative project is written as:

The cost that A pays:
$$C_A = \frac{LRA_{N,A} \times C_N}{LRA_N} + \frac{LRA_{P,A} \times C_P}{LRA_P}$$

The cost that B pays:
$$C_B = \frac{LRA_{N,B} \times C_N}{LRA_N} + \frac{LRA_{P,B} \times C_P}{LRA_P}$$

where

 LRA_N , RLA_P : LRA for N and P, respectively, fulfilled by B in this project

 $LRA_{N,A}$, $LRA_{P,A}$: LRA for N and P, respectively, transferred from A and fulfilled by B in this project

 $LRA_{N,B}$, $RLA_{P,B}$: Baseline LRA for N and P, respectively, fulfilled by B for itself in this project

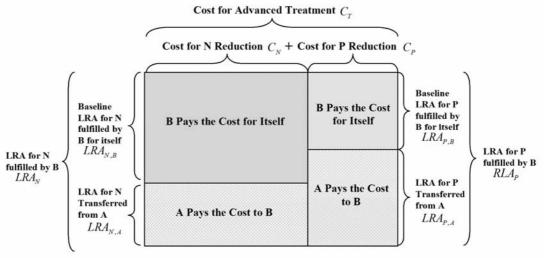


Figure 9 : Cost Allocation in the Cooperative Project with the Transfer of LRA from A to B

Those proportionate relations between LRA and its cost suggest that the prices of permits would be C_N/LRA_N for nitrogen and C_P/LRA_P for phosphorus, if the loads of nitrogen and phosphorus discharged from WWTPs were traded independently from each other.

In the cooperative projects with the transfer of LRA, the capacity of the advanced treatment of B can exceed sum total of LRA that should be fulfilled by B. The cost for that allowance could be allocated easily, according to the above-mentioned manner. In any way, the details of the cost allocations should be discussed enough among relevant local entities and it is desirable to make an agreement about the result before starting the legal procedures shown in Figure 4.

Construction projects for advanced treatment are usually funded by national government. The subsidy rate is 0.55 for public sewerage and 2/3 for regional sewerage. In the cooperative project with the transfer of LRA shown in Figure 9, the subsidy rate for WWTP A is applied to the construction cost of C_A , and subsidy rate for WWTP B is applied to that of C_B .

Local entities that conduct advanced treatment are privileged to get a national subsidy for wider range of collection networks. In the cooperative projects with the transfer of LRA, the local entities that transfer their LRA to the other local entities are also privileged in the same manner.

These kinds of modifications were made so that national subsidy system might not affect the smooth and cost-effective load reduction through the transfer of LRA.

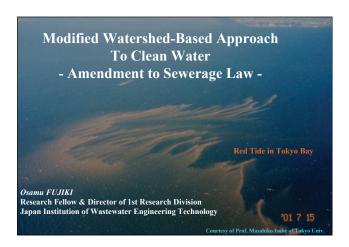
9. Conclusion

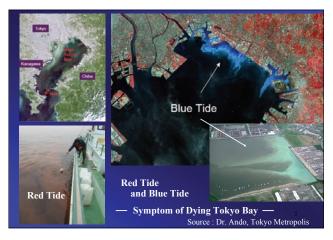
- (a) Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of LRA (Load Reduction Assignment) for nitrogen and phosphorus in the basin of enclosed water bodies.
- (b) Though there is no legal concept of transferable LRA in Japan, the concepts of LRA and substituting for another local entity in terms of LRA were introduced to substantially establish the transferable LRA on the basis of CBPSS (Comprehensive Basin-wide Plan of Sewerage Systems).
- (c) Transferable LRA is somewhat similar to transferable permit in WQT (Water Quality Trading) employed in the U.S.. While WQT is founded upon NPDES (National Pollution Discharge Elimination System), LRA is a concept in CBPSS and therefore only applied to the advanced treatment of WWTPs (Wastewater Treatment Plants).
- (d) In preliminary discussions before the amendment to Sewerage Law, it was pointed out that effluent charge system has quite a bit advantage over WQT. However, the modified approach seems to have been favoured by policy makers mainly because of its plain structure that could be designed easily on the basis of predetermined target as well as of the general public resistance to charging/taxation.
- (e) The guideline issued by MLIT (Ministry of Land, Infrastructure and Transport) proposes how to determine the baseline LRA, laying an emphasis on the attainment of equity between local entities
- (f) After the discussions on the relation between the load in the effluent discharged from each WWTP and its load reaching the point of EWQS, environmental equivalence is expected to be appropriately maintained by evaluating the impacts of the load discharged from every WWTP and avoiding the transfer of LRA that creates "Hot Spot".
- (g) In order to facilitate the transfer of LRA in a watershed, "phased program" of the transfer of LRA and a kind of "LRA Clearinghouse" would be required to explore the opportunities for the transfer of LRA between WWTPs.
- (h) Draft guideline issued by MLIT proposes the cost allocation based upon the proportionate relation between transferred LRA and its cost, taking the virtues of WQT into consideration.
- (i) As to the system of the national subsidy, modifications were made so that the subsidy might not affect the smooth and cost-effective load reduction through the transfer of LRA.

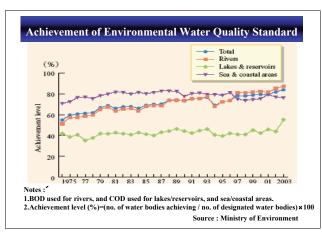
Now is progressing the formulating work of CBPSSs for the clean waters in the 3 big bays (Tokyo Bay, Osaka Bay and Ise Bay) and other enclosed water bodies. In that process, transfer of LRA is also discussed among local entities in parallel with the determination of baseline LRA.

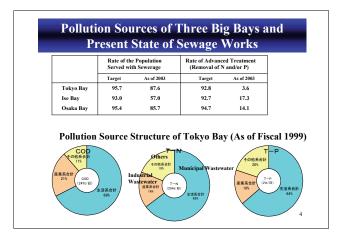
References

- 1) Mark S. Kieser and "Andrew" Feng Fang: *Economic and Environmental Benefits of Water Quality Trading An Overview of U.S. Trading Program -*, "Proceedings of the Workshop on Urban Renaissance and Watershed Management, organized by the Ministry of Land, Infrastructure and Transport and Shiga Prefecture, 3, February 2004, Otsu "
- 2) US-EPA: Water Quality Trading Policy, January 2003
- 3) US-EPA: Water Quality Trading Assessment Handbook: EPA Region 10's Guide to Analyzing Your Watershed, July 2003
- 4) T. H. Tietenberg: *Emission Trading, an exercise in reforming pollution policy*, Resources for the Future, Inc., 1985
- 5) William J. Baumol and Wallace E. Oates: *The theory of environmental policy, second edition*, Cambridge University Press, 1988
- 6) Yoshida, T. and Fujiki, O.: *Investigations on Economic Efficiency and Cost Sharing for Water-shed Management in Japan*, "Proceedings of the 3rd U.S.-Japan Governmental Conference on Drinking Water Quality Management and Wastewater Control, July 12-15, 2004, Hawaii, U.S."
- 7) Fujiki, O.: Economic Instruments for Basin-wide Efficient Pollution Load Reduction Comparison between Effluent Charges and Water Quality Trading -, "Proceedings of the 10th Japanese-German Workshop of Wastewater and Sludge Treatment Technologies, October 9-10, Munich, Germany"
- 8) Sewerage and Wastewater Management Department, MLIT: Guideline to Determine the Baseline Load Reduction Assignment of Nitrogen and Phosphorus for Each Wastewater Treatment Plant, June 2006
- 9) Sewerage and Wastewater Management Department, MLIT: Draft Guideline and Its Commentary on the Cooperation between Local Entities Relating to Advanced Treatment For Addressing the Load Reduction Assignment , 2006



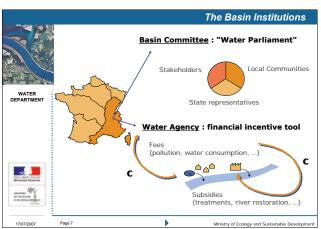


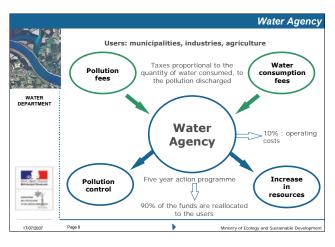


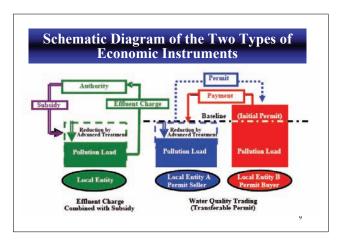


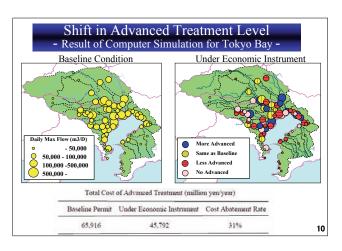


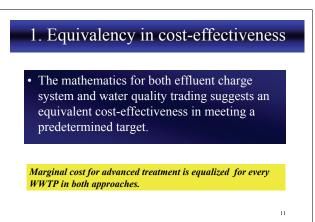


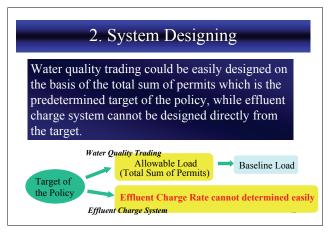


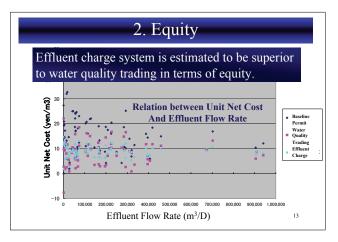




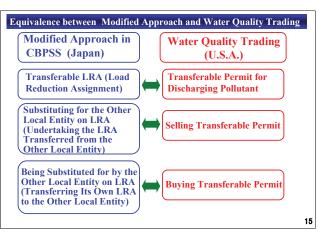


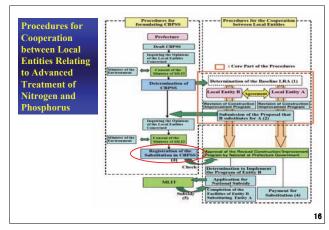












Modified Approach

- A. Determination of the Baseline LRA
- Prefecture shall determine the baseline LRA (Load Reduction Assignment) for nitrogen or phosphorus contained in the effluent of relevant WWTPs in the CBPSS which targets on enclosed water bodies where EWQS (Environmental Water Quality Standard) of nitrogen or phosphorus is set.
- <u>B. Cooperation for Advanced Treatment between Local Entities</u>
- B-1 Proposal of Substitution
- Local entity can submit to the prefecture a proposal that it will substitutively fulfil the LRA assigned to the other entity's WWTP, after reaching the agreement with the local entity to be substituted for on this issue.

B-2 Registration in CBPSS

- The prefecture that has received the proposal of substitution can register the information of the substitution including the estimated cost and its sharing in the CBPSS.
- B-3 Payment for Substitution
- The local entity that substitutively fulfills the LRA
 assigned for the other entity's WWTP can, as the legal
 effect of the registration in CBPSS, make the entity to be
 substituted for pay the cost for the substitution including
 the cost of construction, improvement, rehabilitation,
 repair, maintenance and control.

Concrete Methodology for the Modified Approach

- 1. How to determine baseline LRA for every
- WWTP concerned.
- ⇒ Guideline issued by MLIT
- 2. How to transfer LRA from a WWTP to
- another WWTP
- 3. How to allocate the cost between local entities.
- ⇒ Graft guideline issued by MLIT

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Determination of Baseline LRA

- According to the guideline issued by MLIT, Baseline LRA is determined for every WWTP concerned as follows:
- Baseline $LRA(kg/day) = \frac{(C_r C_t) \times Q_t}{1,000}$
- · where
- ${\bf C}_r$: Water Quality of Reference (mg/L) set by taking the present water quality requirement into account.
- • C_t : Average Water Quality Required in the Target Year (mg/L)
- Q_t : Average Daily Flow Rate of the Effluent in the Target Year (m3/day)

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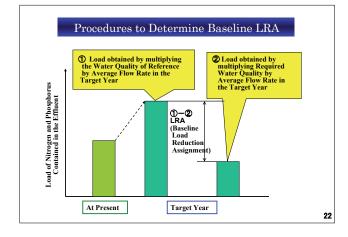
C_t is determined so that the municipal wastewater treatment might make the targeted public waters fulfil their EWQSs.

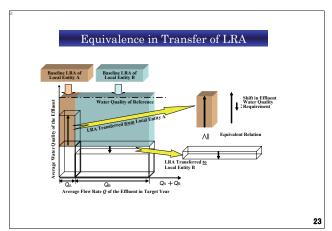
- (a) Set a value for C
 _t common to all the WWTPs at higher level at
 first. Then decrease the value gradually until it fulfils all the EWQSs
 in the water areas in target year by means of computer simulation
 with appropriate boundary conditions e.g. the other countermeasures
 against pollution. C
 _t can be set in this way at nearly maximum
 value to fulfil the EWQSs.
- (b) As for for each WWTP, relevant local entity *i* determines the values of for its WWTP *j*, so that they may satisfy the equation:

$$\sum_{i=1}^{n_i} C_{t,i,j} \times Q_{t,i,j} \leq \overline{C}_t \times \sum_{i=1}^{n_i} Q_{t,i,j}$$

• where the local entity i has WWTPs.

21





How should we evaluate the decrease in the load in the river basin?

The coefficient α is supposed to be 1.0, because most of the WWTPs discharge their effluents directly into rivers, seas and lakes.

There are quite a few data for β , but most of them are obtained in the fieldwork in dry weather. The aquatic plants and the river beds trap and keep nitrogen and phosphorus in dry weather. But most of the deposited nitrogen and phosphorus are supposed to be washed out into the enclosed water bodies in wet weather.

 \Rightarrow β river may be presupposed to be 1.0 in most cases.

 $L_{r} = \alpha \times \beta \times L_{o}$ $L_{r} = \alpha \times \beta \times L_{o}$ 0 in most cases.

In order to facilitate the transfer of LRA

Flexible processes are proposed as shown in Figure 8. The WWTP can undertake the LRA transferred from the other WWTP, even if the WWTP fulfils only a part of its own

"Phased program" of the transfer of LRA and a kind of Clearinghouse would be required to explore the opportunities for the transfer of LRA between WWTPs.

25

Phased Program of the WWTP (B) Undertaking the LRA Transferred from Another WWTP(A) 26

Cost Allocation in the Cooperative Project With the Transfer of LRA from A to B

- (a) Specify the facilities of B and the total project cost C_T for cooperative project of A and B relating to the advanced treatment of N(nitrogen) and/or P(phosphorus).
- (b) Divide the specified facilities into 2 parts: part for the removal of N and the part for the removal of P. Then the project cost C_T is also divided into 2 parts: the costs C_N and C_P related to the facilities for the removal of N and P, respectively.
- (c) Cost allocation for the cooperative project is shown as:

27

Formulating work of CBPSSs for the clean waters in the 3 big bays (Tokyo Bay, Osaka Bay and Ise Bay) and other enclosed water bodies are now progressing



Cost Allocation in the Cooperative Project With the Transfer of LRA from A to B Cost for Advanced Treatment C_{τ} Cost for N Reduction C_N + Cost for P Reduction LRA_{p}

This proportionate relation between LRA and its cost is recommended so that the result of the modified approach may be nearly equalized to the result of WQT.

Application of Clean Water Act Tools to Restore and Protect Watersheds

James Hanlon
Office of Wastewater Management
United States Environmental Protection Agency

1. Introduction

Surface water quality in the United States is governed by the terms, conditions, requirements and programs of the Clean Water Act. Since 1972 this statute has provided the foundation upon which water quality programs across the nation are built. This presentation discusses current efforts by the US Environmental Protection Agency (EPA) to use the foundation of the Clean Water Act and current tools to protect and restore watersheds across the United States.

2 Overview

The stated objective of the 1972 Clean Water Act (CWA) is to protect and restore the physical, chemical and biological integrity of our Nations waters. In 1972 that was a lofty goal recognizing the Cuyahoga River in Cleveland, Ohio occasionally caught on fire; Lake Erie, one of the Great Lakes, was declared dead; and the Potomac River in Washington, DC was often called an open sewer. These were symptoms of a wider and deeper set of problems affecting water resources across the United States.

The water quality management program established by the CWA, beginning with designated uses and numeric and narrative standards; monitoring; assessment and impaired water listings; total maximum daily load (TMDL) calculations that include point source and non-point source allocations to meet standards; a point source permitting program (National Pollutant Discharge Elimination System – NPDES), along with compliance monitoring and enforcement has been the foundation of efforts in the U. S. for the last 34 years. Implementation has been consistent and methodical. In the early years, grant programs funded billions of dollars in municipal infrastructure, the NPDES program focused on issuing over 50,000 permits to municipal and industrial point source dischargers, first focusing on technology based minimum levels of treatment and then additional treatment to meet water quality objectivities. Toxic limits in permits and a focus on wet weather sources of pollution from separate and combined sewer overflows and municipal, industrial and construction stormwater were priority areas in the late 1980's and thru the 1990's. In the mid-1990's a focus on total maximum daily loads (TMDL's) and the assessment of what combination of point and non-point source loads watersheds could sustain, were completed in many areas for the first time. In the past five years thousands of TMDL's have been completed.

The above abbreviated history, as it unfolded, was largely completed thru separate, focused initiatives that individually made significant progress in assessing, designing, building, permitting, or enforcing to meet a single parameter objective. Loadings were reduced, but in many cases, systematic restoration of water quality did not result. Beginning with the focus on TMDL's and thru the related assessment of the effect of point and non-point sources, land use patterns, hydrologic and atmospheric impacts, the concept of watersheds management has evolved.

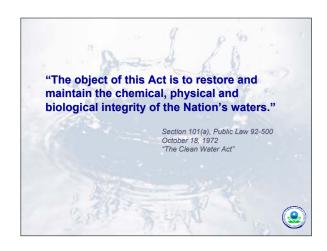
Over the last ten years, the focus of EPA efforts in the National Water Program has been on the watershed. The objective is to use the available tools, ever improving through better science and technology, and apply them in a systematic method to protect and restore watersheds across the country.

In the United States, EPA has the nationwide responsibility to establish a framework using regulation, policy, guidance and funding to facilitate the implementation of the CWA. Most of the implementation occurs at the State or local level. There are thousands of watershed groups across the country, working with local government, universities, and business and citizens groups to improve their watershed.

This presentation focuses on one approach being taken by the water program in EPA Region 4, located in Atlanta, Georgia, and having EPA jurisdiction in eight southeastern States. They are leaders in the implementation of the watershed approach.

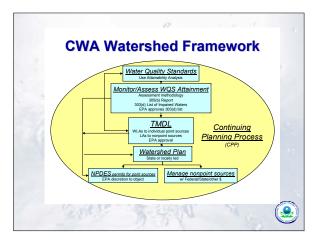
The national water program at EPA is committed to the protection and restoration of watersheds. The 2006-2011 EPA Strategic Plan, dated September 2006, includes numeric targets for the improvement of impaired watersheds and for the improvement of waterbody segments within watersheds. Through the application of sound science and focused public policy, improvements will happen. Lake Erie today supports a multi-million dollar boating and sport fishing industry and the Potomac River hosts national bass fishing tournaments. Watersheds across the nation await this progress.



















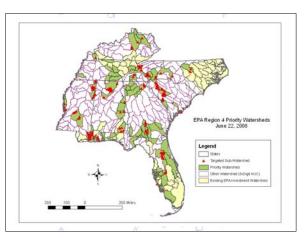




Technical Tools Restoration project management (wetlands, streams, lakes) Problem solving (technical) Landscape level assessments, mapping and analysis Modeling and technology transfer Planning Assistance (Watershed Plans, Source Water Assessment and Protection Planning, TMDL Implementation, Wetlands Advanced Identification) Analytical Methods

Direct Involvement Leadership/sponsorship role Broker/Facilitator role Influencing the Federal Community Leverage Funding Implementing the Watershed Approach by overseeing its various phases.

EPA Watershed Selection Criteria Value of resource at risk or seriousness of threat Likelihood of achieving positive environmental outcomes Evidence of strong public and local/state government support Existence of scientific studies or data about the watershed Existence of an entity with a proven track record to promote and coordinate partnerships Benefits associated with EPA leadership and addition of EPA's significant expertise in this area



2	Phase I: Explore	Phase II: Build/Prepare	Phase III: Implement	Phase IV: Trans. To Maint.
tressor/Source			-0.23	P Co
Ability to Act				
Communication				
Funding				
Action Plan				
Exit Strategy		-		

Phase I Example Criteria: EXPLORE

■ Stressor/Source Identification

- Collect, map and perform cluster analysis on impaired waters
- Collect and review pertinent TMDLS and NPDES permits Collect information gathered at the watershed by locals where relevant

■ Ability to Act

Check with the state for acceptability and synergies Check with workgroup for programmatic priority overlaps Do the locals want EPA involved in the watershed?

Phase II: BUILD/PREPARE

■ Stressor/Source Identification

Have data needed to perform a detailed assessment been identified?

Has the group identified who can best collect and/or analyze the needed data?

Has the spatial distribution of pollutant loading been sufficiently defined to establish areas of concern within the watershed?

Ability to Act

Have all identified skill/role gaps been filled?

Does the coalition have a legal structure for acquiring/administering funds or a clearly identified mechanism for accomplishing this function through a partner?

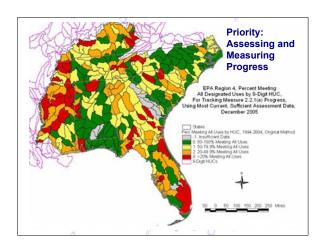


Priority: Achieving Results

Between FY02-FY05, Twenty four 8-Digit HUC watersheds moved into the "restored" category in Region 4



Neuse River Results Achieved Goal Greater than 30% reduction in nitrogen loading between 1997 and 2003

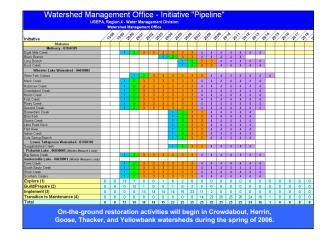


TRADING ASSOCIATIONS

■ Neuse River, North Carolina

- Nitrogen trading agreement
- 23 members, primarily large municipalities
- Single, general permit for nitrogen
- If the association exceeds it allocation, it is subject to enforcement action
 - Any member exceeding its allocation is then subject to enforcement





Watershed Goals

EPA 2006-2011 Strategic Plan

By 2012:

- Attain standards for all pollutants and impairments in more than 2,250 waterbodies by 2012 (baseline 39,798)
- Remove at least 5,600 of the specific causes of water body impairment identified in 2002 (baseline 69,677)
- Improve water quality conditions in 250 impaired watersheds nationwide using the watershed approach





Seawater Desalination Facility on Okinawa

Toru Yamazato

Seawater Desalination Center, Chatan Water Administration Office, Okinawa Prefectural Enterprise Bureau

1. Introduction

Okinawa Seawater Desalination Center was completed with full capacity in 1997. The facility was constructed to ease water shortage on Okinawa by converting surrounding clean seawater into drinking water. With ten years of operation, the facility has proved to be successfully functioning to meet demand for drinking water especially in drought situation.

This presentation covers an overview of Okinawa Seawater Desalination Center, issues including product water quality and facility maintenance, and finally, the facility's overall performance of the past ten years.

2. Overview

2.1 Need for desalination facility on Okinawa

Due to population growth and economic development, the average water consumption on Okinawa doubled from approximately 200,000 m³/day in 1972 to 420,000 m³/day in 2002. Water rationing occurred in 14 years out of 34 years since 1972. The longest water rationing continued for 326 days from 1981 to 1982. The most recent water rationing occurred in 1993.

Shortages were anticipated for water resources dependent on the development of dams and rivers. As a countermeasure, the Enterprise Bureau of Okinawa Prefecture decided to promote the desalination project. The first survey was conducted by the Japanese government in 1977, and construction began in 1993.

2.2 Reverse osmosis seawater desalination facility

The construction cost of Okinawa Seawater Desalination Center was 34.7 billion yen, 85% of which was subsidized by the national government.

The facility exploits reverse osmosis technology to desalt seawater. The production capacity is 40,000 m³/day, which is nearly equal to 10% of the average water consumption on Okinawa. Fig.1 shows the process flow.

The facility needs approximately 9,000 kW of electricity for full operation.

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High pressure pumps, which are necessary to bring about reverse osmosis, consume most of the energy. Energy recovery turbines retrieve approximately 30% of the energy from the brine, which still has high pressure.

The desalted fresh water is sent to adjoining Chatan Water Purification Plant and mixed with potable water produced from inland water.

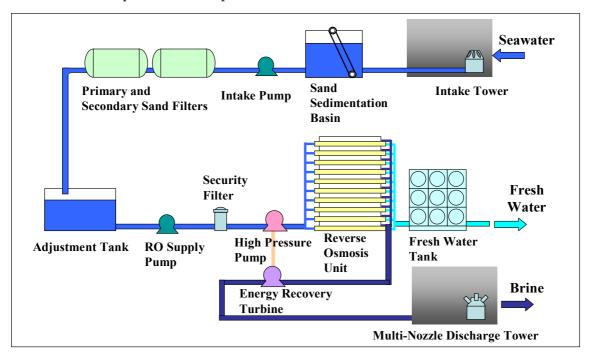


Fig.1 Process flow of Okinawa Seawater Desalination Center

3. Water quality

3.1 Effect of desalination

In the reverse osmosis (RO) process, most of the substances in seawater are removed. Table.1 compares quality of the RO feed seawater, the desalted product water, and the mixed potable water.

Table.1 Comparison of water quality

Item	RO feed water	Desalted water	Mixed water	
Total Dissolved Solids	34,800	278	256	
Chloride Ion	19,800	119	46.5	
Sodium and its compounds	11,400	96.1	38.8	
Sulfate Ion	2,490	5.9	36.8	
Hardness	6,360	10	113	
Electrical conductivity	50,800	456	436	
Boron and its compounds	4.68	1.14	0.12	

(Units: $[\mu \text{ S/cm}]$ for electrical conductivity and [mg/l] for others)

The mixing strategy has several advantages, as explained in the following sections.

3.2 Hardness

Desalted fresh water has an extremely low hardness and is considered corrosive. Usually, a mineralizing process follows the RO process as a post-treatment in order to prevent corrosion. However, since the water produced in Chatan Water Purification Plant has relatively high hardness, the hardness of the mixed water becomes moderate. Therefore, the post-treatment is not needed.

3.3 Conductivity

Salt rejection rate is a great concern in the desalination facility. Electrical conductivity is a good scale of salinity and easy to monitor continuously. Okinawa Seawater Desalination Center has set $720\,\mu$ S/cm as the maximum operational conductivity for the product water. This value corresponds to the allowable concentration of chloride ion according to water quality regulations.

3.4 Boron concentration

Boron is hard to remove in a single stage reverse osmosis process. Japanese water quality regulations demand boron concentration to be less than 1.0 mg/l. Table.1 shows that boron concentration was not sufficiently reduced by the desalination process alone but successfully suppressed by mixing.

4. Maintenance

4.1 Biofouling

The RO process utilizes polyamide membrane, which does not tolerate oxidizing agents. Since the feed water does not contain chlorine, biofilm tends to grow inside the seawater channel and obstruct the feed flow in the RO elements. This phenomenon, biofouling, may cause irreversible damage to the membrane elements. Okinawa Seawater Desalination Center conducts sulfuric acid shock treatment and membrane cleaning to control biofouling. An effective cleaning method has been established. However, the shock treatment still needs to be investigated to achieve reliable efficiency.

4.2 Element replacement

As the RO elements are used, the salt rejection rate declines, and average conductivity of the product water increases. The deteriorated elements must be replaced in order to maintain quality of the product water. The life span of an RO element depends on the operating conditions such as quality of pretreatment. Okinawa Seawater Desalination Center began element replacement in 2000 and had replaced about a half of the originally installed 3,024 elements by 2006.

5. Overall performance

5.1 Production

Ten years have passed since the facility started operating. For the first five years, Okinawa had enough rainfall, and full operation of the desalination facility was not necessary. Since 2001, there have been occasional drought, and Okinawa Seawater Desalination Center has performed long term full operations. Fig.2 shows the annual production and the operating rate of each year. The total production through 2005 had reached over 37 million cubic meters. Due to recent droughty climate, the operating rate reached 44.2%, the facility's highest record.

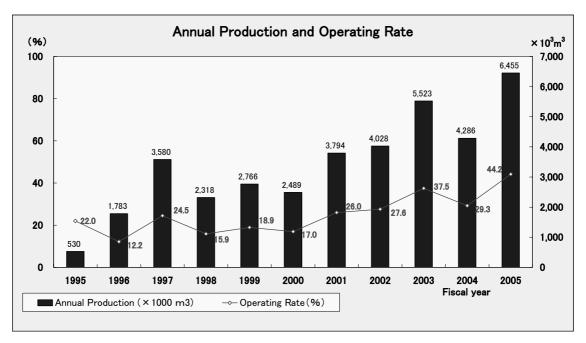


Fig.2 Annual production and operating rate

5.2 Cost

As of 2004, the production cost of the fresh water produced in Okinawa Seawater Desalination Center is approximately 132 yen/m³. Fig.3 shows the components of the cost. As shown, electricity is the most dominant factor of the cost.

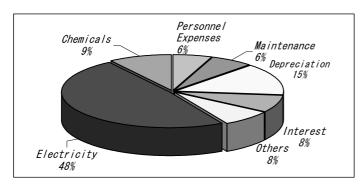


Fig.3 Components of the production cost

5.3 Water quality and element replacement

Table.2 lists some of the water quality items maintained in Okinawa Seawater Desalination Center. Fig.4 shows the ten year trends of the product water quality. The standards have been maintained for all the items except boron. Fig.4 also shows the numbers of replaced membrane elements within the same period. The figure clearly shows the effect of the membrane replacement on the product water quality.

Table.2 Water quality items

Standard	Item	Value	
Max Operational Value	Conductivity	720 μ s/cm	
Water Quality Regulations	Total Dissolved Solids	500 mg/l	
	Chloride Ion	200 mg/l	
	Boron	1.0 mg/l	

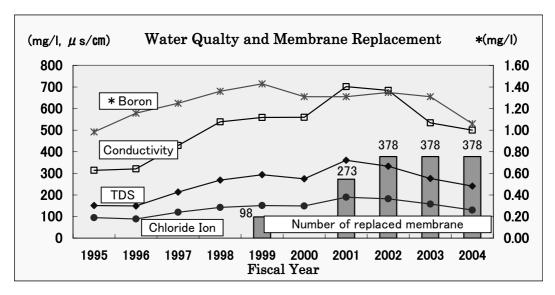


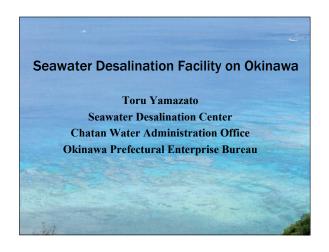
Fig.4 Water quality and membrane replacement

6. Conclusion

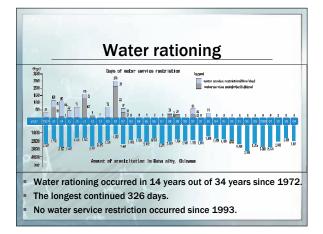
With ten years of operation, Okinawa Seawater Desalination Center has accumulated valuable technical experiences. The membrane cleaning and the element replacement have been successful in maintaining quantity and quality of the product water. Since biofouling is a drawback for long term full operation, an effective shock treatment method is sought. The operating rate of the facility has been increasing due to the droughty climate. Therefore, the facility has been functioning as a crucial water resource on main island of Okinawa.

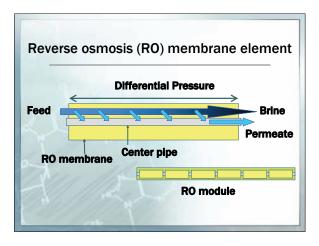
Reference

Japan Water Works Association, Design Criteria for Waterworks Facilities (2000) 352



Needs for desalination Reverse osmosis seawater desalination facility

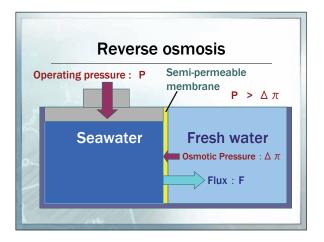


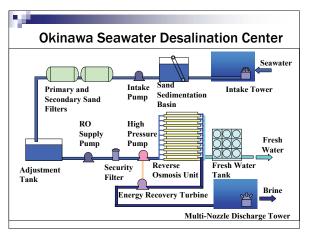


Introduction 1. Overview 2. Water quality 3. Facility maintenance 4. Overall performance

Needs for desalination

- Water demand doubled in 30 years
- Supply dependent on dams and rivers
- Merit of desalination
 - Abundant water from the sea
 - Short construction period
 - Location near consumers





Okinawa Seawater Desalination Center

Production capacity: 40,000m³/day

Recovery rate: 40%

Maximum power consumption: 9,000 kW

• 378 elements / unit \times 8 units = 3,024 elements

 Product water is sent to adjoining water purification plant to be mixed with water from inland.

Construction cost: 34.7 billion yen

85% subsidized by the national government

Partly operational in 1995

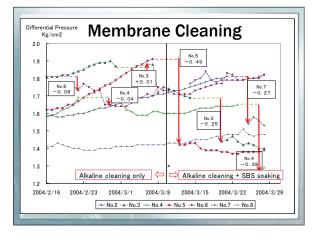
• Fully operational in 1997

2. Water quality RO feed water Desalted water Mixed water **Total Dissolved Solids** 34,800 278 256 Chloride Ion 19 800 119 46.5 Sodium 11.400 96.1 38.8 Sulfate Ion 2.490 5.9 36.8 Hardness 6,360 10 113 Electrical conductivity 50,800 456 436 4.68 1.14 0.12 (Units: [µS/cm] for electrical conductivity and [mg/l] for others)

3. Maintenance

Biofouling

- Polyamide membrane and oxidizing agents
- Biofilm in the feed channel
- Damage to the membrane elements



4. Overall performance

- Production
- Cost
- Water quality and membrane elements

Countermeasure for biofouling

Sulfuric acid shock treatment

- Acid injection to the feed
- pH = $2.5 \sim 3.0$ 30 minutes
- Advantage : Long running time of RO units

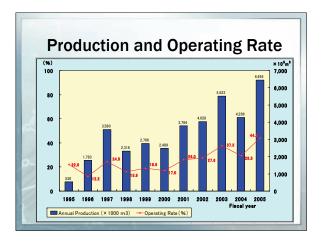
Membrane cleaning

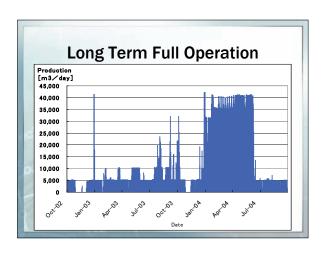
- Off-line cleaning
- -pH = 10.5 3 days
- Advantage : Fundamental and efficient

Element replacement

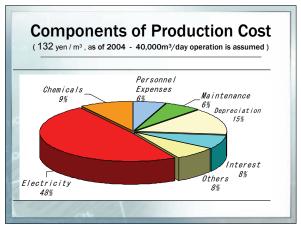
Salt rejection declines

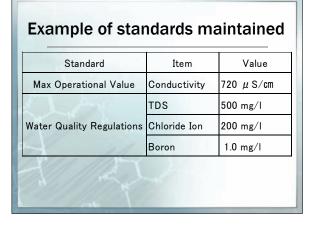
- Conductivity of the product water increases.
- Replacement started in 2000.
- About a half of the elements were replaced by 2006.

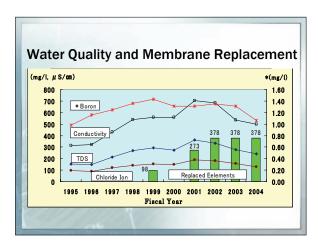












Conclusion

- Okinawa Seawater Desalination Center accumulated valuable technical experiences.
- Membrane cleaning and element replacement have been successful.
- An effective shock treatment method is needed.
- The operating rate has been increasing due to droughty climate.
- Therefore, the facility has been functioning as a crucial water resource on Okinawa.



Reuse and Desalination Technologies to Improve the Sustainability of Drinking Water Supplies

Marty Allen, Ph.D.¹
Director of Technology Transfer
Awwa Research Foundation

1. Introduction

Sustainability, in its most fundamental definition, is the ability to meet current and future needs without causing unacceptable consequences. Sustainability has become a framework for water supply strategic planning in a manner similar to the watershed concept in the late 1980s and early 1990s. Like the watershed approach, sustainability is a very broad-based construct that provides a holistic context to water supply planning. From a water utility perspective, the key focus of sustainability is to ensure the long-term availability of safe and affordable drinking water for consumers, with recognition that other water uses (e.g., agricultural, recreational) and other priorities (e.g., ecology and environment, general economic prosperity and welfare) must also be sustained. Water supply management strategies such as conservation and demand management have a role in the sustainability of drinking water supplies, but new technologies for water reuse and desalination are becoming increasingly important.

Water reuse and desalination research coordinated and funded by the Awwa Research Foundation (AwwaRF) has developed both practical management strategies and proven technological advances that can aid utilities in making the most of their source water resources. Water quality, energy consumption, and waste management drive AwwaRF's reuse and desalination research. This paper describes AwwaRF's research program involving water reuse and desalination to improve the sustainability of drinking water supplies.

2. Water Reuse, Recycling and Reclamation

2.1 Brief Overview

2.1 Brief Overviev

Water reuse refers to the use of treated municipal wastewater as a source of supply for nonpotable uses (nonpotable reuse) or as a supplement to a drinking water supply through blending with raw water sources (indirect potable reuse). Nonpotable and indirect potable reuse applications can supplement a water utility's source water resources by using advanced processes to treat municipal and industrial wastewater, stormwater, and agricultural drainage to create high-quality water for a variety of uses. Water reuse is also referred to as water recycling and water reclamation.

Nonpotable reuse applications may include landscape and agricultural irrigation, industrial use, vehicle washing, toilet flushing, and air conditioning. Reclaimed water produced for nonpotable uses is not intended for drinking or other household uses. Indirect potable reuse applications may involve purposely discharging reclaimed water into either groundwater or surface water

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that ultimately supplies a public drinking water system. The quality of recycled water, and the ability to meet required water quality objectives via natural and advanced treatment technologies drives research in this area. AwwaRF has funded several projects in partnership with other organizations to advance the science of water reuse strategies and technologies.

2.2 Sustainable Underground Storage and Soil Aquifer Treatment

Treatment scenarios need not be technologically complex for reclaimed water quality requirements. One of the key emerging approaches to help ensure sustainability is underground storage – water deliberately recharged into an aquifer and later extracted for use. While relatively simple in concept, the actual practice presents a number of challenges, both technical and institutional. The term sustainable underground storage (SUS) refers to underground storage projects in which these technical and institutional challenges are overcome, resulting in the long-term viability and success of the projects. AwwaRF has partnered with domestic and international organizations to advance the science of SUS, including many projects on aquifer storage and recovery and a large, comprehensive phased study on soil aquifer treatment.

Soil aquifer treatment (SAT) is a treatment and storage system that allows for augmentation of potable water supplies with recycled water (indirect potable reuse). It includes three components; 1) infiltration through a biologically active interface less than three feet in depth, 2) percolation through a vadose zone, 10 to 100 feet deep, and 3) storage and/or transport in an underlying aquifer (0.5 to 10 years duration), prior to withdrawal via wells. AwwaRF has completed a phased research plan investigating SAT.

- Soil Treatability Pilot Studies to Design and Model Soil Aquifer
 Treatment Systems (1998) studies the treatment of wastewater
 effluent as it percolates through soil and evaluated means to
 maximize the treatment efficiency and capacity of SAT systems. The
 study included a systematic evaluation of the effects of soil type and
 effluent pretreatment on the efficacy of SAT.
- Soil Aquifer Treatment for Sustainable Water Reuse (Phase 1 published in 2001, Phase 2 published in 2006) evaluated the sustainability of SAT and elucidated SAT processes to improve the design of these systems. For indirect, potable reuse, the two SAT options are:
 - SAT with reclaimed water without membrane pretreatment, or
 - Groundwater recharge with reclaimed water treated by reverse osmosis (RO).

The study found that effluent pretreatment did not affect final soil-aquifer treatment (SAT) product water with respect to organic carbon concentrations. Additionally, removal of organics occurs under saturated anoxic conditions, and a vadose zone is not necessary for an SAT system. If nitrogen removal is desired during SAT, nitrogen must be applied in a reduced form, and a vadose zone combined with soils that can exchange ammonium ions is required. It was also

noted that the distribution of disinfection by-products produced during chlorination of SAT product water is affected by elevated bromide concentrations in reclaimed water.

2.3 Advanced Treatment Technologies

Advanced treatment technologies (e.g., membranes) can be used to produce water of necessary quality for nonpotable and indirect potable reuse. Two primary challenges for implementing and operating advanced treatment technologies, particularly membranes, regardless of application are 1) energy consumption and 2) concentrate (or waste) management. AwwaRF is carefully studying these issues for water reuse applications as described below, but also for desalination applications as described later in the summary.

The feasibility of nanofiltration (NF) and ultra-low-pressure reverse osmosis (ULPRO) membranes for rejecting total organic carbon, total nitrogen, and unregulated trace organic compounds under a range of experimental conditions at the laboratory-, pilot-, and full-scale to produce water suitable to augment drinking water supplies are currently being evaluated in the on-going study "Comparison of Nanofiltration and Reverse Osmosis in Terms of Water Quality and Performance for Treating Recycled Water" (Project #3012). This report should provide utilities with guidance on selecting membranes and predicting solute rejection during NF-ULPRO membrane treatment.

"Membrane Concentrate Treatment Strategies for Inland Water Reclamation Systems" (Project 3096) is developing methods to manage waste (or concentrate) streams from water reclamation systems (including agricultural drainage) so that the water may be recovered for potable or industrial purposes while the salts are converted into solid by-products. The research also aims to determine the optimum combination of membrane, thermal and solid-liquid separation processes for different concentrate solutions, and develop a computer model for optimizing unit processes for different water qualities.

2.4 Additional Information on Reuse Research

Industrial users are amongst a water utility's largest consumers of high quality distributed water. Water Quality Requirements for Reclaimed Water (2004) identified industries that can use reclaimed water (excluding irrigation and groundwater recharge) and determined the water quality requirements for certain industrial uses. One key finding among industrial users is that consistent water quality is more important than actual water quality. General concerns about water quality that crossed industry lines include bacterial and residual organic issues, presence of ammonia, presence of nutrients, suspended solids, scale formation, staining, and sulfate corrosion.

Following is a select list of additional on-going research projects and published reports on water reuse, recycling, and reclamation by AwwaRF:

- "Design, Operation, and Maintenance Considerations for Sustainable Underground Storage Facilities" (Project 3034)
- "Water Quality Changes Associated With Aquifer Storage and Recovery" (Project 2974)

- Framework for Developing Water Reuse Criteria With Reference to Drinking Water Supplies (2005)
- Characterizing Microbial Water Quality in Reclaimed Water Distribution Systems (2005)

3. Desalination

3.1 Brief Overview

Desalting technology (reverse osmosis, nanofiltration, electrodialysis/electrodialysis reversal) is used in water treatment to provide new sources of potable water via the treatment of lower quality water resources. Over 230 desalination plants providing greater than 25,000 gpd of produced water were identified in a study by Mickley (2006) for the United States Bureau of Reclamation (Bureau). This represents a nearly 100% increase in implemented desalinating plants since Mickley performed the first study for the Bureau in 1992. Still challenging to all desalination plants are high energy costs and the lack of environmentally-sensitive and cost-effective concentrate treatment and disposal options. Inland facilities without access to large surface water bodies for concentrate discharge are especially burdened by lack of disposal options. Before desalination can be seen as a sustainable solution for drinking water supplies, these economic and environmental issues must be solved. Current AwwaRF desalination research focuses on the development of technologies to decrease energy consumption and provide for sustainable concentrate management options. More than a dozen studies are currently underway.

3.2 Advanced Treatment Technologies

In coordination with the Long Beach Water Department (California), the research resulting in the report *A Novel Approach to Seawater Desalination Using Dual-Staged Nanofiltration Process* (2006) proved that a dual-staged nanofiltration (known as NF²) can desalt seawater to potable water levels with less energy than is theoretically needed for traditional single-pass seawater reverse osmosis. Additionally, the boron concentration in the permeate is below state regulations at certain pH levels. The permeate may however contain bromide ions that exert additional chlorine demand during contact-time requirements, and the brominated residuals thus formed will produce brominated DBPs and deplete disinfectant residual when desalinated water is blended with surface water. Thus, controlling the effects of bromination is essential for system implementation.

"Water Quality Implications of Large-Scale Application of Seawater Desalination" (Project 2841) aims to develop water quality and design information for desalination systems. The research is testing and monitoring membrane performance, analyzing finished water quality, and assessing operating costs as well as examining the impact of desalination on blended water quality and the disposal options for concentrate streams.

Projects 3030 "Desalination Product Water Recovery and Concentrate Volume Minimization" is developing a new membrane-based process to improve the recovery of high quality product water while reducing the

concentrate volume. This is a phased study and the researchers have proven a concept at the bench-scale which is now being testing at the pilot level.

Enhanced Reverse Osmosis Systems: Intermediate Treatment to Improve Recovery #4061 will design and develop two inter-stage treatment systems to increase recovery in reverse osmosis plants and thus reduce disposal costs, in particular for inland facilities. The research will also compare recovery using advanced oxidation of anti-scaling compounds with that of electrodialysis.

3.3 Concentrate Treatment and Disposal

AwwaRF is giving concentrate management considerable emphasis in its research program. Currently in the United States there are four primary concentrate disposal options, 1) wastewater (or sewer) discharge, 2) surface water discharge, 3) subsurface injection, and 4) land application. Nearly 72% of desalting plants in the U.S. discharge to surface waters (Mickley, 2006). In the inland and arid regions of the U.S. where available new water supply is minimal and where desalting may provide a sustainable solution, surface water disposal is not available. AwwaRF has partnered with several organizations in the U.S. to fund numerous projects to advance the science of this challenging area, including:

- Beneficial and Non-Traditional Uses of Concentrate (2006)
- "Zero Liquid Discharge and Concentrate Volume Minimization for Inland Desalination" (Project 3010) – a technology based project where a new process has been developed and tested at the benchand pilot-scales.
- "Regional Solutions for Concentrate Disposal" (Project 4071)
- "Membrane Plant Impacts on Wastewater Treatment" (Project 4072)
- "Zero Liquid Discharge for Water Utility Applications" (Project 4073) a survey-based informational project about ZLD within and outside the water industry.

3.4 Additional Information on Desalination Research

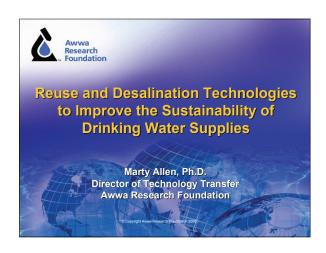
The implementation of desalination technology is being critically and comprehensively evaluated in Project 4006 ("Critical Assessment of Implementing Desalination Technology"). The researchers will survey domestic and international desalination plants to obtain and report real implementation experiences including siting, permitting, capital and operating costs, water quality considerations, etc. One final project of note, "Desalination Facility Design and Operation for Maximum Energy Efficiency" (Project 4038) will compile and analyze data from operating brackish (ground and surface), seawater, and wastewater membrane desalination facilities to result in recommendations for the design and operation of desalination facilities to maximize energy efficiency and reduce energy use and costs. This partnership with the California Energy Commission will also investigate the relationships between plant location, design, operation and maintenance, and energy use and cost.

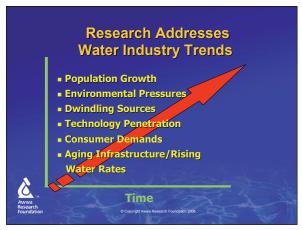
4. AwwaRF Website

Information is available for all projects funded by AwwaRF in the Project Center at www.awwarf.org.

References

Mickley, M. 2006. Desalination and Water Purification Research and Development Program Report No. 123 (Second Edition) - Membrane Concentrate Disposal: Practices and Regulation. U.S. Department of the Interior Bureau of Reclamation. Denver, Colorado.

















Membrane Research AwwaRF first funded membrane treatment research in 1988 ■ ~50 projects funded at nearly \$20 Million Topics: - integration reverse osmosis (RO) fouling - nanofiltration (NF) - contaminant removal ultrafiltration (UF) - process optimization microfiltration (MF) electrodialysis (ED) - desalination concentrate management















Current Desalination Research, Cont'd

- Enhanced RO Systems: Intermediate Treatment to Improve Recovery (Project
 - \$250K effort with the Univ of Texas Austin, HDR, Carollo, B&V, and CDM
 - Developing two inter-stage treatment systems to increase recovery and reduce concentrate volume



Current Desalination Research, Cont'd

- Desalination Facility Design and Operation for Maximum Energy Efficiency (Project 4038)
 - \$300K effort with Carollo, CEC and 16 water
 - Project title says it all...guidance, guidance, quidance



Current Concentrate Management Research

- Zero Liquid Discharge and Volume Minimization for Inland Desalination (Project 3010)
 - \$850K partnership with CEC, B&V and five water utilities
 - Develop ZLD technologies that are less energyintensive for inland desalination



Began September 2004, Report available 2007

Current Concentrate Management Research, Cont'd

- Concentrate Disposal for Inland Regions Partnership Program
 - \$385K Joint Water Reuse & Desalination Task Force initiative; managed by WateReuse Foundation
 - - Impacts of Membrane Process Residuals on Wastewater Treatment



Investigation of Regional Solutions for Disposing Concentrate

Available Reports

- A Novel Approach to Seawater Desalination Using Dual-Staged NF Process (2006)
 - \$450K partnership with LBWD (EE&T and UN-Reno)
 - One year pilot at LBWD
 - Proven less energy intensive than traditional single-pass RO



Available Reports Continued

- Characterizing and Managing Salinity Loadings in Reclaimed Water Systems (2006)
 - Partnership with IRWD, WateReuse Foundation, WateReuse Assoc, and 11 water utilities
 - Protocol for characterizing commercial, industrial, and residential salinity contributions to sewers and reclaimed systems
 - Guidelines for identifying economic impacts of salinity management practices



Available Reports Continued

- Nonthermal Technologies for Salinity Removal (AwwaRF 1997, Order No. 90840)
 - Partnership with MWD, OCWD, and Lawrence Livermore Nat'l Lab
 - Evaluates RO w/ ultra-low pressure membranes to desalinate CO River water
 - Evaluates capacitive deionization w/ carbon aerogel electrodes at the bench-scale



What's Next?

- Seawater and Brackish Water Research and **Development Program Partnership**
 - California Department of Water Resources grant
 - Research program designed by the Joint Water Reuse and Desalination Task Force through a research needs roadmapping process
 - Solicited and unsolicited projects to be funded beginning in 2007





New Research Project on Drinking Water Quality Management

Masahiro Fujiwara Japan Water Research Center

1. Introduction

Currently, a considerable number of water purification plants in Japan are due for renewal within the next ten years. Also, when comparing the current water resource quality with that at the time of plant construction, the ratio of dam water (discharge/storage) to surface water relatively increased, and water quality has worsened due to development in the surrounding region. Furthermore, as is the case with cryptosporidium, there is a problem with pathogenic microorganisms that are resistant to chlorine disinfection. Meanwhile, in order to respond to consumer needs for safe and palatable water, contamination counter-measures against odor-causing compounds, including 2-MIB and geosmin, are vital to the water utilities.

The Japan Water Research Center (hereinafter JWRC) has employed the following kinds of methods in water technology research and development for about the past 20 years. Using Grant-in-Aid for Scientific Research from the Ministry of Health, Labour and Welfare, and research contributions from private companies as funds, the JWRC has carried out large-scale research projects through cooperation of private companies, water utilities and scholars. In these industry-utility-academia research and development projects, the research objective was to develop a technology that could actually be used in practice. A good example of the success of this research is membrane filtration technology. The researched and developed membrane filtration technology was put into practical use, and is now in use at many water purification plants around the country. The aforementioned industry-utility-academia research system is unique to Japan, and it is thought to be a method well suited to Japanese society.

2. History of research projects

As shown in Table-1, with regards to water purification technology, research started in 1991 with Pilot Plant for MF/UF Membrane (MAC21), then went on to Pilot Plant for NF Membrane (Advanced-MAC21). Next came R&D on High-Efficiency Water Purification Technology (ACT21). Following that there was R&D on Sustainable Water Purification Technology (*e-Water*), which finished the fiscal year before last, and now we have the 5th project, R&D on the Establishment of Advanced Water Purification Technology for Safe and Palatable Water (*e-Water II*). Pipeline technology research and development projects also began in 1996, and after finishing research on a water service system without receiving tank

Table-1 Research & Development Projects

Project Name Content

Year	Project Name	Content		
1991~1993	MAC21	Pilot Plant for MF / UF Membrane		
1994~1996	Advanced-MAC21	Pilot Plant for NF Membrane		
1997~2001	ACT21	R&D on High-efficiency Water Purification Technology		
2002~2004	e-Water	R&D on Sustainable Water Purification Technology		
2002 2004	Epoch	R&D on Movement of Suspended Solid in Pipeline		
2005~2007	e-Water II	R&D on the Establishment of Advanced Water Purification Technology		
2005: -2007	New Epoch	R&D on Pipeline Diagnosis Technology		

and an earthquake-resistant pipeline system, work began in 2002 on R&D on Movement of Suspended Solid in Pipeline (*Epoch*). R&D on Pipeline Diagnosis Technology (*New Epoch*) has been ongoing since 2005.

The development and diffusion of membrane water purification plants are a representation of the success originating from these research and development projects. Since the introduction of 7 plants (600m³/d) around the country in 1993, the number of those plants has grown year by year and as of now (March 2006), the number has reached 550 plants with an accumulated plant capacity of 622,650m³/d.

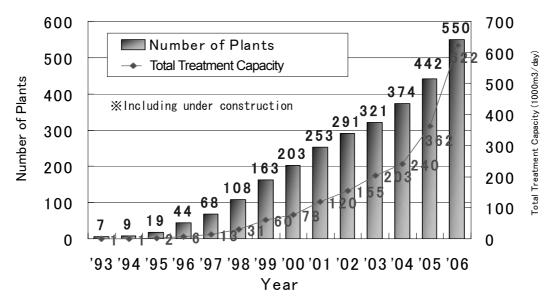


Figure-1 Membrane Water Purification Plants in Japan (researched by JWRC in 2006)

3. Recent Research Results and Ongoing Research Projects

3.1 Research Project Organization and Scale

To facilitate its smooth implementation, the ongoing water purification research project has been organized into 4 committees such as The General Research Committee for integration of research contents. There are five research sub-committees under the committee for each specific research theme. The pipeline technology research project has been organized so that for each research theme, two research sub-committees are working under the Pipeline Research Committee.

With regards to the scale of the projects, the water purification technology project involves 32 private companies, 18 university scholars, and 25 water utilities and related organizations. The number of researchers exceeds 150. The pipeline technology project involves 14 private companies, 7 university scholars, and 16 water utilities. The total research budget is US \$6,000,000, which comprises of direct expense only. (*e-Water II* makes up US \$5,000,000 and *New Epoch* makes up US \$1,000,000.)

3.2 Water Purification Technology Research Contents

The fundamentals of the 3-year *e-Water* Project starting in 2002 were summarized and published as Guideline for introduction of large-scale membrane filtration facilities, Guideline for use of iron-based and

organic-polymer coagulants, Guideline for introduction of Ultraviolet-Rays (UV) disinfection, and Manual of integrated treatment for sludge from water purification plant and sewage treatment plant.

The ongoing 3-year *e-Water II* Project, which started in FY2005, is conducting a research on the following themes:.

(1) Research on a Suitable Purification System in Accordance with Raw Water Conditions

Raw water conditions nationwide are classified into groups based on water quality. They are then, through a water purification system implementing a combination of unit water purification processes, evaluated on such criteria as safety of treated water quality, sustainability and manageability, economical use of energy, a Life Cycle Assessment taking into account reduced environmental burden, drainage and sludge treatment process, and monitoring and instrumentation systems, and suitable water purification process guidelines are then investigated.

- The classification of treatment systems and the establishment of desirable treated water quality levels
- The study of coagulant dosage, mixing conditions and pretreatment methods with regard to the combination of membrane filtration treatment and iron-based coagulant (Plant experiment)
- Measurement, analysis and evaluation of raw water quality
- Evaluation of water quality and function in each purification process
- Establishment of Life Cycle Assessment (LCA) technique





Photo-1 Pilot Plant

(2) Research on Odor-Causing Compounds for Safe and Palatable Water

Traditionally, 2-MIB and geosmin have been stated as being the representative odorants. However, there are instances where even though these two substances have not been detected in the raw water, odors still occur after the purification treatment, or at the water taps. It may be that odor-causing compounds present in the raw water are denatured in the chlorine process, and then forms some sort of odorants.

In order to supply safe and palatable water, we are carrying out research which will improve on safety and



Photo-2 Odor-Causing Compound Detection Equipment (VOC Monitoring System)

comfort through such means as promptly detecting unknown odor-causing compounds, changing the method of water intake, and advancing the water purification process.

- Simulation by means of water quality prediction models
- Creation of hazard maps
- Examination of counter-measure technologies against odor-causing compounds (including 2-MIB, geosmin)
- Implementation of online observation experiments using VOC monitoring system

3.3 Pipeline Technology Research Contents

The 3-year *Epoch* Project, which started in FY2002, elucidated the condition of the movement of suspended solid in the pipeline. In addition, research was carried out on the effective usage of energy by small generator in the pipelines, and practical apparatus was developed.

Regarding the ongoing 3-year *New Epoch* Project, "R&D on Pipeline Diagnosis Technology", which started in 2005, the following themes are being researched.

(1) Research on Water Quality Deterioration in Decrepit Pipeline and Preventive Measures

Using the decrease and disappearance of residual chlorine as a main indicator, investigate methods to diagnose and evaluate the deterioration status of inside the pipes, and developing a pipeline function diagnosis technology in terms of water quality.

- Investigation of the relationship between water quality and decrease in residual chlorine
- Investigation of the relationship between pipeline material and decrease in residual chlorine
- Examination of actual water quality in decrepit pipelines
- Examination of water deterioration prevention by improving the Langelier's Index

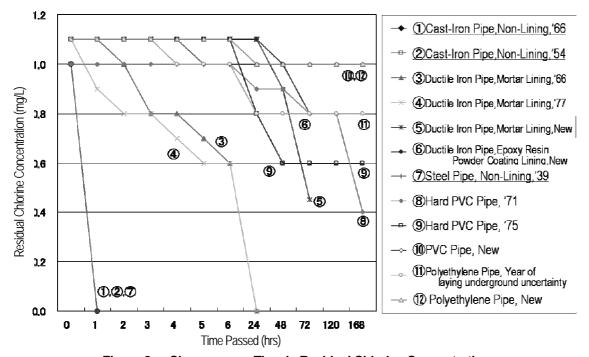


Figure-2 Changes over Time in Residual Chlorine Concentration

With regards to the investigation into the relationship between pipeline material and the decrease in residual chlorine, samples were taken from underground pipelines of various types that had been constructed in different years. These pipes were filled with water (residual chlorine concentration 1.0-1.2mg/l, pH7.0). The changes over time in residual chlorine concentration and various water qualities were measured. The results confirmed that the non-lining cast-iron pipe and the non-coated iron pipe showed a trend of decreased residual chlorine.

(2) Research on Diagnosis Technology of Decrepit Pipeline

By making use of statistical as well as physical methods, develop a new diagnostic technology to easily and efficiently determine the condition of underground pipeline, and consider its application to existing pipeline.

- Study of existing pipeline diagnosis technology
- Examination of diagnosis method of decrepit pipeline using statistical method
- Basic research towards No-Dig diagnosis

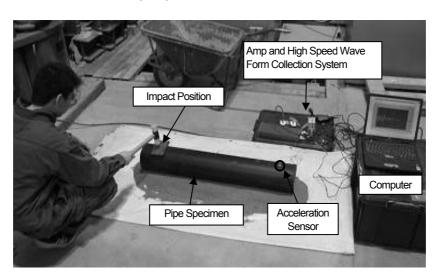


Photo-3 Impact-elastic wave method Experiment

4. Conclusion

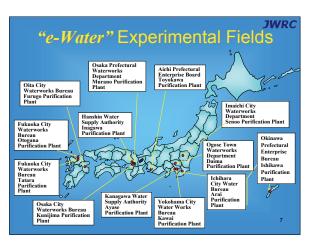
The objective of the ongoing study is to create suitable water purification process selection guidelines for various raw water conditions, conducted research on counter-measures for odor-causing compounds in order to supply palatable water, and carry out research on pipeline diagnosis technology for systematic and efficient pipeline renewal, and deliver safe and palatable water. We intend to continue to endeavor to achieve our objectives, and utilize the knowledge gained from every participant to further our research.

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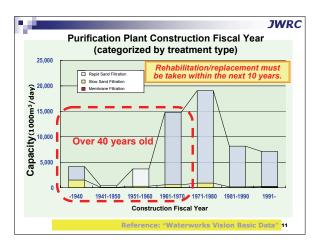
Outline Tripartite Industry-Utilities-Academia R&D on Water Technology History of JWRC R&D Projects Research Budget Projects and its Results "e-Water" & "e-Water II" for Purification Technology "Epoch" & "New Epoch" for Pipeline Technology

Large Scale R&Ds				
Term	Project Name	Themes		
1991– 93	MAC21	Pilot Plant for MF / UF Membrane		
1994– 96	Advanced- MAC21	Pilot Plant for NF Membrane		
1997– 2001	ACT21	R&D on High-efficiency Purification Technology		
2002- 04	e-Water	R&D on Sustainable Purification Technology		
2002-04	Epoch	R&D on Movement of SS in Pipelines		
e-Water II		R&D on Establishment of Advanced Purification Technology		
2003-07	New Epoch	R&D on Pipeline Diagnosis Technology 4		

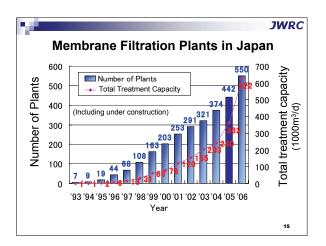


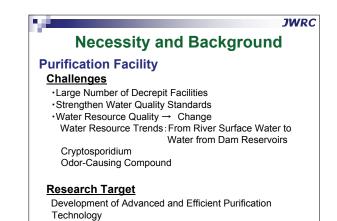


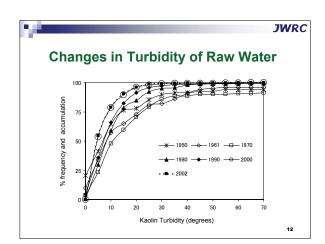
Budget and Researchers (2005- 07) Total Budget for Direct Expense Only: U\$\$6 million U\$\$5 million for "e-Water II" (Purification Technology) U\$\$1 million for "New Epoch" (Pipeline Technology) Participating Organizations "e-Water II": 32 Private Companies 18 Scholars 25 Water Utilities (incl. Related Organizations) "New Epoch": 14 Private Companies 7 Scholars 16 Water Utilities Number of Researchers: approx. 200

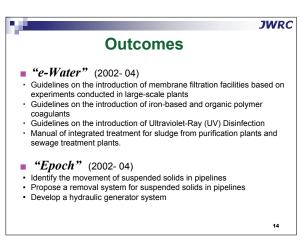






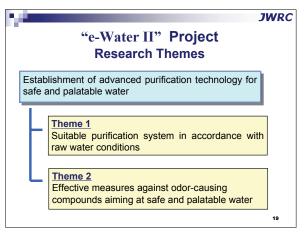


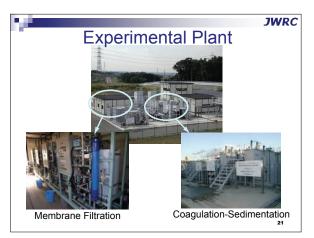


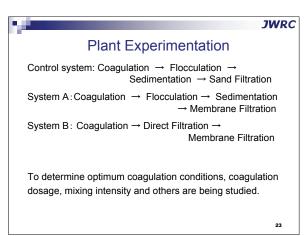


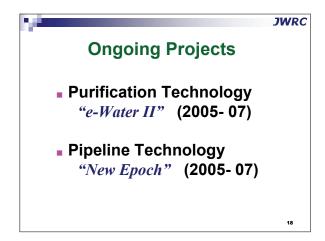


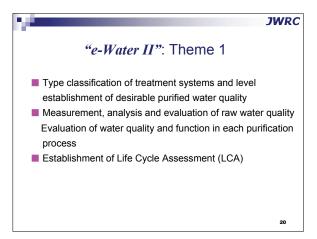


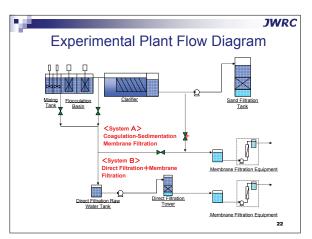


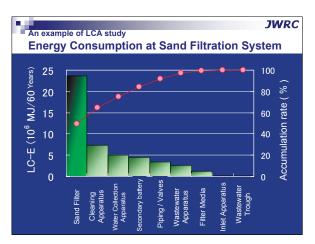


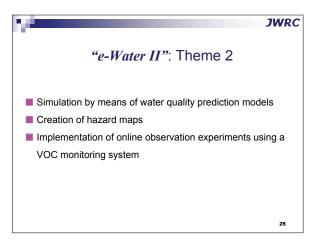




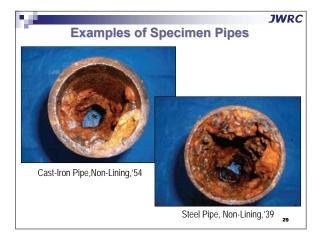


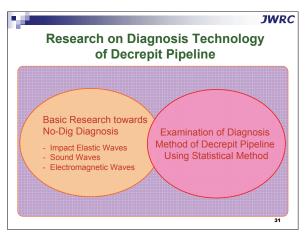


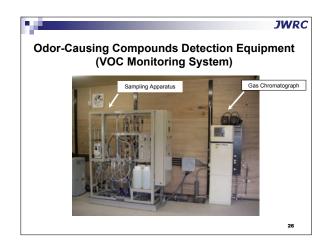


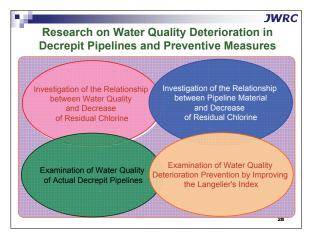


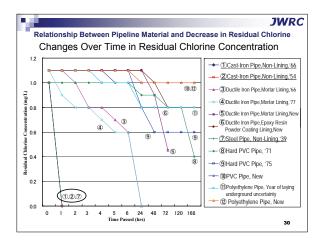


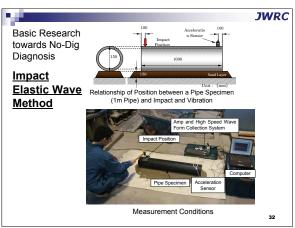


















New Technology for Wastewater Control

-Cutting-edge of Wastewater Treatment Technology-

Takao Murakami

R&D Dept., Japan Sewage Works Agency

1. MBR for municipal wastewater treatment

The membrane bioreactor (MBR) is a wastewater treatment technology that offers many advantages. In Japan, although MBRs have long been used for industrial wastewater treatment or for reuse of wastewater in large buildings and so on, the introduction of MBRs in sewerage systems has lagged behind compared with other water related fields. However, the first MBR for municipal wastewater treatment in Japan started operation in March 2005, and this accelerated the introduction of MBRs in Japanese sewerage systems. Five MBR plants for municipal wastewater treatment are in operation at present. In addition, there are some 10 MBR plants currently in the design or planning stage. The number of MBRs for municipal wastewater is expected to increase in the years ahead. Some fruits of research work of JSWA about MBR are introduced to below.

Risk reduction of the water environment

It is known that a high degree of virus removal could be achieved by MBR.[1] According to our previous research, it was found that Colipharges and *Norovirus* of approximately one-tenth membrane pore size were almost completely removed by a MF membrane. It was also found that most of the virus existed in the activated sludge, indicating that they attached themselves to the activated sludge. [2] It is suggested that the virus captured in the gel layer that forms on the surface of the membrane also contribute to virus removal. [3] Therefore it is considered that virus removal is influenced by the chemical cleaning of the membrane.

The behavior of *Norovirus* captured in the MBR activated sludge and the influence of the chemical cleaning of the membrane was investigated using a pilot scale MBR which treats $48 \text{ m}^3/\text{d}$ of actual municipal wastewater. A hollow fiber MF membrane unit with $0.4 \mu \text{m}$ pore size was immersed in the oxic tank and operated at a permeate flux of $0.8 \text{ m}^3/\text{m}^2/\text{d}$.

The pilot plant was operated with a HRT of 6 hrs in Run-1, in which the oxic tank HRT was 3 hrs. During the experiment however, in order to evaluate the effect of the HRT on virus removal, the total HRT was then extended to 18 hrs in which the oxic tank HRT was 6 hrs in Run-2 and 18 hrs in Run-3 respectively.

The number of *Norovirus* in the activated sludge decreased with prolonged oxic tank HRT, and the number of G I type in Run –2 was about 1/1000 that of Run-1 as shown in Table 1.

Table 1. Norovirus measurement results for different aerobic tank HRT

	Run-1		Run-2		Run-3	
Oxic tank tank HRT(hrs)	3		6		18	
Genome type	G I	GΙ	G I	GΙ	G I	GΙ
Influent	4.20E+07	3.50E+08	2.50E+07	1.90E+08	2.50E+07	1.90E+08
Aerobic tank sludge	1.10E+08	6.20E+07	1.50E+06	N.D.	2.70E+05	N.D.
Effluent	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

(Copies/L)

This indicates that the aerobic decomposition of the virus, which was adsorbed in the activated sludge and retained in the oxic tank, will progress with the elapse of time.

The number of *Norovirus* was measured at 30, 60, and 120 minutes after the in-line chemical membrane cleaning using a 0.3% NaOCI solution. No *Norovirus* were detected in the MBR effluent after the completion of chemical cleaning procedure. This may suggest that the role of gel layer of the membrane surface on virus removal is less important than the adsorption effect of the activated sludge.

Application to BNR process

Figure 1 shows a new biological nutrient removal (BNR) process for large facilities with membrane separation.[4] This process combines the step feed multi-stage nitrification-denitrification process, which is a popular BNR process in Japan, and membrane separation. In a single-stage MBR, in order to obtain nitrogen removal efficiency of more than 80%, circulation ratio of some 400% (R=4) is necessary.

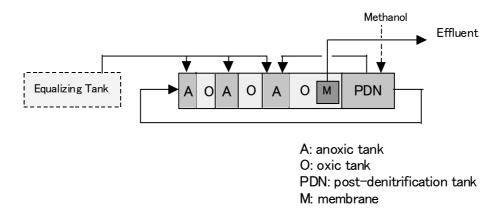


Figure 1. Flow of the BNR process with membrane

However, in the membrane BNR process shown in Figure 1, a T-N removal efficiency of about 80% is acquired at a circulation ratio of 200%. The experiment results showed that stable nitrification and denitrification could be achieved even in low water temperature period. Good and stable biological phosphorus removal can be achieved if the first anoxic tank acts as an anaerobic tank. This is enabled by adding methanol to the post-denitrification tank and eliminating NOx-N in the returned mixed liquor.

Perspective of the future development of MBR

The MBR will not remain just one of many wastewater treatment technologies, but is expected to become a core technology that will be used for various types of wastewater management.

In Japan, MBR is expected to be increasingly used for municipal wastewater treatment. Although the MBR has been used mainly for small scale plants so far, it will likely be applied to larger plants in the future. To enable the wider use of MBR for various purposes, the following issues are considered to be essential.

- 1) Optimization of the design method.
- 2) Optimization of the maintenance method, especially fouling control and chemical cleaning of membrane.
- 3) Reduction of membrane cost and prolongation of membrane life.
- 4) Reduction of energy consumption, especially air supply for membrane cleaning.

JSWA will continue technology development of MBR in cooperation with universities and private enterprises and will conduct the second technical evaluation of MBR based on the data obtained from the five operating actual MBR plants in the near future.

2. Removal of EDCs by ozonation[5]

Since the natural estrogens 17 β -estradiol (E2) and estron (E1), and the synthetic estrogen 17 α -ethynyl estradiol (EE2) have strong endocrine disrupting effects and the tendency to persist in effluent from wastewater treatment plants, effective measures are needed to remove them from wastewater.

In our research, to gain an understanding of the characteristics of estrogen decomposition by ozonation, experiments were conducted using effluent from an actual wastewater treatment plant. In this experiment, estrogen was added to effluent at a concentration of 200 ng/l and 20ng/l before the ozonation experiments.

The results showed 90% or more of estrogen concentration and estrogenic activity of E2, E1 and EE2 to be removed at an ozone dose of 1 mg/l as seen in Figure 2. At an ozone dose of 3 mg/l, the estrogen concentration and estrogenic activity of E2, E1 and EE2 in the treated water fell below the detection limit.

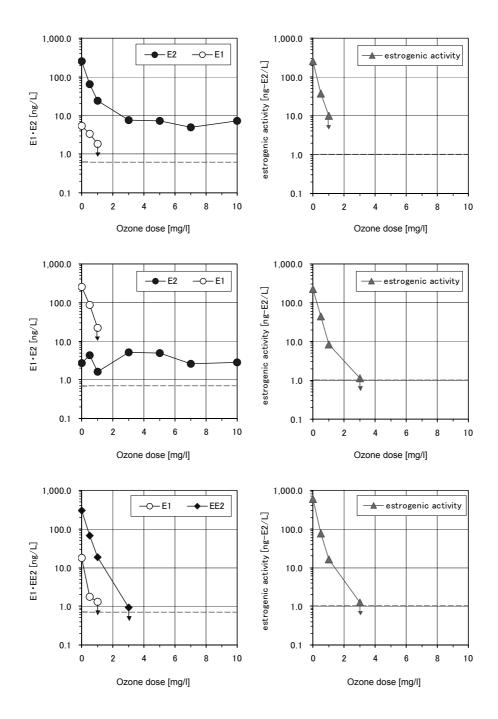


Figure 2. Changes of estrogen concentration and estrogenic activity with ozone dose.

Initial estrogen concentration: 200ng/l, contact time: 15min.

(Top row:E2 added, middle row:E1 added, bottom row:EE2 added)

The removal rate was not influenced by type of estrogen. No generation of byproducts with estrogenic activity was observed. It is concluded that estrogen in secondary treated wastewater can be almost entirely removed at the practical ozone dose rate applied for the purpose of disinfection, which is up to about 5 mg/l.

3. New biological nitrogen removal method -annamox process-

The biological nitrification-denitrification process is widely used for nitrogen removal from municipal wastewater. The annamox reaction is a biological nitrogen removal reaction that completely differs from usual nitrification-denitrification as expressed by the following chemical reaction.

$$1.0NH_4^+ + 1.32NO_2^- + 0.066HCO_3^- + 0.13H^+ \rightarrow 1.02N_2 + 0.26NO_3^- + 0.066CH_2O_{0.5}N_{0.15} + 2.03H_2O_{0.5}N_{0.15} + 0.066CH_2O_{0.5}N_{0.15} + 0.066CH_2O_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{0.5}N_{$$

Under the anaerobic conditions, ammoniac nitrogen and nitrite react producing nitrogen gas.

The bacteria which participate in the reaction are called annamox bacteria and they are tinged with peculiar red color.

There are following merits in the annamox reaction as compared with the conventional nitrification-denitrification reaction.

- Since about the half of ammoniac nitrogen in wastewater has to be converted into nitrite, the required oxygen amount is theoretically about 50% of that of the conventional nitrification-denitrification process.
- Since the biological reaction is an autotrophic reaction, carbon source for denitirfication is not necessary.
- 3) The excess sludge production is small by the same reason.

On the other hand, there are following subjects remaining to be solved.

- 1) Since the growth rate of annamox bacteria is low, enrichment of bacterial culture is not easy in starting-up of the plant.
- 2) Applicable conditions are limited to wastewater with relatively high ammonia concentration, low C/N ratio and high water temperature.
- The stable conversion of half of the ammoniac nitrogen in the wastewater into nitrite is essential as the preceding procedure.

It is supposed that the annamox process is suitable to treat sidestreams from anaerobic digester or from deodorization equipment of sludge drying process. Especially the reduction of nitrogen load of sidestreams from sludge treatment process will enable good and stable performance of biological nitrogen removal process. JSWA is carrying a research on the utilization of the annamox process including a joint research with private companies.

References

[1] Ottoson, J., Hansen, A., Bjorlenius, B., et al, "Removal of Viruses, Parasitic Protozoa and Microbial Indicators in Conventional and Membrane Processes in a Wastewter Pilot Plant"

Water Research 40 (2006) 1449-1457

- [2] Oota,S., Murakami, T.,Takemura, K. and Noto, K. "Evaluation of MBR Effluent Characteristics for Reuse Purposes" Water Science & Technology Vol. 51 No6-7 pp441-446, 2005
- [3] Ueda,T.,Horan,N.j.,"Fate of Indigenous Bacteriophage in a Membrane Bioreactor" Water Research 34 (2000) 2151-2159
- [4] Oota,S., Murakami, T., and Uriu, M. "Advanced BNR Process Combined with Membrane Separation", Proceeding of IWA Asia-Pacific Regional Conference "Aspire 2005" (CD-ROM), July 2005
- [5] Hashimoto, T., Takahashi, k., and Murakami, T. "Characteristics of estrogen decomposition by ozonation", Water Science & Technology Vol. 54 No.10 pp87-93, 2006

2006.1.24



New Technology for Wastewater Control

-Cutting-edge of Wastewater Treatment Technology-

Takao Murakami

R&D Dept., Japan Sewage Works Agency

1

Introduction of JSWA

- Public organization established by the government and local municipalities
- Purpose: Support local municipalities in sewage works
- Activities

Planning/Design/Construction of WTPs Technical assistance

Training of local municipality staff

Research & Development



The Section 1 & Development

JSWA Mouka research center



3

Contents of the presentation

- 1. MBR for municipal wastewater treatment
- 2. Removal of EDCs by ozonation
- 3. New biological nitrogen removal method



MBR for municipal wastewater treatment

3

Outputs of JSWA Researches on MBR

• "Technical evaluation of MBR "(2003)

Process configuration
Operation & maintenance
Performance
Conditions of MBR application

Costs

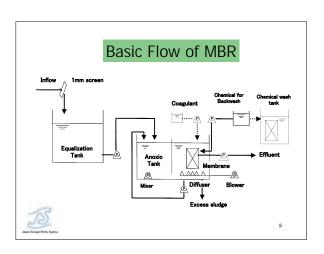
etc.

- "The temporary design guideline "(2003)
- Five MBRs are in operation (2006)

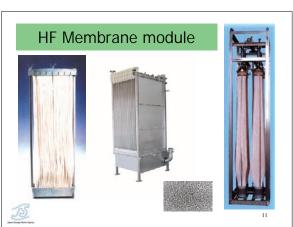
MBRs in operation or under construction

Name of the plant	Total design capacity (m ³ /d)	Capacity for installation (m ³ /d)	Membrane type	Start of operation
Fukusaki	12,500	2,100	Flat sheet	April, 2005
Kobuhara	240	240	Flat sheet	July, 2005
Yusuhara	720	360	Flat sheet	December, 2005
Okutsu	580	580	Hollow fiber	April, 2006
Daito	2,000	1,000	Flat sheet	September,2006
Kaietsu	230	230	Hollow fiber	April, 2007
Zyosai	1,375	1,375	Hollow fiber	March, 2008
Heta	3,200	2,140	Flat sheet	March, 2008
Ooda	8,600	1.075	Undecided	March, 2009











FS Membrane module for large-scale

application

Purposes of MBR application

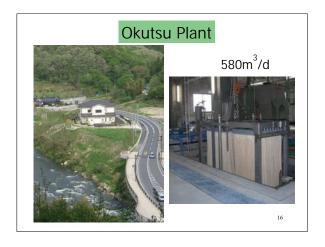
- Small footprint
- Advanced treatment (C,N,P)
- · Reuse of effluent
- Retrofitting
- · Grade up of treatment
- · Avoid chrolination in disinfection

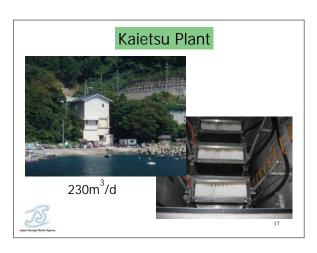


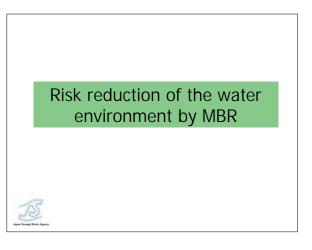
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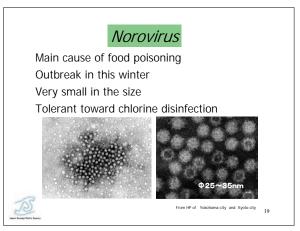


Fukusaki Plant The first MBR for municipal wastewater in Japan Started operation from the end of March, 2005 Capacity 2,100m³/d (Planned Capacity 12,500m³/d) Marchael March, 2005 14

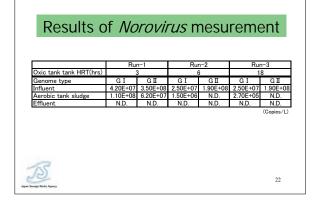


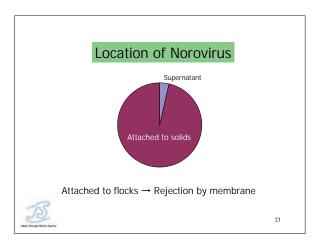






Pilot plant Capacity (m³/d) 48 MLSS (g/L) 8-10 Membrane module HF Material PVDF Pore size (\(\mu \) m 0.4 Flux (L/m²/hr) 33 TMP (kPa) <30





	ie Glien	nical clear	mιć
Elapsed time after	Norovii	rus type	
chemical cleaning	G I	GΙ	
30min	N.D.	N.D.	
60min	N.D.	N.D.	
120min	N.D.	N.D.	
		(Copies/L)	

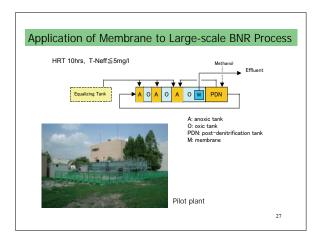
Summery of *Norovirus* removal

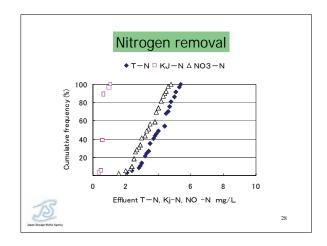
- High removal efficiency by MF MBR
- Adsorption of virus to sludge flocks is the reason of removal
- Gel layer on the membrane surface is not important for virus removal

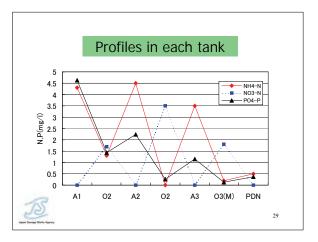


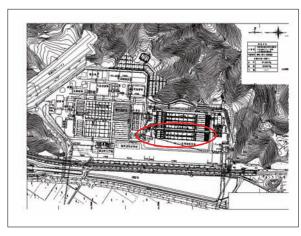
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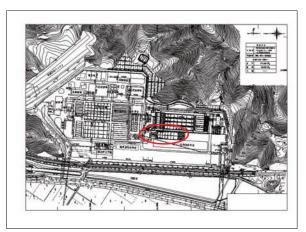




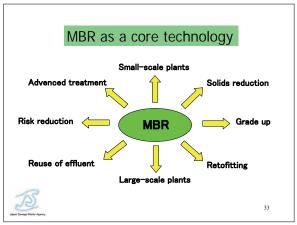


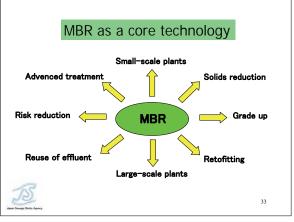


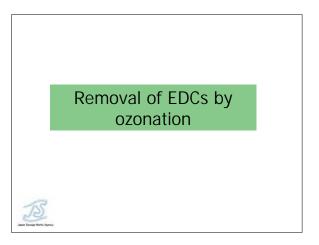


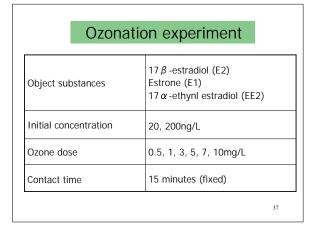


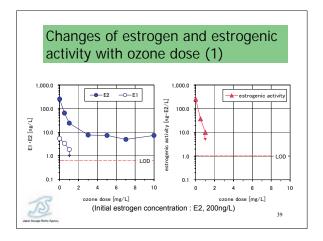
Perspective of future development of MBR











- · Opimization of the design method
- · Optimization of the maintenance methods, especially fouling control and chemical cleaning of membrane
- · Reduction of membrane cost and prolongation of membrane life
- Reduction of energy consumption, especially supply air for membrane cleaning

are essential.

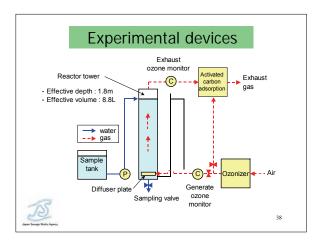


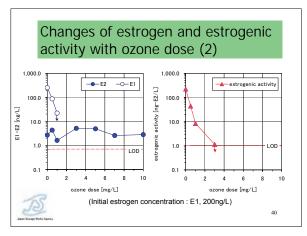
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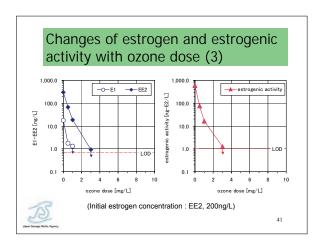
Purpose of the study

• To reveal the efficiency and characteristics of estrogen decomposition by ozonation in treated wastewater.









Initial concentration and kinetic constant

	Estrogen concentration		Estrogenic activity	
Kind of estrogen	Initial concentration	Kinetic constant	Initial concentration	Kinetic constant
	P _o [ng/L]	k[min ⁻¹]	P _o [ng/L]	k[min ⁻¹]
E2	252	0.205	261	0.286
E1	253	0.171	226	0.236
EE2	299	0.191	589	0.250
E2	36.4	0.121	21.3	0.190
E1	48.4	0.130	37.4	0.156
EE2	18.1	0.115	18.0	0.112

43

Conclusions

- The removal efficiencies of estrogens and estrogenic activity were greater than 90% for an ozone dose of about 1 mg/L.
- Estrogens could be removed almost completely at an ozone dose of 5mg/L or less, which is a practical ozone dose level for disinfection.



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Conclusions (continued)

- No byproduct with estrogenic activity was produced during the decomposition process of estrogen by ozonation.
- The kinetic constant *k* was not much influenced by the type of estrogen.



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New biological nitrogen removal method -annamox process-



annamox (anaerobic ammonium oxidation)

 $NH_4+1.32NO_2^-+0.066HCO_3^-+0.13H^+\rightarrow$ $1.02N_2+0.26NO_3^-+0.066CH_2O_{0.5}N_{0.15}+2.03H_2O$

- Reduced oxygen requirement
- External carbon source is not necessary
- Small excess sludge production



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Possible application of annamox process

Reduction of N load of sidestream from;

- · Anaerobic digester
- Deodorization equipment of sludge drying or composting process

A pilot-scale experiment starts soon.





Thank you for your kind attention!

New Technology for Wastewater Control - Cutting-Edge Treatment Technology to Reduce Odors in Biosolids -

Daniel WOLTERING¹ Water Environment Research Foundation

1. Introduction

The overall purpose of this research is to seek ways to enhance anaerobically digested and dewatered biosolids to reduce odor intensity in biosolids cake and thereby reduce the impact on the environment of its beneficial use or disposal. Reduction of biosolids cake odors is one of the most important needs expressed by Water Environment Research Foundation (WERF) members. At a WERF-sponsored specialty workshop at the 2000 Water Environment Federation Technical Exposition and Conference (WEFTEC) in Anaheim, California, the WERF members voted biosolids odor issues as the highest priority for future research and specifically the influence of in-plant solids treatment processes (such as storage, thickening, anaerobic digestion, and dewatering) on biosolids odor quality. In addition, the biosolids management industry is in a state of flux as to how to properly handle, treat, dewater, and store biosolids to prevent odors while assuring compliance with present and anticipated changes to the USEPA 40 CFR Part 503 regulations governing biosolids quality.

This study focuses on the dewatering and digestion processes and equipment currently used by wastewater treatment plants (WWTPs), as well as those that are proposed to meet 40 CFR Part 503 requirements. Equipment or process vendors were invited to demonstrate their products full-scale at one or two WWTPs while the WERF team collects and analyzes data and compares results. Any promising laboratory study result will be considered for full-scale field testing in this project, in anticipation that it would lead to changes in how biosolids are digested, handled, dewatered, treated, or stored. Practical economic considerations were also be factored into the evaluation and selection of promising laboratory results to be translated to full-scale.

The conclusions of this study are intended to provide a wastewater treatment plant owner with a roadmap to develop approaches and strategies that will reduce dewatered biosolids cake odors. Biosolids cakes with minimal odors lead to better public acceptance near biosolids management sites and in neighborhoods adjacent to WWTPs. Reduced odors also could open this dewatered biosolids cake to other biosolids recycling or disposal opportunities currently not used due to odor concerns (including on-plant site composting or storage). Additionally, significant cost savings could be realized by not requiring extensive odor control or other expensive options for containment and management of biosolids.

2. Overview

This research is a multi-year study (2000–2007) conducted in three distinct phases by the same team of researchers. Different team members participated in the phases depending upon expertise required and the objectives of each phase. At the time of the January 2007 Japan-US Conference, the research team is preparing the final report including the "roadmap" to guide wastewater treatment plant owners to reduce odors associated with biosolids at their plants.

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e-mail:dwoltering@werf.org

The first phase, conducted between 2000 and 2001 involved literature and practitioner surveys of odors in the municipal wastewater environment. The intent was to summarize information on odor characterization for wastewater treatment systems including applicable odor sampling and measurement approaches for potential sources, state-of-the-art odor control technologies and strategies, lessons learned for viable and innovative odor control strategies and technologies, and key gaps in knowledge of technology in addressing odor issues from collection through final treatment and effluent disposal including biosolids disposal. These findings were summarized in a WERF report entitled *Identifying and Controlling the Municipal Wastewater Odor Environment*.

In the second phase of research, conducted between 2002-2003, field work at 11 WWTPs lead to a better understanding of the various locations and possible causes of odors during digestion and dewatering. It was confirmed that biosolids cakes, following dewatering, typically produce the worst odors in a wastewater treatment plant. Further it was found that high shear dewatering processes such as high speed centrifugation produces more odors than pressing type processes. Biologically available protein was confirmed to be the main contributor to the odor potential of biosolids. Odorous compounds are produced as proteins degrade to form polypeptides and amino acids which are consumed by microbes. Also as part of the research, a new method for sampling and analyzing odors in biosolids cake was developed. Biosolids samples were collected and incubated (under ambient conditions) in small, air-tight sample bottles for at least 6 days. The olfactometry measurements in the bottle headspace were much higher than would be sensed by an individual onsite, or from the olfactory analysis of an air sample gathered by flux chamber or another type of field headspace (as opposed to sample-bottle headspace). While it is recognized that the bottle-headspace sampling method may not represent actual field conditions, the consistency of sampling and analytical protocols that were used for all 11 WWTPs in the study resulted in a useful and statistically valid comparison of the large number of samples collected. The complete results of the second phase are reported in a WERF publication entitled *Impacts of In-Plant Operational Parameters on Biosolids Odor Ouality*.

An ancillary part of the second phase of research was an evaluation of whether the experience of odors, i.e., odors as sensations, from biosolids at wastewater treatment plants (WWTPs) might cause illness. There exists no repository of information on the numbers of complainants with illness, their specific complaints, or the relationship between degree of exposure and complaints. Anecdotal reports nevertheless imply a pattern much like that associated with other industrial malodors. Symptoms claimed in connection to odors from biosolids in particular seem to come from olfactory rather than chemesthetic (irritating) stimulation. Although not inappropriate to the experience of malodors, the symptoms seem to occur via intermediate variables, such as annoyance, anxiety, and frustration. Persons who experience no such distress apparently experience no symptoms. Any connection between odor and illness has received little note among the large number of articles in the medical literature. This state of affairs presumably exists because odors *per se* generate no objective signs of illness in otherwise healthy persons. However, malodors may exacerbate both symptoms and signs of illness in persons with certain chronic disorders, such as asthma and migraine. Vulnerability to such effects may vary considerably from person to person. The WERF report is entitled *Health* Effects of Biosolids Odors: Literature Review and Analysis.

As a follow on to this work, WERF is currently conducting research to develop a protocol for the timely characterization of reports of adverse health effects following likely exposure to land-applied biosolids. The intent is that local health officials would use the protocol in their evaluation of reported health incidents and that the information would be used to identify and

reduce exposures if, in fact, there are any health effects or risks identified. The protocol should be available by the end of 2007.

The third and current phase of this research program began in 2004. The laboratory and field work has been completed and the data analyzed. The final report is expected to be available by the end of the first quarter of 2007. This phase is entitled *Biosolids Processing Modifications* for Cake Odor Reduction.

This phase focuses on the dewatering and digestion processes and equipment currently used by WWTPs as well as those that are proposed to meet 40 CFR Part 503 requirements. Evaluate cake odors and reduction as a function of chemical addition, and digestion and dewatering process. Eleven WWTPs across the USA were involved in the collection of information and data as well as sampling and analysis. Eight commercial vendors of agents intended to reduce biosolids odors were invited to submit their chemical, biological or enzymatic agents (CEBAs) for test demonstrations in the laboratory and at the full-scale if they showed promise in the laboratory.

The laboratory studies done at the beginning of the third phase confirmed that volatile organic sulfur compounds (VOSCs) are the main source of odors in anaerobically digested biosolids. The principal components of VOSCs and those that were monitored in the study include methyl mercaptan (MT), dimethyl sulfide (DMS) and dimethyl disulfide (DMDS). These VOSCs and odors are produced and then degraded during biosolids storage.

The effects of chemical addition before and after digestion and dewatering were evaluated for iron, aluminum sulfate (alum) and a wide range of CEBAs. More iron in wastewater leads to more VOSCs and more odor. This was demonstrated in the laboratory and confirmed in the field at one wastewater treatment plant. Eight (8) proprietary CEBAs were tested. 4 were added pre-digestion and 4 added post-digestion (either before or after dewatering). The dosage amount and frequency was done according to the directions from the vendor. Only one of the eight CEBAs tested appeared to improve cake odor reduction over the untreated controls, but that one severely inhibited the digestion process and thus was not a viable solution. One of the eight actually increased the odor in the biosolids cakes. Post-digestion alum addition showed promise for odor reduction in the laboratory. Alum field trials showed less consistent, but largely positive results in reducing odor. Peak VOSC levels were significantly reduced with the addition of both 2% and 4% alum by weight.

The evaluation of various anaerobic digester processes on odor included the study of digestion time (SRT or solids retention time), the homogenization of the sludge prior to digestion, and the configuration of the digester comparing egg-shaped digesters with two-phase (acid-gas) digesters with a more conventional mesophilic digester.

While VOSC was reduced with SRTs extended beyond 10 days up to 30 days, the levels did not get below 1000 ppmv which is still an odorous sludge. Utilizing the MicroSludgeTM process before mesophilic anaerobic digestion significantly reduced cake odors. The MicroSludge System uses chemical pre-treatment and a cell disrupter to burst the microbial cells in waste activated sludge (WAS). The resulting liquefied WAS is readily converted to biogas in an anaerobic digester. The egg-shaped digester produced less odor than the two-phase (acid/gas) digester. And both of these configurations produced considerably less odor in biosolids cake than did the conventional mesophilic anaerobic digester.

A Centrifuge Scroll Test was conducted on a high speed centrifuge as part of the study to determine the effect of dewatering processes on cake odor. Several locations within the

centrifuge were sampled and the analysis of VSOC clearly indicated the level of odor was higher immediately after the digested sludge was sheared and as it left the centrifuge. The overall comparison of various dewatering processes indicated that cake produced by centrifuge had the highest odors produced followed by rotary press and then belt filter press. Centrifuge type and operation (bowl speed, torque, and feed rate) was also seen to impact odor production. The dewatering effect appears to be related to centrifugal shearing of the biosolids, which appears to make protein more bioavailable, thereby producing more TVOSC from protein decay.

In summary, the aspects of the digestion and dewatering processes that appear to have the best potential for reducing biosolids cake odor include: sludge homogenization before digestion, increased solids retention time, lower iron in the wastewater, digester configuration, and reduced shear during dewatering and handling. The addition of alum post-digestion but prior to dewatering was also found to help reduce cake odor. These aspects may work in a complementary manner, and some or all may be needed for significant odor reduction in biosolids cake. The eight commercially available CEBAs that were tested did not reduce cake odor.

While much was learned from this research program, it only forms the foundation for what will need to be numerous further trials, demonstrations and the sharing of findings by wastewater treatment plants to build a database of experience. This experience will provide guidance as to what adjustments work and are cost effective. The final report (available by the end of the first quarter of 2007) will provide an initial "roadmap" of approaches and strategies that a wastewater treatment plant owner can try in order to reduce dewatered biosolids cake odors. It will cover both the processing equipment and the chemical addition aspects of operational decisions as well as the designs of digesters and dewatering to minimize cake odors.

Japan - US Governmental Conference on Drinking Water Quality Management and Wastewater Control

January 22-25, 2007, Bankoku Shinryokan, Okinawa

Treatment Technology to Reduce Odors in Biosolids

presented by

Dan Woltering, Ph.D. Director of Research



Water Environment Research Foundation Top Issues for Wastewater

- Nutrient removal
- Sustainable asset management
- STP operation optimization
- Risk of trace contaminants
- Health risks of wastewater microbes
- Stormwater management
- Biosolids health risks and odors

Project Participants



Principal Investigators

- CH2M Hill
- Los Angeles County Sanitation Districts

Additional Research Participants

- Virginia Polytechnic Institute & State University
- Bucknell University
- Moore Engineering Consultants
- 11 participating wastewater utilities
- 8 participating commercial product vendors

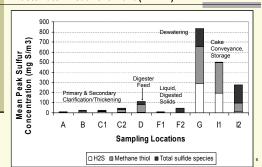
Project Goals

- To cost-effectively produce dewatered biosolids of significantly reduced odor intensity
- Provide treatment plant owner with a "roadmap" of process modifications that can be considered to reduce dewatered biosolids cake odor
 - Focus on digestion and dewatering equipment and processes now in use to meet regulations

Project History/Overview

- Phase 1 (2000-2001): Literature survey of odors in the municipal wastewater environment. Product: Literature Search, Review, & Analysis
- Phase 2 (2002-2003): Field work at 11 WWTPs that helped understand the various locations and possible causes of doors during digestion and dewatering. Product: Impacts of In-Plant Parameters on Biosolids Odors
- Health Effects Addendum (2004): Review and summarize evidence surrounding potential health effects of biosolids odors. Product: Health Effects of Biosolids Odors: Literature Review and Analysis
- Phase 3 (2004-2006): Laboratory and field tests with additives to determine if odor reductions can be achieved and recommendations on what a plant can do to reduce odors. Product: Biosolids Processing Modifications for Cake Odor Reduction

Phase 2 confirmed that biosolids cakes typically produce the worst odors in a Wastewater Treatment Plant (WWTP)

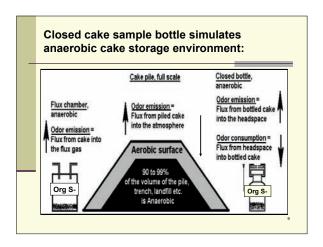


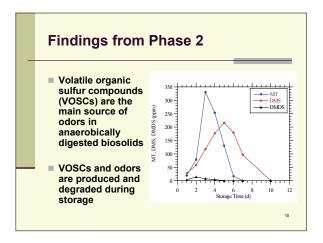
Phase 3 Objectives

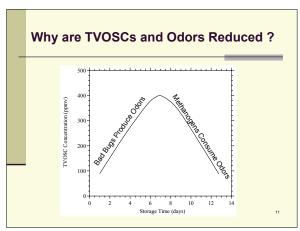
- Evaluate cake odors and reduction as a function of:
 - Chemical addition
 - Digestion
 - Dewatering process
- Lab scale first and then try it in the field

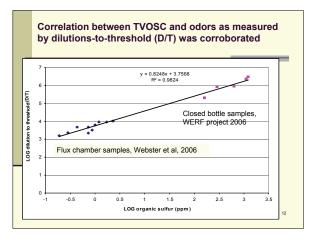
Components of Phase 2 Research

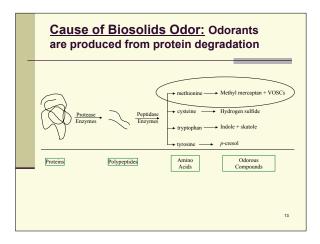
- Develop sampling methods for total volatile organic sulfur compound (TVOSC) as a surrogate for odors
- Confirm correlation between TVOSC and odors from biosolids

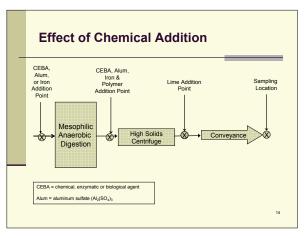


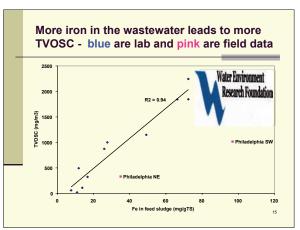






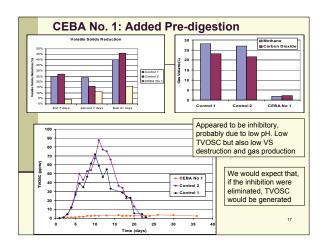


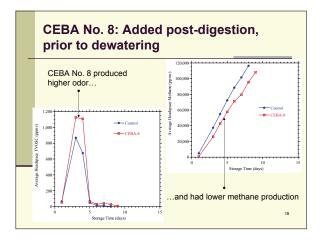


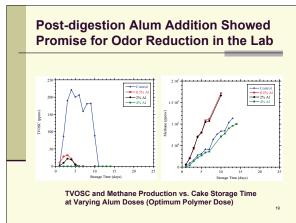


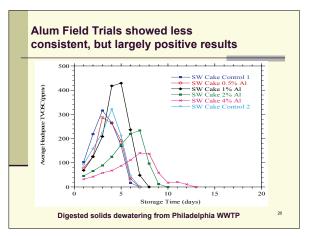
Tests of Chemical, Enzymatic, and Biological Agents (CEBAs)

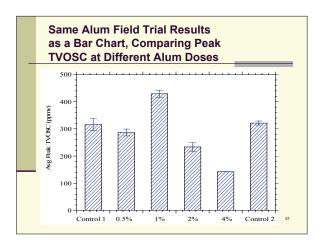
Eight (8) proprietary CEBAs were tested, 4 added predigestion and 4 added post-digestion
The dosage amount and frequency was according to the directions from the Vendor
Digestion was batch-wise with two different 50% exchanges of fresh sludge on days 7 and 14 with an additional 21 days of digestion
An initial 20% seed of digested sludge and a balance of 50/50 mix of primary/secondary sludge was used
Post-digestion CEBAs were added before & after dewatering
Only one of the eight (8) CEBAs tested appeared to improve cake odor reduction over the untreated controls, but that one severely inhibited the digestion process...







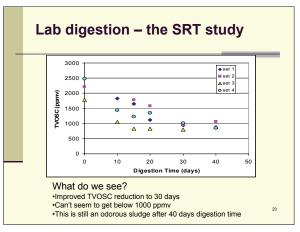


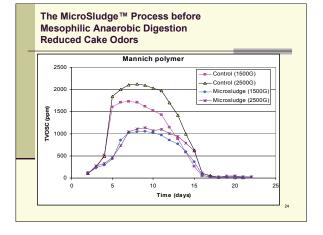


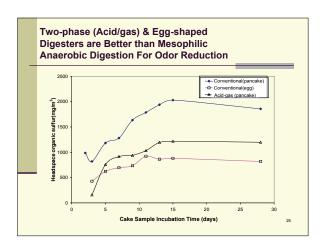
Effects of Anaerobic Digestion Processes on Cake Odor

- The next three slides show:
 - Effect of Mesophilic Anaerobic Digestion Time (SRT) on Volatile Solids Reduction and TVOSC
 - Effect of Activated Sludge Homogenization prior to Anaerobic Digestion on TVOSC
 - Effects of Egg-shaped Digesters and Twophase (Acid-gas) Digestion compared with Conventional Mesophilic Anaerobic Digestion

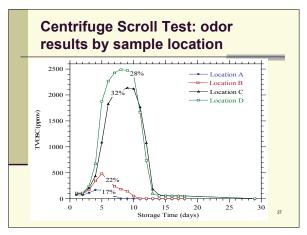












Dewatering Conclusions

- Dewatering process has significant impact on odor production:
 - Centrifuge >> Rotary Press > Belt Filter Press, in terms of cake odors produced
- Centrifuge type and operation (bowl speed, torque, feed rate) can also impact odor production
- Main effect appears to be related to centrifugal shearing of the biosolids, which appears to make protein more bioavailable, thereby producing more TVOSC from protein decay

al Reduction Measures of Biosolids Cake Odor Options Summary Chart ["Roadmap"] 28

Phase 3 - Overall Observations

- Sludge homogenization before digestion can reduce odor
- Increased solids retention time can reduce odor
- Higher iron in the wastewater can lead to increased odor
- Digester configuration can affect cake odor
- Addition of alum post-digestion but prior to dewatering can reduce odor
- Reduced shear during dewatering and handling can reduce odors
- These aspects may work in a complementary manner, and some or all may be needed for significant odor reduction in biosolid cake
- The commercially available CEBAs that were tested did not reduce odor.

| Development |

Thank you

The final report, which will include the "roadmap" is expected in Q1 of 2007

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