RESEARCH ON THE STANDARDS OF THE TREATED WASTEWATER REUSE SYSTEM

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Project period: 2001-2005

OBJECTIVES

In Japan, since the first reuse of treated wastewater as toilet flushing water was undertaken in 1980 in Fukuoka City in response to the severe drought in 1978, treated wastewater has been used as toilet flushing water, snow melting water, environmental water, industrial water, sprinkling water and for a variety of other uses. However, only 200 million m^3 per year of treated wastewater from 246 wastewater treatment plants (WTPs) is being reused outside the plants, which is less than 2% of the 1.4 billion m^3 of effluent from 1,924 plants in FY 2003. It is expected that such applications will increase in the future from the viewpoint of saving water resources in urban areas, which will in turn increase the importance of appropriately reusing treated wastewater.

Therefore, care must be taken to maintain the appropriate color, turbidity, odor, and other aesthetic elements of reclaimed wastewater so that it is not unpleasant for users, and suitable measures taken to prevent corrosion, clogging, and other problems that impair the functions of the treated wastewater reuse system.

For the above reasons, the Sewerage and Wastewater Management Department of the Ministry of Land, Infrastructure and Transport and the Water Quality Control Department of the National Institute for Land and Infrastructure Management decided to revise the water quality standards and the water quality targets stipulated in the previous guidelines and manuals for the reuse of treated wastewater. And, in order to establish new standards from the viewpoint of appeal and acceptance, these organizations have carried out the surveys on users' consciousness to the reuse of treated wastewater. This report presents the results of the surveys and the results of studies on new standards based on these surveys.

MATERIALS AND METHODS

Table 1 Methods of survey

Category of use	Toilet flushing water		Landscaping water / Recreational water	
Period	2003.12 – 2004.2	2004.7	2003.12 – 2004.1	2004.7
Number of survey location	7	3	4	3
Number of people who answered	1,124	734	731	482
Measured items of water quality	Turbidity, color and odor			

It is important to investigate users' taste for the reclaimed wastewater in order to study the criteria on appeal and acceptance of the reclaimed wastewater because there is close relationship between the appeal and acceptance of the reclaimed wastewater and users' taste. Therefore, in order to study the influence of turbidity, color and odor of the reclaimed wastewater on the users' taste, the survey on users' taste for turbidity, color and odor of the reclaimed wastewater was performed at the facilities where reclaimed wastewater is used. The method of the survey is shown as Table 1 and the questionnaires were handed to the users

directly at the survey location or by mail. We dealt the answer in case of just looking at the surface of water as landscaping water and the answer in case of touching the water as recreational water.

RESULTS

Through the survey and the study, we acquired the following knowledge.

(1) The ratio of users' acceptance of color, clearness and odor for landscaping water are 64-84%, 63-82% and 72-86% and the ratio of those for recreational water are 55-81%, 51-78% and 57-79%,while the ratio of those for toilet flushing water are 89-98%, 89-97% and 85-96%. These results show that the ratio of those for landscaping water and recreational water disperses more than those of toilet flushing water. The reason may be that there are big differences of facility types among each location and differences among users' taste.

(2) There was no definite relationship between the users' preference and the reclaimed wastewater quality (color, turbidity and odor) because of the difference among users and influence of facility type, etc.

(3) It is preferable that the criteria from the viewpoint of appeal and acceptance be set based on the regional users' wishes due to the difference among users and influence of facility type, etc.

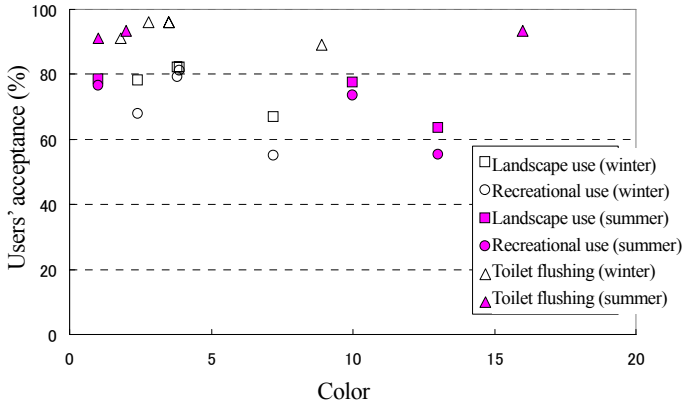

Fig.1 Relationship between the color and the users' acceptance

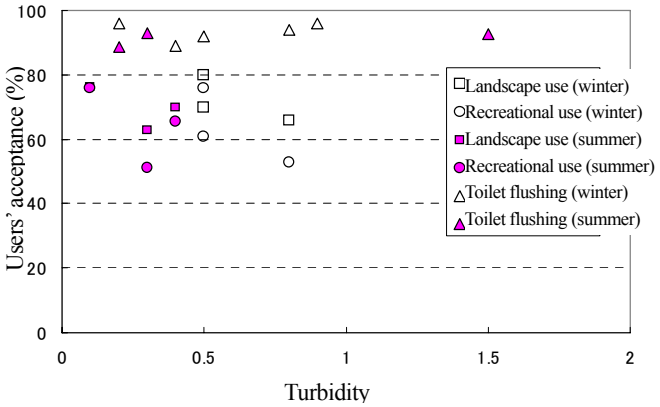

Fig.2 Relationship between the turbidity and the users' acceptance

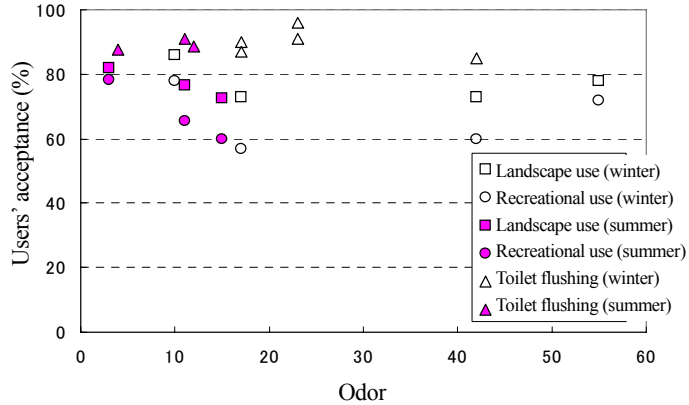

Fig.3 Relationship between the odor and the users' acceptance

APPLICATION OF LCA TO WASTEWATER SYSTEM

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Project period: FY2001-2004

OBJECTIVES

Recently, it has become necessary to evaluate the impacts of public works projects on the environment from the viewpoint of global environmental protection. Life-cycle assessment (LCA) is an effective method for such evaluations. This research examined the application of LCA to wastewater projects. The environmental load of CO_2 emissions ($LC\text{-}CO_2$) and energy consumptions (LCE) were calculated over the four life-cycle stages of a wastewater system: construction, operation and maintenance, recycling and reuse, and scrapping.

In FY 2004, we analyzed the possibility of simplifying life-cycle inventory (LCI) analysis in the LCA process for wastewater treatment systems and the effects of updating input-output tables (I-O tables) on the primary unit load and results of LCI analysis.

METHODS

(1) Simplification of LCI analysis for wastewater treatment system

Our previous studies on the characteristics of environmental load of wastewater treatment systems showed that most of the environmental load derives from electricity consumption of some main equipment during the operation and maintenance stage in the life-cycle of wastewater treatment systems. In this study, we tried to simplify the LCI analysis for the oxidation ditch (OD) process. We calculated $LC\text{-}CO_2$ and LCE for four wastewater treatment plants treated by the process and analyzed the relationship between the environmental load and electric power of the equipment used.

(2) Effects of updating I-O tables on primary unit load and results of LCI analysis

The primary unit load for LCI analysis is generally based on the unit load taken from I-O tables in Japan; in our previous studies, the primary unit load from the 1990 edition of the tables was used. I-O tables are updated every five years and the 1995 edition is now publicly available. In this study, we analyzed the effects of changing the primary unit load resulting from the I-O tables being updated from the 1990 edition to the 1995 edition on the results of LCI analysis for wastewater treatment systems, calculating $LC\text{-}CO_2$ and LCE at the operation and maintenance stage for four wastewater treatment plants which have various types of treatment process and treatment capacities.

RESULTS

(1) Simplification of LCI analysis for wastewater treatment system

In this case study, aeration equipment (blower, mixer) was selected as having the greatest influence on the environmental load among the equipment of wastewater treatment plants using the OD process. Table 1 shows a summary and the environmental load for the four plants. As shown in Fig. 1 and Fig. 2, there are positive correlations between the output (kW) of the aeration equipment and $LC\text{-}CO_2$ and LCE. These relations indicate that if the output of aeration equipment is known, the environmental load can be simply calculated. According to our previous studies, most

Table 1 Summary and environmental loads of four wastewater treatment plants

Treatment plant[1)]	A	B	C	D
Output of aeration[2)] (kW)	30	194	30	78.4
Type of aeration	Vertical shaft	Horizontal shaft	Vertical shaft	Diffuser and propeller
LC-CO_2 (t-CO_2/year)	1.56×10^2	8.90×10^2	1.54×10^2	5.14×10^2
LCE (GJ/year)	3.04×10^3	1.80×10^4	3.11×10^3	9.46×10^3

1) Oxidation ditch process
2) Data in FY 2002

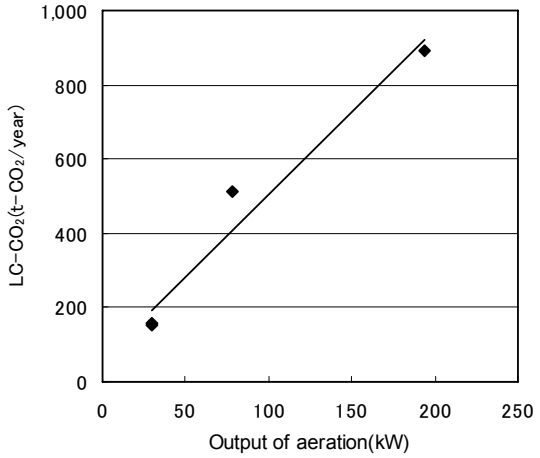

Fig. 1 Output of aeration and LC-CO_2

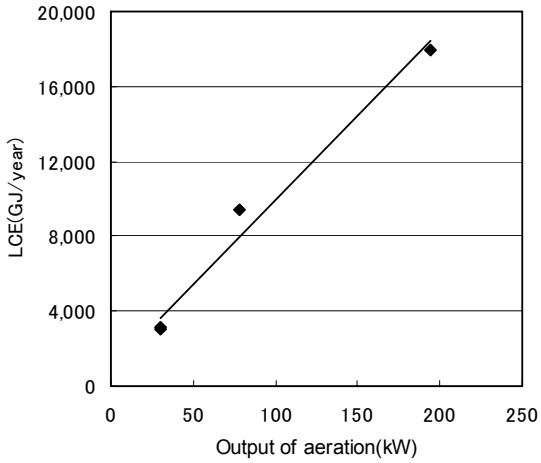

Fig. 2 Output of aeration and LCE

of the environmental load of other types of treatment process except OD derives from electricity consumption of some main equipment at the operation and maintenance stage in the life-cycle, too. By capturing the LCI analysis data for other types of treatment process, it may be possible to clarify the relationship between the main equipment and the environmental load for each type of treatment process. When it is necessary to evaluate the impacts of the wastewater treatment process in terms of global environmental protection assuming that the information and data for LCI analysis are limited as projects are planned and facilities are designed, these relationships could be used to simply calculate the environmental load.

(2) Effects of update of I-O tables on primary unit load and results of LCI analysis

With the updating of the primary unit load based on I-O tables from the 1990 edition to the 1995 edition, LC-CO_2 at the operation and maintenance stage in the life-cycle for the four treatment plants increased approximately 3–5% and LCE decreased approximately 5–7%. As a result, LC-CO_2 and LCE derived from electricity consumption increased 5.8% and decreased 6.2%, respectively, so it is inferred that the environmental load derived from the consumption of chemicals (coagulant, sodium hypochlorite, etc.) and fuel (oil, gas, etc.) had little influence on the total environmental load.

Except for particular plants which use large quantities of chemicals and fuel, it is assumed that the updating of the primary unit load based on I-O tables from the 1990 edition to the 1995 edition has little influence on the environmental load for wastewater treatment plant at the operation and maintenance stage in the life-cycle.

This research examined the application of LCA to wastewater systems as a project evaluation method at the planning and design stage of projects. The results will be used to promote wastewater projects appropriately from the perspective of global environmental protection.

EVALUATION METHOD FOR ADVANCED WASTEWATER TREATMENT SYSTEMS

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Project period: 2002-2004

Objective

The water quality in enclosed water bodies must be improved, and advanced wastewater treatment is one effective means. Part of the cost for advanced treatment is to be collected from sewerage fees in accordance with the polluter-pays principle. Thus, ways of explaining to people the need for advanced treatment through discussions based on scientific information including the cost and benefit of advanced treatment, are required. Therefore, in cooperation with an NPO that is involved in preserving the water of Lake Biwa and sewerage systems, we developed a method of evaluating advanced treatment from the view of people .

Method and Results

In this study, we developed a method for obtaining an understanding of advanced wastewater treatment by increasing the knowledge of people concerning the water environment using newsletters and questionnaires (Figure.1) .

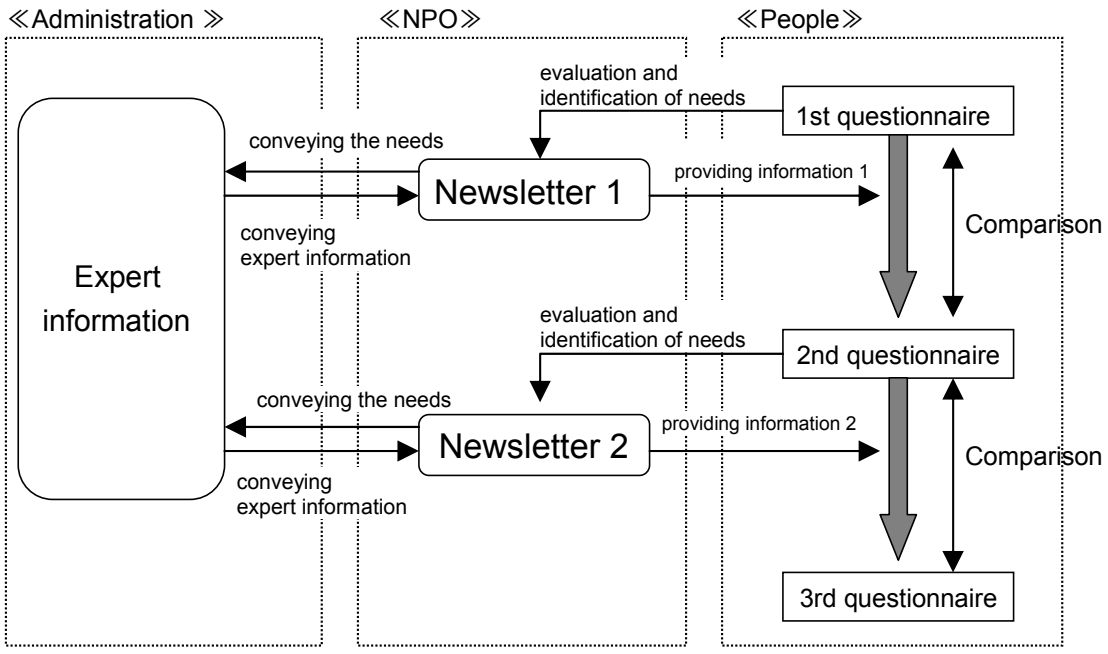

Figure 1 Survey of change in people awareness by providing information in collaboration with NPO

The results were as follows.

(1) To increase the knowledge of people concerning the water environment, we developed the new process that an NPO as a neutral position between the administration and people, identified the information needed by people, obtained expert information from the administration, and conveyed it to the people in a simple newsletter.

(2) Conveying information to the people twice by newsletters has increased their knowledge concerning water environment problems and measures. For example, the number of people who understand that agriculture wastewater and road wastewater other than domestic wastewater are sources of pollution of Lake Biwa has increased; the number of people who are aware of the dioxin and endocrine disrupter other than the red tide as an environmental problem of Lake Biwa has increased; the number of people who understand the need to adopt the advanced wastewater treatment and urban rain wastewater treatment to protect the environment of Lake Biwa has increased; and the number of people who recognize various effects such as further removal of nitrogen/phosphor and removal of trihalomethane formation potential and endocrine disrupters by adopting ultra-advanced wastewater treatment has increased.

(3) After information was provided for the first time, the number of people willing to pay for the preservation of the water environment of Lake Biwa increased. The willingness to pay for ultra-advanced wastewater treatment was 189 yen per month/household, which was relatively higher than its maintenance expenses of about 160 yen per month/household.. However, 30% of people were not willing to pay anything, so there is a need to reduce this ratio.

RESEARCH ON THE STANDARDS FOR HYGEINIC SADETY OF THE TREATED WASTEWATER

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Project period: 2001-2005

OBJECTIVES

It is expected that reuse of treated wastewater will increase in the future from the viewpoint of saving water resources in urban areas, which will in turn increase the importance of appropriately reusing treated wastewater.

On the other hand, the health risk posed by *Cryptosporidium* and other pathogenic microbes through drinking water and food has become a severe social problem in recent years, raising concerns over the safety of water. It is, therefore, necessary that the reuse of treated wastewater employ countermeasures against these new problems from now on.

For the above reasons, the Sewerage and Wastewater Management Department of the Ministry of Land, Infrastructure and Transport and the Water Quality Control Department of the National Institute for Land and Infrastructure Management decided to revise the water quality standards and the water quality targets stipulated in the previous guidelines and manuals for the reuse of treated wastewater. And, in order to establish new standards from the perspective of guaranteeing hygienic safety, these organizations have carried out fact-finding surveys on bacteria and protozoa in the reuse of treated wastewater. This report presents the results of the fact-finding surveys and the results of studies on new standards based on these surveys.

MATERIALS AND METHODS

(1) In order to study standards for bacteria in the reuse of treated wastewater, the pathogenic microbes and related indices shown in Table 1 were measured throughout a one-year period in the treated wastewater reuse systems that use the five reclamation treatment processes at four WTPs in Japan.

Category		Items analyzed
General items		pH, water temperature, turbidity, SS, residual chlorine (free, combined)
Bacteria	Index	Total coliforms
		E. coli
		Heterotrophic plate counts (HPC)*
	Pathogenic bacteria	*Legionella*
		Salmonella, *Campylobacter*, EHEC O-157

The measured pathogenic bacteria were *Salmonella* and *Campylobacter* that are major causes of food poisoning in Japan, EHEC O-157 that caused a severe outbreak of group infections in Japan, and *Legionella* that can propagate in the reclaimed water supply process.

Samples were obtained at three locations – water overflowing from the final settling tank, immediately after the reclamation treatment process, and in the tank receiving supplied water.

(2) In order to study standards for protozoa in the reuse of treated wastewater, sand-filtered water from two WTPs in Japan were surveyed for *Cryptosporidium* every month for two years and then evaluated the risk of *Cryptosporidium* in the reuse of treated wastewater based on the results of the survey to study treatment standards capable of ensuring an

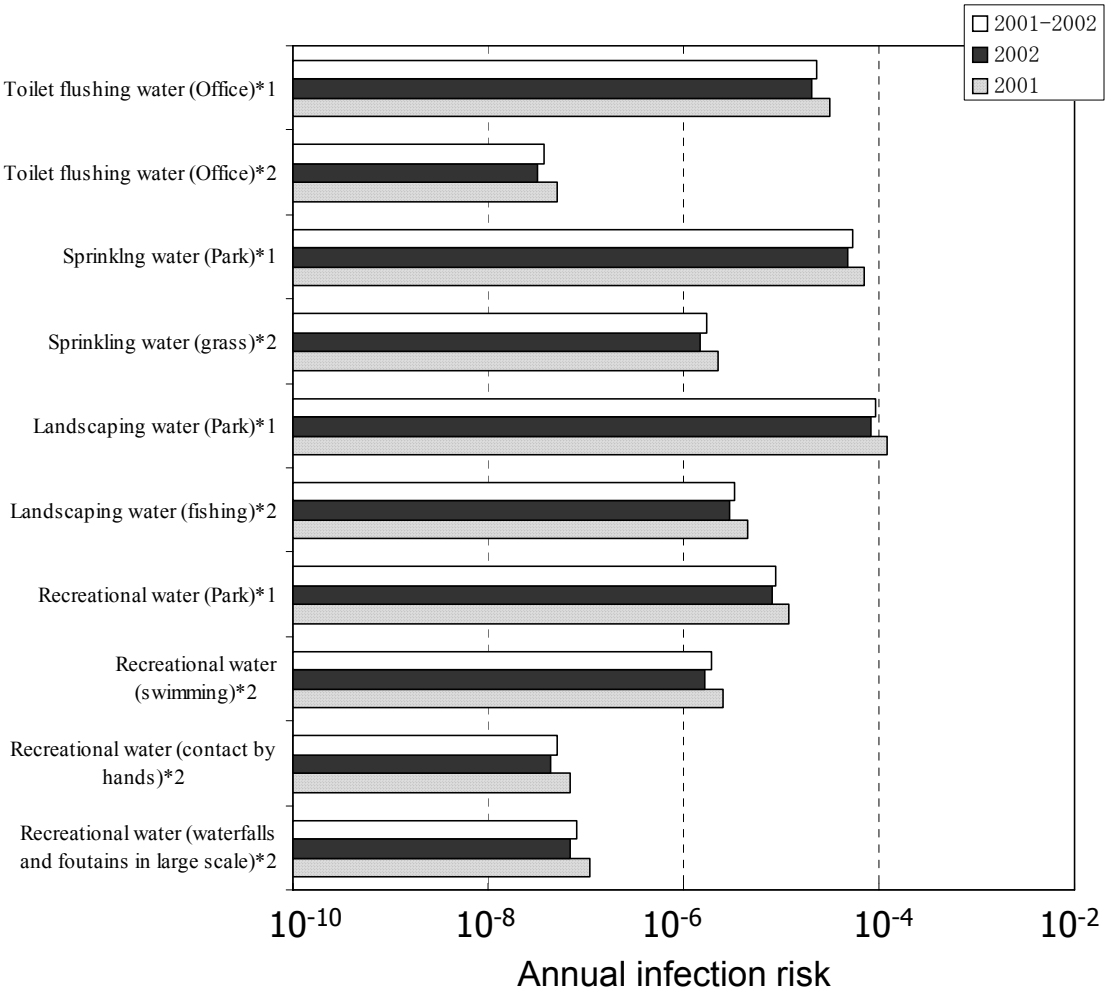
appropriate risk level.

RESULTS

(1) There were cases where total coliforms propagated in the supply tank, but there were almost no cases where *E. coli* propagated in the supply tank. Because it is assumed that when a certain period of time has passed after reclamation treatment, it is considered inappropriate to use bacteria that have propagated in the water environment as index bacteria, suggesting that *E. coli* would be more appropriate than total coliforms as the index bacteria in the reuse of treated wastewater.

(2) The fact that it is possible to lower HPC to a specified level by maintaining the combined residual chlorine concentration at 0.3 mg/L or more suggests that a standard value of 0.3 mg/L or more is necessary for the combined residual chlorine concentration. On the other hand, target pathogenic bacteria were not detected in any samples.

(3) When it is assumed that toilet flushing water, sprinkling water, and landscaping water are produced by sand filtration, and recreational water is produced by coagulation treatment and sand filtration, the annual *Cryptosporidium* infection risk is about 10^{-4} or less for the reuse of treated wastewater at normal times, suggesting that it is possible to satisfy the target infection risk advocated by the USEPA.



Note: The infection risk for recreational water assumes treatment by coagulation treatment and sand filtration, and for other uses, it assums sand filtration.
Note: *1 : Table 6 is applied. *2 : Table 7 is applied

FATE OF SANITARY INDICATORS IN TREATED WASTEWATER

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Project period: 2002-2004

OBJECTIVES

The spread of wastewater treatment systems has raised the quantities of treated wastewater discharged by wastewater treatment plants, increasing the percentage of treated wastewater in river water. And the treated wastewater is reused in a variety of ways in urban regions. This means an increase in opportunities for people to come into direct contact with treated wastewater.

However, treated wastewater contains a variety of pathogenic microorganisms produced by human activities. Traditionally, total coliforms have been used to indicate the existence of pathogenic microorganisms, but they are not adequately reliable as an index. In order to appropriately maintain the hygienic safety of treated wastewater and environmental water, the properties of various kinds of indicator microorganisms should be clarified to select an index appropriate to each purpose. This study was a survey conducted to compare the behavior of total coliforms that have been used in the past, *E.coli*, faecal streptococcus, and *C.Perfringens* spores in receiving waters to clarify the properties of indicator microorganisms.

METHOD and RESULTS

From FY2002 to FY2004, research was carried out in order to clarify the behavior of various kinds of indicator microorganisms after the discharge of treated wastewater. The results have revealed that total coliforms that have been used as an index of faecal pollution in the past do play a certain role as an index that clarifies disinfection effects on treated wastewater. However, under conditions such as its use as an index of hygienic safety after a certain degree of time has passed since it is discharged, when treated wastewater is reused for example, there are cases where it cannot necessarily be described as a an appropriate index because total coliforms increases during a short period of time, even in the same water. There are cases where it would be better to use *E.coli* that measured by a specific enzyme substrate culture that did not increase or decrease very much even after chlorine disinfection during this testing as the index. It would be difficult to use faecal streptococcus that has a low absolute count as an indicator microorganism. It can be concluded that *C.Perfringens* spores show strong chlorine resistance, because their count did not change even when the degree of chlorine disinfection was varied, so they can be used as an indicator of pathogenic microorganisms that are chlorine resistant. But, the fact that *C.Perfringens* spores appeared to have stronger settleability than *E.coli* etc., has suggested that it would be difficult to make a judgment that there are no pollutants by pathogenic microorganisms simply because *C.Perfringens* spores are not detected.

EFFICIENT REMOVAL OF SLIGHT HAZARDOUS MATERIALS BY OZONATION

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Project period: 2002-2004

OBJECTIVES

The problems of the slight hazardous materials represented by the endocrine disruptors are getting more serious year by year. These materials may have a bad influence on natural environment, ecosystem and human health even if these are slightly contained. Endocrine disruptor is said to decrease sharply in process of wastewater treatment by some researches, but the influence which endocrine disruptor have on ecosystem is unknown and it may be needed to decrease more on the basis of the influence. The objectives of this research is to establish the way of efficient removal of slight hazardous materials by ozonation.

RESULTS

We decided nonylphenol (below written, "NP"), bisphenol-A (below written, "BPA"), 17β-estradiol (below written, "E2") and estorone (below written, "E1") as the target substances. In order to clarify ozonation operating conditions that effectively remove the target substances from treated wastewater, and influences that the treated wastewater qualities have on removing the target substances by ozonation, pilot plant experiments were carried out. The results are as follows.

(1) When the ozone contact times were from 3 to 15min and the reactor height is 1.6m or 4.1m, BPA was reduced to below the detection limit at an ozone injection rate of 5mg-O3/L, NP and E2 were reduced to below the detection limit at ozone injection rates of 3mg-O3/L or higher, E1 was reduced to below the quantitative limit at an ozone injection rate of 5mg-O3/L.

(2) When an ozone injection rate was 1.5mg-O3/L, there were several cases where NP, BPA and E2 were not reduced to below the detection limit, E1 was not reduced to below the quantitative limit. There was no correlation between the ozone contact times and the removal rates of the target substances at an ozone injection rate of 1.5mg-O3/L, when the ozone contact times were from 3 to 15min.

(3) When an ozone injection rate was 1.5mg-O3/L and E260(the absorbance of ultraviolet rays of 260nm-wavelength), which is the index of organic materials which have unsaturated combinations, was less than 0.09, NP, BPA and E2 were reduced to below the detection limit, E1 was reduced to below the quantitative limit. It is expected that E260 could be used as the index of materials which are more easily oxidized by ozonation than the target substances, and that we could find an effective ozone injection rate by using E260.

Study on Wastewater Reclamation System for the River Ecosystem

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Project period: FY2001-2005

OBJECTIVES

As the amount of treated wastewater is increasing in response to the coverage of sewerage systems, there is a growing tendency to utilize treated wastewater to create water environments. Treated wastewater is sometimes extensively utilized to create streams and other water environments in urban areas that have disappeared due to urbanization. Streams and other water environments are valuable spaces not only for human lives but also as habitats for all kinds of aquatic lives. However, the relationship between aquatic lives that inhabit these water environments and the quality of treated wastewater is not clearly understood. Because treated wastewater is a valuable water resource, it is important to evaluate wastewater treatment systems from the perspective of habitat environments in the receiving water bodies of treated wastewater. Tadotsu town in Kagawa prefecture tries to utilize treated wastewater as reclaimed wastewater in an artificial stream as a receiving water body. This stream was first operated using drinking water, but now reclaimed wastewater is used. This study was carried out to clarify the effects of the water qualities of reclaimed wastewater and drinking water such as nutrients on periphytic algae grown in the artificial stream in the town.

METHOD

In the artificial stream in Tadotsu town, Kagawa prefecture, two types of field survey were carried out, one for the effects of drinking water and the other for the effects of reclaimed wastewater on aquatic life. The surveys for drinking water were carried out two times from January and March 2004, and for reclaimed wastewater two times from September and November 2004 and from January and March 2005. To compare the effects of the two types of water, periphytic algae and water qualities were analyzed. Unglazed ceramic plates were installed in the upper reaches to analyze periphytic algae, and the biomass (cell count), the community composition and the diversity of periphytic algae were analyzed.

RESULTS

(1) Biomass

The concentration of nitrogen of reclaimed wastewater was ten times as high as that of drinking water. On the other hand, the concentration of phosphorus of reclaimed wastewater and drinking water was the same level. It is supposed that there were no differences between the biomass for drinking water and reclaimed wastewater because of the same concentration level of phosphorus.

(2) Community composition

In the survey of reclaimed wastewater from September and November 2004, *Homoeothrix janthina* of Cyanophyceae was dominant, which is a representative species in relatively clean rivers in Japan.

Bacillariophyceae and Cyanophyceae were dominant and there were no differences between drinking water and reclaimed wastewater in the number of cells by taxonomic class in the same survey period from January and March.

(3) Diversity

The number of species was at the same level between the survey of drinking water and that of reclaimed wastewater.

RESEARCH ON THE RISK ASSESSMENT OF CHEMICAL SUBSTANCES IN A WATER ENVIRONMENT

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Project period: 2003-2005

Objective

The influence of chemical substances such as endocrine disrupters on human beings and the ecosystem has become a serious social problem, and there has been a growing interest in chemical substances.

The Ministry of Land Infrastructure and Transport is in charge of managing the risks of chemical substances in the environment in cooperation with local organizations in charge of managing rivers, sewerage systems, roads and the like. However, it is not easy to grasp which substances have a high risk in the target basins, and which substances should be the object of priority studies, because there are many kinds of chemical substances. Nevertheless, the results of PRTR studies have been compiled and published since fiscal 2002, showing the current state of discharge of chemical substances in the target basins. This study aimed to grasp the amount of chemical substances discharged into river basins and the behavior in the water environment based on PRTR information; to perform a risk assessment based on the current state; to share the results with stakeholders related to the areas; and to establish a risk management method for the basins.

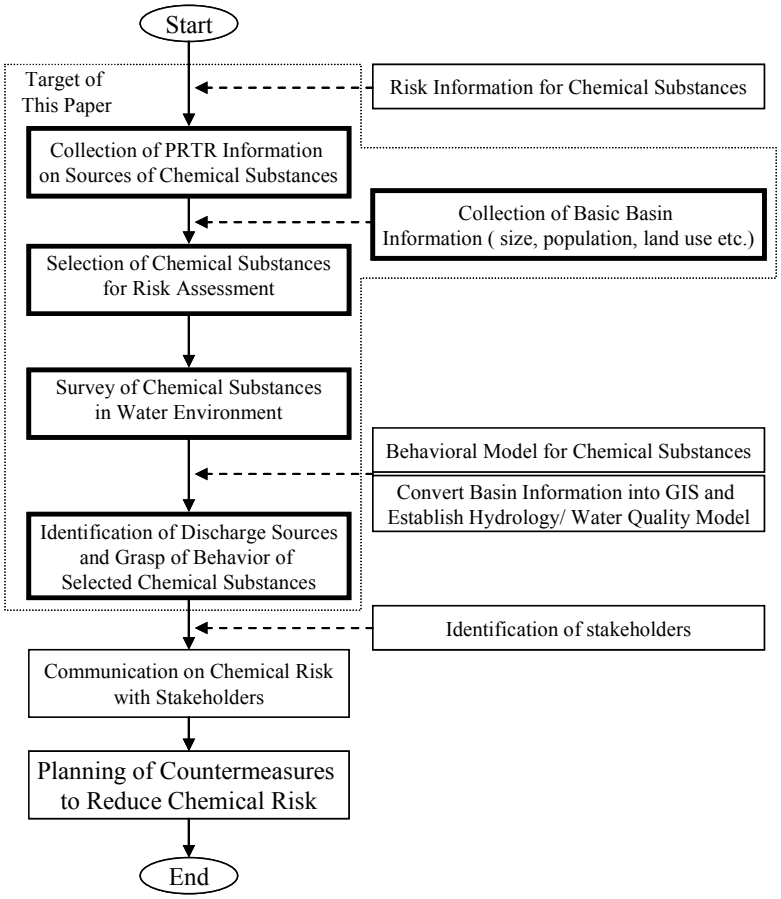

Figure 1 Scheme of Comprehensive Management of Chemical Risk and Target of This Research

Method and Results

In fiscal 2004 the study covered the following.

1) Regarding the target chemical substances (zinc, lead, arsenic, manganese, nickel, copper, chrome, fluorine, boron, polyoxyethylene nonionic surface-active agents, 17 β -estradiol, estrone, nonylphenol, nonylphenolethoxylate, nonyl phenoxyacetic acid) which were detected in the model rivers in fiscal 2003, the concentration in the rivers including water, suspended substances, and bottom sediments was surveyed, and the concentration was evaluated in terms of human health and protection of aquatic ecosystem based on domestic and overseas information. In the model rivers, zinc was identified as being a priority for risk management in order to protect aquatic ecosystem.
2) Based on research on the status of the target chemical substances in the influent and effluent of sewerage treatment plants in the model area in order to identify the discharge sources of the detected target chemical substances, the contribution in the sewerage effluent water of estrone and boron was higher than that of CODcr and SS, but the contribution with respect to the other chemical substances was low. Nonylphenol ethoxylate, nonylphenol, and polyoxyethylene nonionic surface-active agents were effectively removed by the sewerage treatment plants.
3) The businesses which must report their discharge amount of target chemical substances by PRTR law (so called “designated businesses”) in the basins of the model river were grasped, and the contributions of the loads of target chemical substances in the model rivers were evaluated. The results suggested that it is difficult to evaluate the concentrations of target chemical substances in rivers receiving effluent when using only the annual loads reported from the designated businesses. This could be because the concentration of the target chemical substances in the effluent water from the designated businesses has a large daily and seasonal variation in accordance with the operational situation, etc.; that the flow of the river has daily and seasonal variations; and that there is a contribution from the businesses which do not have to report their discharge amount of target chemical substances and other discharge sources such as domestic wastewater, agricultural wastewater, etc.

Sustainable water policy scenarios for river basins with rapidly in creasing population
- Countermeasure strategy to global hydrological variation in monsoon Asia -

EVALUATION OF WATER QUALITY SECURITY MEASURES IN THE GANGES RIVER BASIN

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Wastewater and Sludge Management Division

Project period: FY2003-2008

OBJECTIVES

In Asia and other regions, rapid population growth, urban development, and industrialization have exacerbated water problems, and human activities have caused fluctuation of water cycles and other problems. The goal of this research is to help resolve these problems by presenting policy scenarios for nine typical Asian river systems. This research is done as team research (CREST type) led by research representative Professor Sunada of the University of Yamanashi, because the area studied is vast and faces many challenges. The Wastewater and Sludge Management Division of the NILIM is in charge of the presentation of policy scenarios with priority on water problems in the Ganges river basin.

OBJECT AREA

The Ganges River is the most heavily populated river basin in Asia, and here, population growth and urbanization have been accompanied by water quality pollution and the consequent shortage of sanitary water, flooding, and other serious problems. Asian rivers typified by the Ganges River are irreplaceable for the daily life of the people, many of whom use them for bathing and washing clothes, and who discharge their human waste in their waters. These results in rampant infectious diseases originating in the river water, and in regions where urbanization is particularly advanced, water pollution accompanied by health problems caused by pathogenic microorganisms are serious public issues. Therefore, water quality preservation measures have been proposed as ways to prevent health problems caused by pathogenic microorganisms, taking the Ganges River Basin as the major example.

Figure 1 Ganges river area

METHOD

This research is carried out by first conducting a field survey to collect adequate basic documents concerning the life style of the local people, state of pollution of the river, pollution sources and basic units,

then based on these findings, organizing step-by-step sewerage system provision methods that hypothesize future developments to present scenarios with the priority on water quality problems. The field survey is a survey centered on the Indian capitol city of New Delhi where water pollution is particularly severe. The Yamuna River is a tributary of the Ganges river in New Delhi. The survey included observations of the region and measurements of water quality in New Delhi and its surroundings.

RESULT

The pollutant load per unit activity of source was calculated based on the results of a field survey. Among high income, middle income, and low income districts in the city, the SS load was high in the high income districts, but the values in other districts were equal those values in Japan. A high discharge per unit production was predicted in slums because it was only toilet wastewater, but values other than T-N were low and it was assumed that the septic tanks function adequately.

In local villages, all loads were extremely low values. It is assumed that the quantity of water used is low because it is not supplied by a public water supply system, but is manually pumped up ground water. Regarding other loads, assuming that people do not stay in their houses during the day when they are performing agriculture work and that there is a strong tendency for people to excrete outdoors relatively often when performing agricultural work, there is a discharge load that is not counted.

Because there are differences between Japan and three types of domestic animals in Gazipur, Bhalsawa, and Madanpur and the feed, rearing environment, and types of cattle (cattle and water buffalo) also differ, an equivalent discrepancy appeared. The number of cattle barns in suburbs is now soaring as a result of the concentration of the population in cities, and it is predicted that demand will increase in the future, so it is assumed that cattle barn excreta will also increase. They must, therefore, be surveyed in detail as large sources of discharge.

Table 1 pollutant load per unit activity of source

			water volume L/person/day	BOD g/person/day	CODcr g/person/day	SS g/person/day	T-N g/person/day	T-P g/person/day	coliform group MPN/person/day
wastewater in Japan				58	27 (Mn)	45	11	1	
wastewater in India	high income in the city	Jor Bagh	140	27	50	122	9	2	6.2×10^{10}
	middle income in the city	Pachkuian Road	216	24	42	10	11	1	5.2×10^{10}
		Paharganj	73	37	47	4	6	1	1.7×10^{10}
	low income in the city	Shalimar Bagh	108	26	69	39	10	4	6.2×10^{05}
	slum, night soil only	Vikaspuri	27	3	11	2	16	1	4.5×10^{08}
	local village	Palla	47	5	8	3	3	1	1.2×10^{10}
		Latpur Chatera	17	4	6	4	2	1	6.5×10^{03}
		Mujeri	37	9	21	8	3	1	1.7×10^{06}
barn wastewater in Japan				640	530 (Mn)	3000	290	50	
dairy farm wastewater in India		Ghazipur	123	183	878	59	60	5	1.3×10^{12}
		Bhalsawa	71	875	1849	1536	84	9	3.3×10^{05}
		Madanpur	97	875	1529	1099	119	13	1.6×10^{05}

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RESEARCH ON THE INFLUENCE OF SOIL AND GROUNDWATER CONTAMINATION TO SURFACE WATER

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Objective

Groundwater contamination by volatile organic compounds (VOC), heavy metals, nitrate nitrogen, etc. has become a problem. In fiscal 2002, the Soil Contamination Countermeasures Law came into force. However, the influence of chemical substances from ground water to surface water remain unclear.

Therefore, this study selected chemical substances to be surveyed from the view of the influence from ground water to surface water, and then surveyed the behavior of these chemical substances in ground water.

Method and Results

1) Selection of substances to be surveyed

Chemical substances that could affect water bodies via ground water were selected to be surveyed in this study from the following points of view.

(1) Chemical substances designated in the Soil Contamination Countermeasures Law

In the Soil Contamination Countermeasures Law, the elution amount standard is provided for class-1 specified harmful substances (VOC 11 substances), class-2 specified harmful substance (nine substances such as heavy metals), and class-3 specified harmful substances (five substances such as agricultural chemicals) in accordance with the Environmental Quality Standard Items relating to soil contamination, in terms of their influence on human health through ingestion in contaminated ground water, etc. These substances were selected as survey targets.

(2) Nitrate nitrogen and ammonia nitrogen

Nitrate nitrogen and ammonia nitrogen were specified to be Environmental Quality Standard Items relating to water contamination of ground water in 1998 due to their influence on human health. In this study, nitrate nitrogen is included as a survey target. Ammonia nitride, which is contained in waste from humans and animals, was included as a survey target because it is nitrified.

(3) Environmental Quality Standard Substances concerning preservation of aquatic organisms

Total zinc was specified as an Environmental Quality Standard Item concerning preservation of aquatic ecosystem in 2003. Total zinc was included as a survey target because it contaminates water bodies from ground water.

(4) Higher-ranked substances in the PRTR which are discharged in large quantities to soil or disposed of in landfills on business

According to the PRTR, the substance that was discharged into the soil on business premises in the largest amounts was ethylene glycol, so ethylene glycol was included as a survey target.

(5) Others

Among the six substances which were specified as targets of the Environmental Survey for Exposure Study in fiscal 2002 by the Ministry of the Environment, perfluoro octane sulfuric acid (PFOS), has extremely high repeated-dose toxicity, and is considered to have high acute toxicity to aquatic organisms, so PFOS was included as a survey target.

Hydrazine and polyoxyethylene alkyl ether (C=12–15) and D-D (1,3 dichloropropene) were included as survey targets, because the amounts used and discharged are estimated to be comparatively large based on surveys held by Graduate School of Yokohama National University.

2) Survey of Abundance of Chemical Substances in Ground Water

The Nagata area in the middle reaches of the Tama river of Tokyo(Fig.1) and the Yata river basin in Ibaragi prefecture(Fig.2) were selected as survey target areas because ground water has influenced their waters.

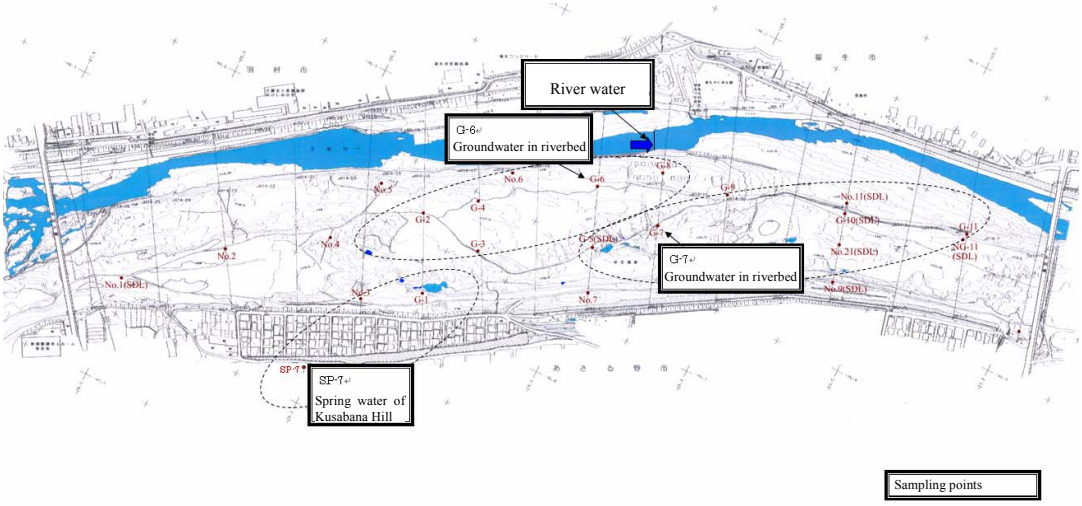

Figure 1 Nagata Area of Tama River

(1) Undetected substances in all or most of the areas

Cadmium and its compounds, PCB, carbon tetrachloride, standard agricultural chemicals (thiuram, simazine, thiobencarb, organic phosphorous compounds), and D-D were not detected in any of the areas.

As for VOC, dichloromethane and trichloroethylene were not detected or detected slightly in the Tama river, spring water from Kusabana hill, and ground water of the Yata river basin.

(2) Substances detected in all the areas

The substances which were detected in all the areas were ethylene glycol, total zinc, nitrate nitrogen, ammonia nitrogen, hydrazine, and PFOS. Manganese and its compounds, total chromium, selenium and boron were not detected or detected slightly.

As for nitrate nitrogen, concentration was more than the level of the ground water environmental quality standard value (10 mg/1) in W2 and W3 (both are fields), and W9 (lawn grass) of the Yata river basin in Ibaragi prefecture, presumably due to the application of fertilizer. Nitrate nitrogen was found at a low concentration in W9 (paddy field), which was considered to be caused by the application of a small quantity of fertilizer. Nitrate nitrogen concentration was larger in SP7 (spring water of Kusabana hill) of the Nagata than in G6 and G7 (underflow water in riverbed of the Tama river), so the contribution of nitrate nitrogen derived from the application of fertilizers on farmland, golf courses, etc. in the Kusabana hill was considered to be large.

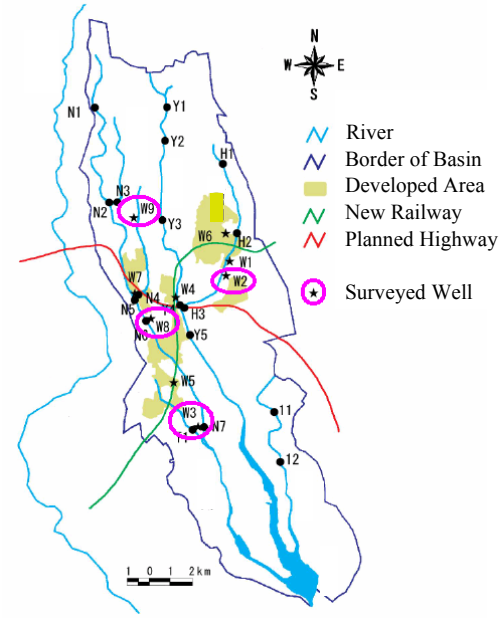

Figure 2 Yata river basin (Ibaraki)

As for total zinc, substantially constant concentrations (0.01 to 0.02 mg/1) were detected in both of ground water and river water.

As for hydrazine, it was detected in the river water of the Tama river, W2 and W3 (both are fields), and W9 (lawn grass) in the Yata river basin in Ibaragi prefecture.

As for PFOS, about 0.0005 μg/l was detected in the ground water and the river water in the Nagata area, and about 0.0002 μg/l in the Yata river basin. PFOS in the spring water of Kusabana hill of the Nagata area was found in a higher concentration by one order (0.0024 μg/l). From the survey of PFOS in the Tama river, PFOS concentration was reported to be 0022 μg/l upstream from the sewerage treatment plant, which was close to the value observed in the Nagata area and the Yata river basin.