

ESTABLISHMENT OF GUIDELINES FOR THE REUSE OF TREATED WASTEWATER

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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 toilet flushing water, sprinkling water, water for landscape use and water for recreational use. To establish new criteria and considerations, hygienic safety of users, appearance and acceptance of users, and risk of facility malfunction were discussed. The new criteria and considerations were published as the Guidelines for Reuse of Treated Wastewater from the Ministry of Land, Infrastructure and Transport in Japan. In the guidelines, new criteria were established for *Escherichia coli* (N.D. /100mL) instead of coliform groups in the former guidelines with the exception of reuse as water for landscape use. Facility standards including required treatment methods and turbidity as the index used for ensuring effective treatment were also established. In addition, measures against loss of residual chlorine, cross connection, and accidental intake were established as considerations for treated wastewater reuse.

Keywords: reclaimed wastewater quality standard, treated wastewater reuse.

Introduction

Japan's average annual rainfall is approximately 1,700mm, which is twice the world average, but because of its small land area and large population, the annual per capita water resource is about 3,300m³, less than half the world average 7,800m³. There is only 905m³ (almost same as Egypt) available in the Kanto district where Tokyo is located. Furthermore, the precipitation has been 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 to reuse treated wastewater as important water resources 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 of 246 wastewater treatment plants (WTPs) has been 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 urban areas, which will in turn increase the importance of appropriately reusing treated wastewater.

On the other hand, since some cases of the human health damages by the pathogenic microbes have reported in recent years in Japan, many people have become interested in hygienic safety of water. Therefore, measures against these new problems must be taken from now on when we

promote reuse of treated wastewater. In addition, it is necessary to maintain an appropriate color, clearness, and less odor of the reclaimed wastewater to ensure that the public feels comfortable using 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.

The scope of applications to use the treated wastewater in the guidelines

Because there were many kinds of applications to use the treated wastewater, we could study limited applications to use on the basis of the actual conditions of treated wastewater reuse in Japan. In the guidelines, toilet flushing, sprinkling, landscape use (untouchable) and recreational use (touchable) could be considered. These applications were usage for many and unspecified persons and the reclaimed wastewater was distributed directly from WTPs. Sprinkling refers for watering to trees, plants and lawns or for road flushing. Landscape and recreational use refers for environmental water.

For the time being, we decided to consider that reuse as large-scale waterfalls or fountains were recreational use, because they might produce mist.

Actual conditions of the 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 of the guidelines concerning appearance and acceptance, and facility malfunction were based on a study concerning complaints and problems on actual treated wastewater reuse in Japan. The outline of the study is as follows.

Methods

Questionnaires were sent out to WTPs that distributed reclaimed wastewater outside themselves in FY 2002 as toilet flushing water, sprinkling water, water for landscape use, and water for recreational use. The results of this research enabled us to know the details of the 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 the treated wastewater are used as water for landscape use and water for recreational use
Reclaimed wastewater generally contains more nutrients such as nitrogen and phosphorus than drinking water. Nutrients accelerate the propagation of periphytic algae. These algae lead complaints from user of the facilities.
- Chironomid in toilet flushing water
There were complaints concerning the growth and propagation of Chironomid in the reservoir tank or toilet flushing water after being distributed from the WTP to the place of use. On the other hand, there were few complaints about this problem in landscape use and recreational use water because Chironomid scatters easily and is not as prominent.

Facility malfunction

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

Troubles of water supply due to the blockage of drains or bended points of the pipes were reported, also. Blockage of pipes may occur because the dissolved iron from corrosion is oxidized by residual chlorine or dissolved oxygen and stored at the bended points or narrow areas of the pipes. Measures have already been taken against these problems and they have now been solved (Fukuoka city, 1999; Fukuoka city, 2000).

The guidelines for the reuse of treated wastewater

The guidelines are divided into two parts such as 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 to establish the guidelines

Hygienic safety

To establish the guidelines, measures against the bacteria which chlorine was comparatively effective and protozoa which comparatively had the chlorine tolerance were considered.. Measures against viruses could not be considered because of the numerous problems in the detection methods of viruses.

Appearance and acceptance

Three points listed below were considered to establish the guidelines. The second and third points were considered only in the considerations for wastewater reuse, not in the criteria part, because different types of facilities caused different conditions for the second point and the effects of measures have not been clarified for the third point.

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

Facility malfunction

Measures against corrosion and blockage of pipes and other equipment were considered to establish 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

These criteria were selected from the viewpoint of measures against bacteria.

E.coli N.D./100mL was set as a new criterion instead of 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./100mL was set as the quality criteria for drinking water in Japan in 2003 on the basis of 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 the treated wastewater reuse (coliform groups 1,000CFU/100mL) was adopted on a provisional basis.

Facility standards (Required treatment methods and Turbidity as control parameter of the facility)

The facility standards were established from the viewpoint of measures against facility malfunction and 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 required as the 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 on the basis of research results demonstrating that turbidity of the treated wastewater from a properly operated filtration system hardly exceeded 2 mg-kaolin equivalent/L.

Chemical precipitation followed by sand filtration or an equivalent treatment method were required as the facility standards 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.

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

pH

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 or other equipment. In addition to this, it was recommended that corrosion-resistant structure and materials for pipes or other equipment should be adopted.

Appearance, Color, and Odor

Appearance, color and odor were established from the viewpoint of appeal and acceptance. These criteria were 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 the color of 40 units under the premise of not handling the water and the color of 10 units under the premise of handling (JSWA, 1981; MOC et al., 1990). However, it is preferable that the values should be set based on the regional users' wishes.

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 0.1mg/L or combined: more than 0.4mg/L) was applied to the criteria for treated wastewater reuse. It was also, based on the results of research indicating that bacteria hardly developed in the distribution process under conditions of values greater than 0.1mg/L for free residual chlorine or 0.4mg/L for combined residual chlorine.

For sprinkling and recreational use of treated wastewater, the 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 except chlorine disinfection may be adopted from the viewpoint of ecosystem preservation.

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

	Standards applying location	Toilet flushing water	Sprinkling water	Water for landscape use	Water for recreational use
E. coli	Outlet of the reclaimed treatment facilities	N.D./100mL	N.D./100mL	\leq 1000CFU/100mL as coliform groups ¹⁾	N.D./100mL
Appearance		Not unpleasant			
Turbidity		≤ 2 ²⁾³⁾			≤ 2 ³⁾
Color				≤ 40 units	≤ 10 units
Odor		Not unpleasant			
pH		5.8 - 8.6			
Residual chlorine	Administration boundary	\geq free: 0.1mg/L or combined: 0.4mg/L ²⁾	\geq free: 0.1mg/L or combined: 0.4mg/L ²⁾⁴⁾		\geq free: 0.1mg/L or combined: 0.4mg/L ²⁾⁴⁾
Treatment		Sand filtration or equivalent			Chemical 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

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 the secondary treatment and reclamation treatment.
- Construct distribution networks so as to shorten the retention time. For example, the selection of pipes with suitable diameter and the avoidance of dead ends by looping of pipes. Also pipes should be used to the material not easily oxidized by residual chlorine.
- Consider additional chlorine disinfection in places where residual chlorine is significantly decreased.
- Confirm of suitable volume of 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 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 inspecting for cross connection 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 sewerage law

The new criteria and considerations were published as the Guidelines on Reclaimed Wastewater Quality Criteria from the Ministry of Land, Infrastructure and Transport in Japan. The guidelines were used as reference for the amendment of the Sewerage Law.

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

Last amendment of the Sewerage Law in October 2005 (enforced in April 2006) newly added the criteria for the hygienic safety of recreational water in order to preserve living environments 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 specified condition is that the recreational water that is used satisfies quality standards for final effluent, contains E.coli N.D./100mL, and has turbidity of less than 2mg-kaolin equivalent/L.

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

Acknowledgements

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.

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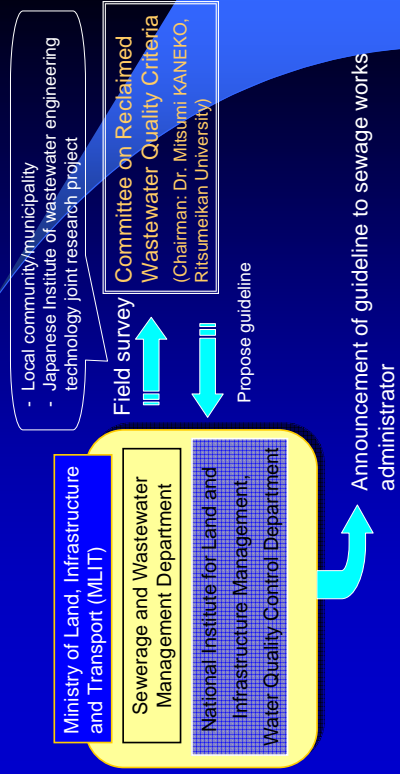
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2. Framework of Establishment



Announcement of guideline to sewage works
administrator

3

1. Introduction

Importance of saving water resources in urban areas

Annual per capita water resources - 3,300m³ (Japan) / 7,800m³ (world average)
Decrease of the rainfall in drought years

Importance of hygienic safety of water

Outbreak of Cryptosporidium disease (1996) etc.

Importance of appropriate use of treated wastewater

Review the guideline...

New Guidelines (2005)

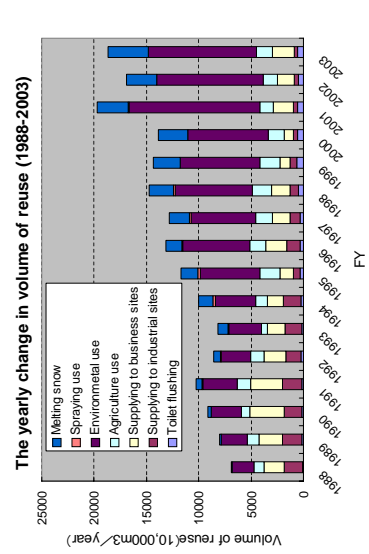
- Three points of view
 - hygienic safety
 - appearance and acceptance
 - risk of facility malfunction

Field survey
(hygienic safety of reclaimed wastewater)

2

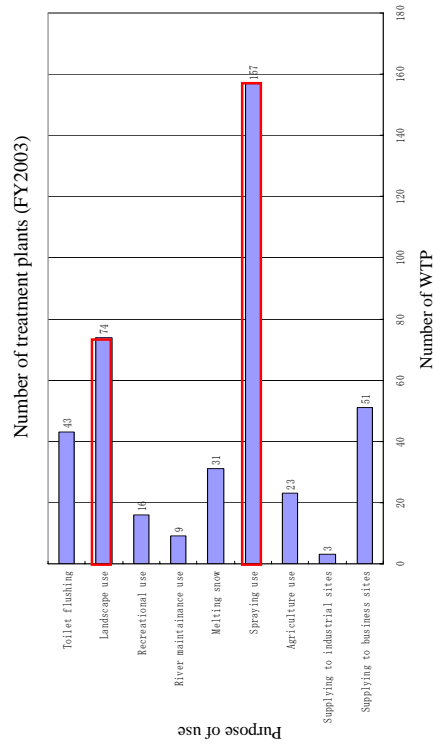
3. Present status of treated wastewater reuse in Japan (1)

186 million m³ (FY2003) = 1.4% of the total treated wastewater
246 treatment plants (FY2003) = 13% of the total treatment plants

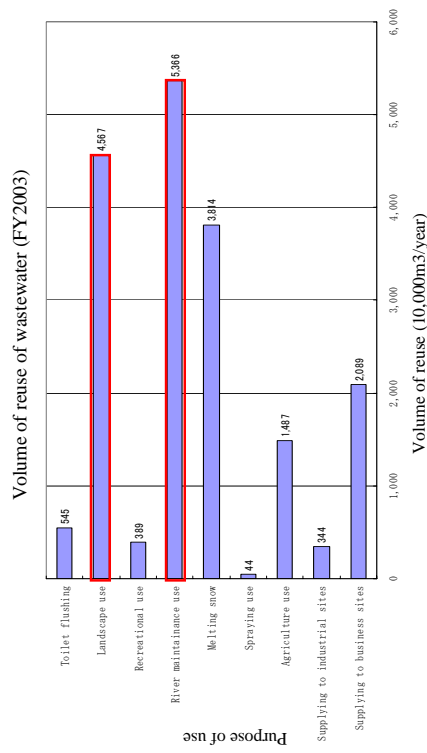


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3. Present status of treated wastewater reuse in Japan (2)



3. Present status of treated wastewater reuse in Japan (3)



4. Scope of application (1)

- Applications for many and unspecified persons
- Reclaimed wastewater that was distributed directly from Wastewater Treatment Plants



Toilet flushing



Sprinkling

(trees, plants, lawns, road flushing)

4. Scope of application (2)



Landscape use

(Environmental use (untouchable))



Recreational use

(Environmental use)

* Including large-scale waterfalls or fountains that may produce aerosol

5. Details of the examination

Details		Standard-ization
Appearance and acceptance	Appearance (color, clearness, odor)	Yes
	Growth of algae (Landscape use, Recreational use)	No
	Outbreak of Chironomid (imago/larva) (toilet flushing)	No
Facility malfunction	Corrosion and blockage of pipes and other equipment	Yes
	Pathogenic microbes (bacteria, protozoa) *	Yes

* Not cover criteria for viruses for following reasons in this new guidelines

- Not establishment of identification and culture of virus
- PCR is not enough to evaluate infectuousness
- Fate of virus should be further investigated
- Dose/response model is to be developed for some species
- Resistance to disinfection is not sufficiently clarified/evaluated yet.

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7. New criteria for treated wastewater reuse

Toilet flushing	Sprinkling	Landscape use	Recreational use
<i>E. coli</i>	N.D./100mL	N.D./100mL	Total coliforms 10CFU/mL ¹⁾
Turbidity	2 or less (target value) ²⁾	5.8 - 8.6	2 or less ²⁾
pH	Not unpleasant		
Appearance	N.A.		
Color	40 or less		
Odor	Not unpleasant		
Treatment	Sand filtration		
Residual chlorine (target value)	free: 0.4mg/L or combined: 0.4mg/L ³⁾	free: 0.1mg/L or combined: 0.4mg/L ³⁾	N.A.
Notes	1) Provisional criteria 2) Unit: mg-kaolin equivalent/L 3) Not applicable for cases in which long-term effects of disinfection is unnecessary		

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6. Previous guidelines/standards for treated wastewater use (Reference)

	Japan Sewage Works Association (proposed in 1981)		Working group composed of Ministry of Construction and some big cities (proposed in 1990)	
	Toilet flushing use	Spraying use	Landscape use	Recreational use ^{***}
Coliform group	10 or below (cfu/mL)	Not detective	Not detective	50 or below (air/roomL)
Chlorine Residual (mg/L) [*]	Trace amount	0.4 or over	-	-
Appearance	Not unpleasant	Not unpleasant	Not unpleasant	-
Color (color unit)	-	-	-	40 or below
Turbidity (mg-kaolin equivalent/L)	-	-	10 or below	10 or below
Odor	Not unpleasant	Not unpleasant	Not unpleasant	Not unpleasant
pH	5.8 - 8.6	5.8 - 8.6	5.8 - 8.6	5.8 - 8.6
BOD (mg/L)	-	-	10 or below	3 or below

Note: * combined residual chlorine, ** restricted human contact, *** limited human contact

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8-1. Grounds for the new criteria (1)

E-coli (Coliform groups)

Coliform groups not suitable as the index of contamination by excrement

N.D. of *E-coli* in 100mL in drinking water by establishing a quick and easy culture method



No detection in 100mL, new criteria

However,

For landscape use, tentatively same as previous (Coliform groups 10CFU/mL) because handling not permitted and effluent criteria set as coliform group

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8-1. Grounds for the new criteria (2)

Residual chlorine

Control of regrowth of pathogenic bacteria in distribution

Field survey...

(Drinking water criteria)

Free: 0.1mg/L or more

Combined: 0.4mg/L or more

Possible to control regrowth

new criteria

Free: 0.1mg/L or more

Combined: 0.4mg/L or more

However:

Not applicable for landscape use (handling not permitted, ecosystem preservation)

Not applicable for cases in which long-term effects of disinfection is unnecessary (sprinkling use, recreational use)

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8-1. Grounds for the new criteria (3)

Treatments / Turbidity

Against facility malfunction

No blockage, sand filtration should be added

Turbidity of 2 or less as target value to ensure effective treatment

Control of protozoa (recreational use)

Coagulation and sand filtration should be added

Turbidity of 2 or less as value to be observed at all times to ensure effective treatment

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8-1. Grounds for the new criteria (4)

pH

Corrosion control / same as previous (pH: 5.8 - 8.6)

Appearance / Color / Odor

Appeal and acceptance / same as previous

(Appearance, Odor: Not unpleasant

Color: 40 units or less (Landscape use),

10 units or less (Recreational use))

However,

It is preferable to give criteria considering the regional uses' wishes

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9-1. Consideration for treated wastewater reuse

Hygienic safety

1. Loss of residual chlorine in the distribution system

2. Cross-connection

3. Accidental intake

4. Deterioration of the quality of reclaimed wastewater

Appeal and acceptance

1. Red water, colorless, cloud

2. Growth of algae (Landscape use, Recreational use)

3. Outbreak of Chirnomid (imago/larva) (toilet flushing)

facility malfunction

1. Corrosion and blockage of pipes and other equipment

16



9-2. Cross connection (1)

1) Place signs on or color-code pipes and other equipment



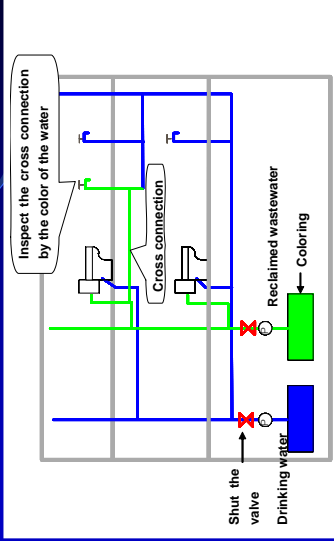
Example of distinction by color-coding the pipes
(Yellow is reclaimed wastewater, blue is drinking water)

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9-2. Cross connection (2)

2) Inspection for cross connection



Example of method for confirming cross connection

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9-3. Accidental intake (1)

1) Posting of notices to users that reclaimed wastewater is used



Example of posting of notices that reclaimed wastewater is used and not for drink

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9-3. Accidental intake (2)

2) Prevent of accidental intake of aerosol (sprinkling use)



Example of sprinkling use that is hard to produce aerosol

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10. Amendment of sewerage law (1)

Objective

- Sound urban development
- Enhancement of public sanitation
- Water quality control of public water bodies

public sanitation

prevention of inundation

spread of flush toilet

water quality control in public water body

utilization of sewerage resources

creation of preferable water circulation and water environment

Growing interest in favorable water environment

Changes in roles of sewerage

10. Amendment of sewerage law (2)

Structural standards

~~Shielding, fences etc. must be installed to prevent entry to the facilities~~

- Culvert
- **Recreational use facilities** ~~REU~~
Quality standards for final effluent
E.coli N.D./100mL
Turbidity of less than 2mg-kaolin equivalent/L
- ...

Amendment in October 2005

Suitable reuse of treated wastewater

Recovery of good quality waterside spaces in urban areas



11. Future task

1. Study on the criteria for viruses
2. Study on the ingestion scenario
3. Improvement of analysis methods of pathogens
4. Development of cheap and advanced wastewater treatment
5. Study on the possibility of application to new purpose of use

Acknowledgement

The new criteria and considerations were proposed by the Committee on Reclaimed Wastewater Quality Criteria. We express our deep appreciation to the members of the committee who extensive effort into developing and proposing the guidelines.



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*Thank you very much
for your attention !*