# STANDARD FOR DISCHARGE OF DOMESTIC WASTEWATER WITH HIGH CONCENTRATION

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Project period: 2000-2003

## Objective

As part of our overall research on the introduction of disposers, we examined the influence that a disposer has on a wastewater system. Our final objective is to propose technological standards to be used when a disposer is introduced.

## Experiment City

This research was conducted in Utanobori, Hokkaido Prefecture. Disposers have been set up for a number of general homes in the treatment area since 1999. We have evaluated their influence on the wastewater and garbage disposal systems and have conducted overall evaluations using LCA and cost-effectiveness analysis. Disposers are presently set up in approximately 35% of the homes in the treatment area.

## Experimental Outline

Soil and sand accumulate in sewer pipes due to various reasons. Garbage might accumulate and increase sediment in sewer pipes when a disposer is introduced. We started our investigation of the amount of sediment in sewer pipes in 1999 when we first set up the disposers. We conducted internal inspections using a TV camera and observed garbage such as eggshell and seashell that were thought to have been exhausted from disposers in the lower reaches of sewer pipes of houses that had research disposers set up since last year.

In the current year's research, we investigated the amount of sediment in sewer pipes since last year. We also conducted sewer pipe inclination investigations, inorganic matter analysis of sediment to obtain mass balance, and fixed-point observation using a video camera.

We estimated the amount of sediment for each unit length of sewer pipe in which we observed sediment as a result of our previous investigation. We attempted to establish a relationship between the unclean sewer period and amount of sediment in sewer pipes to examine the possibility of sewer pipe clogging due to increased sediment, and we examined whether or not sediment increased with time. In addition, we analyzed the substances adhering to the sides of the sewer pipes in both the disposer installation area and non-disposer area.

In the process of investigating the amount of sediment in the sewer pipe, we conclude that increased sediment was not necessarily constant time wise, and there was a possibility that traction of sediment occurred. Fixed-point observation was executed to observe the generation of sediment.

## Conclusion

1) Sediment, other than soil and sand, originating from garbage was generated in the lower reaches of the main line that was estimated to have fast flow velocity. The reason for this was assumed to be that flow velocity decreased when rainwater invaded the sewer pipe.

2) We observed substances adhering to the sides of the sewer pipes in the non-disposer area that closely resembled the substances in the disposer installation area.

3) A positive correlation was not necessarily seen between the amount of sediment and the unclean sewer period.

4) About 76% of the sediment was generated in reverse-inclination sewer pipes, determined from the results of establishing a relationship between sewer pipe inclination and amount of sediment.

5) A large amount of calcium content was present in the sediment of the disposer installation area, determined from the results of inorganic matter analysis of the sediment. This was assumed to be from eggshell derived from the garbage.

6) Sediment in the sewer pipe was determined to be the result of traction and movement along with the sewage. The possibility that infiltration took part in the traction of sediment was suggested, because at the maximum there is double or more the amount of flow from the treatment plant when rainfall is heavy.

# STUDY OF CONDUIT MAINTENANCE LEVELS

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Project period: 2001-2003

## OBJECTIVES

The force main, which is one of the systems of sewer transportation, may produce sulfide in sewerage, which causes concrete pipe corrosion. A sewer structure that may become corroded with sulfide could be changed to a structure protected against sulfide by controlling the generation of sulfide or by using material that is resistant to corrosion by hydrogen sulfide.

It is very important to predict the amount of generation and influence of sulfide, when presuming the sulfide corrosion range and selecting the required countermeasure to it. Some prediction techniques have been proposed regarding sulfide generation in the force main. However, few research reports are available regarding the action of a sulfide in the gravity main. Therefore, it is difficult to predict the action of a sulfide with practical accuracy in the design stage for sewer pipe.

Therefore, in order to predict the action of the sulfide in sewer pipe, a WATS model, which expresses the water quality change, was arranged. We made our evaluation based on previous research results on applicability.

## RESULTS

It is necessary to experiment with some reactions when attempting to reproduce the actions of sulfide in sewer pipe using the WATS model. The contents required to reproduce the actions using the model are shown in Table 1.

Table 1 Contents required to reproduce actions when using the WATS model

| | Reaction | Research situation |
|---|---|---|
| Reaction in the wastewater | The reaction that decomposes the organic matter | There are some research reports. However, it is necessary that the parameter of each model formula be improved in accuracy through the experiments. |
| | The reaction that generates sulfide in the biofilm | There are many research reports. The accuracy of predictions using the model can be increased by a theoretical approach related to the reaction of the organic matter. |
| | The reaction by which sulfide oxidizes in the wastewater | There are some research reports. However, that alone is inadequate for determining the coefficient of the equations. |
| | The reaction by which sulfide oxidizes in the biofilm | There is almost no research reported. Verification by experiments is required. |
| | The reaction by which oxygen dissolves in the wastewater | It is possible to quantify a reaction from examples in previous research, and to incorporate in a WATS model. |
| | The reaction by which hydrogen sulfide is emitted from the wastewater | It is possible to quantify the reactions from previous research results, and to incorporate in the WATS model. |
| Reaction in the air in the sewer pipe | The reaction by which hydrogen sulfide is emitted from the wastewater | It is possible to be able to quantify the reactions from the past research results, and to take in to the WATS model. |
| | The reaction by which hydrogen sulfide adsorbs and oxidizes on the surface in the sewer pipe | There are few research reports and theoretical considerations based on field survey, which is required. |
| Reaction in the fall in the sewer (Substance movement between air-water) | The reaction by which oxygen dissolves in the wastewater | There are some research reports. However, that alone is inadequate for determining the coefficient of the equations. |
| | The reaction by which hydrogen sulfide is emitted from the wastewater | There are few research reports and theoretical consideration based on field survey, which is required. |

# STUDY ON IMPROVEMENT OF URBAN RAINWATER MEASUREMENT SYSTEM

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Project period: 2001-2003

## INTRODUCTION

In recent years, the problems of city rainwater in Japan have focused on both quantity and quality, such as city-type flood damage and combined sewer overflow. Therefore, development of a pollution load outflow model in wet weather for combined sewer was studied, and a technique for safely checking the blow-out phenomenon of manhole covers installed in the storage pipe of an inverted siphon form was developed using a numerical model of the multiphase flow of air and water formed by high head falling inflow based on the results of hydraulic model experiments.

## I. DEVELOPMENT OF A LOAD OUTFLOW MODEL OF COMBINED SEWER

*Objectives*

This study aims to improve the Yamaguchi-Nakamura Model, which is a lumped type model, into a distributed type model and to simultaneously apply this model to many points. The study also aims at establishing the calculation method of total nitrogen, total phosphorus, and the total number of coliform groups (TC).

*Improvement of the Yamaguchi-Nakamura Model*

The Yamaguchi-Nakamura model was improved to the distributed type model. As a basic composition element of a distributed type model, we decided to combine two models, a basin model and a pipeline model. The results of calculation in rainy weather are shown in Fig. 1. Here, in addition to the observed value, comparison with the calculation results using the concentrated type model is also conducted.

As a result of calculation, in the distributed type model, reappearance of the same grade as a lumped type model is possible regarding the amount of loads, and, in addition, it was shown that reproducibility is higher than in a concentrated type model on the whole. However, regarding TC, a future subject remains in respect of the behavior in pipes, and it is necessary to add examination and improvement of these points from now on.

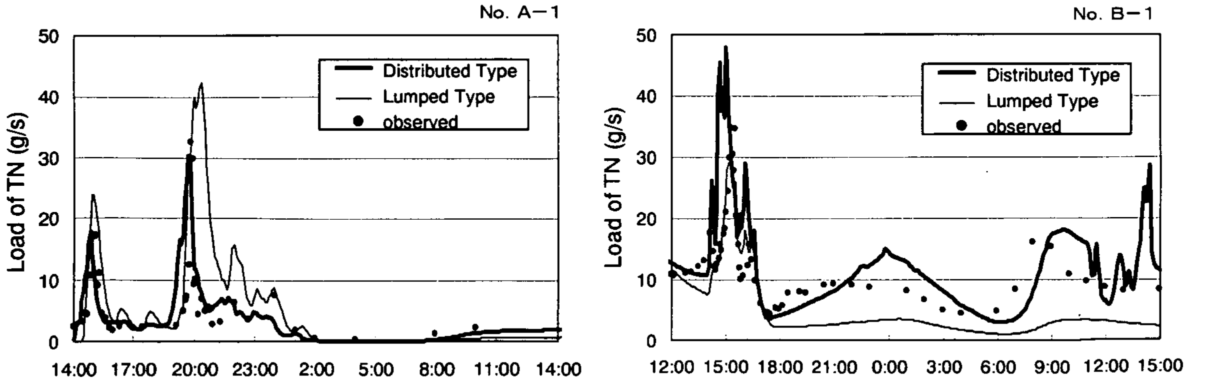


Fig. 1 Results of comparison with calculation

## II. STUDY OF AIR MIXING AND DISCHARGE IN RAINWATER SEWERS

*Objectives*

In this study, we examined the phenomenon of air mixing and discharge in a storage pipe, in order to clarify the mechanism and develop a design method that considers the blowing-out of manhole covers. The behavior of water and air is quantitatively grasped by hydraulic model experiments of a storage pipe of the inverted siphon form, and then a numerical model of the multiphase flow of air and water is derived.

*Development of numerical model*

The storage pipe was divided into two manhole blocks and 48 pipe blocks, and the analysis factors were defined in each block and each section. These analysis factors correspond to variables of a fundamental equation and to physical quantities calculated by numerical analysis. The main analysis factors of the multiphase flow model, which were defined based on the results of hydraulic model experiments, are shown in Fig. 2. Among these, seven factors (water density, air density, bubble density, flow rate of water, flow rate of air, water depth and air pressure) should be modeled, as other analysis factors can be calculated from these seven factors.

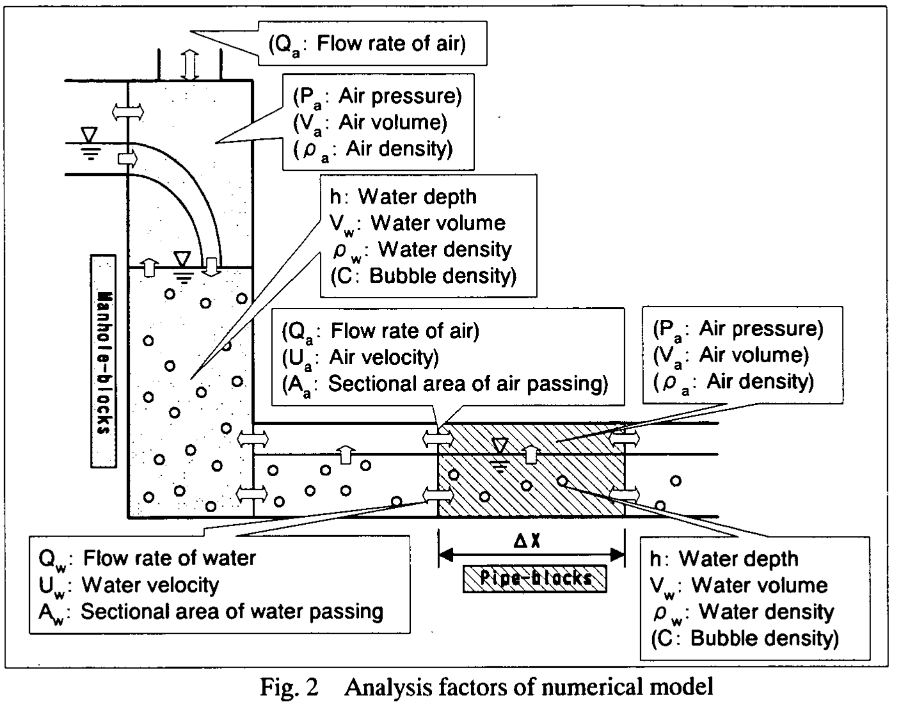


Fig. 2 Analysis factors of numerical model

*Verification*

The results of hydraulic model experiments and those of numerical analysis were compared to examine the accuracy and validity of the numerical model. However, it is difficult to perfectly match the wave shapes (the changes with time) of both, so the peak air pressure, which was a criterion for checking the safety of blowing-out of manhole covers, was examined in the verification. The verification was done at two water flow rates in three cases, that is, in Model 1, in Model 2 and in Model 3. (Model 1: Q1 = 150 liter/s, Q3 = 100 liter/s, Model 2: Q1 = 27 liter/s, Q3 = 18 liter/s, Model 3: Q1 = 5 liter/s, Q3 = 3 liter/s.)

As a result, the difference between the two (= |(Result of hydraulic model experiment) – (Result of numerical analysis)| ÷ (Result of hydraulic model experiment) ×100) ranged from 9% to 66% for Q1 and 2% to 209% for Q3. The difference was large in the case of small water flow rate (Q3), but the accuracy for a large water flow rate (Q1), in which the peak air pressure was big, was found to be relatively good.

# STRATEGIC INVESTMENT IN SEWAGE WORKS

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Project period: 2002-2005

## OBJECTIVES

Cost benefit analysis can be effective in setting the target for water quality improvement in public water areas. The effect of water quality improvement by sewage works is categorized into two items: use value such as recreation, and non-use value such as ecosystem conservation. The Contingent Valuation Method (CVM) can be used to measure the benefits including non-use value, but there are not many researches involving the benefit measurement technique in our country, and thus general application methodologies should be established.

On the other hand, the United States, which has actively adopted CVM in environmental assessment, evaluated the nationwide benefit of water quality improvement due to the Clean Water Act, based on CVM surveys conducted at 61 sites. In Japan, the establishment of benefit transfer must be researched further, and various conditions such as assumptions of function forms must be examined for possible cases. Therefore, this research considers the applicability of benefit transfer and presents a general methodology of benefit measurement for water quality improvement.

The framework of this multi-year research is shown in the following, among which (1) and (2) were conducted in FY 2002.

(1) Literature review on benefit transfer
(2) Examination of the relation between preferred water quality level and attributes of individuals
(3) Examination of nationwide research
(4) Implementation of pre-survey
(5) Implementation of nationwide survey
(6) Examination of methodology of benefit transfer

## RESULTS

(1) Literature review on benefit transfer

The practice of benefit transfer by USEPA (United States Environmental Protection Agency) was found to be a leading and relevant case that should be carefully reviewed. Its methodology is to measure the Willingness To Pay (WTP) per household for all major rivers and lakes to be improved into either a swimmable, fishable or boatable condition, and to implement a benefit transfer by adopting WTP as a unit value. One of the major weaknesses of the methodology is that features other than water quality level, for example, largeness of water bodies and attributes of individuals, were neglected. Another is that there is a lack of theoretical ground in terms of distribution method among local/in-place benefits and non-local/existence benefits. In order to address the former weakness, application of benefit transfer is appropriate, and then the validity of benefit transfer must be examined statistically. For the latter, conjoint analysis can assure theoretical validity.

(2) Examination of the relation between preferred water quality level and attributes of individuals

In measuring the benefit of ambient water quality improvement, regions incurring benefits and water quality level preferred by beneficiaries must be grasped. Desirable water quality level from a standpoint of efficiency or equity presumably differs among regions and/or individuals. The relation between preferred water quality level and attributes of individuals was therefore examined by using the results of the questionnaire "Towards Sewage Works Reflecting Your Voices" conducted by Sewerage and Wastewater Management Department, Ministry of Land, Infrastructure and Transport. This examination also considers how to set study sites of a nationwide CVM research, which is expected to be conducted in the subsequent year.

As a result, the following attributes of individuals are suggested to have significant influence on preferred water quality level: availability of sewerage services, awareness of sewerage fees, and recognition of riparian life and surrounding landscape. It is also suggested that preferred water quality level differs between prefectures. Therefore, an applicable benefit transfer function on a national level must take into consideration attributes of individuals and regions. We intend to examine a methodology for CVM for benefit transfer in subsequent fiscal years.

# LOW-COST SEWERAGE SYSTEM FOR DEVELOPING COUNTRIES

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Project period: 2001-2004

## OBJECTIVES

As hygiene deteriorates with the remarkable progression of urbanization, improving the water environment and securing water resources become important in developing countries. Especially in rural areas, people live in poor hygienic conditions caused by the spread of epidemics and the shortage of water resources, because they have less understanding of the importance of wastewater treatment than those who live in urban areas. To solve these problems, the quality of these water resources should be improved by establishing low-cost sewerage systems through improving existing drainage facilities such as septic tanks, wetland and soil filtration. Therefore, the objective of this research is to develop low-cost sewerage systems suitable to the characteristics of developing countries, such as high temperature and low cost for labor and land, including citizen participation and efficient management of sewerage systems.

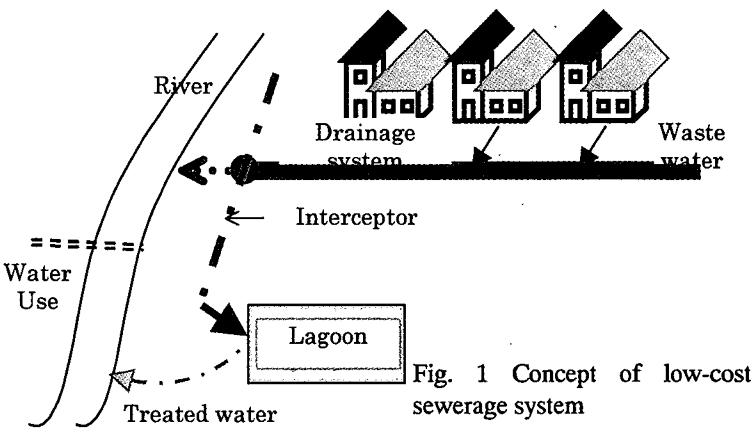

Fig. 1 Concept of low-cost sewerage system

## RESULT

### FIELD SURVEY OF DRAINAGE SYSTEMS AND WASTEWATER TREATMENT PLANTS IN THAILAND

The combination of interceptor and lagoon create low-cost sewerage systems that are suitable for improving water quality and hygiene in the rural areas of developing countries. But the present interceptor and lagoon systems are not functioning. We carried out field surveys to determine the problems of the present interceptor and lagoon systems in Thailand and Indonesia in October 2002.

Our survey revealed two results. First, although sedimentation and biodegradation in interceptor pipes was not confirmed, the concentration of BOD in wastewater was lower than that in Japan because river water ran into the interceptor. Second, the concentration of suspended solid in the effluent of lagoon systems was higher that that of wastewater treatment plants in Japan because algae grew in the lagoon and was contained in the effluent.

### EXPERIMENT TO IMPROVE THE TREATMENT OF LAGOON SYSTEMS IN THE TROPICS OR SUBTROPICS

Wastewater influent with low BOD in lagoons of the tropics or subtropics is a problem. The first step is to change the method used for operation and maintenance, which are inadequate. In addition, there is the problem of algae and the sanitary condition of the treated wastewater from the lagoon. We researched these matters and conducted experiments in

Okinawa Prefecture, the sole subtropics area in Japan.

The lagoon has a water depth of 2 m and a capacity of 100 $m^3$. BOD of the wastewater influent was changed to 50, 100, and 200 mg/L. The hydraulic retention time (HRT) of the lagoon was changed to 2, 5, 10, and 20 days. The processing condition of the lagoon was confirmed. This fiscal year, the BOD was set at 50,100 mg/L (except HRT at 20 days) and we conducted experiments using hygrophyte purification to advance the lagoon treated wastewater. We waited for the HRT set to 20 days and for the hygrophyte to grow.

For the lagoon results, in the case of wastewater influent BOD 50 mg/L, the necessary HRT was 5 days. In the case of wastewater influent BOD 100 mg/L, the necessary HRT was 10 days. When sanitary conditions are considered, in the case of wastewater influent BOD 50 mg/L, proper HRT was 10 days. In the case of wastewater influent BOD 100 mg/L, proper HRT was 30 days. However, HRT of 20 days was not set for the wastewater influent BOD 100 mg/L period. When we evaluated the treated wastewater of the lagoon, it was not possible in only the evaluation of the total samples (T-BOD, SS etc) because it does not check wastewater that was not treated or algae that appeared with treatment. Therefore, we must evaluate it taking into consideration the dissolved solids and lagoon conditions.

In the results of the hygrophyte purification, T-BOD and T-COD, SS of the treated water was low because the sunlight does not reach the water. In this way, algae growth is restrained and the density of algae in the treated water was reduced.

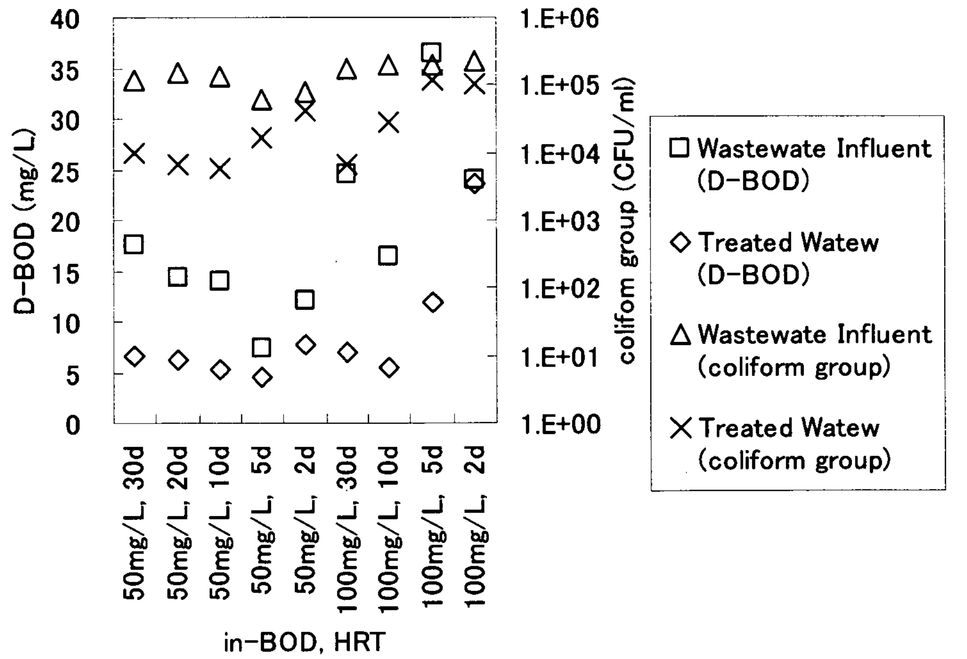


Fig. 2 Water quality of the lagoon

# STUDY ON CHARACTERISTICS OF TRACTION OF SEDIMENT FROM GARBAGE IN SEWER PIPE

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Wastewater System Division

Project period: 2002-2004

## OBJECTIVES

In the town of Utanobori, which has installed garbage disposers, sediment such as eggshell and seashell were observed at the bottom of sewer pipes. The objective of this study is to clarify the traction flow velocity of eggshell and seashell (thereafter, sediment). Therefore, we examined sediment shapes after they were crushed in the garbage disposer, and measured the traction flow velocity of the sediment by sewer pipe model experiment.

## EXPERIMENTAL OUTLINE

(1) Test sediment properties

After crushing the sediment in the garbage disposer, we measured specific gravity, average grain size and shell thickness. Specific gravity was measured using the Test Method for Density of Soil Particles (JIS A 1202). Average grain size was measured using the Test Method for Particle Size Distribution of Soils (JSF T131-1990). Sediment has an indefinite shape and cannot be assumed to be spherical. Therefore, we measured the shell thickness by taking the average thickness of five pieces of shell using vernier calipers.

(2) Specification of sewer pipe model

Vinyl chloride pipe of f 200 is generally used in Utanobori. Therefore, we used transparent acrylic pipe of f 200 for this experiment, because the coefficient of roughness of acrylic pipe is almost the same as the vinyl chloride pipe, and observation is easy. Pipe length was 15 m (pumping area of 2 m, experimental area of 10 m, and drop-down area of 3 m). A flow meter was set up in the feed water pipe. Flowing quantity was adjusted with a flowing quantity adjustment valve.

(3) Traction experiment on existing sediment

Flowing quantity was increased one by one after setting up sediment, and we measured the flow velocity and depth at which the sediment began to move. We used fixed sediment from a weir made of clay, and the sediment was set up at a length of 2 m and a depth of 2 cm. Three kinds (1/478, 1/202, 1/103) of sewer pipe model of inclinations were set. The traction condition was classified into three stages, and we measured the flow velocity and depth at each stage.

(4) Experiment on sedimentation and traction of pumped sediment

We observed the flow velocity of sedimentation generation and traction according to increase in amount of flow to examine the relationship between change of sediment (sedimentation and traction) and flow velocity in the sewer pipe.

## CONCLUSION

(1) Test sediment properties

The specific gravity of eggshell was 2.6 and that of seashell was 2.8. Average grain size was 1.9–2.5 mm. Eggshell thickness was 0.5 mm and seashell thickness was 1.0 mm.

(2) Traction experiment on existing sediment

The traction flow velocity of eggshell was 42.9 cm/s at the beginning of movement, 47.5 cm/s in the middle of movement, and 55.9 cm/s during overall movement. The traction flow velocity of seashell was 44.9 cm/s at the beginning of movement, 52.4 cm/s in the middle of movement, and 60.1 cm/s during overall movement.

(3) Experiment on sedimentation and traction of pumped sediment

Sediment is not generated if the amount of flow is 2.0L/s (flow velocity 54 cm/s) or more in sewer pipes of inclination 1/200.

# OPTIMUM MANAGEMENT OF FOOD WASTE THROUGH SEWERAGE SYSTEMS FOR ABATEMENT OF ENVIRONMENTAL IMPACT

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Project period: 2002 - 2004

## OBJECTIVES

The efficient collection and reuse of residential food waste is expected through the introduction of a food waste disposer (FWD) to discharge it to sewerage systems and digestion and composting of sludge waste. In addition, the introduction of FWD should improve the situation in an aging society. However, FWD increases sedimentation in sewer pipes, pollution load to wastewater treatment facilities and pollution discharge through combined sewer overflows, so FWDs are not allowed in Japanese sewerage systems. The objective of this research is to comprehensively evaluate the effects of FWD on sewerage systems, waste disposal systems and society by applying Life Cycle Analysis (LCA) and Cost Benefit Analysis (CBA), and to propose the optimum management of food waste through sewerage systems.

The research topics in FY2002 are as follows:

1) Overseas research on the effect of FWD

   We investigated reports on the current status of introduction of FWD overseas, and conducted field surveys on the effect of diffusion of FWD to frequency of cleaning of sewer pipes (separate systems) in the United States where diffusion of FWD is high.

2) LCA and CBA of the introduction of FWD

   We conducted LCA of the effect of diffusion of FWD on the frequency of cleaning of sewer pipes in the town of Utanobori where FWD was first introduced in sewered areas in Japan in 1999. We also conducted an economic evaluation of the benefit of users of FWD through application of the contingent valuation method (CVM) at Utanobori.

## RESULTS

### 1) Overseas research on the effect of FWD

The coverage of sewer pipes in the United States is higher than that in Japan. However, there is no particular relation between diffusion of FWD and frequency of sewer pipes (**Fig. 1**). According to interviews with managers of sewerage systems at Denver, CO, where both diffusion of FWD and frequency of sewer pipes are very high, stoppage of sewer pipes are mainly caused by kitchen grease from such places as restaurants, high frequency of sewer pipes is the result of preventive maintenance, and the effect of diffusion of FWD to frequency of sewer pipes is not affirmed.

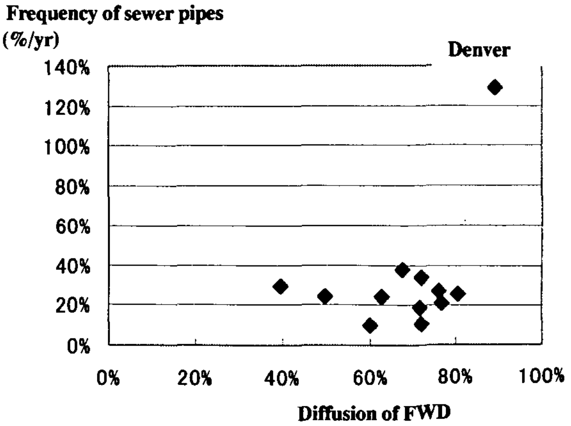


**Fig. 1 Frequency of sewer pipes compared to diffusion of FWD (12 cities in USA)**

### 2) LCA and CBA of the introduction of FWD

(1) LCA of the effect of diffusion of FWD to frequency of cleaning of sewer pipes

We conducted a questionnaire on the cleaning of sewer pipes to municipalities in Hokkaido prefecture to establish a basic unit of the environmental effect per distance of drive and time to run high-pressure cleaning cars, sludge vacuum cars and water wagons. We set the sedimentation depth and cleaning distance of sewer pipes and calculated the environmental effect of cleaning sewer pipes if diffusion of FWD is 100% in Utanobori. According to the calculation, LC-$CO_2$ of cleaning sewer pipes is increased by 182 kg $CO_2$/yr, and LCE is increased by 2,596 MJ/yr (**Fig. 2**).

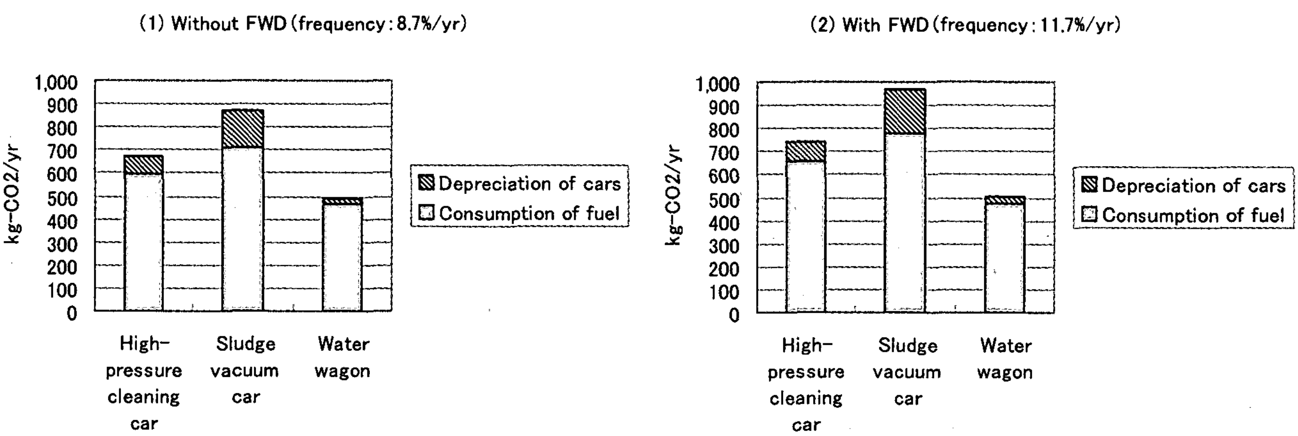


**Fig. 2 LC-$CO_2$ of cleaning of sewer pipes with/without FWD in the town of Utanobori**

(2) Economic evaluation of the benefits to users of FWD.

We conducted a questionnaire on the benefits of FWD to 272 users in the town of Utanobori. The distribution of Willingness to Pay (WTP) is shown in **Fig. 3.** According to the questionnaire, the average WTP of public houses where FWD was introduced whether or not installation was wanted is 550 yen/month/household, and the average WTP of private houses where FWD was installed only where installation was wanted is 957 yen/month/household.

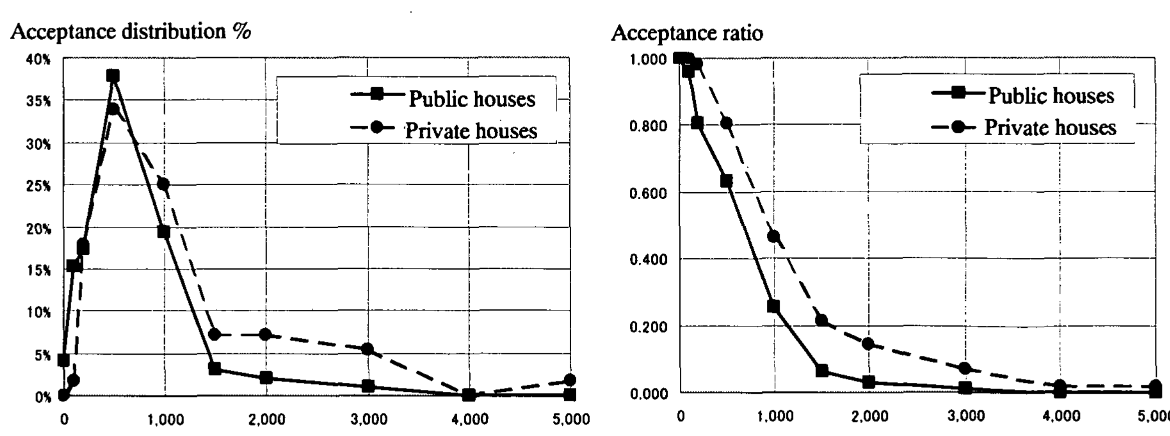


**Fig. 3 Distribution of WTP to use of FWD in the town of Utanobori**

# STUDY ON DEVELOPMENT OF THE EVALUATION TECHNOLOGY OF INFLUENCE ON WATER CYCLE AND SUBSTANCE CIRCULATION CHANGE

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Project period: 2002-2004

## INTRODUCTION

The objective of this study was to estimate the influence of combined sewer overflow on the river basin and city and to promote effective improvement of combined sewer system. The actual survey at the model basin including the sea was carried out in this fiscal year.

## METHODS

The Hirasaku river basin in Yokosuka city, Kanagawa prefecture was selected as the model basin. The characteristics of this basin are as follows:

1) The main rainwater inflow course from the city to Tokyo bay is only Hirasaku River.
2) Most of the area of this basin is urbanized with a high rate of population-served sewers, including a combined sewer system.

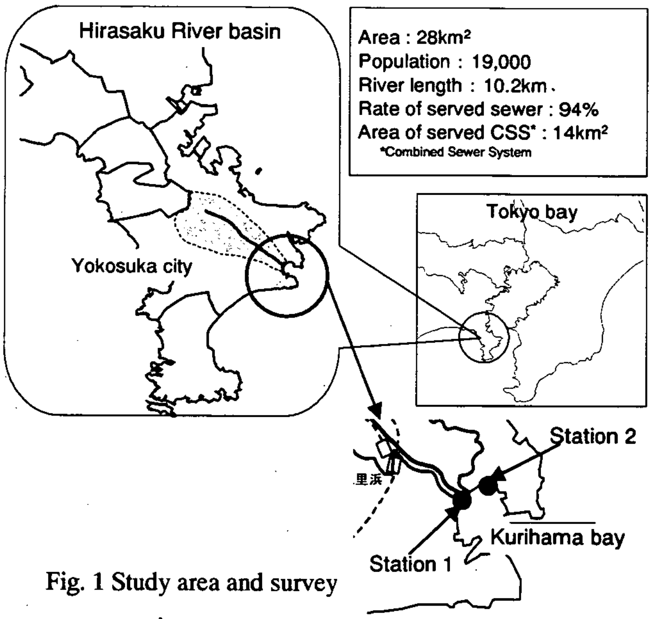


Fig. 1 Study area and survey stations

Surveys were carried out in both fine weather and wet weather. The survey conducted during fine weather collected two water samples at two survey points. The survey conducted during wet weather collected water samples for five days after rain at the two survey points. The water samples were collected in accordance with the ebb and flow of the tide at six times in two days, which is the survey starting day and the next day. After those days, the water samples were collected at the time of ebb tide in the daytime once a day.

Water quality analysis items were COD, SS, T-N, T-P, the total number of coliform groups (TC), and the total number of fecal coliform groups (FC). TC was analyzed by BGLB culture medium – MPN method, and FC was analyzed by M-FC agar culture medium method. In addition, the water temperature, DO, and electrical conductivity were measured.

## RESULTS AND DISCUSSION

The rate of the peak water quality in wet weather and the average water quality in fine weather is arranged as shown in Fig. 2. It was found that COD, T-N and T-P have a comparatively small difference at the time of rainy weather and fine weather, but TC and FC have a large difference, which has the value of a ratio as large as $10^2$ to about $10^4$. The figure also shows that water quality differs greatly between fine weather and rainy weather.

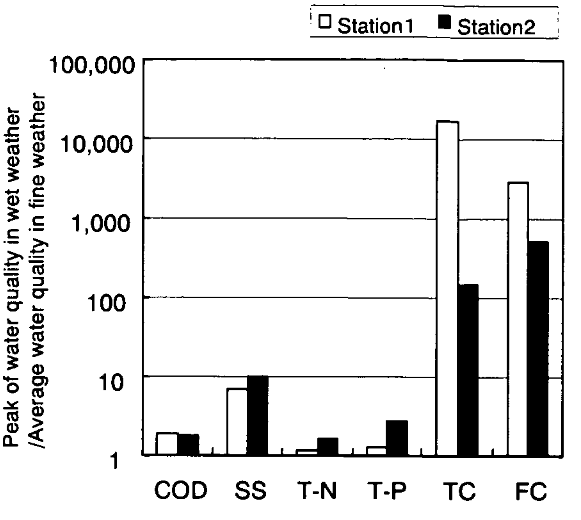


Fig. 2 Rate of water quality in wet weather and in fine weather

The arrangement of the days taken to recover the water quality that had deteriorated by rainwater to the average water quality at the time of fine weather for each water quality item was studied. The result shows that COD, T-N, and T-P were recovered one day after the rain ended, but SS, TC and FC required about three days. It is considered to be one of the reasons why the water quality differs greatly between fine weather and rainy weather as mentioned above.

The ratio of the value at Station 1 to the value at Station 2 for the water quality items is shown in Fig. 2. Their tendencies can be roughly classified into three.

i) The ratio of COD, T-N and T-P is almost entirely fixed.

ii) The ratio of SS may be less than 1.

iii) The ratio of TC and FC is large in the early stages of an outflow.

Regarding ii), it is assumed that SS increased due to the influence of floating sediment and drifting. Regarding iii), it is assumed that the inflow water quality in rainy weather is markedly worse compared with that in fine weather, and that the ratio becomes large due to extinction of the coliform in the sea.

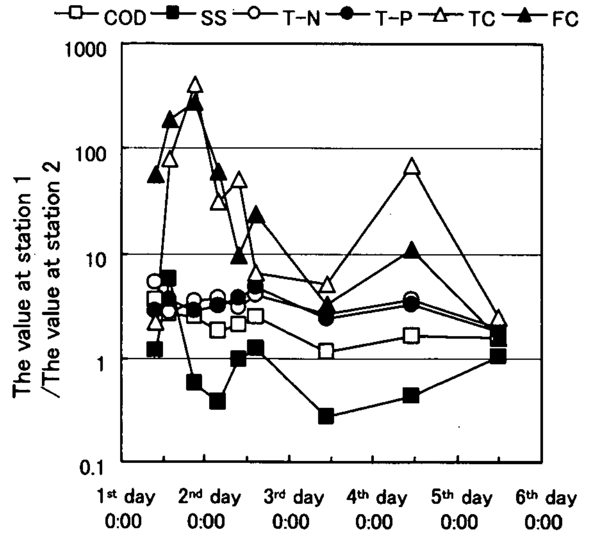


Fig. 3 The rate of water quality at two survey stations

## CONCLUSION

The water quality survey was conducted on rainy weather in the sea into which CSO flowed. The conclusion is as follows:

i) SS, TC and FC differ greatly in fine weather and rainy weather. Especially for TC and FC, the peak of water quality in rainy weather was about $10^2$ to $10^4$ times the average in fine weather.

ii) COD, T-N and T-P took one day to recover, but SS, TC and FC needed about three days to recover to the average water quality in fine weather after the rain stopped.

iii) The feature of the water quality change in the sea was classified into three groups: COD, T-N, T-P; SS; TC and FC.

The behavior of pollution that flowed into the sea will be clarified by more detailed survey, and it will be necessary to study the relation between the amount of inflow loads and the water quality of the sea by conducting both a water quality investigation of CSO flying into the sea and rainwater of separated sewers.