# STANDARD FOR DISCHARGE OF DOMESTIC WASTEWATER WITH HIGH CONCENTRATION

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Project period: 2000-2003

## Objectives

The purpose of this research is to clarify the impacts of the introduction of garbage disposers on sewage systems in regions where they are introduced.

## Experimental Outline

In the town of Utanobori in Hokkaido, a trial installation of garbage disposers was done in and around a housing estate managed by the town from August 1999 to March 2002. At this time, garbage disposers are installed in 301 households (639 people) that is a garbage disposer penetration rate of 36% (/person).

Conditions in sewer mains, pumping stations and sewage treatment plants before and after the introduction of the garbage disposers in Utanobori in Hokkaido were surveyed. TV cameras were used to examine the inside of sewer mains to clarify conditions inside them, and materials deposited inside the mains were sampled and their composition surveyed. At pumping stations, the state of maintenance was surveyed by interviewing sewage system managers, and materials deposited in the pumping stations were sampled and their oil etc. content was analyzed. At treatment plants, the qualities of the influent and treated water were analyzed. Spot samples taken twice a month at 9:00 a.m. were used to analyze the influent and the treated water.

## Conclusion

1) It was confirmed that regardless of whether garbage disposers are installed or not, materials adhere to the inside surfaces of sewer mains.
2) After installation of garbage disposers, the frequency that pumping stations were cleaned and the quantities of materials deposited in them did not change.
3) Materials deposited in pumping stations were 86.5 soil and 8.0% garbage, n-Hex content was 3.83%, and the volatile solids content was 34.8%.
4) The results suggest that during the peak garbage disposer operation period, water discharged from garbage disposers in households has an impact on the quality of the influent to treatment plants.
5) It is assumed that at garbage disposer penetration of 100%, good processing will be possible, because the ASRT necessary for nitrification inside treatment tanks can be guaranteed.

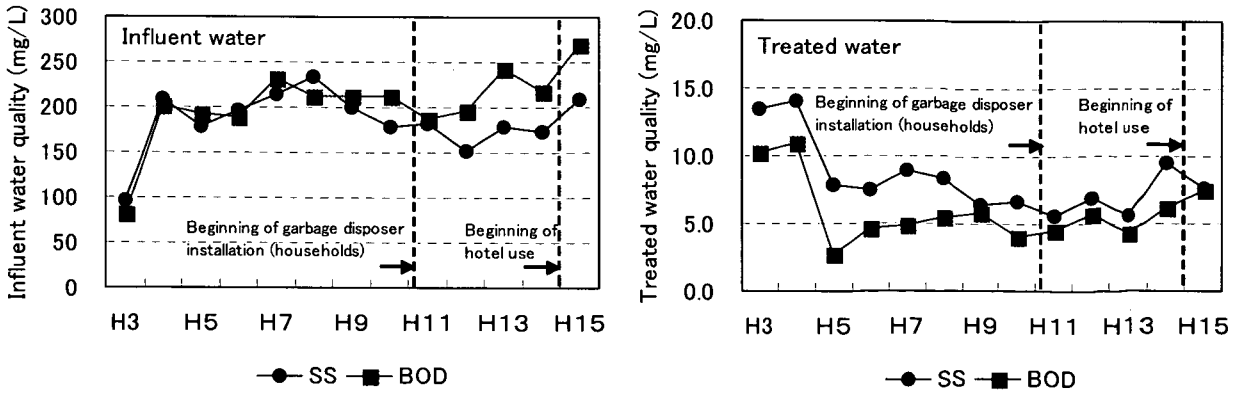


Figure 1. Change Over Years of Influent Water Quality and Treated Water Quality (Spot Samples taken at 9:00 a.m.)

# STUDY OF CONDUIT MAINTENANCE LEVELS

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Project period: 2001-2003

## OBJECTIVES

Some metropolises began to construct the sewer, there are few sewers used for above 50 years. But most of the sewers were constructed after 1960's in Japan. Therefore, the sewer rehabilitation will increase suddenly in the near future, because the lifetime of sewer may be 50 years. When the sewers will become superannuated, the sewers will lose the function for cracking, corroding, and shifting the seams. The sharp loss of the function of the sewer will cause the collapse of the important lifelines, and it is important theme should be avoided.

For the maintaining the sewer functions, it is necessary to establish the method of investigating of the condition of the sewers, and the efficient method to rehabilitation of the sewers. But it is difficult to find the function losing sewers, because the sewers have been constructed under the ground. It is not fully solved that the lifetime and the conditions of the superannuated sewers, and it is also difficult to plan the rehabilitation of sewers.

Therefore, in order to rehabilitation of the superannuated sewers intentionally, it is necessary to investigate the actual condition of the sewers constructed in the past, and the actual condition of the superannuated sewers. This study arranged the construction conditions of sewer classification by the statistics of sewers, and it analyzed the reply by the questionnaire about the actual condition of the repair works in Japan.

## RESULTS

This study was classified sewers into four kinds, concrete pipes, polyvinyl chloride pipes, vitrified clay pipes, and others. The construction conditions of sewer classification arranged by the statistics of sewers, and it analyzed the reply by the questionnaire about the actual condition of the repair works that were rehabilitated in 2000 in Japan. It is shown follow the result matters.

1) The rate of concrete pipes was as high as 92% in the sewers that diameter is 1,000mm or more. The rate of polyvinyl chloride pipes was as the highest as 48% in the sewer that diameter is 500mm or less.
2) In rehabilitated sewers, the rate of sewers that diameter is 500mm or less was as high as 81% in concrete pipes, polyvinyl chloride pipes and vitrified clay pipes.
3) About the age of rehabilitated sewers, about 30 years was the highest in concrete pipes and vitrified clay pipes, and those rehabilitation extensions per a year were about 5.7km/year and about 1.0km/year. In polyvinyl chloride pipes, the rehabilitation extension was always about 0.2km/year.
4) About the condition of the superannuated sewers, it saw with the tendency much that concrete pipes lost the function for corroding and cracking, polyvinyl chloride pipes lost it for meandering and shifting the seams, vitrified clay pipes lost it for cracking, shifting the seams and breaking of the wall.
5) About caving in the surface above sewers, it had generated mostly in concrete pipes and vitrified clay pipes, and there were few cases in polyvinyl chloride pipes.
6) About corroding, it had only in concrete pipes, and the rate of force main and industrial wastewater were high with the factors for corroding.

# A STUDY OF IMPROVEMENT OF URBAN RAINWATER MEASUREMENT SYSTEM

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Wastewater System Division

Project period: 2001-2003

## INTRODUCTION

In recent years, the problems of city rain water are focused from both sides of quantity and quality, such as city type flood damage and combined sewer overflow in Japan. Then, development of a pollution load outflow model in wet weather of combined sewer is studied, and a technique for safely checking the blow-out phenomenon of manhole covers installed in a storage pipe of an inverted siphon form is 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 apply this model to simultaneous many points, and 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 result of calculation in rainy weather is shown in Fig.1. Here, in addition to the observed value, comparison with the calculation result by 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 about the amount of loads, and, in addition, it was shown that reproducibility is higher than a concentrated type model on the whole. As for the TC, it was found that the distributed type model is highly applicable when the coefficient is the same as BOD (m=1, n=0). However, in respect of the agreement of the peaks, the model may not be applicable enough. The model must be improved further by examining other river basins and sub-models of the increase and decrease of the number of TC in the sewer tunnels.

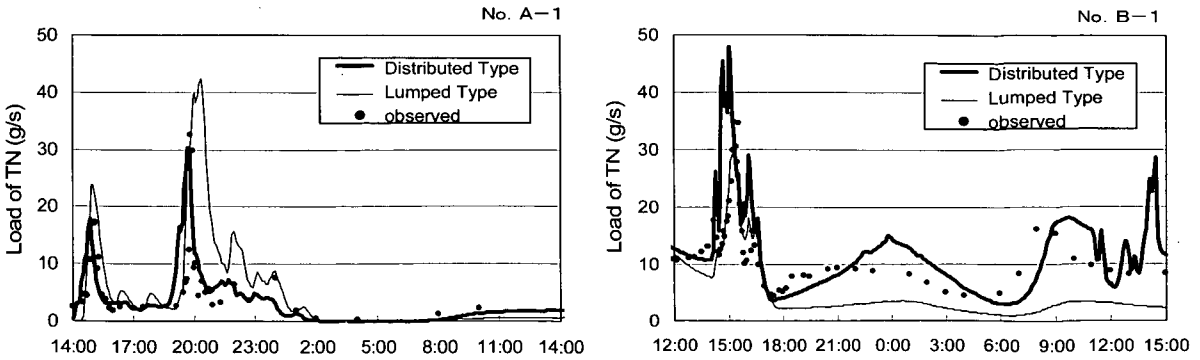


Fig.1 Results of comparison with calculation

## 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 Figure 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.

Checking Method of Safety of Facilities

To take measures from the design phase for the phenomenon in which a manhole cover rises up and flies upward, we analyzed air entrainment and blowout behavior numerically. Then, using graphs and other information, we examined a simple method to compare the maximum pressure that may occur in the designed facility and the withstanding inner pressure below the manhole cover. As a result, when the opening area of the upper part of the manhole is $2.0m^2$ or larger, the peak air pressure of the upstream manhole and the downstream manhole is almost equal. On the other hand, when the opening area is smaller than $2.0m^2$, the peak air pressure of the downstream manhole becomes larger than that of the upstream one. This trend becomes more apparent when the diameter of the main pipe increases. Moreover, when the opening area of the upper part of the manhole is less than $0.5m^2$, the peak air pressure rises drastically. When the diameter of the main pipe is φ3000mm or less and the opening area is $2.0m^2$ or larger, the peak air pressure will not exceed the withstanding inner pressure of the flat-type iron cover. However, in designing a storage pipe with the diameter of φ5000mm or more, a detailed examination is required. The effect of the difference of conduit extension on the peak air pressure was not confirmed.

Table 1 Preparation of Simple Determination Chart

| Item | Unit | Range |
|---|---|---|
| Flow volume | -- | Flow volume equivalent to full bobbin flow rate of 1.0, 2.0, 3.0, 4.0, and 5.0m/s to each diameter of main pipe is set. |
| Diameter of main pipe | mm | φ1350, φ2000, φ3000, φ5000, φ6000 |
| Extension of main pipe | m | 250, 1000, 3000 |
| Depth of manhole | m | 25 |
| Diameter of manhole | -- | 1.5 times of main pipe diameter |
| Opening area of vent hole | m2 | 0.125, 0.25, 0.50, 1.00, 2.00, 4.00 |

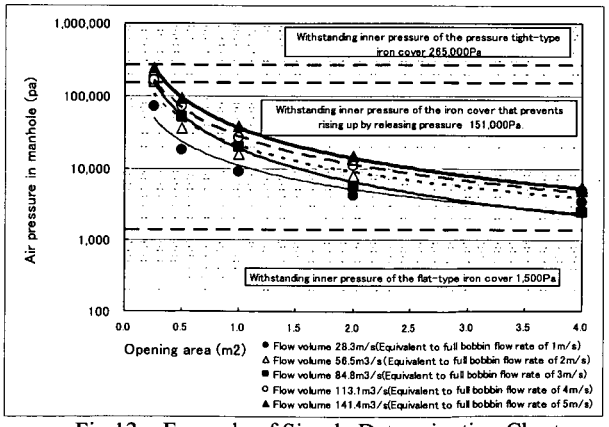


Fig.13 Example of Simple Determination Chart (Peak Air Pressure at Downstream Manhole)

(Diameter of main pipe: φ6000mm, Extension: 1000m, Diameter of manhole: φ9000mm, Depth of manhole: 25m)

# STRATEGIC INVESTMENT IN SEWAGE WORKS

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Project period: 2002-2005

## OBJECTIVES

Cost benefit analysis can be effective in setting 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 environment 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.

In addition to the benefit transfer research, the methodology of asset management was investigated in light of strategic investment in sewage works. This concept provides a basis to sustain the function of existing facilities and to efficiently manage sewage facilities in response to the surroundings.

## RESULTS

A case study of benefit transfer was conducted targeting the watershed of Arakawa, where the relevant data were obtained in a CVM survey conducted by Wastewater System Division. The benefit transfer function was estimated with its validity verified. The function's explanatory variables were resident attributes, such as income and water environment awareness, and local characteristics. In analysis, data was categorized into three regional locations in the watershed, i.e. the upper, middle, and down areas. Random utility model, assuming application of logit model, was selected among several possible function models. Equation (1) is an example of the estimated function.

$$\Pr(yes) = \frac{1}{1+\exp[-C-\gamma \cdot PAY-\alpha_1 \cdot UN-\alpha_2 \cdot INC]} \quad \text{----------} \quad (1)$$

where Pr(*yes*): probability that respondents reply yes to a bid amount; $C$, $\gamma$, $\alpha$ i: parameters; *PAY*: a bid amount (yen); *UN*: use of Arakawa (no use: 1, use: 0); and *INC*: rank of income (the larger means the higher income.).

"n-1 model" was a model constructed by using data excluding one regional location. In case of n-1 model of down area, for example, the function was constructed using middle and upper area data, and the estimation of down area was obtained through the function and the down area data. In this fashion, the comparison between the estimation and the local model verified the validity of the benefit transfer. These results are shown in Table 1.

Table 1. Verification of Benefit Transfer Function by n-1 model

| Target | Down area | | | | Middle area | | | | Upper area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Local model | | n-1 model | | Local model | | n-1 model | | Local model | | n-1 model | |
| Variable | Coefficient | (t value) | Coefficient | (t value) | Coefficient | (t value) | Coefficient | (t value) | Coefficient | (t value) | Coefficient | (t value) |
| PAY | 6.5963E-04 | (6.11104) | 5.8291E-04 | (7.74839) | 6.3613E-04 | (5.75226) | 5.9057E-04 | (7.98467) | 5.3239E-04 | (5.15393) | 6.3009E-04 | (8.33520) |
| UN | 1.09282 | (3.85622) | 0.684733 | (2.91002) | 0.617945 | (2.00491) | 0.89731 | (4.05389) | 0.769022 | (2.06878) | 0.844536 | (4.10994) |
| INC | -0.18893 | (-2.43770) | -0.141994 | (-2.95286) | -0.159087 | (-2.54231) | -0.139236 | (-2.55064) | -0.10358 | (-1.31410) | -0.153689 | (-3.24685) |
| C | -0.322982 | (-0.99171) | 9.22E-03 | (-0.03845) | -0.026343 | (-0.81166) | -0.18182 | (-0.75232) | -9.83E-03 | (-0.02696) | -2.12E-01 | (-0.93415) |
| Sample number | 350 | | 661 | | 353 | | 658 | | 308 | | 703 | |
| Log likelihood | -194.588 | | -367.191 | | -197.85 | | -366.206 | | -168.718 | | -394.294 | |
| Goodness of fit | 0.702857 | | 0.698941 | | 0.705382 | | 0.697568 | | 0.688312 | | 0.699858 | |

# LOW-COST SEWERAGE SYSTEM FOR DEVELOPING COUNTRIES

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Project period: 2001-2004

## OBJECTIVES

As hygiene deteriorates with the remarkable progress of urbanization, it is becoming important to improve the water environment and secure water resources in developing countries; especially in rural areas where 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 temperatures and low labor and land costs, including citizen participation and efficient management of sewerage systems.

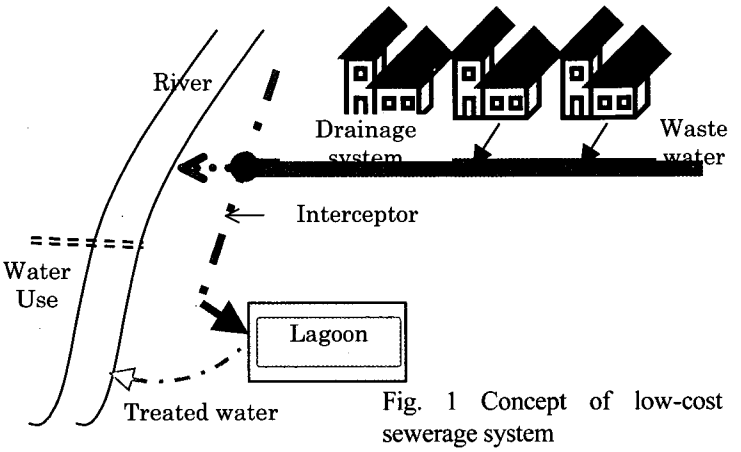


Fig. 1 Concept of low-cost sewerage system

## RESULT

### 1. Survey of the present state of interceptor sewage systems

Interceptor sewage systems are counted on to be suited to suburbs in developing countries where there is a demand for future improvements. In order to clarify the state of the introduction and maintenance of interceptor sewage systems and gain an understanding of problem points, an interview survey of sewage system managers was conducted and documents were collected in March 2004 in Khon Kaen City in the northern part of the Kingdom of Thailand where an interceptor sewage system has been introduced. The results revealed a number of problems. (1) No progress has been achieved in linking the sewage system to homes, and individual treatment methods such as septic tanks or soil penetration pits do not function adequately. (2) There is fear that the flow capacity will be reduced by deposition inside interceptors, but appropriate maintenance is not done because there are no guidebooks to pipeline maintenance methods and because of a shortage of personnel and funds necessary for maintenance. (3) Regarding the planned treatment capacity of treatment plants, it is necessary to study maintenance methods suited to the inflow load, because although it is assumed that sewage system connection has advanced, the present inflow load of BOD is only a little less than 20% of the planned level and the facility capacity is excessive.

2. Experiment to improve treatment by lagoon systems in the tropics or subtropics

Wastewater influent with low BOD is a problem in lagoons in the tropics or subtropics. The first step is to replace inadequate operation and maintenance methods.. Other problems are algae and the sanitary condition of the treated wastewater from lagoons. We researched these matters and conducted experiments in Okinawa Prefecture: the sole subtropical 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 varied between 50, 100, and 200 mg/L. The hydraulic retention time (HRT) of the lagoon was varied between 2, 5, 10, and 20 days. The processing condition of the lagoon was confirmed. ( except BOD 200 mg/L, HRT 20 d )

According to the lagoon results, the necessary HRT was 5 days in a case of wastewater influent BOD of 50 mg/L. The necessary HRT was 10 days in the case of wastewater influent BOD of 100 mg/L. The necessary HRT was 10 days in the case of wastewater influent BOD of 200 mg/L. When sanitary conditions are considered, the proper HRT was 10 days in the case of wastewater influent BOD of 50 mg/L. The proper HRT was 20 days in the case of wastewater influent BOD of 100 mg/L. The proper HRT was 30 days in the case of wastewater influent BOD of 200 mg/L.The treated wastewater from the lagoon could not be evaluated based on the evaluation of the total samples (T-BOD, SS etc) because it does not check untreated wastewater or algae caused by the treatment. Therefore, we must evaluate it considering the dissolved solids and lagoon conditions.

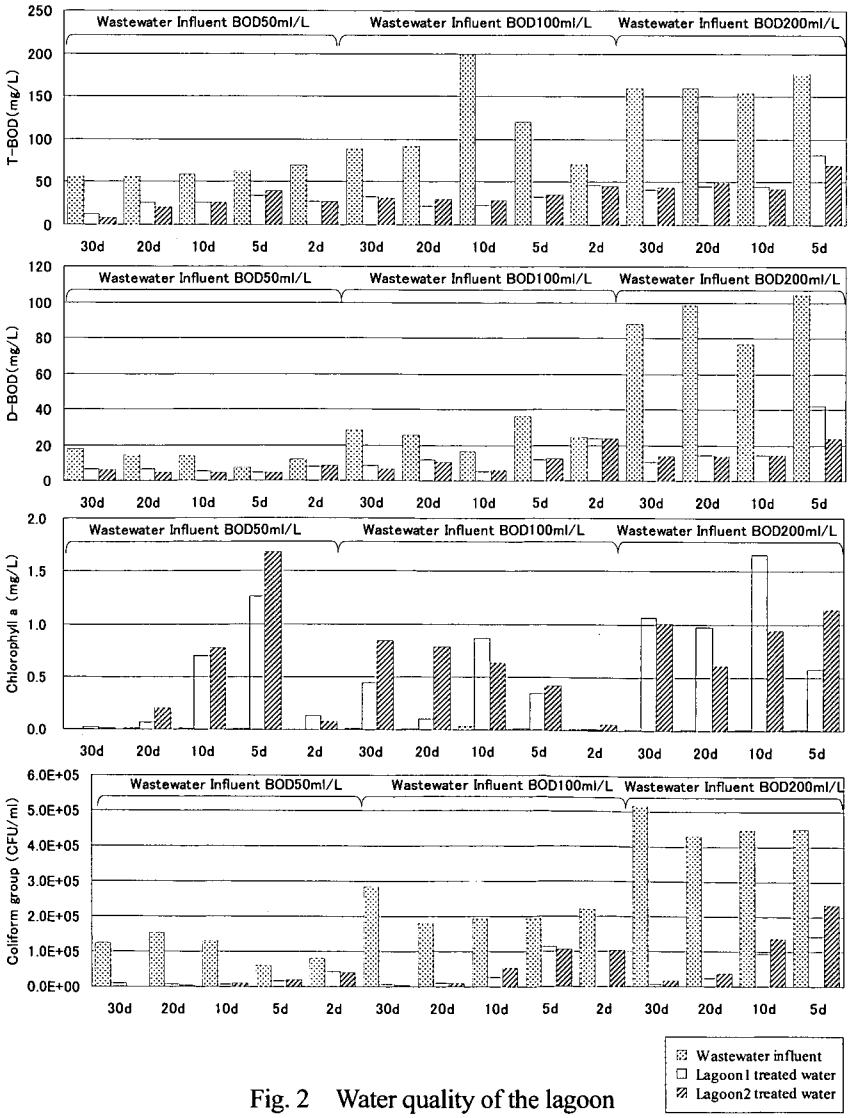


Fig. 2 Water quality of the lagoon

# A STUDY ON DEVELOPMENT OF THE INFLUENCE EVALUATION TECHNOLOGY OF WATER CYCLE AND MATTER CYCLE CHANGE

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Wastewater System Division

Project period: 2002-2004

## INTRODUCTION

This study aims to examine a method to estimate the influence of combined sewer overflow on receiving water body, as well as to promote an effective combined sewer overflow controls.

We investigated in the combined sewer drainage district where the most a lot of loads were discharged in the receiving water body in wet weather and examined the pollutant load runoff model for the calculation of pollutant loads for the combined sewer drainage districts.

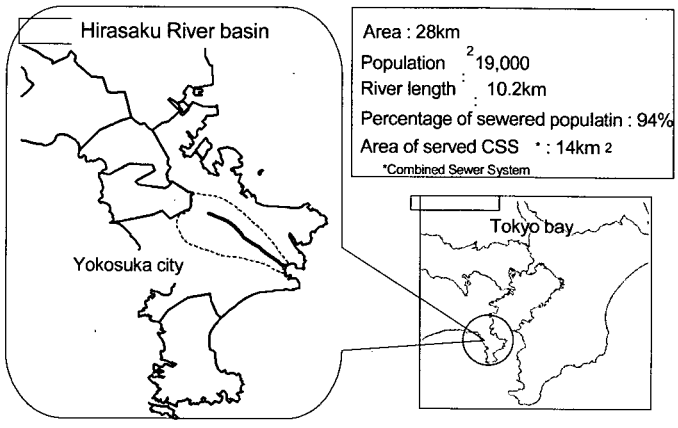


Fig.1 Study area

## METHODS

The Hirasaku River basin in Yokosuka City, Kanagawa Prefecture was selected as the study area. The reasons for the selection are as follows:

1) The combined sewer overflows and storm wastewater from the area flow in Hirasaku River and flow from the Hirasaku River to the Kurihama Bay. And, the river that flows into this bay is only Hirasaku River.
2) Most areas of this drainage basin are urbanized and the percentage of sewered population is high. And the combined sewer system is served in this area.
3) In the Kurihama Bay, there are some water amenity spaces.

Two investigation points were set up in the combined sewer drainage district located upstream of the study area and investigations were done in dry weather and wet weather. The interval of the investigation time was one or two hours in dry weather. In wet weather, the first stage of rainfall was investigated in five minutes, and then the interval of the investigation time was extended with the changes in the rainfall. Water quality analysis indexes are BOD, COD, SS, nitrogen (T-TN), phosphorus (T-TP), and the coliform group (TC).

## RESULTS AND DISCUSSION

The runoff situation pertaining of the water quality (T-TN, T-TP, and TC) as examples of the investigation results in dry and wet weather is shown in Figs. 2 and 3. In dry weather, the peak runoff was observed once in the morning. The tendency of the peak runoff was observed to other investigation results. In wet weather, high concentration runoff was observed in the first stage of the rainfall, and then the water quality fell below one of dry weather. This high

concentration runoff called first flush.

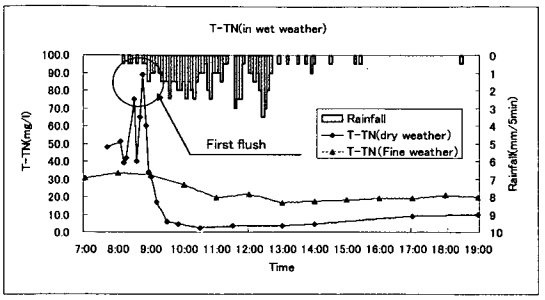


Fig.2 Water quality observation result in wet weather (Point A, T-TN)

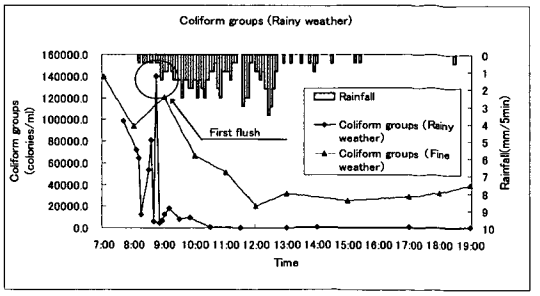


Fig.3 Water quality observation result in wet weather (Point A, Coli groups)

Fig. 4 shows the comparison of the total runoff loads in wet weather versus ones in dry weather. The values of T-TN and T-TP showed a tendency to grow smaller than the values of SS and larger than those of BOD and COD. The values of TC showed a tendency to become small compared with other water quality analysis indexes. Therefore, it can be assumed that T-TN and T-TP have the runoff characteristics similar to those of BOD and COD, the pollution load of TC is lower than other indexes, and TC pollution load supplied from roads, etc. by the rainfall is small.

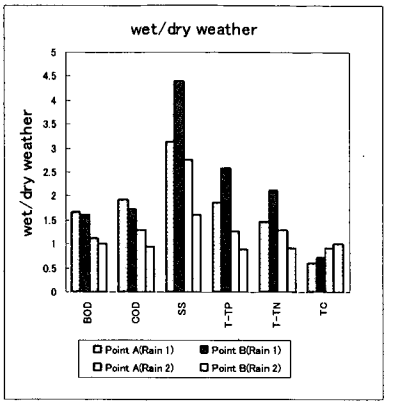


Fig.4 Comparison (wet/dry weather)

## CONCLUSIONS

The following points have been discovered as the runoff characteristics of nitrogen, phosphorus, and the coliform group:

i) As for the runoff situation in dry weather, there is a peak runoff in the morning.

ii) In wet weather, all water quality indexes showed the first flush as in the case of BOD etc. The concentration of runoff in the first stage of rainfall was high, and then the level fell below the value in dry weather. The water quality takes time to recover compared to BOD etc.

iii) It can be assumed that T-TN and T-TP have runoff characteristics similar to BOD and COD, as well as investigation results in other drainage districts. Most of loads of TC are assumed to run out at the first flush unlike other pollutant loads.

iv) Because T-TN and T-TP have the runoff characteristics similar to BOD and COD, it may be reasonable to presume that the formulae similar to BOD and COD can be used in the model construction. It is thought that the TC should be examined as a model that is little affected by the amount of loads from road, etc.

In our future study, we will construct pollutant load runoff model from the combined sewer system and develop a model for the runoff to the sea area and behavior there. Furthermore, as to the TC, the amount of loads from roads, growth and death depending on the temperature, etc. should be examined to construct a model.

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

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Wastewater System Division

Project period: 2002-2004

## Objectives

The purpose of this research is to obtain the flow speed and limit traction necessary for sewage water to remove egg and shellfish shells deposited in sewer mains after the introduction of garbage disposers. Model sewer main experiments verified the physical properties of egg and shellfish shells crushed in garbage disposers, their deposition in sewer mains, and traction conditions.

## Experimental Outline

1) Experiment to investigate the state of traction of egg and shellfish shells deposited in sewer mains

Water was supplied to a pipeline with a gentle gradient in which egg and shellfish shells have been deposited to study the hydraulic quantities that start moving egg and shellfish shells. Differences between the results and the traction properties of particles of sand deposited in ordinary pipelines were studied.

2) Experiment to investigate the state of deposition and traction of egg and shellfish shells that flow continuously into a sewer main

It is assumed that egg and shellfish shells flow semicontinuously when garbage disposers are used. Hypothesizing the state of inflow of egg and shellfish shells when garbage disposers are used, the relationship of hydraulic quantities with change of the state of deposition of egg and shellfish shells (deposition height and length) flowing continuously into a sewer main was studied.

3) Experiment to investigate the state of deposition and traction of egg and shellfish shells flowing continuously into a sewer main using a pipeline model with a reverse gradient.

Because in sewer mains in the region where the garbage disposers were introduced, egg and shellfish shells are deposited where pipeline settlement has created reverse gradients, the state of deposition and traction of egg and shellfish shells on a reverse gradient were studied.

## Results

1) In a sewer pipe designed so that flow velocity of 0.60m/s might be guaranteed, it is possible to guarantee flow velocity between 0.35 and 0.50m/s and deposit will not exceed a height of 3cm at the design flow rate.

2) The traction movement properties discovered by the hydraulic model tests performed with the downstream end of a block of deposited material fixed by clay are represented accurately by an existing equation proposed for sand grain, when analyses are performed by using the average grain diameter of the material.

3) The hydraulic model tests revealed that if a flow of 0.001 m3/s or more was guaranteed in the sewer pipe of uniform gradient of 2‰ or more, the deposited material was moved by traction without exceeding 3cm in height, then flow velocity was between 0.35 and 0.50m/s.

4) In a sewer pipe bent by unequal settlement, the part below an imaginary line drawn between the bottom of the pipe at opposite ends of the bend is filled with deposits as the time passes and finally surface of the deposits become a uniform gradient and flow is identical to that in a pipe installed at a uniform gradient.

# Life Cycle Analysis on Disposal and Reuse of Food Wastes in Sewerage Systems

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Wastewater System Division

Project period: 2002-2004

## Objectives

### 1. Study of technologies to collect and treat organic waste material in sewer systems

Documents have been studied and a field survey conducted in cities in the United States where the garbage disposer penetration rate is already high to obtain information about efficient sewer main maintenance technologies for use after the introduction of garbage disposers. In order to estimate the increase of the load of influent wastewater caused by the introduction of garbage disposers, the quality of garbage disposer wastewater prepared based on the quantity of kitchen garbage placed in the garbage disposers and the kitchen garbage collected from households using garbage disposers was analyzed in Utanobori Town in Hokkaido, Japan where a public garbage disposer introduction trial has already been carried out. The impact on water overflowing from a combined sewer system was studied by setting a model district and simulating the load increase.

### 2. Research on the overall evaluation of the environmental impacts of the introduction of garbage disposers

The impacts on sewer systems (sewer mains and treatment plants), waste treatment systems (collection and incineration facilities, final disposal sites), and on homes of the introduction of garbage disposers (household waste material only, not waste material from business offices) were studied by performing an overall evaluation based on LC-$CO_2$ and LCE (life cycle assessment).

## Results

### 1. Study of technologies to collect and treat organic waste material in sewer systems

1) The sewer main cleaning rate in the United States is 29%, that is higher than the combined sewer main cleaning rate in Japan, but the correlation of the garbage disposer penetration rate – sewer main cleaning rate was low.
2) In Denver where both the garbage disposer penetration rate and the sewer main cleaning rate are both high, the main cause of sewer main plugging is the inflow of grease from kitchens and of tree roots, so it was impossible to confirm the direct impacts of garbage disposer waste water on sewer main cleaning.
3) It is assumed that the introduction of garbage disposers will increase the discharged load from combined sewer systems during rainfall.

### 2. Research on the overall evaluation of the environmental impacts of the introduction of garbage disposers

1) Because the introduction of garbage disposers increased the electric power consumed by sewage treatment plants and the quantity of nitrous oxide discharged during sludge incineration and reduced the quantity of electrical power produced by waste material in a waste material treatment system, the environmental load increased in terms of $CO_2$.
2) The introduction of garbage disposers reduced the environmental load in terms of $CO_2$, because it increases the quantity of energy recovered by anaerobic digestion.
3) A relatively small reduction of environmental load accompanied the rise in electrical power and water consumption by household use of garbage disposers, the increase of sewage sludge polymer coagulant, reduced traveling distance of garbage trucks, and the extension of the lifetime of final disposal sites.