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Report on Social Experiment of Garbage Grinder Introduction

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Preface

The food waste disposer, a device that grinds up household kitchen waste and flushes it down the kitchen drain, was invented in 1927 by John Hammes from the United States. The disposer came into widespread use in America at the beginning of the 1950s, and now has a household adoption rate of 44% (1999) in America. In European countries, however, disposers remain unpopular. There are two general types of disposer systems, direct-discharge (standalone) disposers and disposers with an attached treatment tank. The disposer with an attached treatment tank is essentially a standalone disposer with an added discharge treatment device that is similar to a septic tank. The treatment tank reduces the burden of the disposer discharge on the sewage system, enabling it to be used in conjunction with sewage systems in countries like Japan, which do not support the use of disposers.

In recent years, societal interest in disposers has been on the rise. Amid rising expectations to improve the convenience and comfort of members of the aging society, such as by reducing the amount of labor involved in removing household trash, as well as expectations to reduce amounts of garbage, there are growing concerns about the adverse effects of the growing burden on the sewage system or the growing environmental burden. However, we believe that there are many points in these discussions that are not based on objective fact. For this reason, there are very few actual cases in which disposers have been introduced and evaluated in Japan. We believe this is due to the fact that the disposer problem cuts across the separate areas of sewage systems and waste processing, and that there has been no place to integrate these various points to discuss them.

At present, as for the issue of connecting disposers to the sewage system, it has been determined that the local public entities responsible for sewage management possess separate characteristics in terms of sewage facility configurations and treatment capabilities. Due to concerns about the impact on sewage facilities, the issue is frequently handled with caution. For this reason, the Ministry of Land, Infrastructure and Transport, in cooperation with the Hokkaido government, and the town of Utanobori, designated the town of Utanobori in Esashi County, Hokkaido as the subject (model city) for a field test, in which direct-discharge disposers were installed in general households to study the disposal of kitchen waste with wastewater in the sewage system.

This field test was the first in Japan to introduce disposers to the public sewage system and study the effects. In light of this, we believe that valuable knowledge was obtained. However, because it is the first study of its kind, the experience was fraught with much trial and error, for which we received a wealth of valuable advice. We would like to take this opportunity to express our gratitude for that advice, and we would also like to express our gratitude to everyone involved in this field test for their consistent support and cooperation. We hope this report will serve as a useful reference for those conducting impact studies on the introduction of disposers in other cities.

Chapter 1: General Theory

1.1 Overview of Field Test

Kitchen waste generated in general households negatively impacts both the kitchen environment and garbage collection areas by creating smell and attracting pests. Kitchen waste also attracts crows, which may cause detriment to garbage collection areas. The introduction of disposers, which grind up kitchen waste in the sink and discharge it as kitchen wastewater, may improve the environment of the kitchen and garbage collection areas, and contribute to reducing the amount of labor involved in household trash removal. Disposers are attracting attention as a means of solving a host of problems associated with treating kitchen waste. The reduction in the amount of labor involved in household trash removal is seen as an effective welfare measure in areas of heavy snowfall or where the elderly make up a large proportion of the population.

There are two types of disposers: (1) direct-discharge disposers, which discharge kitchen waste that is ground up (hereinafter referred to as “disposer discharge”) directly into sewer culverts, where it is treated at sewage treatment plants in the same manner as domestic wastewater, and (2) disposers with an attached treatment tank (disposer discharge treatment system), whose attached biological treatment tank or solid-liquid separator treats the disposer discharge before it enters the sewage system. When direct-discharge disposers are introduced, the kitchen waste discharged from a household is collected and treated in the existing sewage system, thus reducing the amount of kitchen waste treated within the solid waste treatment system. This is believed to contribute to a reduction in costs associated with waste treatment, greenhouse gases, and energy consumption for the solid waste treatment system. On the other hand, the costs, greenhouse gases, and energy consumption will increase for the sewage system that receives the disposer discharge. When considering the local community as a whole, there are concerns about the possibility of increases in the public cost and environmental burden. Furthermore, there is the question of whether or not the sewage facilities themselves can handle the added burden posed by the introduction of disposers. Against this backdrop, many local governments in Japan impose limitations or request voluntary restraint when it comes to the installation of direct-discharge disposers, and it is for this reason that thorough studies concerning the introduction of standalone disposers have not been performed.

The Ministry of Land, Infrastructure and Transport, in cooperation with the Hokkaido government and the town of Utanobori, designated the town of Utanobori in Esashi County, Hokkaido as a model area, and direct-discharge disposers (hereinafter referred to as “disposers”) were installed in general households to conduct the “Field Test on the Introduction of Disposers,” which was conducted during the four years from fiscal year 2000 through fiscal year 2003. This field test examined the impact of disposers on the sewage system and waste treatment system, and it has led to efforts to establish a comprehensive evaluation method that uses cost-effectiveness studies, life cycle assessments, etc. of the economic and environmental effects on the entire area.

This report, titled “Report on Social Experiment of Garbage Grinder Introduction,” contains the results of the field test and related experiments, which were conducted over the four years from fiscal year 2000 through fiscal year 2003, and it includes the findings of an additional study conducted in the town of Utanobori in fiscal year 2004.

1.5 Managing the installation and maintenance of disposers

[Disposer installation]

In this field test, the town of Utanobori performed the installation of disposers, as well as maintenance when problems occurred. In addition to the merits and demerits of installing disposers, understanding the circumstances of use and the opinions of users after installation was considered an important point to study. For that purpose, the decision was made to install disposers in public housing, based on the relative ease by which the town of Utanobori could perform installation and maintenance management, as well as understand resident circumstances.

Table 1.5.1 Number of disposers installed

Fiscal year	Installation location	Manufacturer			Total
		I.S.E	Anaheim	Sankyo Trading Co., Ltd.	
FY1999	Wakaba residential complex	21	15	-	36
	Public facilities	2 *1	4	8	14
FY2000	Wakaba residential complex	8	-	-	8
	Konan residential complex	18	38	-	56
FY2001	Shin-ei residential complex	26	25	-	51
	Shinsei residential complex	-	8	-	8
	Higashi-machi residential complex	8	-	-	8
FY2002	Yayoi residential complex	-	7	-	7
	Higaki residential complex	8	-	-	8
	Public facilities	12	23	-	35
	Issued to public	50	20	-	70
Total		153	140	8	301

Proportion by manufacturer	50.83%	46.51%	2.66%	100%
Disposer installation rate (household)	18.4% *2	17.0%	1.0%	36.4%

*1: Industrial disposers installed at hotel (one unit was exchanged for an Anaheim household disposer in fiscal year 2002)

*2: I.S.E.'s rate of installation in the sewage system district does not include the two industrial disposer units (*1) installed in fiscal year 1999.

(3) Disposer maintenance management

Users were asked to provide a report when they experienced a problem with using the disposer, or when the disposer malfunctioned or failed.

As for the number of trouble reports, in the 5 years from 2000 through 2004, there were 12 reports of clogged discharge traps (S-traps), 4 reports of blocked house drainage, and 19 reports of disposer failure.

- Characteristics of trouble

(1) Many problems occurred with the S-trap directly beneath the disposer, which was generally due to low volumes of water when using the disposer. (After stopping the disposer, water soon stopped or did not flow sufficiently.)

(2) Kitchen waste was allowed to accumulate inside the disposer (grind chamber) until full, and then processed in bulk.

(3) Directions for use were provided again after a problem occurred, and in each case the problem did not recur.

(4) The precautions for correct use were explained beforehand, but elderly users experienced many problems. It was believed that it would take a long time for elderly users to become used to using the disposer.

(5) Quick, on-site recovery was possible in all cases where problems occurred.

- Disposer failure

Beginning in fiscal year 2001, malfunctions such as water leakage or faulty rotation were reported for disposers installed during the previous fiscal year. These disposers were replaced by new ones, the disabled disposers were returned to the manufacturer, and the cause of the failure was investigated.

- Requests from residents

Some residents requested that changes be made to the regular waterproof switch. There were requests to change the switch to a hanging switch or a foot switch.

In fiscal year 2002, in response to these requests, foot switches were installed in 10 households.

Chapter 2: Basic Unit of Disposer Discharge

2.1 Amount of Disposer Kitchen Waste

Two possible methods for understanding the amount of kitchen waste put into disposers are: (1) surveys of the amounts and types of waste at garbage collection areas before and after the introduction of disposers, and (2) individual household surveys (kitchen waste is recovered from individual households with disposers installed). In this field study, an attempt was made to estimate the amount of disposer kitchen waste using both of these methods in field surveys over a long period of time. For business establishments such as hotels, it is predicted that the amount of kitchen waste generated per person per day and the amount of disposer kitchen waste vary significantly compared to that of general households. Beginning in fiscal year 2003, the Green Park Hotel, which is located in the "Healing Village" in the town of Utanobori, began to use disposers as a way to treat raw kitchen waste. In fiscal year 2004, as additional research for the field study, a questionnaire survey and a survey of the amounts and types of waste were conducted for the Green Park Hotel, and the amount of disposer kitchen waste was estimated.

[Summary]

Surveys of the amounts and types of waste at garbage collection areas were conducted in three public housing areas with disposers installed (309 people) and in three private residence areas with no disposers installed (60 people). The results of the surveys are shown below.

- 1) At garbage collection areas after the installation of disposers, it was found that kitchen waste was disposed of as burnable waste and as separated raw kitchen waste.
- 2) The average amount of kitchen waste disposed of at public housing before the installation of disposers was 220 grams per person per day, which was near the standard value for

raw kitchen waste.

- 3) In the town of Utanobori, the amount of kitchen waste put into disposers was estimated to be 99 grams per person per day (75% non-overload rate, 135 grams per person per day to satisfy 75% compliance ratio), and the proportion of kitchen waste put into disposers was estimated to be 45%.
- 4) Regardless of whether or not disposers were installed, 60% of kitchen waste at garbage collection areas was disposed of as “burnable waste” and 40% was disposed of as “separated raw kitchen waste.”
- 5) After more than one year since beginning the separated collection of raw kitchen waste, significant changes were found in the rate of separated efficiency and in the amount of disposer kitchen waste.

2.1.3 Amount of disposer kitchen waste at Green Park Hotel

[Study overview]

The research for understanding the circumstances of disposer use at the Green Park Hotel consisted of the following: (1) a questionnaire survey for kitchen staff relating to disposer use and (2) a study of the weight and types of kitchen waste. The questionnaire survey of kitchen staff was conducted in August 2003, and a questionnaire survey and a study of the weight and types of kitchen waste were conducted in fiscal year 2004 as additional research for the field test.

In the questionnaire survey, the time of disposer use, amount of kitchen waste put into the disposer, and amounts of kitchen waste disposed of as solid waste, was recorded over the period of one week. In the survey of the weight and types of waste, actual measurements of kitchen waste, including the amounts of kitchen waste put into the disposer, kitchen waste disposed of as solid waste, and burnable waste, were taken.

The amount of disposer kitchen waste per meal at the Green Park Hotel was estimated based on the results of (1) and (2), as well as the number of tourists and number of meals taken, which were calculated from the number of restaurant users and the number of overnight guests.

[Summary]

The amount of disposer kitchen waste at the Green Park Hotel was determined from (1) questionnaire surveys and (2) surveys of the weight and types of waste. The results that were obtained are shown below.

1) At the Green Park Hotel in fiscal year 2003, the number of tourists per day, which was determined based on number of meals taken, was estimated as 132 at the highest point (August), 40 at the lowest (March), with an average of 79 people per day (overnight guests: 41, day guests: 37).

2) At the Green Park Hotel in fiscal year 2003, the number of meals per day was estimated to be an average of 119 meals per day, with 199 at the highest point (August) and 57 at the lowest point (March).

3) Although kitchen waste is classified as either food waste or burnable waste before disposal, the rate of disposer kitchen waste was 94%, which is higher than the 45% rate of disposer kitchen waste for general households.

4) The amount of kitchen waste disposed of during the peak tourist season (August) is estimated as roughly double the average amount (November), but the amount of waste per meal tends to become larger as the number of tourists decreases.

5) The amount of disposer kitchen waste per day during the peak tourist season (August) was 68.5 kg, and the amount of disposer kitchen waste during the low tourist season (January) was 34 kg.

6) The annual average amount of disposer kitchen waste was estimated to be 51 kg per day, and 431 grams per meal.

Results of Resident Awareness Survey

[Summary]

The results of the resident awareness survey, conducted in the town of Utanobori to study the resident's awareness of disposers, are shown below.

1) Disposer users in public housing (installed in all households)

- Concerning the frequency of disposer use, approximately 60% of all respondents used the disposer after each meal, and about 80% used the disposer at least once per day.
- Concerning the types of garbage processed by the disposer, more than 90% of users responded that they used the disposer to treat fruit/vegetable waste.
- Concerning the usage of water when using the disposer, around 60% of users ran tap water when using the disposer, but around 30% economized on tap water, using the disposer while washing dishes.
- Concerning the experience of trouble when using the disposer, around 40% of users experienced clogged pipes at some point. Compared to clogged pipes, the occurrence of undesirable sounds during use, stoppage due to foreign materials, and water leakage was less frequent.
- Concerning the disposer users' awareness of merits, around 80% had a "strong feeling" or "some feeling" that kitchen hygiene was improved, and around 70% felt that convenience and comfort was greatly improved due to the reduction in the amount of labor involved in removing the household trash.
- Concerning the disposer users' awareness of demerits, a large number of users, around 70%, felt "very bothered" or "fairly bothered" by the undesired sound and vibration of the disposer.
- Concerning the future intent to use disposers, a large number of respondents, around 80%, "want to continue to use" disposers.
- For disposer users in public housing, the minimum average willingness to pay (WTP) for convenience benefits was 732 yen per household per month.

2) Disposer users in private housing (offered to the public)

- Compared to their counterparts in public housing, those who installed disposers in private housing had a more positive opinion about the merits of disposers before installation, though there was a slight drop after installation.
- Concerning the demerits associated with disposer use, concerns that existed before installation about the "occurrence of problems such as disposer failure, blocked pipes due to foreign material, and clogged drains" were reduced dramatically after installation, while concerns about the "undesired noise during use" increased slightly.

- Around 90% of users in private housing want to continue using disposers in the future, slightly higher than the percentage reported by users in public housing.
- For disposer users in private housing, the minimum average WTP for convenience benefits was 892 yen per household per month. This figure is slightly higher than the minimum average WTP in public housing, where disposers were installed regardless of residents' wishes.

3) Disposer non-users

- Concerning the disposer non-users' treatment of raw kitchen waste, 70 to 80% treated it as burnable waste and carried it to a trash collection area, but about 20% of the respondents used it as compost material.
- When non-users were asked why they did not apply for the publicly offered disposers, 34% replied they "experienced no difficulty in processing food waste," and 32% replied that "disposers seemed convenient, but there were some points of concern." In addition, 10% responded they "wanted to use a disposer, but declined due to unsuitable kitchen conditions."

Chapter 12: General Overview

In this field test, disposers were installed in 301 locations in the model area (the town of Utanobori in Esashi County, Hokkaido), predominantly in general households within the town limits (36.5% of households were connected to the sewage system) to study the effects on the sewage system, on the system of solid waste collection and treatment, on the daily lives of town residents, on the economy, and on the environment. The results obtained through this study are shown below.

[Basic unit of disposer discharge]

From the results of the survey of the weight and type of waste at garbage collection areas before and after the introduction of disposers, it became clear that a portion of the amount of kitchen waste generated was put into disposers. The amount of disposer kitchen waste was estimated to be 99 grams per person per day, equivalent to 45% of the amount of kitchen waste generated in a general household.

The rates of change in water quality of kitchen waste collected from general households were SS: 8.2 grams, BOD: 11.3 grams, COD_{Mn}: 5.5 grams, TN: 0.73 grams, TP: 0.11 grams, C1: 0.33 grams, and n-Hex: 1.75 grams. The values for kitchen waste collected from hotel kitchens were similar. The basic unit of pollution load for disposer discharge is calculated by

multiplying the amount of disposer kitchen waste by these rates of change in water quality. The results suggest the possibility that the basic unit of inflow load to the treatment plant increased by 20% for SS, BOD, and COD_{Mn} , and about 10% for TN and TP.

No changes were noticed in the amount of water system usage after the introduction of disposers. The results of the disposer usage simulation were as follows: average processing time: 7.5 seconds, electric power consumption: less than 0.001 kWh, average discharge volume: 0.7 liter per person per day, and average water service usage per 100 grams of kitchen waste: 0.7 liter.

In general households, disposers were used an average of 2.3 times per day per household, and usage often took place around mealtimes in the morning, afternoon, and evening, with 6:30 to 7:00 PM being the most frequent time of use.

[Impact on drainage facilities]

A survey of the slopes of exterior drainage pipes conducted before the installation of disposers revealed gentle slopes of $10^0/00$ or less, as well as inclining slopes, in several places, but even after the introduction of disposers, almost no deposits accumulated in these areas.

A biofilm formed on the inside of the drainage basins, and the presence of inorganic compounds such as calcium carbonate and silicate compounds in households with disposers installed was confirmed. Also, the level of n-Hex in incrustations in households with disposers installed was about the same as that for households with no disposer installed.

[Impact on sewage facilities]

(1) Effects on culverts

Deposits that accumulated in culverts where disposers were introduced consisted mainly of eggshells, and the amount of ignition loss of these deposits was 5 to 8% in districts where disposers were installed, rather high compared to the 2 to 3% in districts where disposers were not installed. The installation of disposers had no effect on the levels of n-Hex in deposits and incrustations.

It was revealed that the frequency of the occurrence of deposits (total length of deposits/total length of culvert examined) after the introduction of disposers was 1.3 to 3 times greater, and the number of deposit sites increased by 2.7 to 3.8 times.

However, these deposits were very minor, with a less than 1% blockage rate for 80% of deposit sites, and the amount of deposits at each site made up only a few percent of the total amount of deposits. In addition, it is clear that 76% of the deposits occurred in sections of inclining slope, where the slope was 0⁰/₀₀ or less, and 10.7% occurred in sections of gentle slope, where the slope was between 0 and 5⁰/₀₀.

In drag tests of the deposits using culvert models, the flow velocity at “full movement,” which brings about continuous movement of deposits, was 0.52 meter/second for eggshells, 0.59 meter/second for seashells, and 0.57 meter/second for mixture A (eggshells:seashells = 40:1), confirming that the flow velocities were less than the minimum flow velocity of 0.60 meter/second stipulated in the design policy. In addition, in continuous deposits and drag tests conducted in uniform, evenly sloped culverts, when a flow amount of 0.001 cubic meter per second or greater was maintained, the height of the deposit would not grow beyond 3 centimeters. Furthermore, deposits filled in the “sagging” portions of culverts with the passage of time, the even surface of the deposits in effect creating evenly sloped culverts.

As for the degree to which deposits contribute to drag, day-to-day fluctuations vary even more widely than the inflow of rainwater, which suggests drag and movement occurs with ordinary fluctuations in flow on clear days.

Deposits made up primarily of eggshells increased after the introduction of disposers. At many sites where they accumulated, during the period of several months in the summer season when temperatures were high, there were moments when around 20 ppm of hydrogen sulfide was generated.

(2) Impact on pump facilities

After the introduction of disposers, there were no large changes in the amount of foreign material and deposits discharged at pump facilities, and the frequency of cleaning did not change. Deposits on the bottom surface of the pump area consisted of 86.5% earth and sand, and 8% kitchen waste, and had a specific gravity of 2.5. Also, the n-Hex level was 3.83%, which was much higher than the 0.1% level for the deposits in the culverts.

The results of the laboratory experiments, in which wastewater that included ground kitchen waste was retained, showed that when wastewater that includes ground kitchen waste was retained for 48 or more hours, the sulfide content became higher than that of normal wastewater. In the town of Utanobori, the concentration of gas-phase hydrogen sulfide in the pump area was measured over a long period of time with a focus on the summer season, but almost no occurrence of hydrogen sulfide was ascertained.

(3) Impact on treatment facilities

After the introduction of disposers, it could not be clearly ascertained whether there was an increase in influent and the amount of foreign material screened out.

The quality of influent changed with the increase in the number of disposer users, and the concentrations of BOD and SS increased in influent at 9:00 AM (spot sample). In other words, at peak periods of disposer use, it was clear that household disposer discharge affected the influent quality at treatment sites.

The quality of treated water was less than 10 mg per liter even after the introduction of disposers, and no effects due to the introduction of disposers were observed.

No changes in levels of SVI, n-Hex, TN, and TP in sludge were observed due to the introduction of disposers, but it was clear that the amount of waste sludge (amount of discharged solid waste) increased along with the increase in the number of disposer users. The sludge conversion rate (amount of discharged solid waste/ amount of incoming solid waste) was approximately 1, and the amount of sludge increase was about the same as the estimated increase when it was assumed that all disposer-originated SS became sludge. Also observed was the tendency of the water content of dehydration sludge to increase rather significantly in line with the increase in the amount of sludge.

[Impact on solid waste treatment facilities]

Until fiscal year 2002, before the separated collection was introduced, it was estimated that the amount of burnable garbage in the areas where disposers were installed was 99 grams per person per day less than in areas where disposers were not installed. In the collection of kitchen waste, regardless of whether or not disposers are installed, it was estimated that about 60% of all kitchen waste disposed of at garbage collection areas consisted of burnable waste. After separated collection began, it was estimated that the amount of burnable waste in areas where disposers were installed was 59 grams per person per day (of which 40 grams per person per day was kitchen waste treated as solid waste) less than in areas where disposers were not installed.

Concerning the amount of sewage sludge discharged, no constant tendency was observed for the amount of solid waste until fiscal year 2002, but in fiscal year 2003, when the use of disposers began at Green Park Hotel, a clear increase was confirmed.

[Impact on the daily life of town residents]

Concerning the frequency of disposer use, about 60% of users used the disposer after each meal, and about 80% used the disposer at least once per day. Also, at least 90% of users used the disposers to treat fruit/vegetable waste, and about 60% used the disposers to treat eggshells.

Concerning the merits of using disposers, about 80% had a “strong feeling” or “some feeling” that kitchen hygiene was improved, and around 70% felt that convenience and comfort was greatly improved due to the reduction in the amount of labor involved in removing the household trash. On the other hand, concerning demerits, around 70% of users felt “very bothered” or “fairly bothered” by the undesired sound and vibration of the disposer. Also, the most common problem that occurred during use was clogged pipes, which made of 40% of all cases of trouble.

Around 80% of users want to continue using disposers in the future, and the minimum average willingness to pay in a disposer rental scenario was determined to be 732 yen per household per month.

[Environmental impact]

When the environmental burden for a 100% household disposer installation rate was compared to that for a 0% household disposer installation rate, there was an estimated 4 tons per year increase in CO₂ and a 114 GJ per year increase in energy consumption. However, the percentage increase in terms of the overall amount was less than 1%, suggesting that the popularization of disposers would cause no changes to the environmental burden.

The main causes of added environmental burden in terms of CO₂ emissions are (1) increased energy consumption at sewage treatment sites, (2) increased water use and energy consumption through the use of disposers, and (3) reduction in gas-generated electricity at sludge reprocessing centers due to reduced amounts of raw kitchen waste. On the other hand, the main causes of reduced environmental burden are (1) the reduction in the operating time of raw waste pulverization equipment at sludge reprocessing centers, due to reduced amounts of raw kitchen waste, (2) life extension of final disposal sites due to the reduction of waste incineration ash, and (3) reduction in the amount of chemicals at waste incineration facilities due to a reduced amounts of burnable waste. These tendencies also apply to energy in the same way.

[Socioeconomic impact]

Administrative costs were calculated based on a 100% household disposer installation rate, and the results showed increased sewage system operating costs (200,000 yen/year) resulting from the increased burden on the sewage system. However, with cost reductions in cleaning operations resulting from reduced amounts of burnable waste (420,000 yen/year less), the town's overall administrative costs were estimated to be 220,000 yen per year lower than before disposers were introduced.

An overall cost-benefit analysis was performed that included the administrative costs of sewage system operations and cleaning operations, and the benefits for disposer users. The convenience benefits and the cost of purchasing and installing a disposer were determined to be an excellent value when compared to the changes in administrative costs and disposer operation costs. Also, the benefit to disposer users was estimated to be 1.65 million yen per year, and the administrative cost reduction of 225 yen per year and the additional 455 yen per year added to the sewage system use fee resulted in a social surplus of 1.92 million yen/year.