FRACTIONING GRAY-WATER IN THE DIFFERENTIABLE ONSITE-WASTEWATER TREATMENT SYSTEM

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1. INTRODUCTION

The wastewater effluent from a household or group of households is made up of contributions from various appliances, such as WC, kitchen sink, wash basin, bath, shower, and washing machine. Elimination of toilet waste (black-water) from the residential wastewater stream by using non-water carriage toilet will reduce the mass of organic matters; pathogenic microorganisms; nitrogen and phosphorous in the remaining waste stream (gray water). We have proposed the Onsite Wastewater Differentiable Treatment System (OWDTS)1) based on the concept of a differentiable management and treatment of household wastewater effluents. Figure 1 shows a hypothetical model for onsite wastewater differentiable treatment system. In this system, the separation of household wastewater into three types is essential. Reduced-volume blackwater, higher-load and lower-load graywater are new concepts that are intended to introduce in this model. Here, treatment of blackwater conceives a change in the traditional way of using the WC; in other words, the use of water in the WC is thought just to clean the toilet, not to transport the toilet wastes; this is a very important change. Reduced volume blackwater is practically eliminated from the household effluent by using the bio-toilet2) system, lower-load gray-water could be treated by utilizing the natural capacity of soil microorganisms; and higher-load gray water needs any conventional treatment process for reaching acceptable quality. In fractioning gray-water into higher- and lower- load portion and planning a suitable treatment process for them, the information on quality, quantity and their fluctuation pattern of effluent from various appliances is essential.

The objectives of this study are 1) summarizing characters of effluent from appliances in house; 2) estimating the size of flow equalization tank and treatment process for higher-load gray-water.

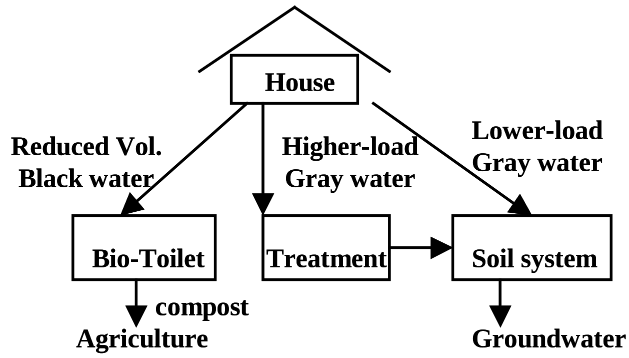

Figure 1. Hypothetical model for Onsite Wastewater Differentiable Treatment System

2. Methods

Character of effluent from various appliances We summarized contributions for daily gray-water discharge volume and pollution load from various appliances, such as kitchen sink (KS), wash basin (WB), bath tub (BT), shower (SW), and washing machine (WM) by referring to 43 reports published in Japan. The data were put in chronological order from the seventies to the nineties (1970s-1990s), and the mean value and standard deviations of them were computed in each decade.

Estimating size of treatment process Design guidelines of gray-water treatment process are used for sizing flow equalization tank and biological treatment process. These guidelines are published in Japan and used for designing gray-water reuse system in large buildings where reclaimed gray-water is used for toilet-flushing.

3. Results

Character of effluent from various appliances Figure 1 shows the contributions of each appliance for daily gray-water discharge in each decade. Since the data for showing the contributions of each appliance on BOD, T-N, and T-P load are not available in 1980s, only total loads are shown in the figures. Comparison of total volume and total load of 1970s, 80s and 90s shows that

- total volume of gray water has not changed, and it has the value is about 200L/day/capita
- BOD load is decreasing
- There is no clear trend in T-N load
- T-P load is decreasing, and this is because of regulation in phosphorous content in detergent.

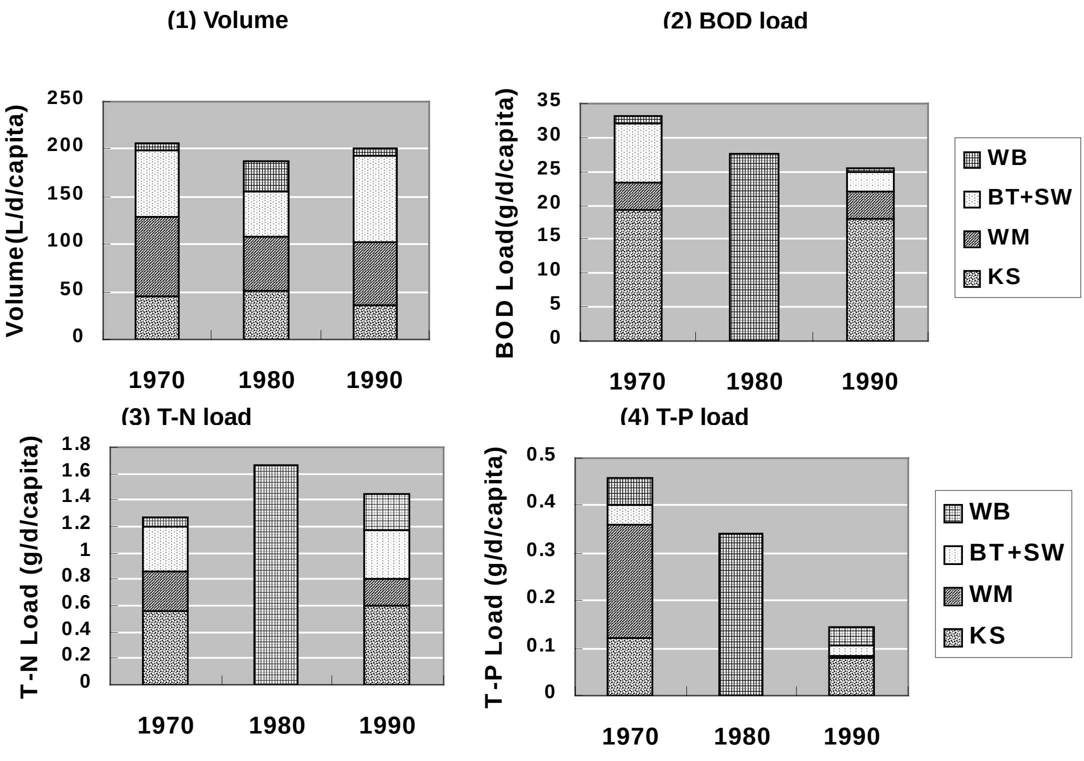

Figure 2. Trends of gray water volume and pollution loads in each appliance

The data of 1990's are shown in Table 1. It is seen from the table that the kitchen sink (KS) is the most important appliance for all constituents, and the effluent from KS must be treated. On the other hand, the bath tub (BT) contributes to the volume, but production of BOD and T-P is very low. We may be able to discharge the effluent from BT without any treatment, and this operation leads to reduction of size of treatment process.

Table 1. Contribution of each appliance for the daily gray water discharge volumes and pollutants loads (% of total volume or mass per capita).

Appliance	Volume	BOD	T-N	T-P
Kitchen Sink (KS)	18.0	70.9	41.4	54.4
Wash Basin (WB)	4.1	2.0	19.3	27.2
Bath Tub (BT)	31.4	1.2	17.2	6.8
Shower (SW)	13.4	9.8	7.6	8.2
Washing Machine (WM)	33.0	16.1	14.5	3.4
Total (per capita per day)	201 L	25.4 g	1.45 g	0.147 g

The variations of flow rate and strength in gray water Gray water discharge from a household strongly depends on water use pattern, and this causes the variation in both flow rate and its strength. The variation in flow rate controls the volume of flow equalization tank, and the variation in concentration

the performance of biological treatment system. We set the model variation pattern of flow rate and concentrations of gray water from each appliance with reference to several reported data. Figure 3 is the pattern of flow rate and Figure 4 is showing the estimated variation of BOD. It is seen from Fig.3 that there are two peaks in the morning and in the evening. The peak in the morning reflects the discharge from washing machine, and Bath Tab water contributes mainly in the evening. But, It should be noted in Fig.4 that main source of BOD is the Kitchen Sink water in any time.

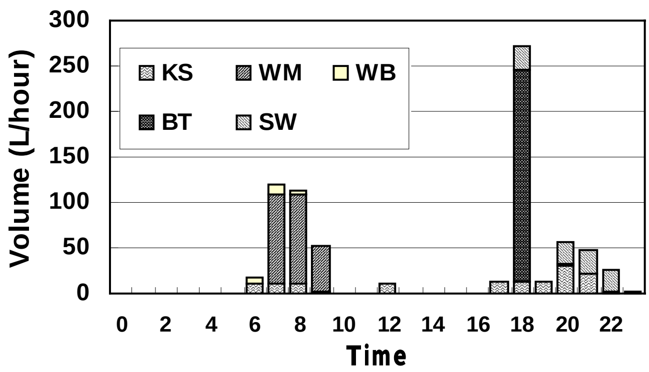

Figure 3 Model variation pattern of flow rate

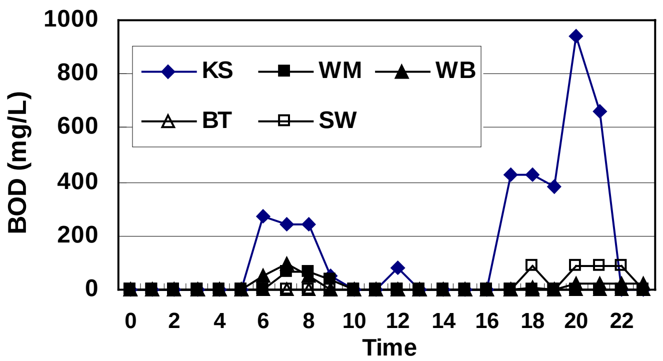

Figure 4 Model variation pattern of BOD

Sizing treatment process

We examined several combinations of gray waters and tried to calculate the size of flow equalization tank and biological reactor. The size of flow equalization tank was estimated by the Ripple method3). The volume of biological reaction basin was calculated by setting that the hydraulic retention time was 8 hours. Fig.5 shows the typical results of sizing treatment process for a household. In these sizing process, we assumed that the water consumption from one household is equivalent to that from 3.7 persons.

Patterns of fractioning gray water of four systems in the figure are follows:
-System-1: Mix effluents from all appliances and treat it.
-System-2: Mix effluents from KS; WB; SW and WM and treat it. Discharge BT effluent without treatment.
-System-3: Mix effluents from KS; WB and SW and treat it. Mix effluents from BT and WM and discharge it without treatment.
-System-4: Mix effluents from KS; WB and WM, and treat it. Mix effluents from BT and SW and discharge it without treatment.

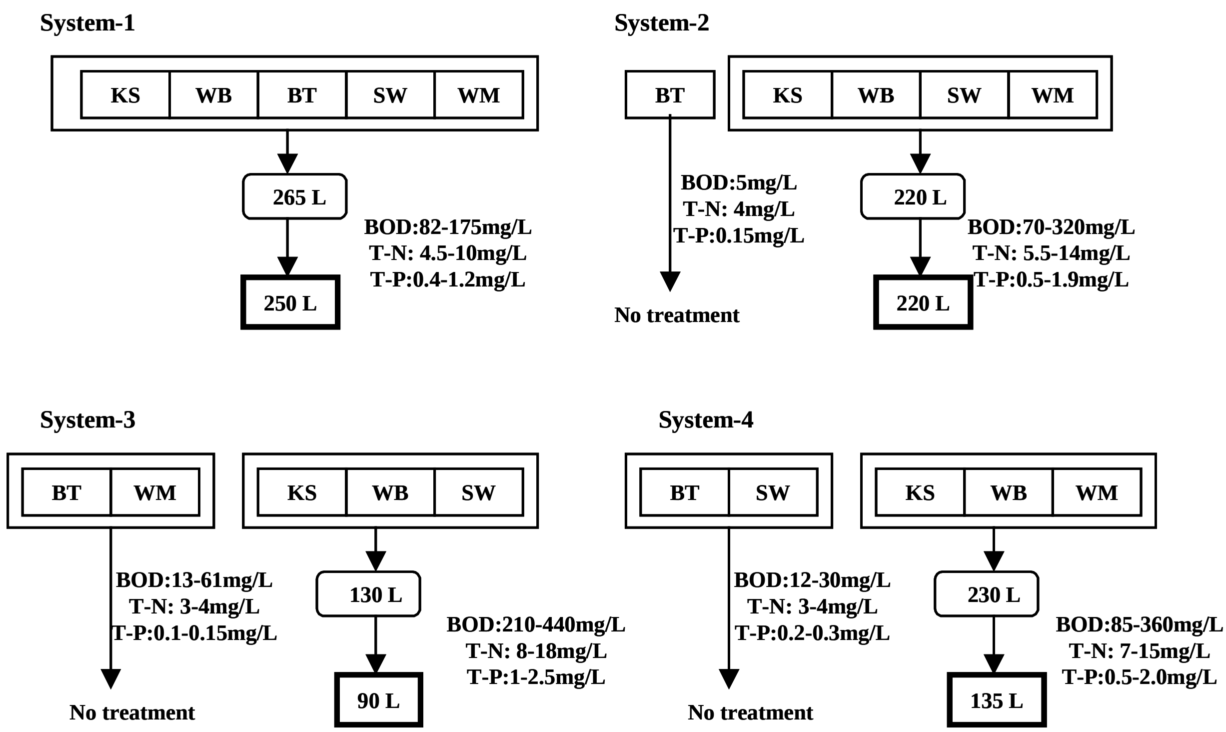

Figure 5 Comparison of sizes of treatment system

System-1 requires 265L of flow equalization tank (FET) and 250L of biological reaction tank (BRT). In System-2, the effluent from BT is fractioned to lower-load gray-water, we can reduce volumes of FET and BRT. In System-3, mixing the effluents from BT and WM causes increase in concentrations of BOD, T-N, and T-P. But, this system yields the smallest volume of FET and BRT.

The required area for disposal of treated effluent and non-treated gray water in soils is estimated by using the allowable hydraulic loading rate or mass loading rate such as organic matters and nutrients. In the case that the hydraulic loading rate is limiting factor, the required area is simply calculated by total volume of gray water from a household, and there is no merits in fractioning gray water in terms of the required area for final disposal. But if the mass loading rate restricts the disposal into soil system, the required area depends on which fraction of gray water is treated.

4. CONCLUSIONS

Considering the actual tendencies towards ecological sanitation in recycling society and the pressure on the world's water resources, the Onsite Wastewater Differentiable Treatment System (OWDTS) seems to be a new approach with dry ecological sanitation, recycle of resources, conservation of water resources. In the OWDTS, separation of wastewater from a household into three streams is essential: back water; higher-load gray water; and lower load gray water. Black water is treated by the bio-toilet system without any water for transporting toilet waste. As to treatment of gray water, fractioning gray-water into higher- and lower- load portion has possibility to reduce required capacity of higher-load gray-water treatment process, and lower-load gray water and treated higher-load gray water might be able to release to soil system where natural biodegradation of lower-load organic matter is expected.

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