Graywater Fractioning in the Onsite Wastewater Differentiable 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, washbasin, bathtub, shower, and washing machine. Elimination of toilet wastes (blackwater) 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 wastewater stream (graywater). 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 introduced in this model. Reduced volume blackwater is practically eliminated from the household effluent by using the bio-toilet system; utilizing the natural capacity of soil microorganisms lower-load graywater could be treated, and higher-load graywater needs any conventional treatment process for reaching acceptable quality. In fractioning graywater 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 character of effluent from appliances in house; 2) estimating the size of flow equalization tank and treatment process for higher-load graywater.

2. METHODOLOGY

Character of effluent from various appliances. We summarized contributions for daily graywater discharge volume and pollution load from various appliances, such as kitchen sink (KS), washbasin (WB), bathtub (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.

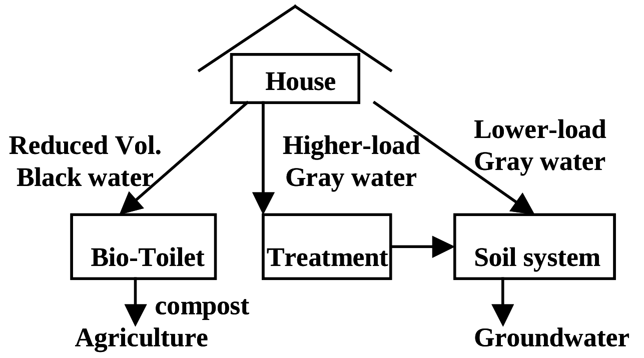

Figure 1. Hypothetical model for Onsite Wastewater Differentiable Treatment System.

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

3. RESULTS AND DISCUSSION

Character of effluent from various appliances. Comparison of total volume and total load of 1970s, 80s and 90s showed that total volume of graywater has not changed and it has the value of about 200 L/day/capita; BOD load is decreasing; there is no clear trend in T-N load, and T-P load is decreasing as a result of regulation of phosphorous content in detergents.

1990’s data are shown in Table 1. As seen, 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 bathtub (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.

Variations of flow rate and strength in graywater. Graywater 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 affects the performance of

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biological treatment system. We set the model variation pattern of flow rate and concentrations of graywater from each appliance with reference to several reported data. Two peaks were observed, one in the morning and another in the evening. Regarding volume, the peak in the morning reflects the discharge from washing machine, and bathtub water contributes mainly in the evening. In case of organic load, the main source of BOD was the kitchen sink water in any time.

Sizing treatment process. We examined several combinations of graywaters and tried to calculate the size of flow equalization tank and biological reactor. The size of flow equalization tank was estimated by the Ripple method[2)]. The volume of biological reaction basin was calculated by setting the hydraulic retention time in 8 hours. Figure 2 shows the typical results of sizing treatment process for a household. In this sizing process, we assumed that the water consumption from one household is equivalent to 3.7 persons. Patterns of fractioning graywater 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.

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

Appliance	Vol.	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
Bathtub (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 (capita/day)	201L	25.4g	1.45g	0.147g

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 graywater, 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 graywater in soils is estimated by using the allowable hydraulic loading rate or mass-loading rate such as organic matter and nutrients. In the case that the hydraulic loading rate is limiting factor, the required area is simply calculated by total volume of graywater from a household, and there is no merits in fractioning graywater 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 graywater is treated.

4. REFERENCES

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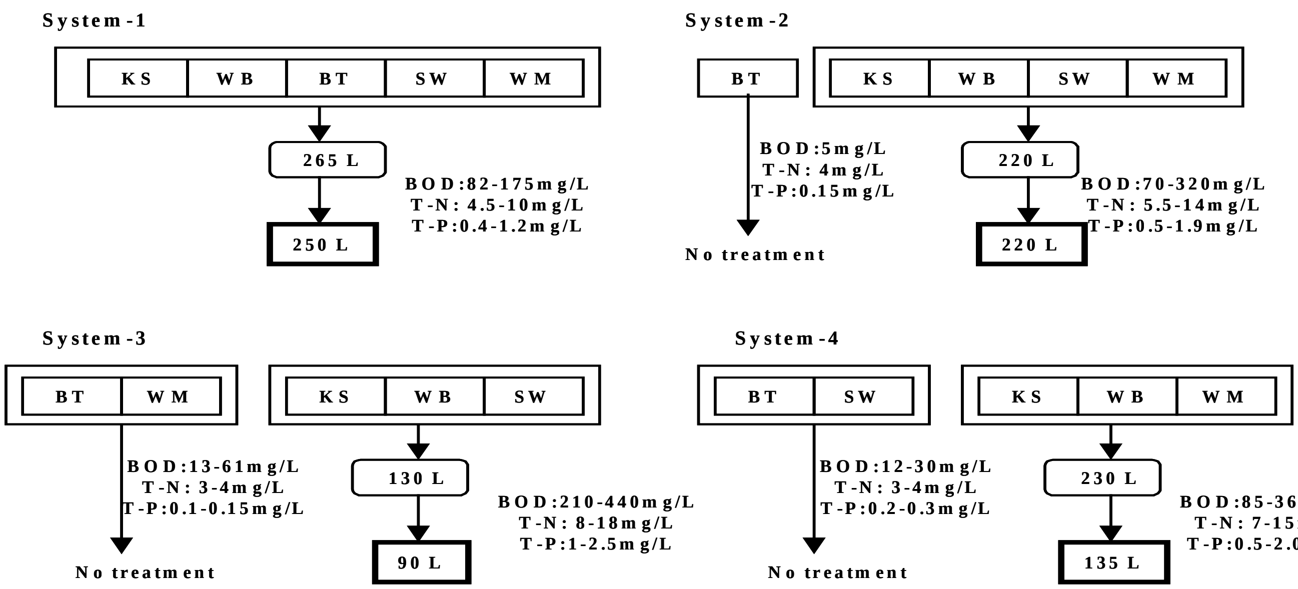

Figure 2. Comparison of sizes of treatment system.