

GRAYWATER TREATMENT BY SLANTED SOIL SYSTEM

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Abstract

Graywater reuse is one of important issues in developing country in arid zone. Slanted soil treatment system (SST) is low-cost simple system and seems one of suitable technologies for graywater reuse in those countries. In this study, basic performance of SST was examined supposing graywater reuse for agriculture. According to the results of continuous treatment experiment, concentration of COD, TSS, LAS were decreased with the formula of $C=C_0 \cdot \text{Exp}(-kt)$. E.Coli was reduced 5 Log in the first BOX using fine soil particles. E.Coli removal ability was kept for 3 weeks. LAS also reduced to under 35mg/l, which is the target level for agriculture. Using coarse soil particles in the first BOX increased the elapsed time for clogging from 3weeks to 8weeks.

Keywords: Decentralized system, Graywater, water reuse, arid zone

Introduction

Onsite Wastewater Differentiable Treatment System (OWDTS), which proposes onsite treatment of graywater, urine and feces separately (Lopez Zavala et al., 2002), is regarded as one of suitable system for developing country because it does not requires large investment such as centralized sewerage system. Furthermore, OWDTS has a merit for water reuse also. Graywater originally has large volume but low concentration of contaminants. Therefore separated graywater can be reused with easy treatment only. These 2 merits are important especially in developing countries in arid zone. Wastewater reuse itself has already been applied for urban agriculture in arid zone however the wastewater was used without any treatment or just with diluted (Asano et al. 2007, Raschid-Sally et al. 2008). The Low-cost simple system which can provide appropriately treated graywater is desired.

Slanted Soil Treatment System (SST) is one of possible low-cost graywater treatment system developed in Japan. SST consists of several boxes containing soil (Fig.1). These boxes are stacked vertically, and its footprint is very small (1.0×0.5m). No energy is required because water flows by natural gravity. The SST box is made by styrene foam, therefore it is not so expensive; current price in

Japan is ¥3000/each box. Installation requires only piping with appropriate gradient. It could be installed by local worker. In this study, basic performance of SST was examined to design it for graywater reuse in agriculture.

Methods

Continuous graywater treatment experiment was carried out to investigate following points; (1) Pathogens (E.Coli, MS-2) which concerns health risk of farmer and consumer of crops, (2) Surfactants (LAS) which may give negative effect on crop growth and also environment, (3) TSS which concerns clogging rate in the BOX, (4) Organic matter(COD, BDOC) which concerns clogging in irrigation pipe. Artificial graywater containing incubated E.coli and bacteriophage MS2 was prepared and continuously discharged to SST. Total 8 series of experiments (Table1) were carried out. Measured items are COD_{Cr}, dissolved-COD_{Cr}, TSS, VSS, E.coli B strain (NBRC13168), MS2 phage (NBRC102619), LAS and BDOC.

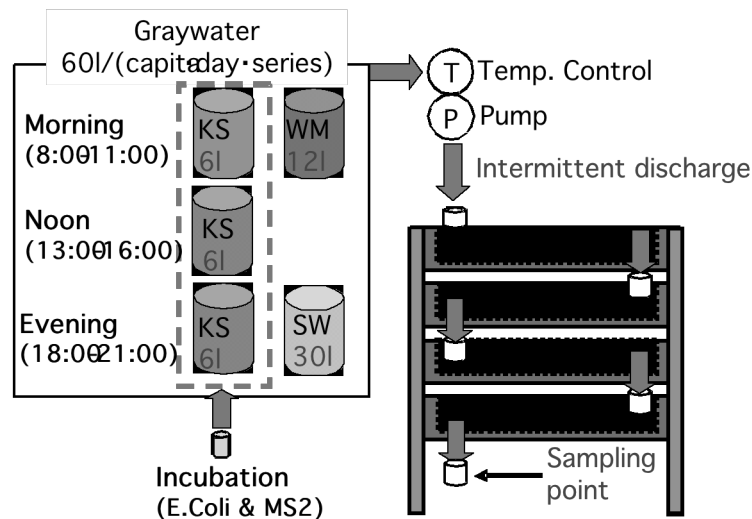


Figure 1. SST applied for the experiment

Table 1. Experimental conditions

Difference of 8 series

Series	BOX1	BOX2,3,4	Flow volume	Operation period
SST1	Kanuma(4-11mm)		60 L/series/day	6weeks
SST2	CBM(4-11mm)			6weeks
SST3	CBM(1-4mm)			5weeks
SST4-1	CBM(1-4mm)		30 L/series/day	3weeks
SST4-2	CBM(1-4mm)			4weeks
SST5	CBM (4-11mm)	CBM (1-4mm)	15 L/series/day	8weeks
SST6-1	CBM(1-4mm)			3weeks
SST6-2	CBM(1-4mm)			4weeks

(CBM : Crush Baked Mud)

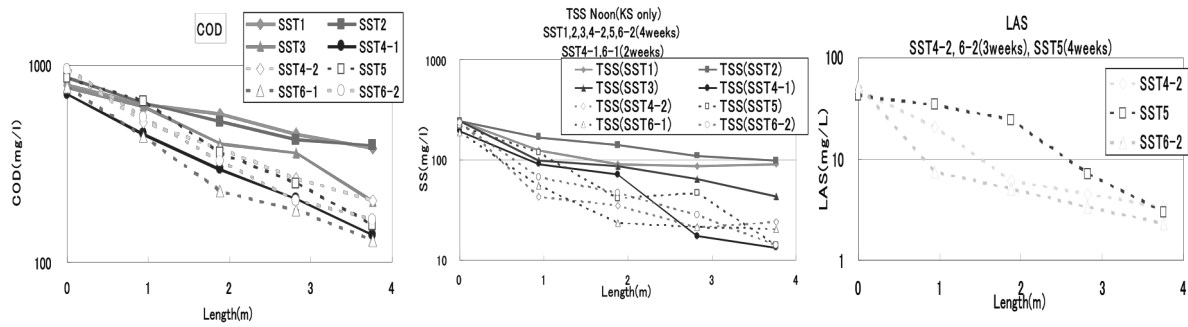


Figure 2. correlation between concentration and length of COD(left), TSS(center) and LAS(right)

Results and discussion

According to the results of COD, TSS and LAS (Fig.2), we applied reaction formulas as follows. COD reduction appears to be linear by flow length in the system, therefore COD removal can be regarded as a 1st order reaction: $C=C_0 \cdot \text{Exp}(-kl)$, where k is the reaction coefficient ranging from 0.20 to 0.51, and l is the flow length. k_{COD} did not change in elapsed time, soil particle size and soil type. The relationship between Q and k was shown by the formula: $k_{\text{COD}} = -0.06Q + 0.6$.

TSS and LAS removal also could be regarded as a 1st order reaction, and k_{TSS} and k_{LAS} were defined as below: $k_{\text{TSS}} = -0.09Q + 0.9$, $k_{\text{LAS}} = -0.02Q + 1.0$. k_{TSS} and k_{LAS} value was not influenced by the elapsed time, soil type or soil particle size, as COD reaction. All series could reduce LAS to under 35mg/l, one of reported concentration causing crop disease (Garland et al. 2004). SST3, 4-1, 5, and 6-1 experienced clogging in 5weeks, 3weeks, 8weeks and 3weeks respectively. There was no relationship between clogging time T and estimated cumulative amount of TSS removal. The fraction of fine soil particles in SST4-1 and SST6-1 were larger than those in SST4-2 and SST6-2, and T depends on soil particle size distribution. To enlarge T , BOX1 should contain coarse soil particles (4-11mm).

Pathogens (E.Coli and MS2) were reduced in SST5 where fine soil particles were used. Although SST5 could not remove pathogens in BOX1 containing coarse soil particles such as SST1 and SST2, SST5 achieved 5 Log E.Coli and 3 log MS2 reductions in BOX2 containing fine soil particles. The box of SST appeared to have the maximum cumulative amount of E.Coli removal because the breakthrough point occurred after several weeks. In this study, maximum cumulative amount of E.Coli removal was estimated as 1010 CFU/box and it means that the replacement of BOX2 in every 3 weeks is required.

Conclusions

SST decreases COD, TSS, LAS concentration with the formula of $C=C_0 \cdot \text{Exp}(-kl)$. SST obtained a 5 Log E.Coli reduction in first BOX using fine soil particles and LAS reduction to the target level under 35mg/l. SST had maximum cumulative amount of E.Coli removal in the BOX with fine soil particles for 3 weeks. BOX replacement is required to keep the target level of pathogens. Placing coarse soil particles in the first BOX increased T (the elapsed time for clogging) from 3weeks to 8weeks.

References

Asano, T., Burton, F.L., Leverenz, H.L., Tsuchihashi, R. and Tchobanoglous, G. (2007) Water Reuse, issues, technologies and application, Metcalf & Eddy, Inc. an AECOM Company.

Garland, J.L., Levine, L.H., Yorio, N.C., Adams, J.L. and Hummerick, M.E. (2004) Response of graywater recycling systems based on hydroponic plant growth to three classes of surfactants, *Wat. Res.* 38(8), 1952-1962.

Lopez Zavala, M.A., Funamizu, N., Takakuwa, T. (2002) Onsite wastewater differentiable treatment system:modelling approach, *Wat. Sci. Tech.* 46(6-7), 317-324.

Raschid-Sally, L. and Jayakody, P. (2008) Drivers and characteristics of wastewater agriculture in developing countries – results from a global assessment, International Wastewater Management Institute.