Modified cesspool system with upflow sludge tank and low-cost photobioreator

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Abstract: Cesspool system is widely used for blackwater treatment of households in developing countries. Typically, the treatment is biological process under anaerobic condition resulted in unsatisfactory effluent quality. Effluent or liquid from cesspool system normally seep into surrounding soil causing the contaminated of groundwater. This research applied upflow sludge tank and photobioreactor tank. It was observed that upflow sludge tank cloud maintain settled sludge and stabilized the velocity of upflow. Symbiotic relationship between algae and bacteria was found in aerobic condition of photobioreactor which produced oxygen was consumed by bacteria to degrade organics and others. Effluent BOD concentrations were finally about 50 mg/L at the hydraulic retention time of 1.5 day of combining upflow sludge tank and photobioreactor tank. Results obtained from this study could be a promising low-cost technology to enhance treatment performance of cesspool system.

Keywords: Blackwater, Cesspool, Photobioreactor, Upflow sludge tank

INTRODUCTION

Cesspool is a simple wastewater treatment system especially used for treating blackwater from the flush toilet in developing countries. Over 90% of effluent is discharged over than value from effluent standard (Langergraber and Muellegger, 2005). The conventional type is easily made by rowing of cement rings in excavated hole. Although the treatment efficiency of cesspool system is quite low people still use it. It is because of the cheap technology and the final disposal into soil. Pattern of cesspool system is applied without any improvement for many decades. Nowadays, modern system like commercial septic tank is available in the market. However, the perception of user is not yet satisfaction. It is due to high cost and the lack of drainage network to receive the final effluent of this system. Photobioreactor has been applied especially in attached form was used to treat organics and nitrogen of industrial wastewater by Munoza et al. (2008), treating nutrient from polluted lake water by Dixner (2013). Application of microalgal-bacterial biofilm treating municipal wastewater was also reported by Posadas et al. (2014) and Boelee et al. (2014). This study was aimed to improve the cesspool system and the quality of effluent by retrofit concept. Investment was focused on low cost materials.

MATERIAL AND METHODS

This study focused on the field experiment in order to test with real blackwater. Household with 5 members using cesspool system was selected to install modified system. The configuration of modified cesspool system with upflow sludge tank (UST) and photobioreactor (PBR) is illustrated in **Figure 1**. Plastic tank of 150 L installed inside cesspool system was UST tank. Another plastic tank of 50 L installed outside cesspool system was PBR tank. In the experiment, blackwater was firstly run through UST tank and effluent was further treated by PBR. Final effluent of PBR was returned to dispose into the existing cesspool system. PBR tank contained low-cost media made by reused plastic bottle with specific surface area was 300 m^2/m^3. Cover lid of the PBR was transparent to allow light passing through and exposing to media.

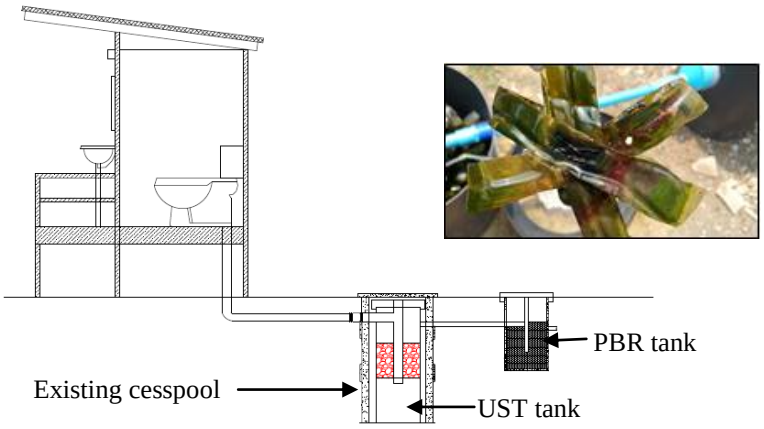

Figure 1 Configuration of modified cesspool system with UST and PBR

RESULTS AND DISCUSSION

Table 1 shows characteristic of blackwater and treatment performance of modified cesspool system.

Table 1 Treatment performance of modified cesspool with UST and PBR

Parameter	Influent	Effluent from UST	Effluent from PBR	Total removal efficiency (%)
TS (mg/l)	1380±835	590±220	480±170	65
TSS (mg/l)	355±250	110±55	70±30	80
TCOD (mg/L)	1560±1450	320±200	180±60	88
BOD_5 (mg/L)	500±310	120±80	40±15	92
TKN (mg/L)	240±90	220±300	210±200	13
NH_4-N (mg/L)	140±40	90±40	80±90	43

Remark: average data from 60 samples of 5 months operation

Hydraulic loading rate (HLR) of this study was 100 - 150 m^3/d calculated from the flushing water. Concentrations of blackwater in terms of TCOD, BOD_5 and TSS were in the similar range of the previous study as reported of 1,500, 700, 560 mg/L, respectively (Nam et al., 2006). Effluent concentrations of supernatant of conventional cesspool in terms of TCOD, BOD_5 and TSS were range between 300-1500, 50-300 and 150-500 mg/L (Nam et al., 2006). The low treatment performance was because of the scum on surface and the uncompleted of anaerobic digestion. The impacts of flushing water and ground water were also factors for uncompleted digestion. After modification, the average concentrations of TCOD, BOD_5 and TSS were reduced to 320, 120 and 110 mg/L at the UST and later reduced to 180, 40 and 70 mg/L as the final effluent concentrations of the PBR, respectively. Only UST could be able to trap sludge, TSS, for 70 %. Then, total removal efficiencies of TCOD, BOD_5 and TSS were 88, 92 and 80 %. In this study, the calculated organic loading rate (OLR) of influent was 62.5 gBOD/day which was removed 76% by the sedimentation process at UST tank and 16 % by the biodegradation at the PBR tank. While, the degradation of

organic loading in PBR was 0.67 gBOD/m^2/day of photo-media. Based on results of this study, the modified cesspool system incorporated with UST and PBR of 1.5 day-HRT could reduce BOD concentrations lower than 50 mg/L. This could meet the weak standard of effluent in Thailand.

CONCLUSION

Symbiotic relationship between algae and bacteria was observed PBR in the aerobic condition. It was found that the effluent BOD concentrations can be lower than 50 mg/L at the HRT of 1.5 day of combining UST and PBR tanks. Modified cesspool system with UST and PBR could be a promising low-cost technology to enhance treatment performance.

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