Low Cost Community Based Treatment Unit for Floating Food Vendors and Slum Community in Thailand

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Abstract
In recent years, water pollution in the canals (klongs) in Thailand has become a great concern due to the health and aesthetic problems to the nearby community. Klong Rangsit, one of the canals in Thailand was found to be highly contaminated resulting from the discharge of untreated wastewater from the floating food vendors and slum community residing along the canal. In this study, a low-cost aerobic wastewater treatment system was designed and fabricated for use by the food vendors and the slum community to improve the canal ecosystem. Monitoring of the treatment system installed in eight food vendors seemed to function as designed despite constraints in size, irregular incoming wastewater flow pattern, and high fluctuation in wastewater quality. For some units, as much as 86% BOD reduction, 99.2% oil and grease reduction and 99.9% suspended solids reduction were achieved, although the effluent quality was not able to consistently meet the local standard for building effluents. Proper maintenance seemed to play a major role in a more effective performance of the system. In the future, similar treatment units can be installed in other floating food vendors located along the canals throughout Thailand.

Introduction
Klong Rangsit, the first irrigation canal in Thailand, was built during the time of King Rama V (1868 -1910), for navigation and agricultural purposes (Suntravanit and Prasongsom, 1997). It is located in Rangsit, an area east of Chao Praya river comprising the following provinces: Pathumthani, Nakornnayok, Ayuthaya, Saraburi, Chachoengsao and Bangkok. Industrialization and development of agricultural communities around the canal have created many new settlements – villages, hospitals, restaurants and factories. These settlements are accused of polluting water in the Klong. Food vendors selling noodles on floating boats along the Klong are a common sight in Thailand, but the discharge of untreated wastewater from these vendors and the nearby community has caused the deterioration of the water quality of the Klong. Since the Klong water is also used by the food vendors and the slum community for domestic purposes, the highly contaminated klong water can be a source of waterborne diseases affecting the health of these people. The current situation therefore calls for improvement in the water quality of the Klong. Moreover, the recent plan of the local government to use the Klong for recreation and tourism purposes has prompted the need for a more sustainable way of protecting the Klong water from further degradation of its ecosystem.

This study attempted to protect the ecosystem of Klong Rangsit by creating environmental awareness and introducing a low-cost wastewater treatment system to the floating vendors and the slum community in the area. Baseline information on the Klong water quality and wastewater quality from the food vendors was used to design the low-cost wastewater treatment system. In order to determine the effectiveness of the treatment system, monitoring

was done after installation in selected participants of the project. Moreover, dissemination of information was done through publication of a Thai manual outlining the benefits of wastewater treatment and proper operation of the treatment units.

Methodology

Survey of study area

The area selected for the study consisted of five sub-canals of Klong Rangsit i.e. Klong Rangsit 1-5 in Pathumthani province, Thailand. Klong Rangsit 1-2 are under the jurisdiction of the Rangsit municipality while Klong Rangsit 3-5 are under the Buengyeetho sub-district office in Pathumthani. A preliminary survey of the floating food vendors and the slum community residing around the selected Klongs was done to determine background information on their water use, wastewater discharge and other environmental practices, as well as health condition and sanitation of the community.

Water and wastewater analysis

Water samples were collected from selected areas along Klong Rangsit 1-5, while wastewater was randomly collected from 11 floating food vendors in the study area. Wastewater samples collected come from dishwashing operations without treatment, as well as those which underwent pre-treatment such as sieving or oil skimming before being discharged into the Klong. Water and wastewater analyses were done on the following parameters: pH, biochemical oxygen demand (BOD), dissolved oxygen (DO), Total kjeldahl nitrogen (TKN), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), oil and grease, turbidity, color (only for water analysis), total coliform and fecal coliform bacteria. Analyses were done according to the Standard Methods for Examination of Water and Wastewater (APHA et al., 1998). The water and wastewater qualities were compared with the local standards on surface water quality and building effluents.

Design of low-cost wastewater treatment system

Based on the wastewater characteristics of the floating food vendors, a low-cost waste water treatment system (Figure 1) was designed for both the food vendors and the slum community.

Figure 1. Low-cost wastewater treatment unit placed underneath dishwashing basins for floating food vendors.

Factors such as size, practical use, operation and maintenance of the system were also considered in the design. The treatment system employs both physical and biological

processes. The system for the food vendors consists of an oil skimmer (left) with a capacity of 30 liters and the treatment bucket (right) of 60 liter capacity. The oil skimmer is used to reduce oil and grease from the wastewater while the treatment bucket is where both physical and biological treatments occur. For physical treatment, a sand filter is used to separate the inorganic solids from the wastewater, while biological treatment (aerobic) is accomplished by the microorganisms cultured in the bioballs. About 4 liters of sand and 300-400 balls are used. For the slum community, the treatment system consists only of the plastic treatment bucket since the wastewater from the community does not contain high amount of oil and grease.

Before fabrication, the efficiency of the treatment system was initially tested by monitoring the COD of the synthetic wastewater, then with wastewater of similar quality as the food vendor. The treatment system was operated aerobically (with air) and anaerobically (without air). Aerobic treatment for synthetic wastewater was done with initial influent concentration of 500, 1,000 and 3,000 mg/L at 5-12 hours and 17-25 hours hydraulic retention time (HRT) for 2 months with continuous feeding. Anaerobic treatment was done with the same influent concentration but with HRT of only 24 hours. The performance of both systems was then compared for final design and fabrication.

Monitoring

A total of 36 units were installed at 21 floating food vendors and 15 households from the slum community. Monitoring was done on the system installed at eight floating food vendors in the Klong. Parameters for monitoring included BOD, oil and grease, TSS and pH, which were analyzed according to the Standard Methods for The Examination of Water and Wastewater (APHA et al., 1998). To ensure proper operation of the system and create environmental awareness among the participants of the project, a booklet in Thai was produced describing water pollution and its impact to the environment, and the low-cost wastewater treatment unit and its proper operation.

Results and Discussions

Survey results

The floating food vendors are food restaurants that float along the bank of Klong Rangsit who sell mainly noodles and operate everyday from late morning till evening. Most floating food restaurants are family-owned, and for some, the boats have become their homes. There are a total of 32 food vendors residing along Klong 1-5. The food vendors use water for a variety of purposes such as drinking, bathing, clothes washing, dishwashing and sanitation, and come from various sources: bottled water (mainly for drinking), tap water and klong water. A small number of food vendors employs pre-treatment (such as the use of alum) of the Klong water before use. About 44% of the food vendors use the Klong water for cleaning, especially for dishwashing and water use per vendor ranged approximately from 60 – 400 liters per day. About 66% of the wastewater is pre-treated using oil skimmer before discharging into the Klong. Although only 34% of the food vendors have proper sanitation facilities (toilets with septic tanks), the health condition of the food vendors is normal as revealed in the survey results.

The slum community called “Bahn Sum Raan” consists of 30 households with a total population of 90. The water used by the community for bathing, clothes and dish washing also come from the tap and the Klong. Bottled water and tap water are used for drinking

purposes. Wastewater produced by the community is discharged into the Klong without treatment. Most of the households have their own sanitation facilities (toilet with cesspool). Survey revealed that the members of the community suffer frequently from skin diseases, as well as respiratory and intestinal tract diseases.

Water and wastewater analysis

Analysis of the Klong water revealed the following: BOD (3-8 mg/L), TSS (7-19 mg/L), TS (260 - 400 mg/L), TDS (240 - 400 mg/L), TKN (2.8 - 4.2 mg/L) total coliform (7.0×10^7 - 1.5×10^9 MPN/100mL), fecal coliform (3.0×10^7 - 7×10^7 MPN/100mL), and DO (0.6 - 2.4 mg/L). The results showed that according to the surface water quality standard of Thailand (National Environment Board, 1994) the low DO and high BOD values of the Klong water make it unsuitable for use as class 3 i.e., medium clean fresh water resources for used in consumption after ordinary treatment and agricultural purposes. The low oxygen level can negatively affect aquatic organisms leading to foul smell, while high BOD values indicate high organic matter in the Klong. The high amount of nitrogen might stimulate rapid growth of aquatic plants, algae and bacteria causing aesthetic problems in the Klong. The large number of total and fecal coliform in the water indicates possible contamination from human activities and other warm-blooded animals. Fecal coliform can cause waterborne diseases such as cholera and typhoid. Thus, the Klong water was found to be unsafe for domestic purposes.

Analysis of wastewater from floating food vendors showed the following: BOD (100 - 2,100 mg/L), TSS (12 -14,100 mg/L), TDS (300 - 6,100 mg/L), TKN (2.8 - 4.2 mg/L), TS (300 - 15,400 mg/L), total coliform (4.3×10^6 - 1.1×10^{10} MPN/100 mL), fecal coliform (7.5×10^5 - 9.3×10^8 MPN/100 mL) and oil and grease (2-12,800 mg/L). The pH of the washing wastewater ranged from 4.2 to 7.2, which seemed to be quite acidic. The results showed that the upper values of BOD, TSS and oil and grease of the wastewater exceed the local building effluent standards for restaurants and food shops or food centers, which are 200 mg/L, 60 mg/L and 100 mg/L, respectively (National Environment Board, 1994). Although some floating food vendors use oil skimmer as pre-treatment for wastewater prior to their discharge, results showed that the pre-treatment was not adequate due to the lack of maintenance of the equipment. In order to minimize further degradation of the water quality of Klong Rangsit, there is a need to treat the wastewater from floating food vendors before discharging into the Klong.

Design of low cost wastewater treatment system

The treatment system designed as shown in Figure 1, was first tested to determine the treatment process to be used, i.e., whether aerobic or anaerobic. The disadvantage of using anaerobic system is the unpleasant odor caused by hydrogen sulfide and ammonia produced. For the aerobic system, oxygen requirement makes the process more expensive compared to anaerobic system. Despite these limitations, aerobic system is still affordable costing only 5,580 Thai Baht ([*] US$ 172) with oil skimmer, and Thai Baht 3,560 (US$ 109.50) without oil skimmer.

Results of testing for aerobic process are shown in Figure 2. As shown, an 80% average COD reduction was achieved for influent concentration of 500 mg/L. At the influent concentration of 1,000 mg/L and 3,000 mg/ L, average COD reductions achieved were 75% and 60%

[*] 1 US$ = 32.50 Thai Baht

respectively. It was also found that the range of HRT (5-12, and 17-25 hours) as tested, did not affect the performance of the system as shown in Figure 2, where the range of COD reduction remains unchanged regardless of HRT used in the process. Variation in COD reduction in the system might have been caused by less DO in the system due to excess microorganism, and clogging of air diffusers.

For the anaerobic system, the average COD reduction achieved at 24 hours HRT was only 40%. Compared to aerobic system, efficiency achieved for anaerobic system was lower as shown in Figure 3, and hence, aerobic system was used in the final design and fabrication of the low-cost wastewater treatment system.

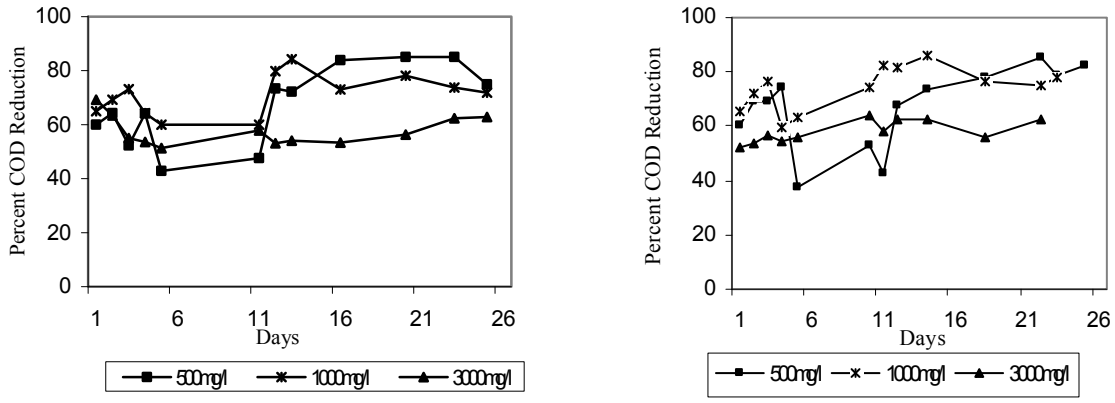

Figure 2. Percent COD reduction over 25 days with (a) HRT of 5-8 hours and (b) HRT of 12 – 18 hours.

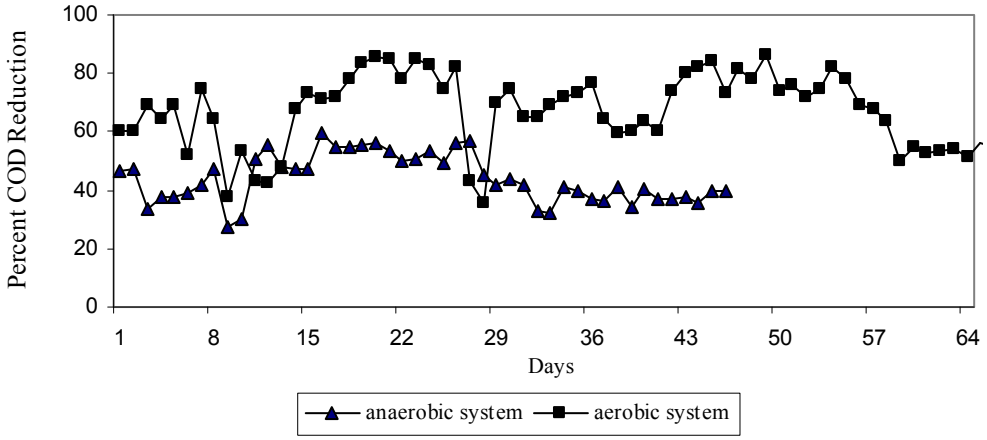

Figure 3. Comparison between aerobic and anaerobic processes for low-cost wastewater treatment system.

Monitoring of treatment system

Monitoring done on the treatment system of the eight food vendors (F1-F8) showed wide variation in efficiencies in terms of parameters analyzed as shown in Figure 4. Reduction of BOD ranged from 47.2% from F1 treatment system to 86.2% from F7 treatment system. Oil and grease reduction ranged from 53.7% from F1 to as high as 99.2 from F3, while suspended solids reduction ranged from only 8% from F1 to as high as 93.9% from F7. Highest system

performance was achieved from units with proper maintenance, adequate aeration, and longest operation time (such as F7). It was also found that the unit is able to tolerate the partial aeration and low pH of the dishwashing wastewater. The effect of pH on system performance may depend on the buffering capacity of the wastewater as well as its prolonged exposure to the microbial population. The effective removal of suspended solids and oil and grease is highly dependent on the maintenance of sand bed and the oil skimmer.

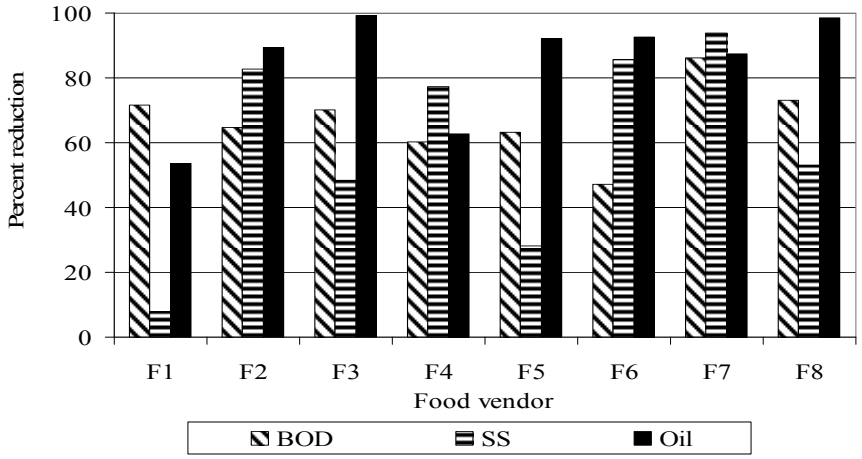

Figure 4. Percent reduction of BOD, Oil and grease and TSS of the low cost wastewater treatment systems from food vendors F1 – F7.

Conclusions

The quality of the wastewater discharged from floating food vendors was found to be highly contaminated and therefore have to be properly treated before discharge into the fast deteriorating Klong water. The low-cost wastewater treatment system fabricated for both the food vendors and the slum community seemed to function as designed despite constraints in size, irregular incoming wastewater flow pattern, and high fluctuation in wastewater quality (such as BOD, pH), achieving as much as 86% BOD reduction, 99.2% oil and grease reduction and 99.9% suspended solids reduction for some units. Although, the effluent quality was not able to consistently meet the local standard for building effluent of 200 mg/L, fabrication of more units of the treatment system can still be done for use by other floating food vendors in water canals throughout Thailand. For a more effective performance of the system, proper maintenance seemed to play a major role.

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