SUBSURFACE - FLOW CONSTRUCTED WETLAND : PROPOSED DESIGN AREA FOR HIGH STRENGTH EFFLUENT DOMESTIC WASTEWATER

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ABSTRACT
The generation of wastewater becomes higher due to the large number of student and staff enrollment is a result of rapid development in KUiTTHO.. Currently some of the wastewater was treaten by using individual septic tank. Some of them collect more wastewater consequently increased the hydraulic and nutrients loading. This paper describes the study of effluent domestic wastewater treatment using sub-surface flow (SSF) constructed wetland. A model of 3 day retention time SSF constructed wetland was build, has gravel and planted with submerged vegetation, cattails (Typha angustifolia). However, studies on the suitability of these plants have been reported are very limited under tropical climate. This study was conducted to measures the effectiveness of SSF constructed wetland to treat the effluent domestic/septic tank wastewater. This study had focused in BOD_5, COD and suspended solids. The results showed that SSF constructed wetland has a potential in polishing high strength effluent domestic/septic tank wastewater. The proposed area was depends on the pollutant removal percentage, the big area is needed for higher removal. The area of 56 m^2, 31 m^2 and 28 m^3 approximately are required each for SS, BOD_5 and COD removal respectively.

Keywords: domestic wastewater, subsurface-flow constructed wetland, cattails (*Typha angustifolia*), removal, area,

1.0 Introduction

The large number of student and staff enrollment is a result of rapid development in KUiTTHO. Thus, the generation of wastewater becomes higher. Currently some of the wastewater was treaten by using individual septic tank. Although septic tanks have been reported to be efficient in the pre-treatment of wastewater, in most cases however, the standard for effluent emission and disposal into receiving bodies are not achievable. The effluents from septic tanks have been reported to contain biological oxygen demand (BOD), chemical oxygen demand (COD), nutrients and pathogenic microorganisms at concentration levels which are far higher than the recommended standards for effluent disposal (M.E Kaseva, 2004).

Poor effluent quality means that the treatment process is not providing the equivalent of a secondary treatment and is often unacceptable for direct discharge in receiving water bodies prior to further polishing it in post-treatment systems. These system are many time ineffective due to shallow soils or poor soils percolation rates, high groundwater table, karst topography or other aspects leading to inefficient treatments (Jorge, 2004). Inadequate treatment of domestic wastewaters contributes to pollution of surface water and might led to groundwater problems.

To cope with the rapid development and the need for the appropriate low cost domestic wastewater treatment to supplement the septic tanks, the subsurface flow constructed wetland has been studied for the treatment of high strength effluent domestic wastewater in particular area in Kolej Universiti Teknologi Tun Hussein Onn, Batu Pahat, Johor.

One of the most promising technologies for the effluent domestic wastewater is natural system which is constructed wetland. A necessary requirement to consider to apply natural systems for the wastewater treatment of a small community are natural systems currently applied can be appropriate to this community, the sources of sewage, the climate and the characteristics of the land. In general, domestic wastewater is composed of a variable array of components characterized by the presence of biodegradable organic matter, particulate and dissolved solids, and nutrients (Jorge, 2004).

From the difference types of natural system potentially applicable for wastewater treatment in small community, the wetland systems occupy an outstanding place because of its advantages and capabilities in order to obtain high quality effluents. Furthermore, constructed wetland have some important characteristics include low construction and operating costs and they are appropriate both for small communities and as final stage treatment in large municipal system (Mohd Fariz Ismail, 2006).

The two basic types of constructed wetland treatment systems included constructed Free Water Surface Systems (FWS) and constructed Subsurface Flow System (SSF). In SSF, the water level is maintained below the surface of the permeable media used in the bed, where the major oxygen source is transferred by the plants to their root systems. These systems are designed to create subsurface flow through a permeable medium, keeping the water being treated below the surface (Jorge, 2004). SSF are engineered systems comprised of one or more, cells lined with low permeability liner. Each cell is filled with porous media, typically gravel and planted with emergent plant species such as reeds (*Phragmites communis*), bulrushes *(Scripus* sp.), cattails (*Typha* sp.), rushes (*Juncus* sp.) and sedges (*Carex* sp) (Bill Leady 1997).

Most of the studies on SSF had used *T. latifolia* as an emergent plant alone or combined with others. *T. latifolia* (broad leaf cattail) is one of Cattail typical varities besides *Typha angustifolia* (narrow-leaf cattail). M.E Kaseva (2003) reported on the performances of a subsurface horizontal flow (SSHF) constructed wetland pilot plant to treat domestic wastewater which was discharged from the student's hostel. The study was carried out at hydraulic retention time of 1.99 days and found that COD removal rate is 60.7 %. The study also indicated that pH increased from the influent to the effluent, probably due to nature of the substrate material (limestone) used in SSF fortunately the changes was within the recommended range ($4.0 < pH < 9.5$). The increase in DO was accompanied with the decrease in temperature.

A study on treatment of effluent septic tank using SSF has been carried out by J Henneck *et al*. In this study a system of SSF was used initially designed to achieve a secondary level of treatment 25mg BOD_5/L and 30 mgTSS/L. This design was based primarily on the EPA/TVA manual with additional size to increase potential for N-removal via nitrification/denitrification. The design parameters for studied SSF were 89m^2 area, 21.4 m^3 volume, 0.63 m^3/d discharges with cattail plants. The results showed that BOD and TSS removal were 79 ± 26 % and 57 ± 47%. Removal for both constituents is higher in summer compared to winter. Five years performance monitoring indicated that SSF constructed wetland area viable, year–round onsite treatment option where the system generally able to achieve design criteria of 25mg BOD_5/L and 30 mgTSS/L.

The Rocky Mountain Shambhala Center wastewater facility is a small evaporative system. Each building in the community has an individual septic system. Overflow from these septic systems are collected and conveyed to a bank of 6 – 2200 gallon septic tanks. Overflow from these tanks is then distributed into two parallel subsurface wetland cells. The design method based on first order plug flow for BOD and the nitrogen removal model was developed by Reed, Middlebrooks, and Crites. The primary design objectives for this system were to decrease BOD and TSS in the septic overflow. This system has two parallel subsurface flow wetland cells that each has a surface area of 5000 square feet (467.3 m^2) which designed to achieve BOD 10mg/L and TSS 50 mg/L. Vegetation cover in both cells of the SSF constructed wetland was less than 30 percent. With the species present, cattail (*Typha latifolia*) is dominant. Other species include hardstem bulrush (*Scirpus acutus*), Nebraska sedge (*Carex nebrascensis*), beaked sedge (*Carex rostata*), curly dock (*Rumex crispus*), and wild iris (*Iris missouriensis*). Both willow (*Salix* spp.) and chokecherry (*Prunus virginiana*) were recently planted in less saturated areas of the subsurface wetland. The results indicated the removal rates in the wetland system varied over the two-year study period were BOD removal fluctuated from a low of 45% to a high of 97% and TSS removal fluctuated between 50% and 70%. Water quality data show the system is not operating to the level intended. However, it does perform the function of polishing septic overflow before discharge into an evaporative lagoon.

2.0 Materials and Method

2.1 Experimental set up

The experimental set up which was used for continuous feeding in this study is shown in Fig.1. The SSF constructed wetland was planted with *Typha Augustifolia*. The effluent wastewater was collected everyday and placed in container and pumped to the SSF model with 2.43 ml/min flowrate.

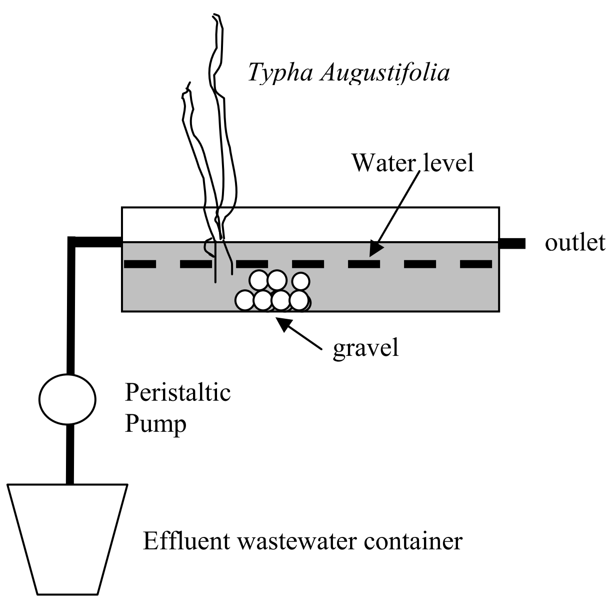

Fig.1 A schematic diagram of the SSF Constructed Wetland

2.2 Monitoring

Wastewater influent and effluent from the SSF constructed wetland were monitored and recorded daily. In situ measurements for temperature, pH and Do were also recorded daily at sampling point. The wastewater samples were collected daily through out the study period. Samples were analyses for BOD_5, COD and SS. All analyses were conducted in accordance with the 19^{th} Edition of the Standard Methods of the Examination of Water and Wastewater.

3.0 Results and Discussions

3.1 Dissolved Oxygen, pH and Temperature

In this study, the influent ranges observed for dissolved oxygen (DO), pH and temperature were 1.50 – 2.91 mg/L, 6.3 -7.2 and 23.5 – 27.2 ^{0}C respectively. The pH observed ranges is within the recommended range (4.0 < pH < 9.5) for promising constructed wetland performance. The relation of DO-temperature could be interpreted as increase in DO was related to the decrease in temperature. Table 1 shows the in situ measurements of DO, pH and temperature.

Table 1 In situ Measurements of DO, pH and Temperature

Sampling	DO (mg/L)	pH	Temperature (^{0}C)
#1	2.91	6.3	23.5
#2	1.91	7.1	26.4
#3	1.76	7.1	27.2
#4	1.50	7.2	27.2

3.2 BOD_5 Concentration and Removal

BOD_5 concentrations for effluent septic tank in this study were found exceed the effluent standard requirement of 50BOD_5 mg/L (Environmental Quality Acts, 1974). Thus, it can be categorized as high strength domestic effluent. It is proved that the septic tank in the study area is not work within the design parameter especially in BOD removal. The range, mean and standard deviation are presented in Table 2. The results shows that SSF constructed wetland had effectively removed BOD_5. Furthermore, effluent BOD_5 is complied with standard requirement of 50BOD_5 mg/L. By considering the results obtained, the surface area for SSF constructed wetland for removing BOD is 31 m^2.

Table 2 BOD_5 Measurements (mg/L)

Sampling	Inlet	Outlet	Removal (%)
#1	59.0	14.2	75.9
#2	75.5	24.1	68.1
#3	72.4	17.8	75.4
#4	76.0	15.1	80.1
Mean	70.7	17.8	74.9
Standard Deviation	8.0	4.5	5.0

3.3 COD Concentrations and Removal

The COD concentrations ranges of effluent septic tanks and removal percentages in the SSF constructed wetland detected during this study are presented in Table 3. The COD concentrations of effluent septic tanks are obviously greater than the effluent standard of 100COD mg/L (Environmental Quality Acts, 1974). The inadequate treatment within the septic tank may leads to the water pollution to the receiving water bodies. The table shows that the BOD:COD ratio is greater than 1: 2. The COD removals within the SSF constructed wetland not occur well where the effluent COD reach the standard limit. This study indicates that the combination of *Typha Augustafolia*-gravel may be not a good combination in treating high strength effluent septic tank. Thus, revealed that the SSF constructed wetland performance is depend on wastewater characteristics, plant, gravel etc. By considering the COD mean value, the surface area for SSF constructed wetland for removing COD is 28 m^2.

Table 3 COD Measurements (mg/L)

Sampling	Inlet	Outlet	% Removal
#1	270.0	92.0	65.9
#2	376.5	88.5	76.5
#3	139.5	86.5	38.0
#4	399.5	69.5	82.6
Mean	294.4	84.1	65.8
Standard Deviation	118.8	10.0	19.7

3.4 SS Concentrations and Removal

In this study, the SS concentrations of effluent septic tank were from 140 to 220 mg/L with average was 172.5 mg/L. This concentrations is categorized as high strength effluent septic tank, means that the values not comply to effluent standard requirement of 100 SS mg/L (Environmental Quality Acts, 1974). The SSF constructed wetland used in this study performed well in SS removal. The SS removal for each sampling is exceeded 80 % with an average removal of 92.1 %. Furthermore, the effluent SS concentrations for the SSF constructed wetland are much lower than 30 mg/L. To achieve these great SS removal, a area of 56 m^2 is needed. Thus, it revealed that to achieve the greater removal percentage, a bigger surface area is needed.

Table 4 SS Measurements (mg/L)

Sampling	Inlet	Outlet	% Removal
#1	215.5	16.0	92.6
#2	143.5	10.0	93.0
#3	182.5	20.0	89.0
#4	148.5	9.5	93.6
Mean	172.5	13.9	92.1
Standard Deviation	33.5	5.0	2.1

4.0 Conclusion

Domestic wastewater treatment using septic tank has accepted as sanitary technology in developing countries. However inadequate treatment in septic tank will produce to water pollution where the effluent discharged could categorized as high strength effluent wastewater. The hypothesis that the SSF constructed wetland is an efficient post-treatment system for effluent septic tank could be confirmed in this study. The removal percentage for BOD_5, COD and SS are 74.9%, 65.8 % and 92.1% respectively where effluent BOD_5 and effluent SS are much lower compared to effluent standard requirements. By considering the average concentration of BOD_5, COD and SS, the surface area of SSF constructed wetland are 31 m^2, 28 m^2 and 56 m^2 respectively. Furthermore, to achieve the greater removal percentage, a bigger surface area is needed. However the combination of *Typha Augustafolia*–gravel might be not a good combination to treat high strength effluent septic tank in term of COD removal. The SSF constructed wetland seem to be appropriate since in tropical countries there is a year-round suitable climate condition for rapid biological growth, which influences the treatment processes. Removal efficiencies obtained in this study suggest a need for further research to show that SSF constructed wetland is capable in producing final effluent, which can meet the requirement standards of for each parameter stated in Environmental Quality Acts 1974.

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