ORIGINAL ARTICLE

Post-treatment of upflow multi-layer granular media beds column in septic tank system

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Abstract. Septic tanks are used to collect black water as an on-site treatment system. However, the septic tank's effluent is still contained a high concentration of pollutants. Several post-treatment processes remove those pollutants, such as media filtration, membrane filtration and electrochemical process. Therefore, upflow muti-layer granular media beds were applied as post-treatment of septic tank effluent. The muti-layer granular media beds comprise alum sludge and granular activated carbon (GAC). Alum sludge media containing high concentrations of iron and aluminium could provide oxidative damage to the pathogens. GAC bed could remove organic compounds and adsorb nutrients. Development for a kinetic model of muti-media layers found that the k_{20} values for BOD removal efficiencies were 4.23 day^{-1} with the R^2 value of more than 0.75. Nevertheless, the kinetic value with actual scale data should be validated.

Keywords: *Aspergillus* sp. MMERU 24, Biodiesel, Marine fungi, Oleaginous, Single-cell oils.

1. Introduction

Septic tanks have been used as a primary treatment device to treat sewage or black water. The effluent of the septic tank is still contained high concentrations of pathogen, solid and organic matter (Koottatep et al. 2005, Pusayanavin et al. 2018). To achieve a certain degree of effluent quality, leaching fields or constructed wetlands are commonly used for secondary treatment to remove those pollutants. However, large area requirements for the secondary treatments are not suitable for densely built cities. Thus, the post-treatment systems to be applied in the septic tank system should be compact and effective. Multi-layer granular media beds column (consisting of alum sludge media and granular activated carbon (GAC)) was found to be an innovative and effective treatment technology (Tamarit et al. 1998). When aluminium (Al) salts are utilized in the coagulation process, alum sludge is the by-product produced by water purification and wastewater treatment facilities. In the literature data, post filtration is provided following the GAC columns to remove organic compounds and adsorb nutrients, while alum sludge containing high concentrations of iron and aluminium could oxidative damage to the pathogens (Touati 2000; Hatt et al. 2013). This study aimed to develop design criteria for up-flow multi-layer granular media beds column as a post-treatment for septic tank system.

2. Materials and Methods

The multi-layer granular media beds column consists were made of PVC pipe (4 inches) and packed with 20 cm of alum sludge (bottom) and 10 cm of granular activated carbon (top) (Figure 1). The multi-layer granular media bed columns were operated at HRTs of 1.5, 3, 6 and 12 h and continuously fed with actual septic tank effluent. Alum sludge was collected from the water treatment in Bangkok, Thailand. To *prevent biofouling,* multi-layer granular media beds column was operated by *upflow feeding*. The effluents were taken twice a week for an analysis of chemical oxygen demand (COD), biochemical oxygen demand (BOD), ammonia nitrogen (NH_3-N), total solid (TS), total volatile solids (TVS), total suspended solids (TSS), total coliform and total *E. coli* (APHA 2005).

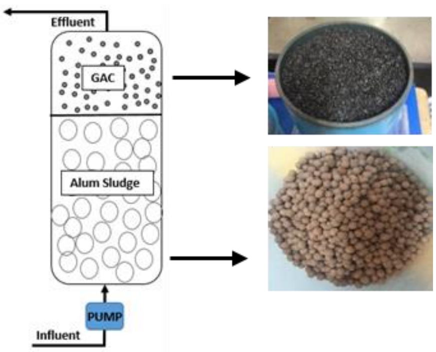

Figure 2. The reactor with muti-media layers

3. Results

The average concentrations of COD, BOD, NH_3-N, TS, TVS and TSS of septic tank effluent were found to be 150±63, 70±47, 55±8, 460±77, 150±46 and 40±15 mg/L, respectively. The total coliform and total *E. coli* were found to be 1.19×10^5 and 2.53×10^4 CFU/mL, respectively. The characteristics of effluents at various HRT are summarized in Table 1. The concentrations of COD, BOD, NH_3-N, and TSS of the effluents were found to decrease with increasing HRT.

The results demonstrated the applicability of first order equation (Metcalf and Eddy 2014) (Eq 1) with the R^2 value of 0.902.

$$\frac{C}{C_0} = \frac{1}{1+k_T t} \qquad (1)$$

Where: C is effluent concentration of BOD (mg/L), C_0 is influent concentration of BOD (mg/L), t is HRTs (h), kT is first-order rate constant at temperatures T (d-1) according to

$$k_T = k_{20}\theta^{T-20} \qquad (2)$$

Where: k_{20} is first-order rate constant at a temperature 20 C (d^{-1}), is the temperature coefficient, which is 1.05. For a first-order reaction, plotting ln[C] with respect to time result in a straight line with a slope equal to k. The k_{20} for BOD removal calculated from Eq.1 was found to be 4.23 day^{-1}. Validation of kinetic values with the results obtained from this study and literatures was done with the correlation coefficient (R^2) values of the model were about more than 0.75.

Table 1. The characteristics of effluents at various HRT

HRT (h)	Parameters							
	COD (mg/L)	**BOD** (mg/L)	**NH_3-N** (mg/L)	**TS** (mg/L)	**TVS** (mg/L)	**TSS** (mg/L)	**Total coliform** (CFU/mL)	**Total *E.coli*** (CFU/mL)
1.5	60±16	20±8	50±9	350±55	90±31	20±9	1.28×10^3	4.57×10^2
3	40±14	20±8	50±10	350±45	80±28	20±10	1.11×10^3	5.70×10^2
6	40±18	20±10	40±9	440±47	90±19	10±7	7.09×10^2	1.24×10^2
12	30±14	20±10	40±7	440±35	80±18	10±9	1.02×10^4	6.57×10^2

4. Discussion

In this study, a relatively high k_{20} of BOD was probably due to mainly physical mechanism but instead with biological reaction. However, it should be noted that the kinetic values for the design and operation of this study TCOD and BOD_5 are applicable for operating of the HRTs of 1.5-12 h and further validation of the kinetic value with actual scale data is required

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