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FOOD CENTER WASTEWATER PROCESSING USING *SLOW SAND FILTRATION* AS SUSTAINABLE ALTERNATIVE TECHNOLOGY IN URBAN AREA

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ABSTRACT

The number of food centres in urban areas has resulted on the amount of wastewater generated. Most of discharged wastewater is not treated which becomes one of causes of water pollution and sustainable technology is required to treat the wastewater. This research aims to determine the effectiveness of bio-filter in processing wastewater of food centres in urban areas. The bio-filter prototype was designed using 36.6 L glass tubular. Wastewater was flowed from tank A to B at 25 mL/minute with flow rate of 0.24 m/minute. The media used in bio-filter was gravel in diameter of 3 mm, 10 mm, and 0.425 mm. It was observed in the hydraulic retention time (HRT) of 6 hours, 12 hours, and 24 hours. Result showed that bio-filter was effective for wastewater generated from food centres in urban areas. Thus, the effectiveness of TSS removal was 97.19%; BOD was 97.7%; COD was 96.03%; and oil and grease was 99.55%. However, the research did not measure the pH affectivity since it was categorized normal as set by East Java Governor Regulation no. 72 Year 2013

KEY WORDS : Bio-filter, Wastewater, Food centres, Sustainable technology

INTRODUCTION

Water is important for living. Clean water availability is vital in developing a nation due to its usability in supporting public health and economy development. Therefore, the availability of clean water as well as good sanitation and hygiene service is significant especially in protecting and developing human resources (Guchi, 2015).

Nowadays, almost all ground water in the world has been contaminated and polluted (Albrechtsen, 2016). More than 70% of fresh water bodies are polluted. This condition is a cause for concern because it is not impossible that clean water will become rare in the future and it is due to unfriendly activities done by human to fulfil one's needs (Turcios and Papenbrock, 2014) (Garkal *et al*., 2015). Food is one of basic needs of human life which cause them ignore the environment.

The development of food centres in urban areas to fulfil people needs impact the environment. Those activities generated wastewater discharged to water bodies without performing any prior treatment. The untreated wastewater expedites eutrophication process and changes water quality (Angelakis and Snyder, 2015). Thence, wastewater treatment is very important to maintain the availability and sustainability of industrial development especially the food industry in future. In order to guarantee the selected technology well-developed in the future, wastewater treatment should be safe, reliable, cost effective, environmental friendly. Besides, it should adjust the wastewater character and the purpose of wastewater treatment (Aziz and Ali, 2016).

Slow sand filter (SSF) is one of simple technology used to eliminate or reduce many pollutants. It is a passive process where the affectivity depends on the bio-film on media called as *hypogeal* (Nancy, *et al*., 2014). Bio-film is microorganisms which are able to dissolve pollutants in the water (Tripathi and Tripathi, 2011).

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The advantages in using SSF are low operational cost, low energy consumed, and no sideline pollutant generated (Abraham *et al.*, 2015); (Ardjmand and Safekordi, 2005). The success in implementing SSF technology was reported by prior researches such as research of wastewater treatment in cigarette and petrochemical industry (Omri *et al.*, 2013) (Coustumer *et al.*, 2008).

Based on the prior success in implementing SSF technology, this research aims to determine effectiveness of SSF technology for wastewater treatment of food centres in urban areas.

MATERIAL AND METHODS

Samples of wastewater was taken from effluent pipe of food centres in one of urban area. Sample taken was 25 litres. Before flown into the bio-filter, the sample was first analyzed its characteristics. Parameters analyzed included pH, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), and oil and fat. The pH analysis used pH meter, whereas for other analyses were gravimetric for TSS, oil and grease, titrimetric reflux for COD and Winkler for BOD. Physico-chemical characteristics are shown in Table 1.

Table 1. Characteristic of wastewater in food centres

Parameter	Point	Effluent standard (East Java Province Government Regulation No. 72 Year 2013)	Unit
pH	8	6-9	
TSS	642	50	mg/L
COD	872	50	mg/L O_2
BOD	453	30	mg/L O_2
Oil and Grease	174	10	mg/L

Based on Table 1, wastewater effluents generated from food centres in urban areas were above the standard set by East Java Province Government Regulation (Gubernur Jawa Timur, 2013). This situation immediately needs to be handled before causing water pollution.

SSF prototype was designed to treat wastewater of food centres in urban areas. The prototype used glass tube of 36.6 L. Wastewater flown from tank A to B at 25 mL/minute with flow rate as 0.24 m^3/minute, and tank C used to store water after passing bio-filter. Fig. 1 shows the SSF prototype design.

The media used in bio-filter was gravel in various sizes. It was arranged from bottom to up as 10 mm pebble flattened up to 10 cm, followed by 3 mm gravel as thick as 5 cm, and the following layer was fine sand sieved using sieving no. 45 as thick as 60 cm.

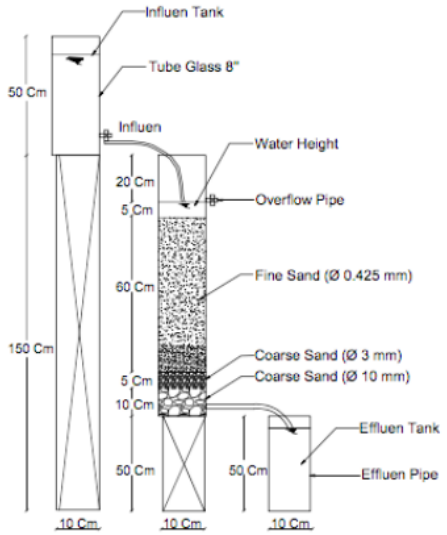

Fig. 1. Design of SSF prototype

Furthermore the water was flown 5 cm above the last layer. The bio-filter effectiveness could be seen by flowing wastewater from tank A to B and storing it in tank C. The debit was maintained in HRT of 6 hours, 12 hours, and 24 hours. The result was determined by analyzing effluent in tank C using the same method as in analyzing the influent.

RESULTS AND DISCUSSION

Amongst all parameters observed in this research, only pH that met the effluent standard set by the government. The results showed that pH of wastewater from food centres were from 7.5 to 8.0 indicating optimal conditions for biological activity in SSF (Rooklidge and Ketchum, 2002); (Trnovec and Britz, 1998). The optimal value of pH affected removal efficiency of other parameters in SSF.

Fig. 2 shows pH decrease from beginning until HRT 6 hours, 12 hours, and 24 hours. pH decrease was possibly caused by the adjustment process of media and wastewater. At HRT 48 hours, pH

gradually increased until at 7.8 and remained stable afterward. It showed that SSF condition was stable and microbacteria in the media started forming bio-film.

Other parameters observed were TSS. This research obtained TSS removal efficiency of 97.19%. Fig. 3 shows the highest removal efficiency occurred at HRT 6 hours then in the following HRT (12 and 24 hours) it was relatively stable until at HRT 48 hours. It indicated that the dissolved particles in the wastewater were trapped in the SSF media.

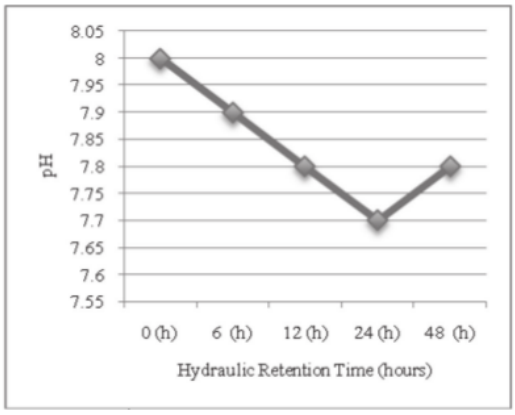

Fig. 2. pH effluent in different HRT

In other researches, implementing SSF possibly reduced TSS as 62% in domestic wastewater treatment (Nancy *et al.*, 2014) on media with 50 cm depth. SSF is affectively proved to reduce TSS to 72.8% in domestic wastewater treatment on media with 200 cm depth (Govahi, 2014). In SSF, the height of media is an important factor to determine the efficiency of filtration process. It is because the existence of new biological activity occurs at a media with depth of more than 0.5 m and an availability of surface area for mechanical filtration (Nancy *et al.*, 2014).

The high efficiency in this research was due to the bio-film layer as a key role in transporting suspended particles. In addition to mechanical adsorption and trapping processes, the existence of bio-film layer increased the particle precipitation at certain flow rates, thereby reducing the particle concentration in water (Bagundol *et al.*, 2013).

TSS removal was highly possibly caused by the physical filtering effect by sand or organic particles attached in media experiencing biological degradation by bio-film (Suprihatin *et al.*, 2017). Most of removal process was in the surface layer of sand media where particulate deposit, algae, as well as bio-masses growth creating layer called as bio-film (Guchi, 2015).

SSF affectivity was also proved in COD removal. In this research, SSF was able to reduce COD to 96.03%. As in the TSS removal process, the highest efficiency was in HRT 6 hours. After HRT 6 h, COD removal was relatively stable (Fig. 4). It was possibly caused by organic particles which experienced biological degradation process over HRT time span of 6 hours - 12 hours. Decreasing in COD along with HRT increase indicated organic material degradation (Araujo *et al.*, 2008).

Fig. 4 shows that the longer HRT was, the higher COD removal was resulted. However, at HRT 48 hours, COD content was increased. Reducing HRT which was resulted in the decreasing COD content showed in other researches as well, where in HRT 3 days, 2 days, and 1 day resulted in COD removal as 44%, 40% and 32% respectively in domestic

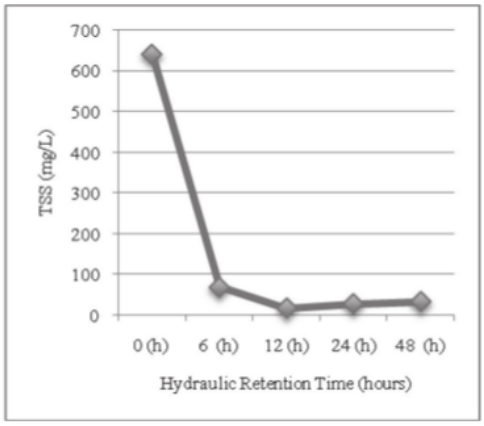

Fig. 3. TSS effluent in different HRT

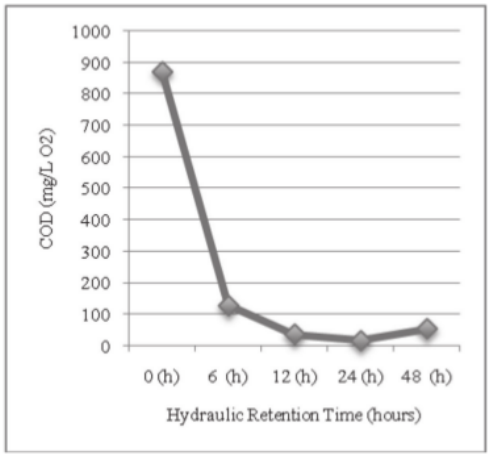

Fig. 4. COD effluent in different HRT

wastewater treatment using *Anaerobic Filtration* (AF) (Ladu & Lü, 2014). Similar condition also appeared in COD removal using bio-filter as 88.2%, 77.7%, 57.7% and 40.3% at HRT 3 hours, 2 hours, 1 hour, and 30 minutes respectively (Suprihatin *et al*., 2017).

Removal efficiency was higher than in other researches as 76%, where SSF was implemented to treat grey water in the media of 100 cm depth and on loading rate of 212 L/hr.m^2 (Abudi, 2011). Other researches using SSF in the media with 200 cm depth resulted COD removal efficiency as 71.85% (Govahi, 2014). Although the depth used in the media in this research was shorter than in the prior research, the grain sizes used was more effective to seize more organic substances.

As well as in TSS and COD, SSF was also effective in decreasing BOD_5 content (Fig. 5). In Fig. 5, the highest removal efficiency was in HRT 6 hours, lowering in HRT 12 hours, and stable in HRT 48 hours. The high removal efficiency in 100 cm depth was due to the oxygen availability so it supported the process in SSF. Generally, the deeper area causes the lack of oxygen which disturbs the removal process of various parameters in wastewater.

BOD_5 removal efficiency was 97.7%. In another research, SSF with 100 cm depth was able to lower BOD_5 as 87% in domestic wastewater treatment (Nancy *et al*., 2014). Similar to prior research, SSF in grey water treatment was able to lower BOD_5 as 83% in the loading rate of 212 L/hr.m^2 (Abudi, 2011). Another research which used SSF with 200 cm depth was obtained BOD_5 as 89% (Govahi, 2014).

High removal efficiency was due to the better biological activity in the depth 100 cm. In this depth, microorganism needed to pass deeper fine sand/ grains resulting in better removal efficiency (Thomas and Kani, 2016). However, according to prior research, in the depth of 200 cm, removal efficiency was lower which was possibly caused by media distribution size.

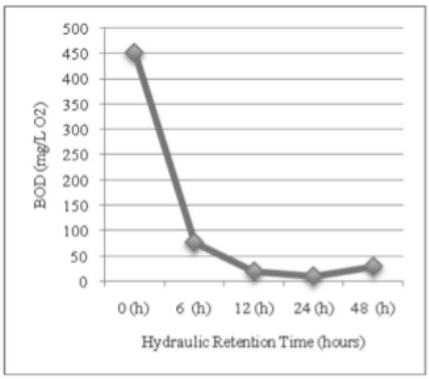

Fig. 5. BOD_5 effluent in different HRT

BOD removal process in SSF was caused by enzymatic process where microorganism in the surface layer of media decomposed the organic substances biologically (Garkal *et al*., 2015).

SSF affectivity happened in oil and grease removal. As in TSS, COD, and BOD, the highest oil and grease removal efficiency was at HRT 6 hours (Fig. 6), thus, at HRT 12 hours, 24 hours, and 48 hours the removal efficiency tended to be stable.

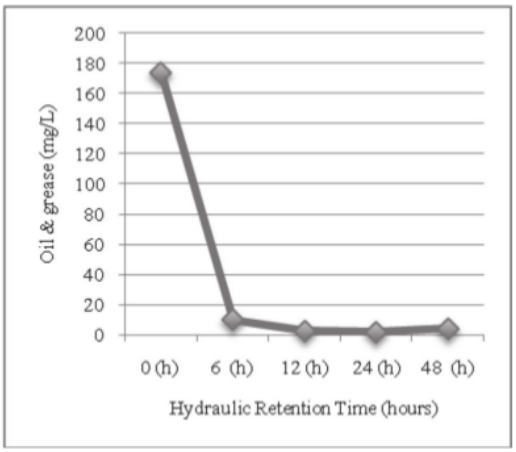

Fig. 6. Oil & grease effluent in different HRT

Oil and grease removal efficiency was 99.95%. those effectiveness was 80% and 90% measured using mixed grain media sized 15 cm and 30 cm to treat the waste in oil refinery industry (Carvalho, Foletto, Barros Neto and Chiavone-Filho, 2016). The different in media depth and distribution was possibly to cause the different in removal affectivity of oil and grease.

CONCLUSIONS

According to research result, bio-filter was proved to be effectively able to treat wastewater generated from food centres in urban areas. Therefore, the removal efficiencies were 97.19% of TSS, 97.7% of BOD, 96.03% of COD, and 99.55% of oil and grease. pH was not specifically measured as it was already fulfil the standard set by East Java Province Government Regulation No. 72 Year 2013.

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