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Prof. Dr. Ir. Enri Damanhuri

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ORGANIC SUBSTANCE REMOVAL USING MODIFIED TRIPIKON-S SYSTEM

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Abstract: *Tripikon-S (Three consentric pipe-septic) technology is modified septic tank to be specifically applied in river, swamp, and high groundwater surface area. The material used are the PVC pipes with three different size and build concentrically each other as the place of anaerobic treatment process. This technology consider as low cost, easy to build, easy finance, and easy replicated wastewater treatment system. Tripikon-S system performance was reported in Saraswati, 2009 with less than 40% removal of organic substance as BOD. In this study, in order to get higher removal efficiency of Tripikon-S system, three Tripikon-S reactors, which are conventional Tripikon-S system, Tripikon-S with the addition of bioball as attached growth media, and Tripikon-S with venturi-aerator shaped chamber inside the system, were examined. Reactors were fed using synthetic domestic wastewater with variation of COD concentration, which are : 1500mg/L and 2000 mg/L. Batch procedure was used to get optimum hydraulic retention time (HRT) in COD removal for each reactor and COD concentration. From this batch experiment, COD removal were found significant in 1-2 days for all reactors and all COD concentracion. Therefore, the next procedure, continuous experiments, were designed using HRT variation for 24, 36, and 48 hours. The highest COD removal were found in HRT 48 hours Tripikon-S with venturi-shaped-chamber, which is 67% removal for 1500mg/L COD inletand 65% removal for 2000mg/L COD inlet. Tripikon-S with addition of bioball performance is slightly different with Tripikon-S with venturi-shaped-chamber addition which are (HRT 48 hours) 66% for 1500mg/L COD inlet, and 64% for 2000mg/L COD inlet.*

Keywords: appropriate technology; organic removal; specific area; tripikon-S; wastewater treatment

1. Introduction

Specific environment, including wet and swampy area around river, estuary, and coastal area, also rocky area, make the application of conventional wastewater system were challenging (Navarro, 1994; Djonoputro et al., 2010; Djonoputro et al., 2011; Sumidjan, 2012). This due to the characteristic of soil that make the construction more difficult with high failure risk, also related to the water table in those specific area (Ghani, 2006; Putri et al., 2014). Other than the specific environment, the settlement in those area, especially in Indonesia and South-East Asia country dominated by illegal settlement and occupied by low income community (Navarro, 1994; Djonoputro et al., 2010; Djonoputro et al., 2011). These issued becoming a challenge to get appropriate technology to be applied both from environmental and community characteristic.

Tripikon-S (Three consentric pipe-septic) technology is the wastewater treatment technology invated by Prof. Hardjoso Prodjopangarso, Gajah Mada University. The system is modified septic tank to be specifically applied in river, swamp, and high groundwater surface area. The materials used are the PVC pipes with three different size and build concentrically each other as the place of anaerobic treatment process, provide 3 days detention time of septic tank system. This technology consider as low cost, easy to build, easy finance, and easy replicated wastewater treatment system (Wijaya et al, 2010) and has big potency as an option of community based technology (Nurmandi, 2012). Not only in river, swamp, and high groundwater surface area, Cahyadi et al (2013) suggested Tripikon-S application in rocky (karst) area. Eventhough Tripikon-S system become one of promising system applied in some specific area, but study about it removal is limited. Tripikon-S system performance was reported in Saraswati, 2009 with less than 40% removal of organic substance as BOD while in Wijaya et al, 2010 reported organic removal (as $KmnO_4$) around 50% to 63% in first month and continue increasing the removal efficiency until 3 to 4 months into about 80%. Both study is based on field used of Tripikon-S.

In order to get higher organic removal efficiency, especially in on site and decentralized wastewater system, several option generally used, which are : 1) using attached growth media, such as biofilter, gravel, bioball, structured packing (Said et al., 2000; Metcalf & Eddy, 2003; Koottatep et al., 2015), 2) Added more chamber to the system (Viet Anh et al., 2008; Koottatep et al., 2015), 3) Using mix condition (aerobic and anaerobic), it is also to increase potency in nutrient removal.

2. Materials and Methods

2.1 Synthetic Domestic Wastewater

Synthetic domestic wastewater were made using glucose ($C_6H_{12}O_6$) as carbon source, ammonium-sulfate ($(NH_4)_2SO_4$ as nitrogen source, KH_2PO_4 as phosphate source, and kaolin ($Al_2Si_2O_5(OH)_4$) as solid compound. Tap water were used as solvent for artificial domestic wastewater. Seeding sludge used cow rumen and septic-tank microbes, with 80% to 20% ratio of synthetic wastewater and sludge with estimated Volatile Suspended Solid (VSS) concentration 2,000 mg/L.

2.2 Laboratory-scale reactors and operating condition

Three laboratory-scale Tripikon-S reactors were used in this experiment. Those reactors are including control Tripikon-S reactor (without modification), Tripikon-S reactor with bioball addition, and Tripikon-S with venturi aerator. The configuration of each reactor was shown in Figure 1. Whole reactors used PVC pipe except the venturi and the biggest chamber in tripikon-S with venturi aerator that used acrylic material. Polypropylene bioball were used as addition media in one modification reactor. The amount of bioball added were 131, with 3.33 cm diameter, 2.6 cm height, specific area 200-240 m^2/m^3, and 86% media porosity. Experiment were conducted in room temperature without any pH regulator.

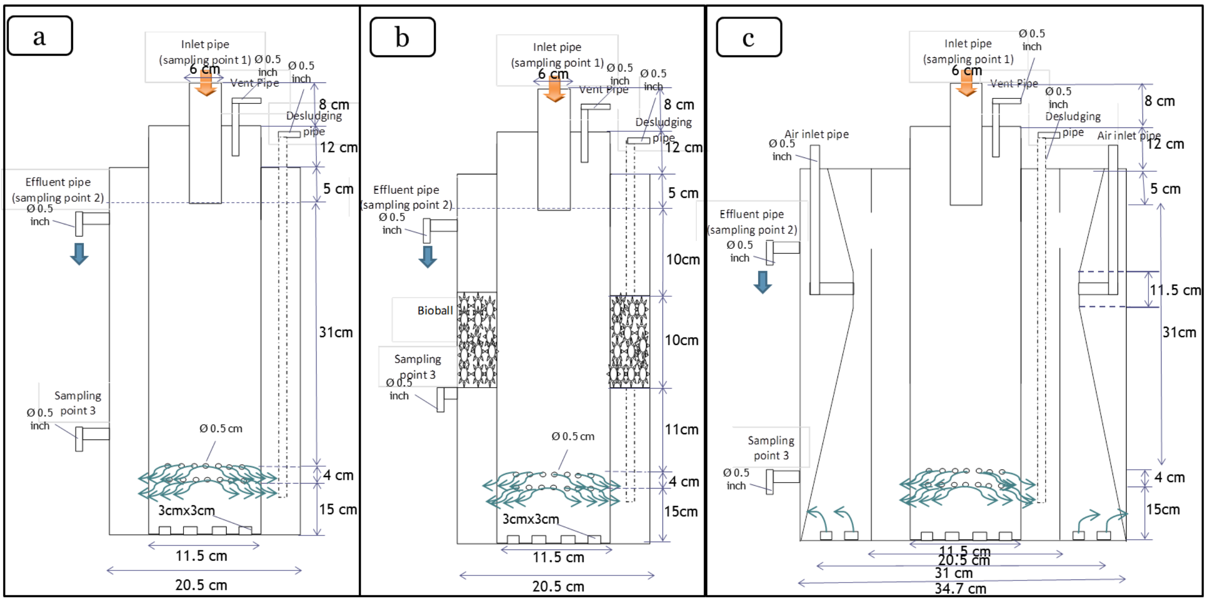

Figure 1 Configuration of reactors a) Tripikon-S control, b) Tripikon-S with bioball addition, c) Tripikon-S with venturi aerator

2.3 Batch Experimental Procedure

Batch experimental procedure for each reactors were conducted using two variations of chemical oxygen demand (COD) concentration, which are 1,500 mg/L and 2,000 mg/L. For each COD variation, three times batch procedure were run. Artificial wastewater were recirculated as close system in batch procedure, effluent from reactor were connected to the inlet as the next influent. Water samples were collected from sampling point 3 with the water quality measurement including temperature (T), pH, dissolved oxygen (DO), COD, and Volatile Suspended Solid (VSS). This procedure were conducted until reach steady state condition (measure as stable COD concentration).

2.4 Continuous Experimental Procedure

Continuous experimental procedure for each reactors were also conducted using two variaton of COD concentration, which are 1,500 mg/L and 2,000 mg/L. Three variations of hydraulic retention time (HRT) were used for each COD influent concentration, which are 24 hours, 36 hours, and 48 hours. Water samples were collected in all sampling points, sampling point 1 as influent characteristic, sampling point 2 as effluent characteristic, and sampling point 3 as water quality in the reactor after settlement process. Water quality measurement including T, pH, DO, COD, Nitrogen Total Kjeldal (NTK), Total Phosphate (TP), and VSS.

2.5 Water Quality Analysis

Table 1 showed the analysis method of water quality parameter that is examined in this experiment.

Table 1 Method for Water Quality Analysis

No	Parameter	Method
1	COD	COD chromate - SMEWW - 5220C
2	pH	SMEWW - 4500 H+
3	Temperature	SMEWW – 2550
4	Dissolved Oxygen	Electrochemical
5	VSS	SMEWW - 2540 E
6	Total Phosphate	SMEWW – 4500 P-B-D
7	NTK	SMEWW - 4500 N org B

3. Results and Discussion

3.1 Characteristic of Synthetic Domestic Wastewater

Synthetic wastewater was made as replacement of domestic wastewater, especially the characteristic of blackwater. By trial and error method in deciding composition of the synthetic wastewater, characteristic synthetic wastewater that is used for this experiment was shown in Table 2. Compared with blackwater characteristic in Palmquist et al (2005), almost all parameter of the synthetic wastewater is in the range of water quality parameter concentration for blackwater. Parameter that showed different with blackwater characteristic in Palmquist et al (2005) are pH and BOD. Elmitwalli (2006) showed that the concentrated blackwater used in the experiment have pH range between 6-8. It confirmed that pH in synthetic wastewater in this experiment was acceptable. While high BOD in synthetic wastewater affecting BOD/COD ratio that typically high for domestic wastewater. Refer to Metcalf & Eddy (2003), the quality of synthetic wastewater in this experiment categorized as very strong domestic wastewater based on high organic content and high solid.

Table 2 Comparison of Synthetic Wastewater and Blackwater Characteristic

Wastewater Parameter	Units	Synthetic wastewater	Blackwater Characteristic (Palmquist et al., 2005) Average (standard deviation)	Range
pH		6.25	8.94 (0,1)	8.87-9.08
Temperature	°C	24		
Dissolved Oxygen	ppm	4.64		
BOD	mg/L	2120	1037 (545)	410-1400
COD	mg/L	2470	2260 (1268)	806-3138
VSS	mg/L	2533	2560 (1900)	420-3660
NTK	mg/L	147	150 (26)	130-180
Total Phosphate	mg/L	39	42.7 (19)	21-58

3.2 Organic Removal in Batch-Experimental Procedure

Environmental condition, including temperature, pH, and DO in batch experiment of three kinds of Tripikon-S reactor did not show any significant different. Range of temperature in the experiment is 23°C-30°C, relatively low pH at 4.1 – 6.8, and DO

1.15 – 6.91 ppm. Venturi aerator that is used in order to make reactor condition becoming aerobic gave slightly higher DO from middle to the end of each batch run. Figure 2 showed the COD removal a) with 1,500 mg/L COD in the influent and b) with 2,000 mg/L COD in the influent. In all run and both COD concentration variation, the rapid COD removal were found in 1-2 days and reach steady state in around 5 days. From this result the HRT variation between 24 to 48 hours was suggested for continuous experiment. HRT 24 and 48 hours was also used in some other experiment with domestic wastewater and septic tank system (Viet Anh et al., 2008; Kootatep et al., 2015).

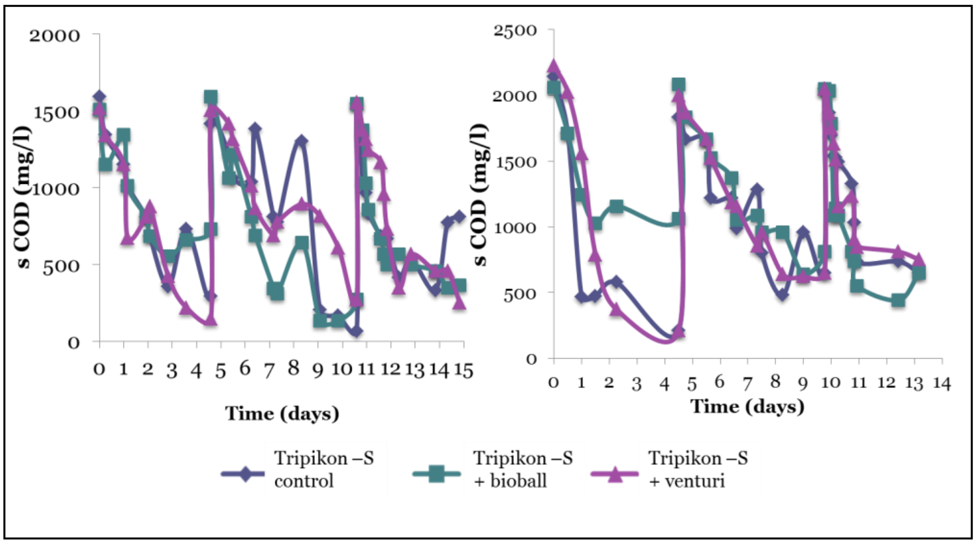

Figure 2. COD Removal in Batch Experiment

3.3 Removal Efficiency in Continuous-Experimental Procedure

Continuous experiment were conducted with pH range 5.45-6.5, temperature 22.9 °C-25.8°C, and DO 1 ppm-4 ppm. Comparison between venturi-shaped modification of Tripikon-S with other reactors did not give any consistent significant different in DO concentration. Figure 3 showed the organic removal, as COD, in the experiment. For influent 1,500 mg/L, optimal condition is HRT 36 hours for tripikon-S without modification with 62% removal of COD, and HRT 48 hours for tripikon-S with modification with 66% removal of COD in Tripikon-S with bioball addition and 67% removal of COD in Tripikon-S with venturi shaped chamber addition. Optimal condition for 2000 mg/L COD is HRT 48 hours for all reactors with 50% removal of COD in Tripikon-S without modification, 64% removal of COD in Tripikon-S with bioball addition, and 65% removal of COD in Tripikon-S with venturi shaped chamber addition. From overall preformance, it suggested that HRT 48 hours is optimal treatment work for Tripikon-S reactors, and both bioball addition and venturi-shaped chamber addition were promising to get higher organic removal efficiency. The increase of organic removal efficiency in venturi-shaped addition chamber of Tripikon-S was suspected as the effect of additional chamber, not because of aerobic condition achieved.

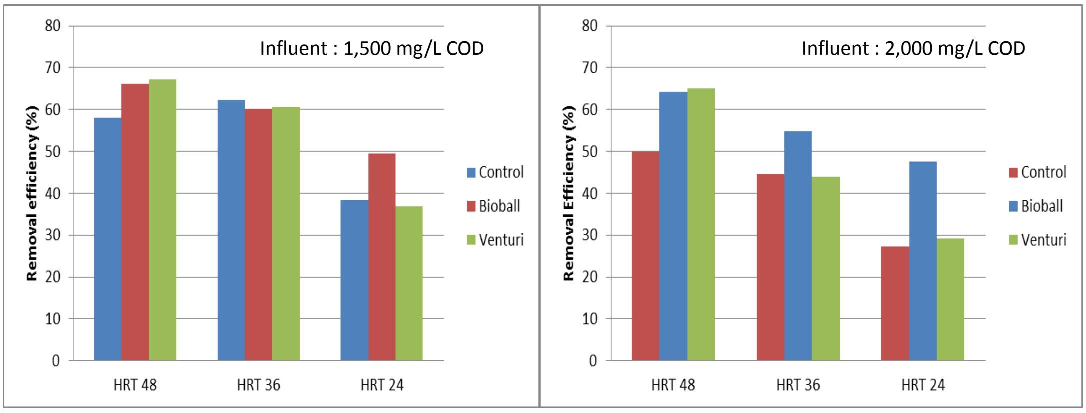

Figure 3. COD Removal in Continuous Experiment

Nitrogen removal (NTK procedure) was detected in the experiment, with optimum removal in COD 2000 mg/L HRT 48 hours with 25.20% removal in Tripikon-S without modification, 26.53% in Tripikon-S with bioball addition, 29.66% for Tripikon-S with venturi-shaped chamber addition. Total Phosphat removal was detected in the experiment with optimum removal in HRT 48 hours with 1500 mg/L COD, which are 34.31% removal in Tripikon-S without modification, 35.90% in Tripikon-S with bioball addition, 35.16% for Tripikon-S with venturi-shaped chamber addition.

4. Conclusions

Tripikon-S system were found as compromising wastewater treatment system to be appropriate applied in specific environmental condition. It was found optimal in organic removal efficiency by operating in HRT 48 hours both for 1,500 mg/ and 2,000 mg/LH L COD influent . The modification of tripikon-S reactor can enhance the removal efficiency of COD, both by bioball addition and the with addition of venturi-shaped chamber even the aeration that is being expected to be formed as the effect of venturi-shaped chamber addition was not worked optimally. Significant nutrient removal (N and P) were also detected in both reactors in this study

Acknowledgement

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