Conference Paper

Eco-friendly Wastewater Treatment Technology in Tidal Area

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Abstract

Access to public sanitation in the tidal area in Indonesia is limited. The people in the tidal area tend to dispose of their domestic wastewater to the water body directly without treating it first. The lack of wastewater infrastructure provision in the tidal area could cause water body pollution that degrades its carrying capacity and destructs aquatic ecosystems. Eco-friendly technology could be used to treat the wastewater in the tidal area as the solution to improve water quality. In this research, the eco-friendly wastewater treatment technology was chosen to observe the effluent quality of individual scale biofilter-phytoremediation. Performance test of wastewater treatment technology was done by measuring the effluent quality. The effluent quality of the biofilter-phytoremediation system was compared to the effluent quality standard that stated in Ministry Regulation of Environment and Forestry No. P.68/Menlhk/Setjen/Kum.1/8/2016. The study showed the following results such as the average concentration of TSS was 7,63 mg/L, pH 6,70, ammonia was 1,78 mg/L, COD was 18,16 mg/L, and BOD was 9,38 mg/L. These results indicated that in general, the effluent quality of biofilter-phytoremediation system had met the above standard.

Keywords: tidal area, wastewater treatment, eco-friendly

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1. Introduction

Indonesia has many communities living in seasonal and tidally flooded areas, such as stage house in the river area. Technical sanitation challenges in the tidal area are lack of land for wastewater treatment plant (WWTP) construction due to densely populated housing, limited access between houses, seasonal elevations in the river water level, unstable land around the river bank, and diurnal tidal forces that results in erosion [1]. As a result, most of the stage house in river area residents practice open defecation in the overhung toilet that discharges the wastewater directly into the river. Whereas on the other hand, people use river water to meet their basic needs [2].

The lack of wastewater infrastructure provision in the tidal area could cause water body pollution, thus degrading its carrying capacity and destruct aquatic ecosystems.

The threat of water body pollution can continue to increase if the wastewater infrastructure provision is not accompanied by wastewater treatment technology. The sustainable wastewater treatment system is important to improve public health as well as an effort to control water body pollution.

Wastewater handling in the tidal area usually is not carried out on municipal wastewater treatment plant because of the lacking urban wastewater network services coverage. In addition, wastewater from tidal area to municipal plant cannot be transported using gravity system that leads to increasing operational costs. Therefore, wastewater handling in the tidal area is carried out using the onsite system, both communal or individual. Onsite wastewater treatment technology choices should be eco-friendly.

Eco-friendly wastewater treatment technology characterized by the protection of environmental sustainability, easy to construct with locally available material, relatively easy operation, low or absent energy (electricity) requirement, permanent and continuous operation without too much interference and with more or less constant efficiency/effluent quality (i.e. robust system), recycle waste or products, and handle the by-product [3]. Therefore, the planning of eco-friendly wastewater treatment facilities in settlements in the tidal and floating area must be based on an assurance there will not be a negative impact to a water body and surrounding area, protection of public health, does not require extensive land, ease of construction, operation, and maintenance. Wastewater treatment system's effluent can be safely discharged into a water body and can improve public health and environmental quality.

Seeing the wastewater problem, in this study biofilter-phytoremediation technology was chosen as an eco-friendly technology to treat wastewater in the tidal area. Performance test of wastewater treatment technology was done by measuring the effluent quality. The effluent quality of biofilter-phytoremediation system was compared to the effluent quality standard that stated in Ministry Regulation of Environment and Forestry No. P.68/Menlhk/Setjen/Kum.1/8/2016.

2. Materials and Method

2.1. Study area

The study area was located in RT 05 of Sei Bilu Village, East Banjarmasin District, Banjarmasin City (**Figure 1**). The house type in study location is stage house in the river area. The material that used to build the house is temporary or semi-temporary. The people use river water to meet their needs of bathing, washing, and defecating while they use clean water from Regional Drinking Water Company (a.k.a. PDAM) to meet their needs of drinking and cooking. This condition is in accordance with the typical people who live in the stage house in river area in Indonesia [1].

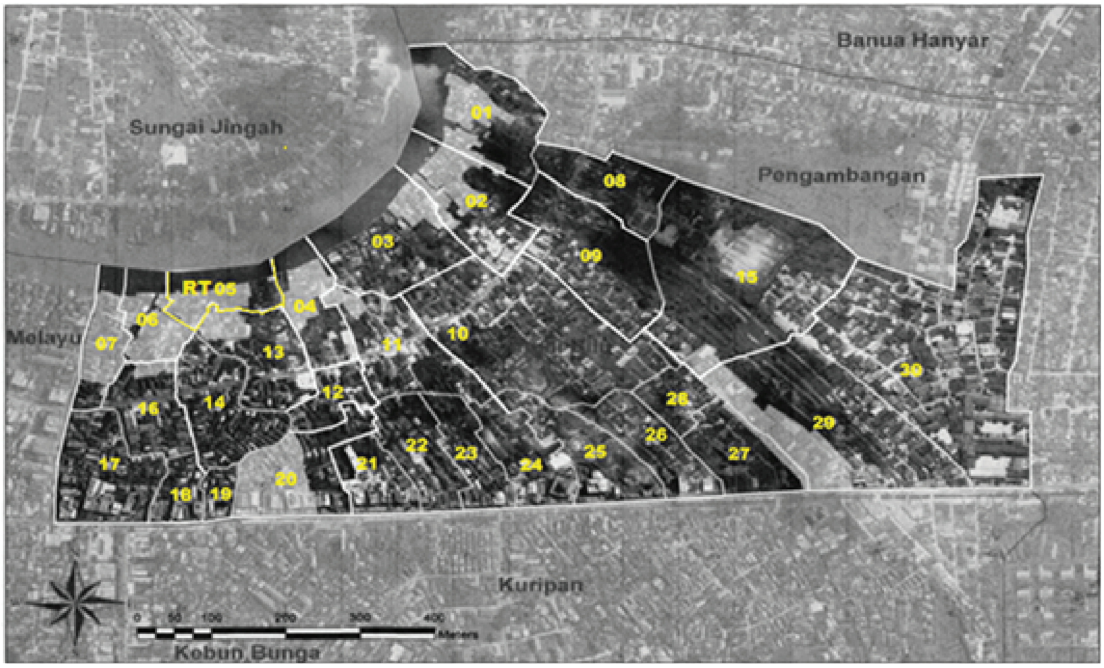

Figure 1: Sei Bilu Village administration area.

Existing sanitation conditions at the study area were 60 percent of the people using latrine to treat their feces and urine, while the rest were directly discharged into water body under the house. 99 percent of grey water had not been treated at all and also directly discharge into water body while 1 percent grey water had been treated by existing communal WWTP near the study area.

Implementation of the biofilter-phytoremediation system as eco-friendly wastewater treatment technology was carried out on an individual scale of 23 households. The implementation of an individual scale was based on the consideration of land unavailability to construct communal WWTP. Location map of technology implementation in Sei Bilu Village could be seen in **Figure 2**.

2.2. System description

The wastewater treatment system in this study consist of a toilet that installed on the stilt floor, biofilter unit, and phytoremediation unit. The treatment scheme could be seen in **Figure 3**.

The stilt floor was installed at the level above the daily maximum tide. The floor was made of wooden planks or concrete slab that had a function as the individual toilet

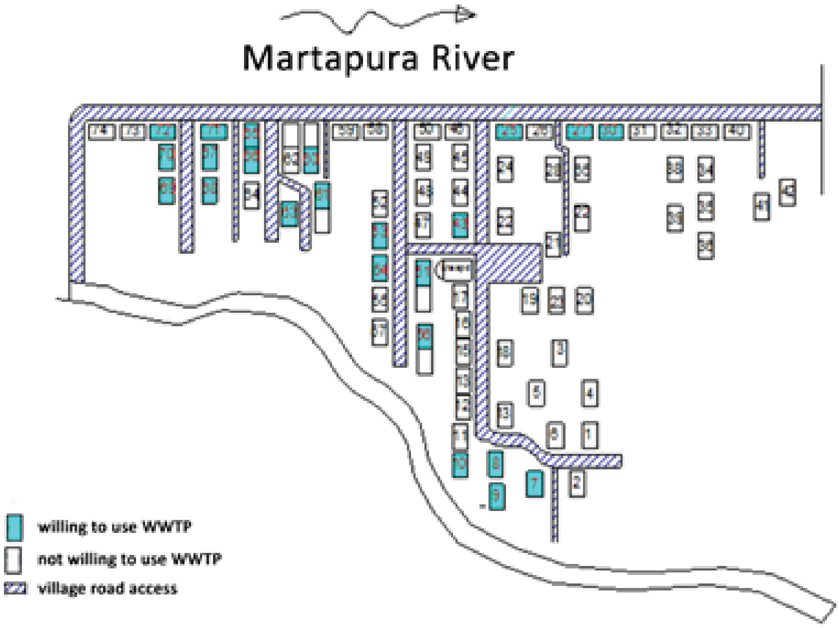

Figure 2: Location map of technology implementation in Sei Bilu Village.

Figure 3: Wastewater treatment scheme.

seat. The biofilter was stored under toilet seat floor plate which was supported by galam wood and ironwood pile holder and pinned using a pile that serves as an anchor so that the biofilter tank would not be shifted by the river flow during high tidal. Installation of the toilet and biofilter unit could be seen in **Figure 4**. The biofilter system operates under anaerobic condition thus it does not need any pump and blower. Besides that, the biofilter unit is easy to operate by the users.

Phytoremediation unit was made of fiberglass reinforced plastic (FRP) material which served as tertiary treatment of biofilter outlet. The installation of this unit was same as the biofilter unit. However, the outlet point was placed higher than water level at maximum daily tidal level. The installation of phytoremediation unit could be seen in **Figure 5**. The plants that used in this unit were canna, papyrus, and water jasmine that each of these plants has different rooting.

2.3. Sampling

The study area is quite wide so the sampling was carried out at 2 points which are in the middle of the location and at the farthest point that located at 10 m and 100 m

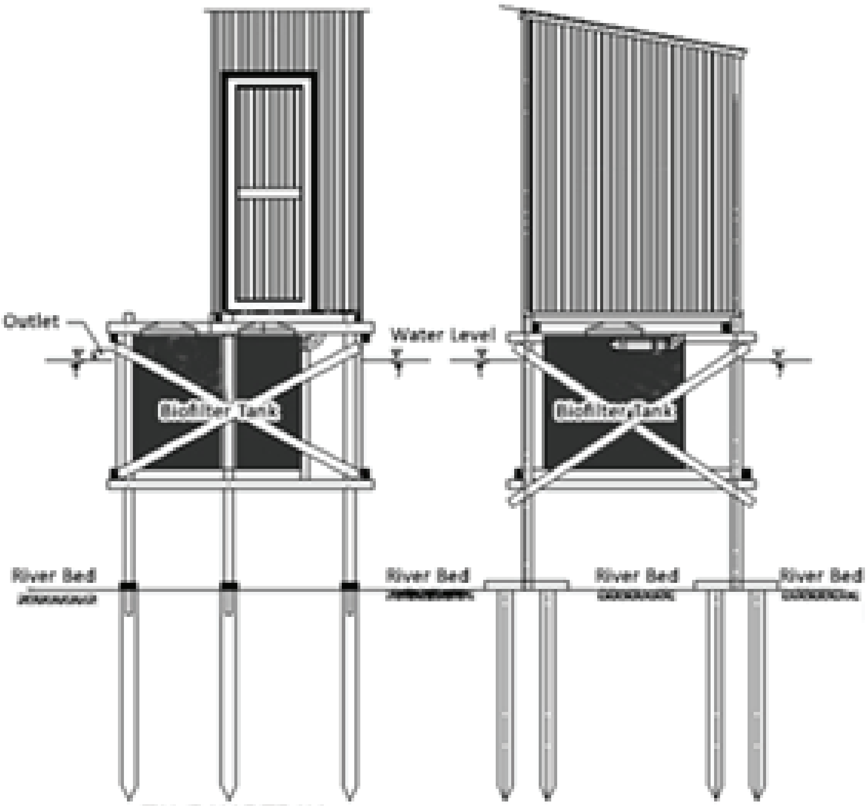

Figure 4: Closet and biofilter unit.

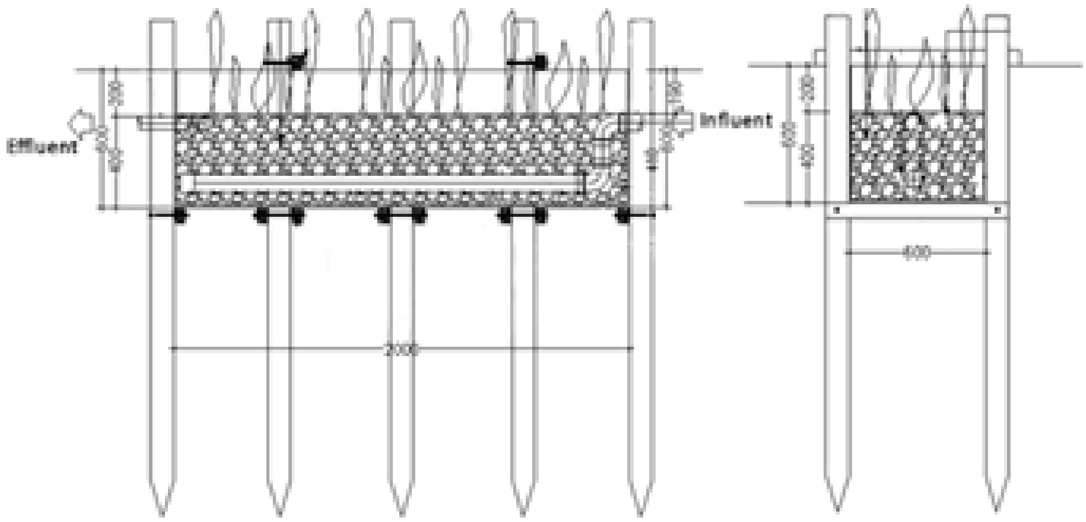

Figure 5: Phytoremediation unit.

from the riverbank respectively. Sampling was done by composite sampling method where the sample was taken in the morning, afternoon, and evening. The parameters measured were Total Suspended Solid (TSS), pH, ammonia, Chemical Oxygen Demand (COD), and Biochemical Oxygen Demand (BOD).

2.4. Data analysis

Effluent quality data will be analyzed using a comparative method. The effluent quality was compared to Ministry Regulation of Environment and Forestry No. P.68/Menlhk/Setjen/Kum.1/8/2016 that regulate quality standard for domestic wastewater effluent. In addition, the calculation of pollutant load reduction before and after the wastewater treating was carried out.

Mathematically, the load is essentially the product of discharge and concentration of a substance in the water [4] that could be seen in Equation (1). The parameter that used in this research was BOD as represent a parameter for organic content in wastewater.

$$W = Q \times C \quad (1)$$

where: W = pollutant load (kg/year); Q = wastewater discharge (L/day); C = BOD effluent concentration (mg/L)

3. Results and Discussion

3.1. Effluent quality

The wastewater effluent that discharges into waterbody must meet the standard of domestic wastewater effluent quality as stipulated in the Ministry Regulation of Environment and Forestry No. P.68/Menlhk/Setjen/Kum.1/8/2016. The effluent standard could be seen in **Table 1**.

Table 1: Standard of domestic wastewater effluent. (Ministry Regulation of Environment and Forestry No. 68 Year 2016)

Parameter	Unit	Standard
BOD	mg/L	30
COD	mg/L	100
TSS	mg/L	30
pH		6-9
Ammonia	mg/L	10

BOD and COD are two parameters that become indicators for organic content in wastewater. **Figure 6** showed that BOD concentration of the 10 m biofilter and 100 m biofilter were 24.87 mg/L and 34.37 mg/L, respectively. The average of BOD concentration was 29.62 mg/L. The BOD concentration from biofilter 100 m effluent had not met the standard so further treatment process is needed. However, the average value of BOD concentration from biofilter effluent had met the standard. Meanwhile, the concentration of COD from the 10 m biofilter and 100 m biofilter was 45.31 mg/L and 69.13 mg/L, respectively. The average of COD concentration was 57.22 mg/L. All of COD concentration had met the standard.

Table 2: BOD and COD concentration of biofilter unit effluent.

	Unit	Standard	Biofilter 10 m	Biofilter 100 m	Average
BOD	mg/L	30	24.87	34.37	29.62
COD	mg/L	100	45.31	69.13	57,22

The treatment process of the biofilter unit was followed by phytoremediation unit. The effluent from phytoremediation unit was the one that discharged into the water body. **Figure 6** showed that BOD concentration of the 10 m phytoremediation unit and 100 m phytoremediation unit were 7.54 mg/L and 11.23 mg/L, respectively. The average of BOD concentration was 9.83 mg/L. Meanwhile, the concentration of COD from the 10 m phytoremediation unit and 100 m phytoremediation unit were 13.74 mg/L and 22.58 mg/L, respectively. The average of COD concentration was 18.16 mg/L.

Table 3: BOD and COD concentration of phytoremediation unit effluent.

	Unit	Standard	Phytoremediation 10 m	Phytoremediation 100 m	Average
BOD	mg/L	30	7.54	11.23	9.83
COD	mg/L	100	13.74	22.58	18.16

The results of BOD and COD concentration determination showed that the effluent quality of phytoremediation unit had met the effluent quality standard that applies in Indonesia. The success of the wastewater treatment system was supported by the wastewater biodegradability characteristic. The level of biodegradability could be known from ration BOD to COD. If BOD/COD is greater than 0.5 then the wastewater is biodegradable. If BOD/COD is less than 0.3 then it is non-biodegradable which mean it is difficult to treat the wastewater biologically. The BOD/COD ratio of the sample in the study area was 0.52 so the wastewater in the study area could be categorized as biodegradable. It is possible that the biofilter unit could remove most part of the organic matter [5].

TSS is a particle in a water column that larger than 2 microns. TSS has a negative impact on water quality because it reduces sun penetration into the water. Suspended matter in water may contain a number of types of contaminants such as nutrient, heavy metal, and an organic compound. These contaminants may be in particulate form or they may be physically or chemically bound to the particulate matter. Thus, the particulate form of the contaminant could be removed efficiently using physical settling [6].

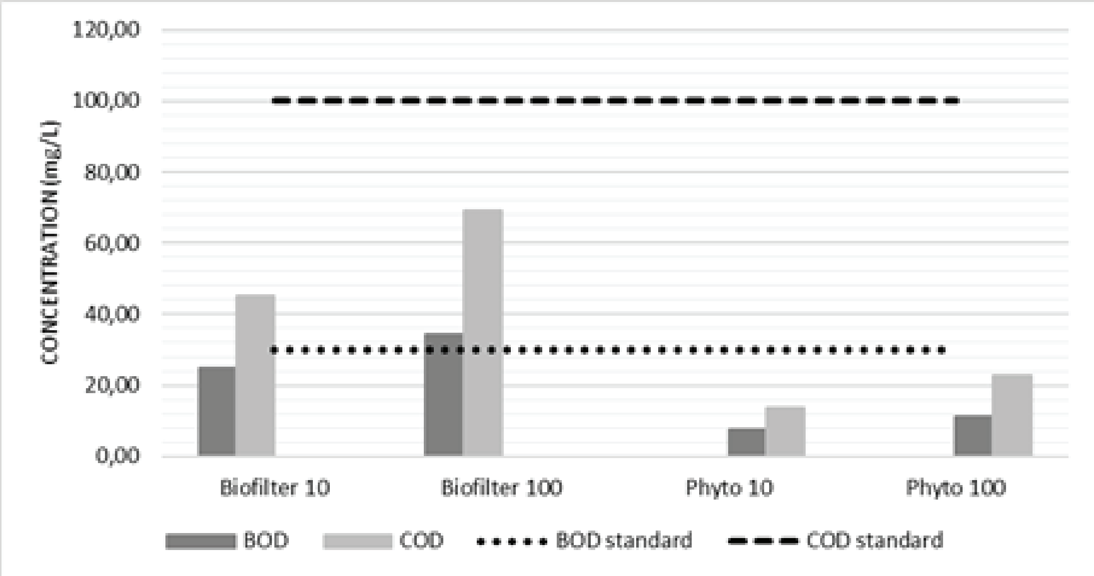

Figure 6: BOD and COD concentration.

Figure 7 showed that TSS concentration of 10 m biofilter unit and 100 m biofilter unit were 6.17 mg/L and 26.83 mg/L, respectively and TSS average concentration was 16.5 mg/L. The remaining TSS concentration could be removed by aquatic plants roots in phytoremediation unit. Roots of the plants could retain both coarse and fine particulate organic materials in the wastewater [6]. TSS concentration of the 10 m phytoremediation unit and 100 m phytoremediation unit were 3.45 mg/L and 11.81 mg/L, respectively. The average of TSS concentration was 7.63 mg/L. TSS measurement showed that TSS concentration in the effluent of biofilter and phytoremediation unit had met the quality standard.

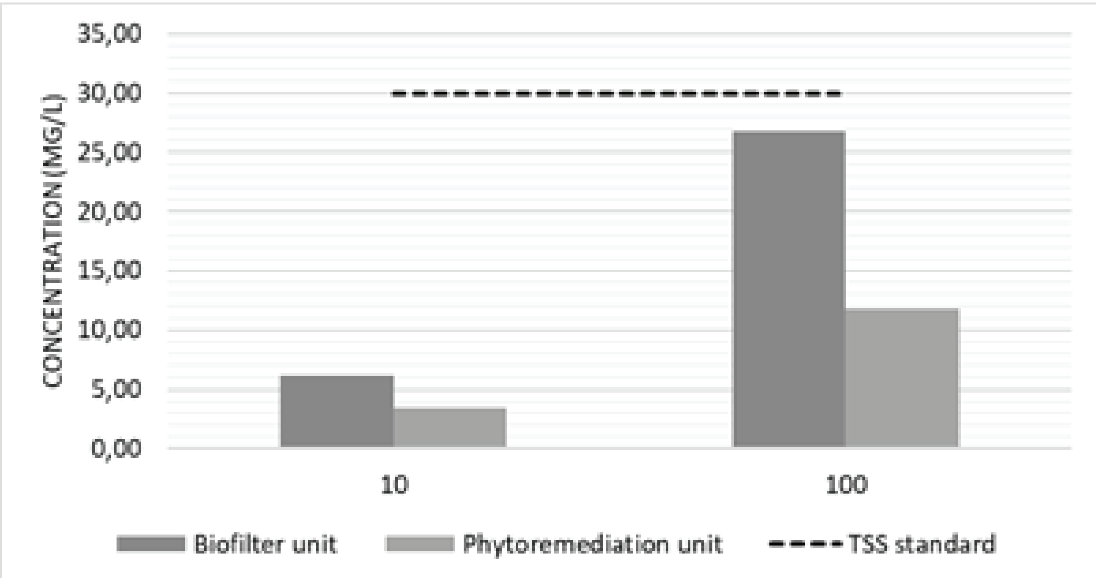

Figure 7: TSS concentration.

pH is the most important parameter in the biosorptive process which affects the solution chemistry of metals, the activity of the functional groups in the biomass, and the competition of metallic ion [6]. The measurement results in **Table 4** showed that pH in the effluent of biofilter and phytoremediation unit was in the normal range and had met the quality standard.

Table 4: pH value of biofilter and phytoremediation unit effluent.

	Standard	pH
Biofilter 10 m	6-9	6.61
Biofilter 100 m	6-9	6.69
Phytoremediation 10 m	6-9	6.65
Phytoremediation 100 m	6-9	6.75

Pure ammonia is a gas which is highly soluble in water. Ammonia in wastewater came from urine and feces. As a base, under neutral conditions, it exists as ammonium ion, which at low external concentration is a preferential nitrogen source for most plants but at higher concentration it is phytotoxic. Phytoremediation is eco-friendly, particularly robust, reliable, and cost-effective technology to remove nitrogen content from wastewater. Phytoremediation uses living higher plants for cleaning up contaminated water by removing, sequestering, or biochemically decomposing the pollutant [7],[8].

The most applicable technology using phytoremediation is constructed wetland technology. However, this technology has limited capacity to remove nitrogen content in wastewater. This happens when the discharge of wastewater is high, causing shorter detention time in the unit. Even though detention time is more influential than plants type in removing nitrogen content such as ammonia and Total Kjeldahl Nitrogen (TKN) [5],[6],[9],[10].

The measurement results in **Figure 8** showed that ammonia concentration in the effluent of the phytoremediation unit had met the quality standard. This was because the wastewater discharge in individual scale WWTP was relatively small so the detention time in the unit increased and gave the plants more time to take more nutrients from wastewater.

3.2. Pollutant load

The load may be defined as the mass substance that passes a particular point in a specified amount of time [4]. Pollutant load for 23 households before wastewater treatment was 537.87 kg-BOD/year. While pollutant load after wastewater treatment was 119.36 kg-BOD/year. It means that the presence of wastewater treatment for 23

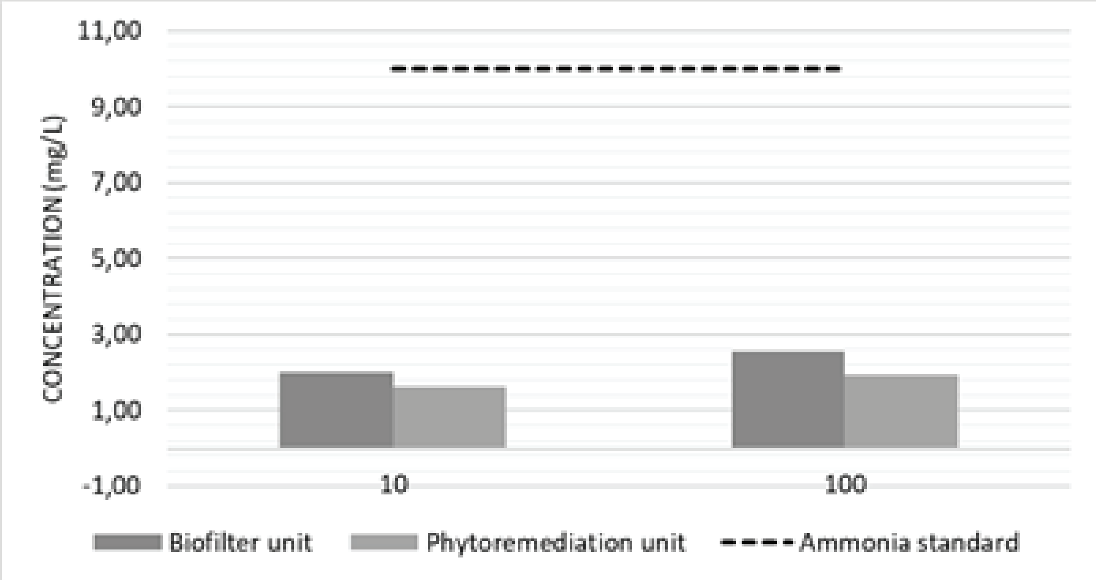

Figure 8: Ammonia concentration.

households had decreased the pollutant load that directly discharged into the water body by 418.51 kg-BOD/year. Roughly, if there are 100 households in the stage house in river area treating their wastewater with the same system, there will be pollutant load reduction that directly discharged into the water body by 1819.63 kg-BOD/year. Overall, the system could reduce the pollutant load by 18.2 kg-BOD/household/year.

Table 5: Pollutant load calculation scenario.

Parameters	**Scenario 1**	**Scenario 2**	**Scenario 3**
Households	23	50	100
Wastewater discharge (L/hari)	11,040	24,000	48,000
BOD influent (mg/L)	133.48	133.48	133.48
BOD effluent (mg/l)	29.62	29.62	29.62
Pollutant load without treatment (kg/year)	537.87	1,169.28	2,338.57
Pollutant load with treatment (kg/year)	119.36	259.47	518.94
Pollutant load reduction (kg/year)	418.51	909.81	1,819.63
Pollutant load reduction (kg/household/year)		18.20	

4. Conclusion

Biofilter-phytoremediation system that implemented in the stage house over the river is easy to construct and operate even in individual scale. It also does not need electricity due to absent of pump and blower. The measurement of system effluent quality showed that all chemical parameters had met Indonesian standard of domestic wastewater effluent that regulated in Ministry Regulation of Environment and Forestry No.

P.68/Menlhk/Setjen/Kum.1/8/2016. This showed that the effluent from the treatment system could be safely discharged into a waterbody. Moreover, the treatment using biofilter-phytoremediation system could reduce pollutant load by 18.2 kg-BOD/household/year. Therefore, the biofilter-phytoremediation system could be categorized as eco-friendly wastewater treatment technology that could be implemented at the tidal areas.

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