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REMOVAL OF AMMONIA EFFLUENT FROM ABR BY CONSTRUCTED WETLANDS

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ABSTRACT

Communal domestic wastewater treatment plant has been widely built in the area in Indonesia. The government through the Ministry of Public Works and Public Housing with several programs has built a Communal IPAL in almost all districts in Indonesia. Domestic wastewater treatment generally uses ABR (Anaerobic Baffle Reactor) technology. Domestic wastewater treatment with ABR can reduce organic carbon and total suspended solid concentration but less effective in reducing ammonia. ABR has a bod seed and efficiency of BOD 80%, COD 90%, TSS 70% and Ammonia 20%. The presence of Ammonia in the receiving water body will lead to decreasing oxygen levels and eutrophication. Applied phytotechnology can be a solution to overcome effluent levels in ABR as long as there is sufficient land. Research has been conducted that the efficiency of ammonia reduction in Wetland reached 76%.

KEY WORDS: Ammonia, Efluent ABR, Constructed Wetland

INTRODUCTION

The Government of Indonesia through the Ministry of Public Works has built a Communal Waste Water Treatment that is evenly distributed in various districts. The construction of sanitation facilities are carried out through various communal sanitation programs such as Sanimas Regular, Sanimas USRI, and SANIMAS IDB. The chosen technologies in general are septic tank, Anaerobic Baffle Reactor (ABR), Degester + ABR, ABR + anaerobic Filter. This is because anaerobic processes are easier to operate and the operation and maintenance costs are lower.

Domestic wastewater quality standards in Indonesia have been issued in The Minister of Environment and Forestry Decree No. 68 Year of 2016. However, in several provinces, the Governor Regulation of Domestic Wastewater Quality Standards was first issued in 2013. The domestic wastewater quality standards based on Minister of Environment and Forestry Decree are more nearly complete than the parameters in Governor decree, namely Ammonia and Total Coliform. Ammonia is quite difficult to be reduced by anaerobic treatment. This is due to the absence of bacteria that convert ammonia to nitrites or nitrates.

Domestic wastewater quality standards in accordance with East Java Governor Regulation No. 72 of year 2013 mention the maximum levels of BOD 30 mg /l, COD 50 mg/l, TSS 50 mg/l, Oil and Grease 10 mg/l and pH 6-9. While The Minister of Environment and Forestry Decree No. 68 Year of 2016 limits the maximum level of BOD 30 mg/l, COD 100 mg/l, TSS 30 mg/l Oil and Grease 5 mg/l, Ammonia 10 mg/l and Total Coliform 3000 mg/l. These regulations presented in Table 1.

Inorganic nitrogen groups such as nitrates (NO_3), nitrites (NO_2), and ammonia (NH_3) have the greatest impact on the waters, this is because these groups are easily available and absorbed by microorganisms (Seitzinger *et al.,* 2002). Efforts to reduce organic matter in wastewater can reach 80-90% with existing wastewater treatment technology. However, the level of misapplication abuse is often unsatisfactory. Various forms of nitrogen in wetlands can be reduced through special treatment processes, such as combined nitrification-

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denitrification and sedimentation, especially at the sediment-water interface and aquatic plants (Taylor *et al.*, 2005).

Communal wastewater treatment plants that have been built by the Central Government and Local Government are quite good in reducing the BOD, COD, and TSS, but the ammonia still exceeds the quality standard. This will give negative impacts on aquatic ecosystems, such as the reduction of dissolved oxygen and eutrophication. To overcome these problems, it is necessary to find the appropriate technologies as the solution so that the ammonia concentration in water meets the quality standards. In this article, the use of phytotechnology to treat wastewater containing ammonia is using wetlands or aquatic plants. This technology is very easy to operate, low-cost on a condition there is sufficient land.

DISCUSSION

Anaerobic Baffled Reactor (ABR)

Anaerobic Baffled Reactor (ABR) is a type of suspended growth treatment that utilizes a partition (baffle) in stirring that aims to enable contact between domestic wastewater and microorganisms. This processing has relatively low operational costs, this is due to the absence of electricity usage and has a fairly good organic removal efficiency. But this technology has a low ability in eliminating pathogenic bacteria and nutrients. Therefore, the effluent still requires additional processing and requires initial processing in the form of deposition / sedimentation to prevent clogging. The flow that occurs in ABR is an upflow and downflow. Microorganisms thrive in domestic wastewater and a layer of sludge is found at the bottom of the compartment. Upflow chamber helps increase the removal of organic substances, more than 90% (Tilley *et al.*, 2014).

ABR is suitable for processing various types of waste with a concentration of BOD more than 150 mg/l. Design criteria for ABR are:velocityupflow ≤ 2.0 m/h, organic load ≤ 3.0 kg COD/m^3.day, Hydraulic Loading Rate (HRT) ≥ 8 hours (Guterrer, *et al.*, 2009). While Metcalf and Eddy (2014) revealed in his book, design criteria for ABR include: Volatile solid concentration = 2-10%,HRT = 6-24 hours SRT e”30 days and Organic Load = 5-10 kg COD/m^3.day.

ABR is an improved Septic Tank with a series of baffles under which the wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment 5. Solids high treatment rates are high, while the overall sludge production is characteristically low. COD removal efficiency of about (65- 90)% and BOD of about (70-95)% (Foxon *et al.*, 2004).

Construction Wetland

Constructed Wetlands are wastewater treatment technology that uses soil components or other media, aquatic plants, and microorganisms (Greg *et al.*, 1998). Wetland dimensions are calculated based on hydraulic load and residence time. Constructed Wetlands include Wetlands with free water surfaces and Wetlands with sub surface flow, while the types of water flows are distinguished horizontal and vertical flow (Vymazal, 2010).

Types of Wetland Construction are based on the type of plant used including the type of plants that are on the water surface or Free Water Surface Wetlands (FWS) and type of flow such as subsurface flow (SSF) using emergent type vegetation which roots are submerged in water (Mitchell *et al.*, 1998). The flow of water in the FWS type is above the

Table 1. Standards Quality Regulation

Parameter	Unit	East Java Governor Regulation No.72 Year 2013	Ministry of Environment and Forestry Regulation No. 68 Year 2016
BE	mg/l	30	30
BOD	mg/l	50	100
TSS	mg/l	50	30
Oils & Fats	mg/l	10	5
pH		6-9	6 – 9
Ammonia	mg/l	-	**10**
Total Coliform	Quantity/100 ml	-	3000
Water consumption	l/cap/day	-	100

bottom of the wetland, and the roots of the plant are in the sediment layer at the bottom of the water column. While the flow of water in the type of *SSF,* penetrates porous media such as gravel, where the roots of plants are located. Thus the type of *FWS* is suitable to be built in the suburbs, because it requires a large enough land and can be a place for community recreation.

The advantages of Contruction Wetlands with SSF system, are: (1) Have Simple Construction, (2) Placement both indoors and outdoors, (3) Can be operated by gravity or use pumps (5) Low operating costs, (6) Odorless; (7) performance is quite good; (8) Not to be a breeding ground for mosquitoes; and (9) Has aesthetic value.

Media of SSF Constructed Wetlands

Media for aquatic plants can be gravel, used bottles, zeolite or charcoal. The use of used bottles can increase the space for the plant root system (Dallas *et al.*, 2005). The media can also be varied or combined with each other so as to improve the performance.

Constructed Wetlands

Performance of Constructed Wetlands in lowering biodegradable organic materials or BOD in some studies reached 60 - 99.7% (Raude *et al.*, 2009; Weissenbacher and Mullegger, 2009; Dallas *et al.*, 2005). Some constraints on Wetlands include: 1) Processing speed is influenced by temperature, pH and dissolved oxygen, 2) Pollutant reduction is less effective when there is excess processing capacity or short residence time (Greg *et al.*, 1998); (3) Environmental conditions of wastewater treatment plants using Aquatic Plant technology (Suswati and Wibisono, 2013) e.g. organic materials, nutrients, toxics, and oxygen deprivation; and (4) Limited surface area so that Wetlands does not meet the residence time for the process of pollutant reduction.

Constructed Wetlands research using grass *Vetiveria zizonioides* (fragrant roots) with residence time of 2 days was able to decrease TSS 97% and BOD_5 99.7%. While the two-stage research using *the Coixlacryma-jobi* plant has BOD removal 99.4%, and *Coliforms* 99.9% (Dallas, 2006). It appears that *Vertiveria zizonioides* grass provides good efficiency in reducing BOD5 concentration, but less in reducing coliforms.

Indonesian Standard is SNI 2398:2017 on Septic tank planning procedures with advanced processing (infiltration wells, catchment fields, up flow filters, Sanita ponds? Sanitary ponds? mentioned that effluent from septic tank can be processed with sanita pond. Sanita pond is a tub of stone pairs, and other impermeable material filled with gravel (diameter 20 - 30 mm), as high as 80% of the height of the tub, and topped with hydrophyte vegetation. Types of *hydrophyte* plants are, among others; *Papyrus, Typa, Khana Sp., Phragmites communis, Echinodorus Palaefolius* and *Nympheaea.*

Removal Ammonia

A series of very complex reactions involving nitrogen transformation occurs in wetlands. Nitrates, nitrites, ammonium, dissolved organic nitrogen and particulates are compounds that represent the total nitrogen load in Constructed Wetlands. Organic nitrogen that associated with organic suspended solids can be eliminated by flocculation, sedimentation, and filtration. The absorption (? atau adsorption) of particulates and dissolved organic nitrogen may occur in biofilms deposited on plants, litter, etc. Physical absorption and exchange capacity of substrate ions can bind ammonium. Biological nitrogen species transformations include mineralization, nitrification, denitrification, nitrogen fixation, and plant uptake. Mineralization involves the biological transformation of organic nitrogen to ammonium nitrogen in aerobic and anaerobic conditions. Once ammonium is formed, it can be absorbed atau absorbed atau uptake by plants or macrophytes through its root system as an essential nutrient, immobilized by the exchange of ions, dissolved and returned to the water column, vaporized as ammonia gas, anaerobicly converted back into organic matter by microbes, or can be aerob-dinitrified by aerobic microorganisms. For example, we note that the nitrogen uptake capacity of emerging macrophytes can vary from 200 to 2500 kg / year.

In general, Vetiver grass has been shown to be tolerant to eutrophic conditions and is able to grow at high strength NH_3-N concentrations of about 390 mg/l (Liao, 2000, in: Truong, 2001). In a study conducted by Klomjek (2005) in Thailand, V*etiveria zizanioides* showed a good performance of NH_3-N for municipal wastewater (?) saya kurang paham arti kalimatnya. The average decrease was 76.5 percent (average concentration: 19.5 mg/l). This species has a much higher rate of water consumption compared to other common wetland

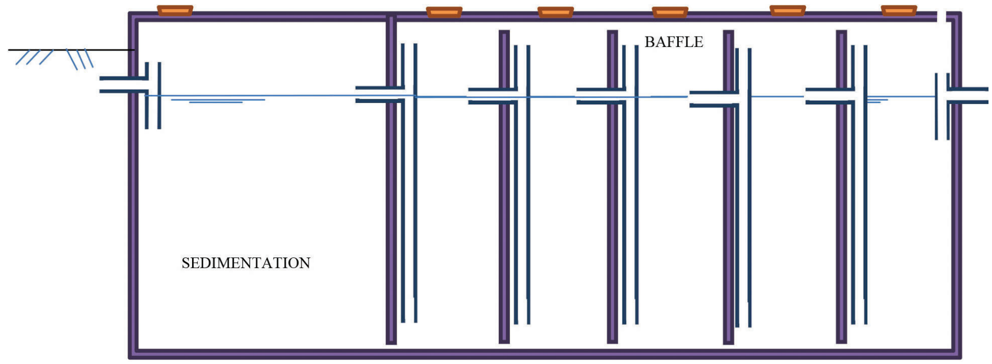

Fig. 1. Long section of ABR and Constructed Wetland

species, e.g. *Typha* sp., *Phragmites* sp. or *Scirpus* sp. and very tolerant of the increase in the concentration of certain heavy metals (e.g. Cd, Cu, Cr, Pb, Ni or Zn), (Truong, 2001).

Research on the efficiency of ammonia seeding in ABR-type Communal WWTPs in Banguntapan and Bantul Districts showed an efficiency rate of less than 20%, while the bod and TSS parameters were 80% and 60%, respectively.

The combination of quartz sand and zeolite filter media was shown to increase allowance efficiency by 11.5 for NH_3, 18 Pb and 20 Zn compared to previous studies. Plants absorb pollutants of 18 with the roots absorbing 9-14 times greater than the leaves, while the filter media absorbs 70 pollutants. Bioretension with the composition of 35 quartz sand, 40 zeolite, 10 soil and 10 compost and Iris pseudacorus is proposed as a combination of filter media with the best performance to improved allowance efficiency (Sari, 2018).

The results showed that zeolite modified with NaCl had better absorption/adsorption for NH_4^+-N, when the concentration of NaCl 6%, the rate of allowance NH_4^+ -N can reach 95.3%, higher removal efficiency was obtained by modified zeolite acid compared to the modified base zeolite, based on a 2-hour soaking time in the HCl solution, higher acid concentrations can decrease the adsorption efficiency of zeolite modified acid into ammonia-nitrogen (Feng *et al.,* 2006)

Alum sludge from drinking water treatment after drying can be used as a medium for Construsted Wetlands to process wastewater. Alum sludge candissorpize Phosphat and Ammonia significantly - while wetlands can lower organic carbon. The combination of alum sludge and constructed wetlands can be an option for domestic wastewater treatment method that is cheap and easy to operate (Zao *et al.,* 2015; Zao, 2011).

Research has also been conducted on the addition of activated carbon and zeolite to anaerobic reactors for the total elimination of nitrogen ammonia, which is a combination of adsorption and biofilm processes. The results provide nitrogen ammonia allowance efficiency of 53% and COD 91%, where the role of the most effective media set aside nitrogen ammonia and COD (Hayati, 2016). The following figure 1 is a solution to remove ammonia in ABR effluent.

CONCLUSION

The problem ofammonia levels that have not met the quality standards in the efficiency of communal wastewater treatment, especially ABR, can be solved by the following methods: 1) ABR effluent is further processed by constructed wetlands, if there is sufficient land. 2) The media on constructed wetlands can be modified with the addition of zeolite that serves to bind ammonia. 3) The addition of Sludge Alum from drinking water treatment sludge on media constructed wetlands is proven to bind ammonia so that the efficiency of ammonia removal increase. This method is the cheapest and utilizes Alum waste of water treatment.

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