

# Constructed Wetland With Flow Water Surface Type For Elimination Of Aquaculture Wastewater From Catfish (*Clarias gariepinus*, Var)

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**Abstract.** The increased of aquaculture activity have a negative impact for the environment, these activities will result pollutants from aquaculture wastewater. Therefore, aquaculture wastewater must be treatment. One technology that is cheap, easy and effective in controlling aquaculture wastewater is constructed wetlands system. The constructed wetlands system combines plants and microbes activity in treating wastewater. The purpose of this study is to determine the ability of vetiver grass (*Chrysopogon zizanioides*, L), cyperus plant (*Cyperus alternifolius*) and water hyacinth (*Eichhornia crassipes*) at the constructed wetlands system to removing pollutants (NH<sub>3</sub> and PO<sub>4</sub><sup>3-</sup>) of Catfish (*Clarias gariepinus*, var) wastewater aquaculture. In this study, the constructed wetlands system used Flow Water Surface type and the plants is planted with a floating system using styrofoam in four treatments, i.e.control (bioball without plant), vetiver grass (*C. zizanioides*, L), cyperus plant (*C. alternifolius*) and water hyacinth (*E. crassipes*). The results showed that the each plant have a different ability to eliminate NH<sub>3</sub> and PO<sub>4</sub><sup>3-</sup>. Vetiver showed NH<sub>3</sub> and PO<sub>4</sub><sup>3-</sup> removal was 2 - 66.7% and 0 - 75.4%, cyperus was 0 - 66.7% and 42.4 - 71.2% and water hyacinth was 0 - 15.8% and 33.1 - 89.7%.

**Keywords:** Constructed wetlands, phytoremediation, wastewater, catfish

## Introduction

Potential production of Indonesia's aquaculture reaches 57.7 million tons per year and only utilized by 23% (SI 2014). Aquaculture business experienced a significant increase, i.e., from 5.4% in 2007 to 23% in 2013 (SI 2014). Based on the potential of aquaculture in Indonesia is expected to experience a significant increase in the coming years.

Indonesia is one of the world's aquaculture producers, so the trend of the development of aquaculture has increased continuously. Increased business activities of intensive fish farming it is certainly give effect to human life or the environment. In addition to the positive impact also gave negative impact. The negative effects that can be caused is exceeding the power support aquatic life, disruption of water organisms, the degradation of water quality, eutrophication and oxygen depletion to cause pollution of the waters (Raharjo et al. 2015a, Riani et al. 2014, FAO 2011, Xin et al. 2010). The water quality is bad causing the spread of various diseases of fish, and eventually lower productivity. Avnimelech (2006) states that aquaculture activities not only cause problems in the recipient's environment (upon receiving waters), but also the intrinsic problems in the system of cultivation. The one



of the big problems in intensive farming systems are a type of inorganic nitrogen accumulation and nitrogen dioxide in the toxic waters (Avnimelech 2007).

Wastewater aquaculture cause elevated levels of ammonia, nitrite, nitrate, and organic materials pospor (Lananan et al, 2014; Mook et al, 2012) so aquaculture wastewater should be managed well before discharging to the recipient's environment if want sustainable aquaculture (Raharjo et al 2015a, 2015b).

Application of wastewater aquaculture for small and medium scale cultivators have criteria is cheap, easy, effective and does not require special care techniques and environmentally friendly. One alternative is to use is Constructed Wetlands System (CWs).

The aim of this study is to investigate the ability CWs and phytoremediation of vetiver grass (*C. zizanioides*, L), cyperus plant (*C. alternifolius*) and water hyacinth (*E. crassipes*) in removing pollutants ( $\text{NH}_3$  and  $\text{PO}_4^{3-}$ ) from the catfish (*C. gariepinus*, var) wastewater.

## Materials and Methods

### Materials

Materials used for wetland media are coarse sand, coral and styrofoam. The plants used are vetiver grass (*C. zizanioides*, L), cyperus plant (*C. alternifolius*) and water hyacinth (*E. crassipes*). All plants are grown in floating system. The selection of floating system is based on previous research, Raharjo (2015a), that the floating system gives the best results compared to the emergent system.

Each type of plant is grown on styrofoam sheet and each treatment is planted as many as 25 clumps. The aquaculture wastewater used for the research comes from of catfish (*C. gariepinus*) with 1000 stocking density. The main pollutant of wastewater comes from the remains of feed and feces during the maintenance activity of catfish. The feed given during the study had a 32% protein composition.

### Methods

*Construction of the system.* The constructed wetlands used Flow Water Surface (FWS) system (FWS-CWs) where the plants is planted with a floating system using styrofoam in four treatments, i.e. control (bioball without plant), vetiver grass (*C. zizanioides*, L), cyperus plant (*C. alternifolius*) and water hyacinth (*E. crassipes*). The design of FWS-CWs is 2 m x 1 m x 0.5 m, with a cement construction. For all the treatment the substrat used coarse sand and corals. Description of each treatment is presented in Table 1.

Table 1. Deskripsi Perlakuan FWS-CWs

No.	Perlakuan	Kode	Description
1.	Control	K	Bioball (without plant) with coarse sand substrate + coral.
2.	Hidroponik Vetiver	HV	Vetiver with a floating medium of styrofoam with coarse substrate + coral.
3.	Hidroponik Cyprus	HC	Cyprus with a floating medium of styrofoam with coarse substrate + coral.
4.	Enceng Gondok	E	Water hyacinth with medium coarse sand + coral.

*Operation and management of the system.* The study was conducted for two months, and set at a one day residence (t) or hydraulic retention time (HRT) with aquaculture effluents average of 0.4 L/min or 576 L/day.

*Removal rate constant.* The removal rate constant used for system design was calculated by equation (Spellman 2004):

$$\% \text{ Removal} = \frac{[\text{Influent concentration} - \text{Effluent concentration}]}{\text{Influent concentration}} \times 100$$

## Results and Discussion

*Indication of Plant Growth.* For two months of research showed that all plants were growing. This is indicated by the increase in the number of buds of each plant, with the fastest growing buds is water hyacinth, followed by vetiver and cyperus. Fig.1 shows that test plant growth is influenced by plant age and each with a linear model:  $y = 0.648x - 4.53$  (Vetiver);  $y = 1.098x - 6.66$  (Cyperus);  $y = 0.171x + 1.16$  (Hyacinth). Age has a strong relationship with increasing number of buds. However, this growth must also be supported by the availability of adequate nutrients for growth. Nutrients in FWS-CWs are obtained from the transformation of organic matter into inorganic by microbes. The main transformation related to plant growth is the transformation of nitrogen and phosphate in FWS-CWs. Kadlec and Wallace (2009), nitrogen transformation is a chemical transformation from inorganic to organic compounds and back from organic to inorganic. Nitrogen elements are usually in the form of organic and inorganic compounds. Nitrogen nutrients in the wetlands will be transformed through a number of processes, i.e. physical processes and microbes. Vymazal and Kropfelova (2008), transformation of phosphate (P) elements does not undergo valence changes during the biotic assimilation process of inorganic phosphate elements or during the decomposition process of organic phosphates by microorganisms. The element P in wetland will be in the form of organic P and an inorganic P compound.

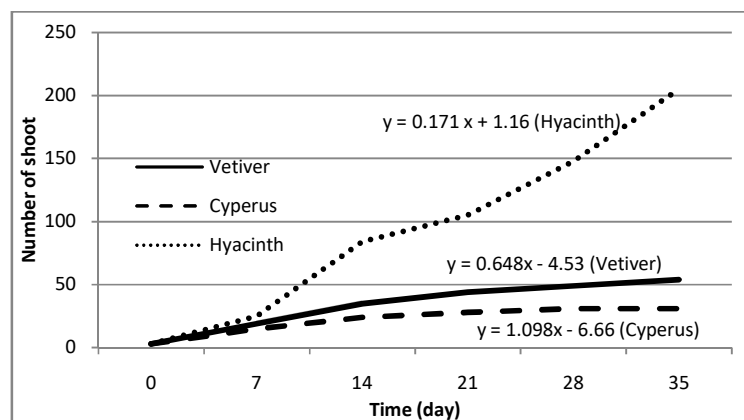


Figure 1. Pattern of the increase in the number of buds

*Performance of FWS-CWs system.* Fig. 2 shows the pollutant's capability by looking at the waste load in the inlet and the waste load in the outlet of FWS-CWs. Removal by FWS-CWs against  $\text{NH}_3$  and  $\text{PO}_4^{3-}$  for each treatment varies for different waste loads. In the first month of treatment, the average feed load was 162 g/day and the second month, the average feed load was 335 g/day. Fig. 2a and 2c show that there is a decrease in the ability of ammonia removal for all treatments. Fig. 2b and 2d illustrate the decrease in the phosphate removal ability of all treatments. The ability to eliminate ammonia and phosphate in the first month shows a better ability than in the second month.

The ability of the removal of  $\text{NH}_3$  first month show that cyperus and vetiver give the best efficiency rate compared to controls and water hyacinth, which is 66.7% (Table 2). While for  $\text{PO}_4^{3-}$  best treatment is water hyacinth with efficiency level 89.7%, followed by vetiver with efficiency level equal to 75.4% and cyperus grass with efficiency level 71.2% (Table 2). The ability to remove  $\text{NH}_3$  and  $\text{PO}_4^{3-}$  in the second month has decreased significantly, this is presumably because the FWS-CWs system with one day residence time is only able to eliminate at feed load less than 335 g/day. Raharjo et al. (2015a, 2015b), that the optimal capability of CWs and phytoremediation is with a residence time of three days or more.

Kadlec and Wallace (2009), residence time in the CWs system in theory ranges from 2.4 to 5.3 days with an average of 3.5 days. While Garcia (2003), HRT is a key factor in the transformation of pollutants by microbes and in general the saturation value in HRT 3 days.

Table 2. Level of treatment efficiency (%)

Month 1 (feed load: 162 g/day)				
Parameters	Control	Vetiver	Cyperus	Hyacinth
NH <sub>3</sub>	35.7	66.7	66.7	0.0
PO <sub>4</sub>	0.0	75.4	71.2	89.7
Month 2 (feed load: 335 g/day)				
Parameters	Control	Vetiver	Cyperus	Hyacinth
NH <sub>3</sub>	21.1	1.8	0.0	15.8
PO <sub>4</sub>	0.0	0.0	42.4	33.1

The dynamics of NH<sub>3</sub> and PO<sub>4</sub><sup>3-</sup> also affect the performance of pollutant removal by the FWS-CWs and the plant phytoremediation capability (Fig. 2). The pollutant's dynamics are highly dependent on how much feeding is given, so that the wastewater load affects the performance of FWS-CWs. Avnimelech (2007), the more feed will be given the more waste generated. This problem can not be avoided because only 20-30% of feed is capable of being assimilated by fish and the rest is excreted as metabolites waste and accumulates in the water. Pedersen et al. (2012), the feed load provided will determine the amount of concentration of nitrogen compounds and organic materials that will affect the water recovery process.

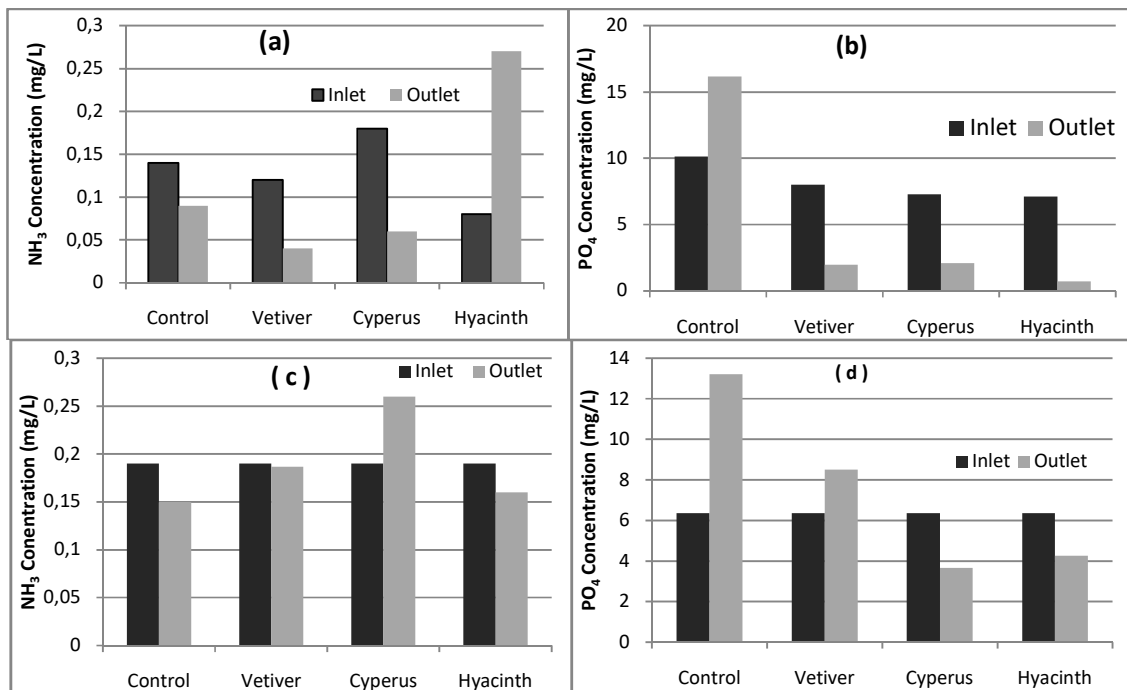


Figure 2. Comparison for ammonia and phosphate in the first month (a, b) and in the second month (c, d)

Efforts to upgrade the contaminant removal can be done by increasing the FWS-CWs capacity and increasing the population of the phytoremediation plant. Kennedy and Murphy (2004), increasing crop density affects the decrease of nitrogen concentrations.

Implementation of CWs and phytoremediation capable of being one of the alternative control of aquaculture wastewater, with attention to the capacity and HRT in the system. Lin et al. (2002), removal of

nutrients derived from aquaculture wastes can use the CWs system. Nasir et al. (2015), phytoremediation development is a sustainable green technology for effective catfish wastewater treatment. Truong et al. (2008) suggests that CWs effectively reduce the amount of contaminants in runoff from agricultural and industrial. Wang et al. (2010) states that wetlands are effective in removing BOD, SS, N and P as well as reducing metals, organic pollutants and pathogens.

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