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Improving productivity and water quality of catfish, *Clarias* sp. cultured in an aquaponic ebb-tide system using different filtration

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Abstract. Intensive culture waste has containing high nitrogen and phosphor elements can cause a negative impact on the fish and aquatic environment. The purpose of this experiment to examine the survival, growth, biomass of catfish, vegetable biomass production, and water quality. The treatments of this experiment were A) catfish culture in aquaponic with settling tank filter; B) catfish culture in aquaponic with settling tank and aerobic tank filters; and C) catfish culture in aquaponic with settling tank, semi-anaerobic tank, and aerobic tank filters. Each treatment consisted of three replicates. The result showed that growth, survival, and biomass of catfish at B and C treatments were higher than that of A treatment ($P<0.05$). Vegetable production such as pakchoy, caisim, tomato, and eggplant at B and C treatments showed higher than that of A treatment ($P<0.05$). Percentage of removal efficiency (RE) such as nitrite, nitrate, total ammonia (TAN), phosphate, total dissolved solids (TDS), and total organic matter (TOM) at B and C treatments were higher compared to A treatment ($P<0.05$). Addition of a filter tank in the aquaponic system should be installed in order to increase fish and vegetable production and to keep water quality stable.

1. Introduction

Catfish, *Clarias* sp. is one of the freshwater fish species which is very important for food security, especially, in developing countries including Indonesia [1]. The catfish culture system has been established from the broodstock, egg, larvae, seed, and grow-out. The culture system is mainly an intensive system. The advantages of the catfish are easy to culture, tolerance to environmental, high stocking density, and acceptable market. Thus, the production of this species can fulfill the market demand due to availability along the year, and the price is chip [2]. However, intensive culture system of catfish has been successfully increased fish produce but it still finds some of the obstacles, especially water quality and waste-product that obtain from culture activity such as feces, urine, and uneaten food. Waste-product aquaculture is mainly containing the high concentration of nitrogen (N) and phosphor (P) elements which negatively impact the aquatic environment i.e. eutrophication and toxic [3]. Waste from an intensive culture system is containing 62% total nitrogen (TN) and 40% total phosphorus (TP) [4].

Some effort has been reported to improve catfish productivity with the difference of culture technique such as biofloc, vaccine and probiotic utility, and recirculating aquaculture system (RAS). Biofloc technique has been done to minimize the waste. This technique is emphasized on heterotrophic bacteria utility during the culture period. The advantages of this culture technique can reduce the feeding rate and keep the water quality stable. However, disadvantages of this system have to continue adding bacteria and wheat powder in order to keep the number of bacteria population and C/N ratio in the water pond within the optimal conditions. If the aeration stop for more than two hours hour, the fish will be died due to oxygen dissolved depletion and another toxic substance concentration (i.e. ammonia and nitrite) increase [5]. Implementation of vaccine and probiotic in term of an increase in fish production [6]. Recirculation aquaculture system (RAS) is also suitable for fish culture due to water conserve, high produce, and easy to maintain during the operation. Nevertheless, the equipment components of RAS

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are expensive. Therefore, to build of RAS needs a high cost. The RAS is fruitful for high price fish species only [7].

Aquaponic is integrated farming between fish and plant. Basically, this system is based on mutualism symbiosis between fish and plant because the waste-product from aquaculture activity such as nitrogen and phosphorus elements can be used by the plant as a fertilizer, especially, nitrate and phosphate [8].Vegetable plant will be able to reduce total ammonia (TN) and total phosphate (TP) are 40.26% and 41.39% [9].40.32 % and 63.87% [10]. and 41.5% dan 75.5% [11], respectively. Many construction designs and types of aquaponic have been applied in the world. Nowadays, this system is very popular. The aquaponic system has an effect in reducing pollutant. The production of aquaponic is influenced by design construction, the ratio between fish and plant, fish species, and the kind of vegetable species [12]. The simplicity of design construction is the pond water transferred using water pump through the aquaponic while the advance of design construction is usually using the filter before the pond water transferred into the aquaponic [13]. This advanced design is a combination between RAS and aquaponic [14]. However, the high cost to construct such a system is needed. Therefore, the experiment focused on the simple design filter construction is a need in order to increase the fish and vegetable production. The purpose of the present experiment is to determine the different filter on survival rate, growth, the biomass of catfish, vegetable productivity, and water quality.

2. Materials and methods

2.1. Time and experimental site

The experiment conducted from June to August 2016 at Research Station for Environmental Technology and Toxicology Freshwater Aquaculture, Cibalagung, Bogor, West Java, Indonesia. Research Institute for Freshwater Aquaculture and Fishery Extension, Bogor, West Java, Indonesia.

2.2. Fish culture

Catfish, *Clarias* sp. used with 6.61±0.70 cm in total length and 5.65±0.63 g in body weight. Stocking density was 300/m2 (equal to 1200 fish each pond). Culture period of fish was 75 days. Feeding rate was 5%/day/biomass. Ten fish was taking as a sample every 15 days in order to measure the length and weight. Nine concrete ponds were set up with a water volume of 9 m^3 (3 m length x 3 m width x 1 m depth) for each pond. Each pond completed by a water pump (Yamano WP 3700), aeration, and an aquaponic unit.

2.3. Aquaponic construction design

One unit of aquaponic consisted of 11 buckets with a volume of 15L as a plant container and filter. The filter number based on the treatment. Design construction of aquaponic installed ebb-tide system. The substrate of aquaponic consisted of gravel stone with a diameter of 2-3 cm, charcoal with a diameter of 2-3 cm, and fern root. The filter consisted of three filters, the first filter using a bucket with the volume of 50L as a settling tank containing limestone with a diameter of 4-5 cm and gravel stone with a diameter of 2-3. The second filter using a plastic barrel with the volume of 100L as a semi-an aerobic tank containing was the same as the first filter and completed by aeration. The third filter using a plastic barrel with a water volume of 100L as an aerobic tank containing bio ball and completed by aeration. The layout of aquaponic construction design (Figure 1) and implementation of the different filter of an aquaponic unit (Figure 2).

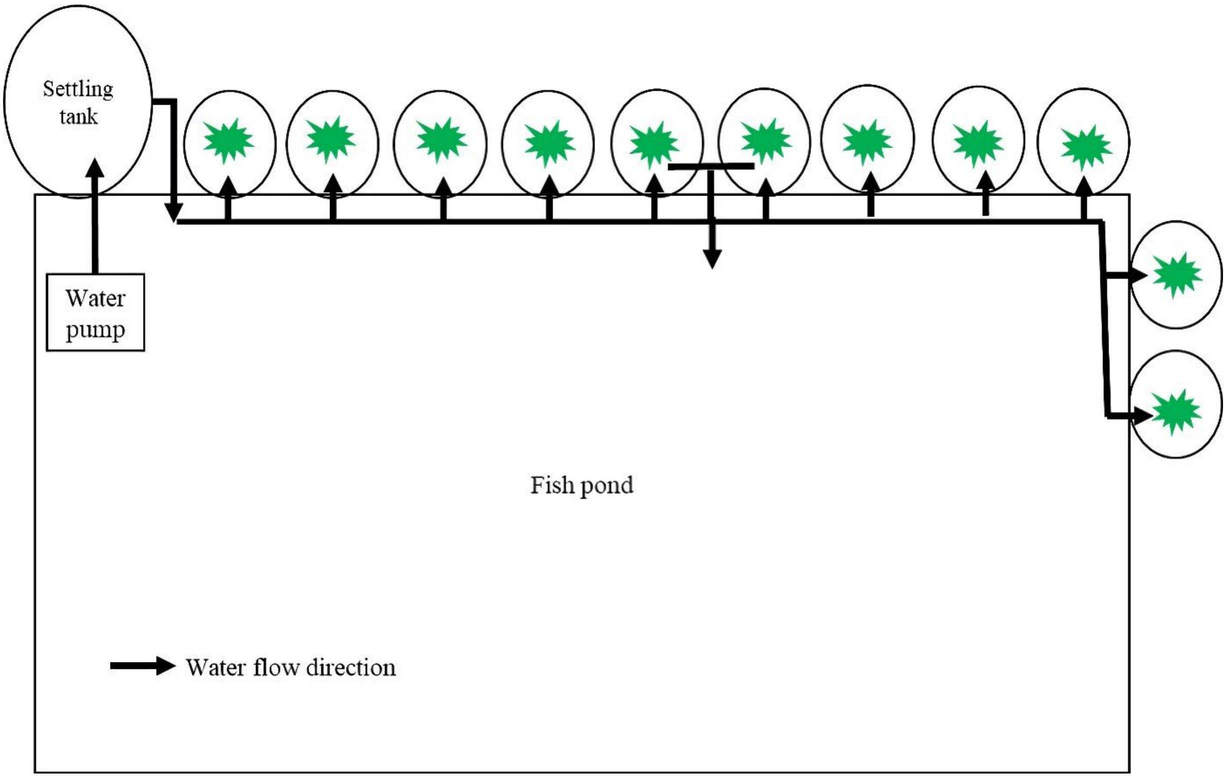


Figure 1. The layout of an aquaponic construction design unit

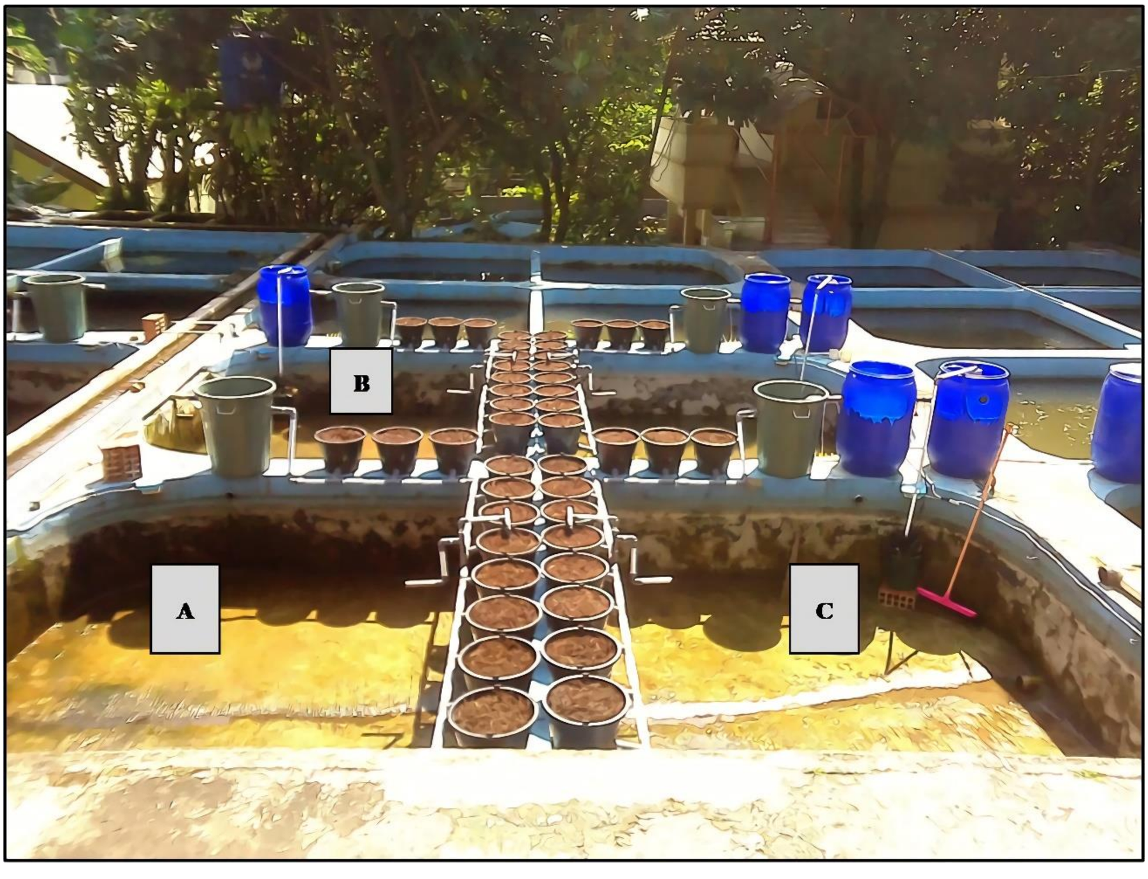


Figure 2. Implementation of aquaponic construction design based on the treatment. A) Aquaponic unit with one filter (settling tank); B) Aquaponic unit with two filters (settling and semi-aerobic tanks); and C) Aquaponic unit with three filters (Settling, semi-aerobic, and aerobic tanks)

2.4. Vegetable plant

Vegetable species in this experiment consisted of leaf vegetable and fruit vegetable. Pakcoy, kailan, and caisim as leaf vegetables were used. Tomato and eggplant as fruit vegetables were used. Leaf vegetable was planted three plants for one bucket where fruit vegetable was planted one plant for one bucket. Seedling both of leaf and fruit vegetables used to height ranged of 5-6 cm. The vegetables planted after the system had operated at least 10 days after fish stocked into the fish pond. Artificial fertilizer, pesticide, and another chemical agent during the culture prohibited.

2.5. Experimental design

Block randomized design performed in this experiment. The experiment consisted of three treatments with three replications. The different filter tank was a treatment. The treatment of different filter as followed:

A) Catfish culture in aquaponic with completed by settling tank as a filter
B) Catfish culture in aquaponic with completed by settling and aerobic tanks as a filters
C) Catfish culture in aquaponic with completed by settling, semi-aerobic, aerobic tanks as filters.

2.6. Parameters observed during the experimental period

Water quality parameter observed such as temperature, pH, dissolved oxygen (DO), total ammonia (TAN), nitrite (NO_2-N), nitrate (NO_3-N), and phosphate (PO_4-P) every ten days. Measured of temperature, pH, and DO, total dissolved solids (TDS) using water checker where measured of TAN, nitrite, nitrate, phosphate, and total organic matter (TOM) analyzed using procedure of Standard Nasional Indonesia (SNI) [15,16,17] at the laboratory of Research Station for Environmental Technology and Toxicology Freshwater Aquaculture, Cibalagung, Bogor, West Java, Indonesia.

Calculation of biological performances data such as survival rate, absolute length, and weight, and removal efficiency of pollutant using formula as following:

Survival rate calculated base on the formula:

$$SR = \left(\frac{Nt}{No}\right) \text{ x } 100\% \quad (1)$$

Where:
SR = Survival Rate (%)
Nt = Number of fish by the end of the experiment
No = Number of fish at the beginning of the experiment

Absolute length calculated using the formula:

$$Pm = Lt - Lo \quad (2)$$

where
Pm = Absolute length gain (cm)
Lt = Average of length at the end of the culture period (cm)
Lo = Average of length at the beginning of culture period (cm)

Absolute weight calculated using the formula:

$$\Delta W = Wt - Wo \quad (3)$$

where:

ΔW = Absolute weight gain (g)
Wt = Average of weight at the end of the culture period (g)
Wo = Average of weight at the beginning of the culture period (g)

Biomass of fish calculated using the formula:

$$B = W\ X\ N \quad (4)$$

where:
B = Biomass
W = Average of weight (g)
N = Number of the population at the end of the experiment

Removal efficiency (RE) calculated base on formula:

$$RE\ (\%) = C_{inlet} - C_{outlet} / C_{inlet} \times 100 \quad (5)$$

where:
RE = Removal efficiency (%)
C_{inlet} = Concentration of pollutant inlet (mg/l)
C_{outlet} = Concentration of pollutant outlet (mg/l)

2.7. *Statistical Analysis*

Data analysis using one-way ANOVA and post hoc multiple comparisons using Tukey's test

3. Results

3.1. Survival rate, absolute growth, and biomass of catfish

Survival rate, absolute length, absolute weight, and biomass of catfish cultured in an aquaponic system with the different filter are presented at Table 1.

Table 1. Survival, absolute length, and weight, and biomass of catfish cultured in an aquaponic system with different filtration

Treatment	Parameters					
	Initially stocked (fish)	Finally Stocked (fish)	Survival (%)	Absolute Length (cm)	Absolute Weight (g)	Biomass (Kg)
A	1200	802.33±77.29a	66.86±6.44a	17.05±0.16a	86.67±0.88a	74.83±5.82a
B	1200	993.33±43.29b	82.78±3.61b	18.69±0.06b	90.46±0.91b	96.42±3.40b
C	1200	995.33±12.10b	82.94±1.01b	19.44±0.23c	102.20±1.21c	108.58±0.59c

Remarks: The values followed with the same letter are not significantly different (P>0.05)

The survival rate at C treatment (82.94±1.01) was the highest, followed by B treatment (82.78±3.61) and the lowest (66.86±6.44) found at A treatment. Statistical analysis revealed that B and C treatments were better than that of A treatment in survival rate (P<0.05). Both of absolute length and weight found that at C treatment (19.44±0.23 cm and 102.20±1.21 g) was the highest then followed by B treatment (18.69±0.06 cm and 90.46±0.91 g) and A treatment (17.05±0.16 cm and 86.67±0.88 g). Statistical analysis showed that C treatment was better than that of B treatment and A treatment in term of absolute length and weight (P<0.05). Biomass of catfish found that the highest at C treatment (108.58±0.59 Kg), followed by B treatment (96.42±3.40 Kg) and A treatment (74.83±5.82 Kg). Statistical analysis showed that significantly different (P<0.05) among the treatments on biomass.

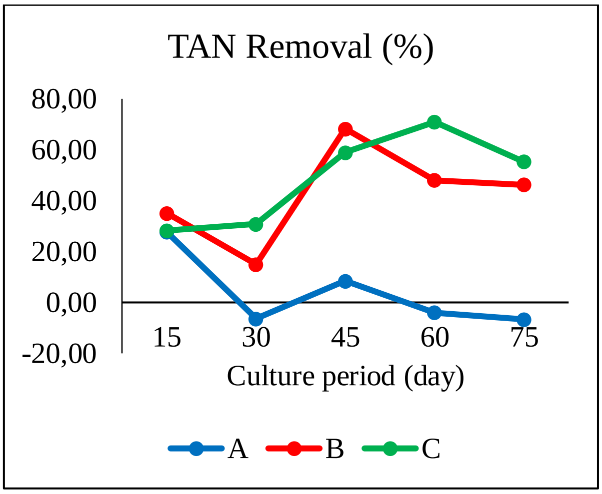
3.2. Vegetable production
Leaf vegetable (Pakcoy, kailan, and caisim) and fruit vegetable (tomato and eggplant) cultivated on aquaponic with different filter is shown at table 2.

Table 2. Average of vegetable production which cultivated in an aquaponic system with different filtration

Treatment	Average of vegetable yield (g)				
	Pakcoy	Caisim	Kailan	Tomato	Eggplant
A	150.00 ± 4.58a	133.33 ± 5.69a	100.00 ± 10.00a	323.33 ± 5.77a	151.67 ± 5.77a
B	300.00 ±3.61b	200.00 ± 10.41b	133.33 ±23.09a	750.00±10.00b	206.67 ±7.64b
C	466.67 ± 7,51c	466.67 ± 7,64c	300.00 ± 15.00b	853.33 ± 12.58c	255.00 ± 8.66c

Remarks: The values followed with the same letter are not significantly different (P>0.05)

3.3. *The pattern of removal efficiency*
The pattern of removal efficiency of water quality parameters such as total ammonia (TAN), nitrite, nitrate, and phosphate, total dissolved solids (TDS), and total organic matter (TOM) are shown at figure 3.



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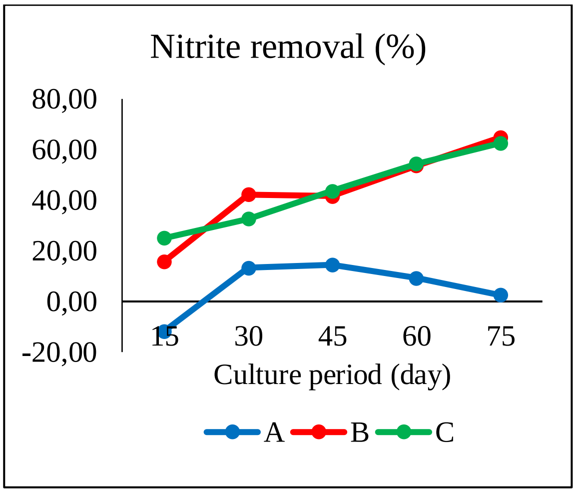

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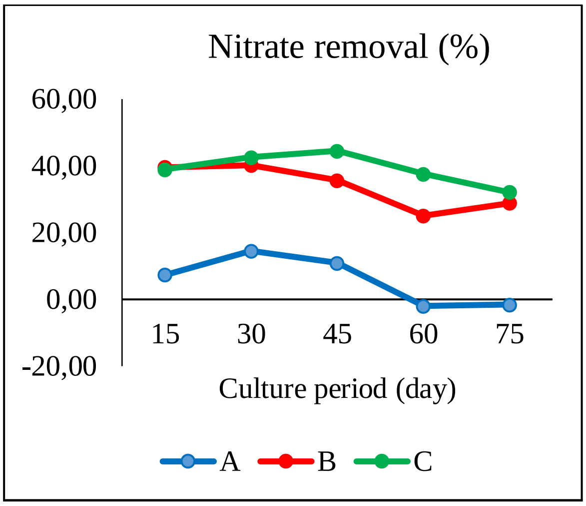

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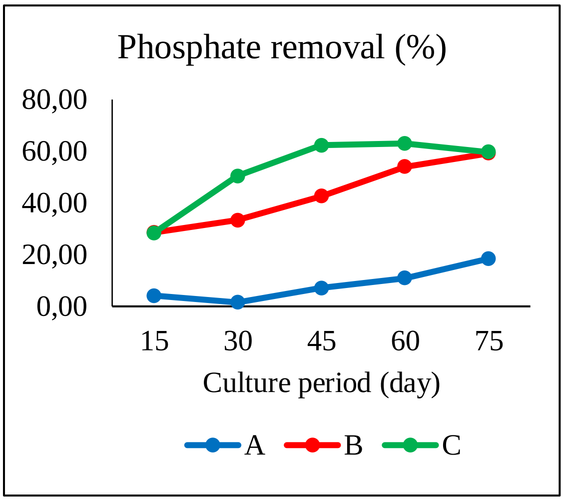

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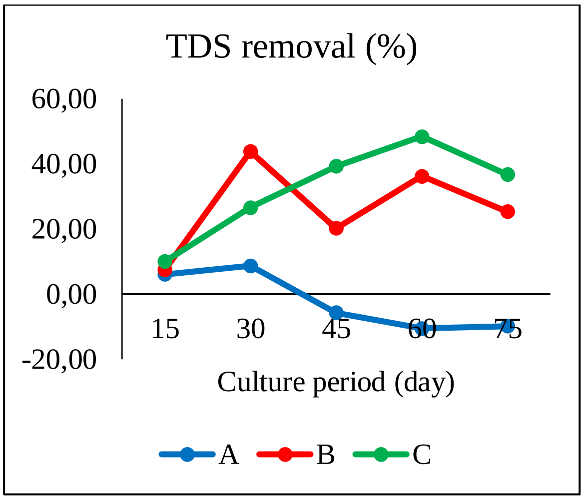

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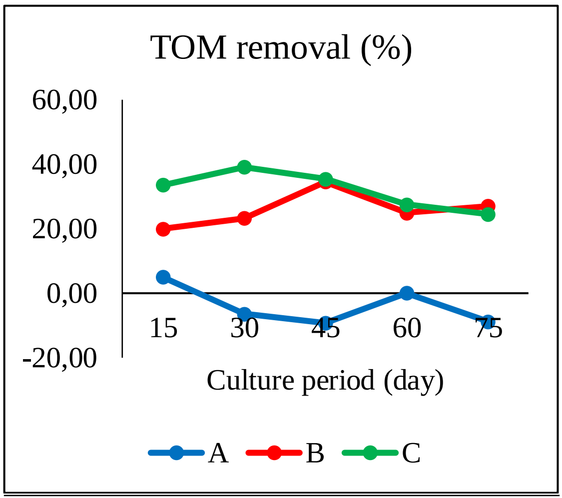

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Figure 3. The pattern of removal efficiency of total ammonia (TAN), nitrite, nitrate, phosphate, total dissolved solids (TDS), and total organic matter (TOM) of catfish cultured in an aquaponic system with different filtration

All data showed that removal efficiency such as total ammonia (TAN), nitrite, nitrate, phosphate, total dissolved solids (TDS), and total organic matter (TOM) was higher at B and C treatments compared to A treatment. B and C treatments showed the same pattern but C treatment was higher than that of B treatment. Total ammonia, nitrate, and TDS at all treatments showed a decrease by the time at the end of an experiment where TOM was relatively constant at B and C treatment unless at A treatment was decrease at the end of the experiment. Nitrite and phosphate showed an increase with increasing culture period, except nitrite was decreased at A treatment. This indicated that utility of filtration in an aquaponic system was very important in terms of removing particulate matter and chemical process which related to keeping water quality during the culture. The physic filter only seemed to be not effective in reducing such pollutant while the addition of semi-aerobic and aerobic filter showed very effective.

The average percentage of removal efficiency of TAN, nitrite, nitrate, phosphate, TDS, and TOM during common carp cultured in an aquaponic system with different filtration is presented at Table 3.

Table 3. The average percentage of removal efficiency of TAN, nitrite, nitrate, phosphate, TDS, and TOM of catfish cultured in an aquaponic system with different filtration

Parameter	Treatment		
	A	B	C
TAN	3.84±14.72a	42.51±19.51b	48.82±18.59b
Nitrite	5.58±10.75a	43.61±18.23b	43.63±15.35b
Nitrate	5.86±7.40a	33.90±6.69b	39.13±4.82b
Phosphate	8.41±6.61a	43.55±13.07b	52.78±14.51b
TDS	-2.25±9.03a	26.60±14.13b	32.20±14.65b
TOM	-3.89±6.17a	25.94±5.43b	32.03±5.93b

Remarks: the value followed with the same letter are not significantly different (P>0.05)

All data of percentage average of removal efficiency (Table 3) such as TAN, nitrite, nitrate, phosphate, TDS, and TOM at B and C treatments were better than that of A treatment (P<0.05). This indicated that B and C treatment is most effective compared to A treatment in removing such pollutant.

3.4 *Water quality*
The range of water quality parameters such as temperature, pH, dissolved oxygen (DO), TAN, nitrite, nitrate, phosphate, TDS, and TOM during the culture period of catfish in an aquaponic system with different filter is presented at table 4.

Table 4. The range of water quality parameters observed during a culture period of catfish in an aquaponic system with different filtration

Parameters	Treatment			Optimal range
	A	B	C	
Temperature °C	26.4-30.8	26.8-30.6	26.4-30.7	26-32°C [19]
pH	6.00-6.79	6.00-6.75	6.00-6.79	6-9[18, 19]
DO (mg/L)	2.33-4.91	3.51-4.90	3.97-4.82	≥3 mg/L [18;19]
TAN (mg/L)	1.255-4.360	0.368-2.660	0.301-2.320	<2.5 mg/L [19]
Nitrite (mg/L)	0.17-0.50	0.19-0.35	0.14-0.315	<0.06 mg/L [18]
Nitrate (mg/L)	1.360-5.373	1.930-3.837	1.100-3.145	<20 mg/L[18]
Phosphate (mg/L)	0.198-0.965	0.193-0.605	0.199-0.496	<1 mg/L [18]
TDS (mg/L)	99-542	94-395	90-387	<1000 mg/L[18]

TOM (mg/L)	15.91-145.60	15.80-77.21	18.45-70.51	<85 mg/L[19]

Overall data (Table 4) of the range of water quality parameters showed that DO, TAN, and TOM at A treatment were beyond the optimal range where at B treatment found that TAN was slightly over the optimal. Nitrite concentration showed beyond the optimal range for all treatments even if nitrite concentration at B and C treatment were lower than that of A treatment.

4. Discussion

4.1. Survival, growth, and biomass of catfish

Catfish (*Clarias* sp.) is freshwater fish that tolerate to the environmental extreme and high stocking density. Thus, catfish is suitable for culturing in an aquaponic system [8]. Survival, growth and biomass productivity of fish culture are correlated to design construction of aquaponic which related to carrying capacity (optimal stocking) should have balanced with the growing area of aquaponic plant component. The existence of settling tank, filter, and other devices are playing important role in term of physical and chemical processes such as nitrification and denitrification and removal of the particulate matters. These components are close to water quality that support to fish growth and survival, and biomass fish production, and also plants production [12]. The present experiment shows that survival, growth and fish production (biomass) is higher at B and C treatments caused by sufficient of filter than that of A treatments (Table 1). Therefore, the addition of physical and biofilter tanks are recommended to increase fish production.

4.2. Vegetable production

The advantage of the aquaponic system is diversification product fish and plan which the healthiest human diet according to current nutritional science [21]. Therefore, this technology can be accepted a base on environmental, economic, and social for sustainability [22]. Plant production in an aquaponic system depends on feeding rate and fish biomass to supply plant growth. Thus, the optimum ratio daily fish feed input to plant growing area will maximize plant production while maintaining relatively stable levels of dissolved nutrients [12]. Components system of aquaponic design affects the dissolved nutrient supply plant growth. If the availability of components system insufficient, it does not work properly in terms transform waste-by product of fish into the plant biomass [23]. The present experiment shows that plant production at C treatment is the highest than that of A treatment (Table 2). This indicated that adding the filter is a significant increase in plant production. Based on the observation of plant at A treatment during the fish culture, it was clear that some of the plants show slowly grow both of leaf and fruit vegetables compared to the other treatments. In addition to the water on the bucket at A treatment was always flow overdue to clogging in the PVC pipe and it occurred after one month culture period up to the end of the experiment when the accumulation of particulate matter increase with increasing culture period. Some of the plants found damage of root. Therefore, leaf and fruit vegetable plant production at A treatment was low. Most of the fecal waste fish generate should be removed from the waste stream before it enters the aquaponic container. Other sources of particulate waste are uneaten food, an organism (e.g. bacteria, fungi, and algae) that grow in the system, it will depress dissolved oxygen levels as it decays and produces carbon dioxide and ammonia. Furthermore, suspended solids entering the aquaponic component have resulted in accumulating on plant root and create anaerobic zones that prevent nutrient uptake by active transport [12].

4.3. Removal efficiency and water quality parameters

The main concern in an aquaponic system is the removal of ammonia, a metabolic waste product excreted through the gill of fish. Ammonia will accumulate and reach toxic levels unless it is removed by the process of nitrification (referred to more generally as biofiltration), in which ammonia is oxidized first to nitrite, which is toxic and then to nitrate, which is relatively non-toxic. The process will be occurred by nitrifying bacteria which live on the substrate in the filter tank[13]. Nitrate will be used as a fertilizer, besides, phosphate for plant grow [24]. The present experiment shows that application of three filters i.e. settling, semi-aerobic, and aerobic tanks (C treatment) is significantly higher in removal of pollutants that generated from fish waste compared to the other treatments (Table 3) and the pattern of removal efficiency from the beginning up to at the end of experiment at C treatment is higher in terms of pollutants removal. This suggesting that the nitrification and denitrification process may be work properly. The critical component in an aquaponic system is filtration. Biofiltration exist is very important in order to improve fish and vegetable production, and water quality [24,25,12].

Water quality parameters are the main factor in aquaculture for fish growing and producing. There are some water quality parameters that play an important role such as temperature, pH, DO, nitrite, and total ammonia [19]. Our result shows that the range of water quality parameters such as DO, TAN, nitrite, and nitrate was beyond the optimal range, even if at B and C treatments are better than that of A treatment (Table 4). Thus, the present experiment shows that survival, growth, and biomass at A treatment are low. Dissolved oxygen (DO) concentration is less than 3 mg/L affect the growth, survival, behavior, and physiology of fish. Nitrite is toxic and in the sub-lethal concentration can inhibit growth [26].

5. Conclusion
The implementation of three filters such as settling, semi-anaerobic, and aerobic tanks in an aquaponic system can increase fish and vegetable production and water quality within in the optimal condition.

6. References
[1] Setiadi E 2017 Kleinschlige aquaponics voor voedselzekerheid in Indonesia. *Aquaculture*, **3**:34-37
[2] Ugwumba C O A 2011 Analysis of catfish farming system and its impact on net farm income in Anambra State, Nigeria. *Journal of Agricultural and Biological Science*, **6** (2): 26-30
[3] Lazzari R and Baldisseroto 2008 Nitrogen and phosphorus waste in fish farming. B. Inst. Pesca, Sao Paulo, **34**(4):591-600
[4] Osti J A S, Moraes M A B, Carmo C F, and Mercante C T J 2018 Nitrogen and phosphorus flux from the production of Nile tilapia through the application of environmental indicators. Brazilian Journal of Biology, **78** (1); 25-31
[5] Widyastuti Y R, and Setiadi E 2017 Application of heterotroph bacteria on “Mutiara” catfish culture. Prosiding Nasional Ikan dan Perikanan. SIPP. Peningkatan Pengelolaan Perikanan serta Konservasi Biodiversitas Ikan dan Ekosistem Aquatik di Indonesia, Bogor 12 September 2017. Jilid I MII, p. 545-554
[6] Taufik I and Setiadi E 2014 Catfish culture (*Clarias gariepinus*) on plastic sheet pond with vaccination and probiotic. Media Aquaculture, **9**(2):103-109
[7] Besson M, Komen H, Aubin J, de Boer I J M, Poelman M, Quillet E, Vancoillie, Vandeputte M, and Arendonk 2014 Economyc values of growth and feed efficiency for fish farming in recirculating aquaculture system with density and nitrogen output limitations: a case study with African catfish (*Clarias gariepinus*). *Journal of Animal Science*, **92**:5394-5405
[8] Taufik I, Setiadi E, and Sutrisno 2015 Harvest Fish, Vegetable, and Fruit with Yumina-Bumina Technique. Penebar Sawadaya, Jakarta. pp. 1-85
[9] Setijaningsih L 2012 The growth of common carp (*Cyprinus carpio*) with different of planted distance of water spinach (*Ipomoea aquatic*) on aquaponic system. Prosiding Forum Inovasi Teknologi. Reseach Center Aquaculture. Research and Development for Marine and Fisheries Agency. P435-439
[10] Zhou X, Wang J, Xue L, Xu X, and Yang L 2005 N and P removal characters of eutrophic water body under planted float. *Water Res.*, **16**(11); 219-223

[11] Hum H, Aoy S, Yang X , and Lit Q 2008 Treating eutrophic water for nutrient reduction using an aquatic macrophyte (*Ipomoea aquatica* Forsskal) in a deep flow technique system. *Aquaculture*, **95**: 607-615
[12] Rakocy J E, Masser M P, and Losordo T M 2006 Recirculating aquaculture tank production systems: Aquaponic-integrating fish and plant culture. SRAC No. 545, p 1-16
[13] Rakocy 2012 Aquaponics-Integrating Fish and Plant Culture. Willey-Blackwell, pp 344-386
[14] Monsees H, Kloas w, and Wuertz S 2017 Decoupled systems on trial: Eliminating bottlenecks to improve aquaponic process. *PLoS ONE*, **12**(9):2-18
[15] Standar Nasional Indonesia 06-6989.30-2005 Water and waste water –Part 30: Test procedure of ammonia concentration using spectrophotometer. ICS 13.060.01.
[16] Standar Nasional Indonesia 06-6989.9-2005 Water and waste water-Part 9. Test procedure of nitrite (NO2-N) by spectrophotometer. ICS 13.060.50.
[17] Standar Nasional Indonesia 6989.79-2011 Water and waste water-Part 79: Test procedure of nitrate (NO3-N) with cadmium reduction using UV-visible spectrophotometer. ICS 13.060.050
[18] Government Regulation Number 82 2001 President Republic of Indonesia. Water quality management and water pollution control pp 299
[19] Bhatnagar A and Devi P 2013 Water quality guidelines for the management of pond fish culture. *International Journal of Environmental Sciences*, **3**(6):1980-2009
[20] Ghate S R, Burtle G J, and Gascho G J 1993 Reuse of water from catfish ponds. Proceeding of the 1993 Georgia Water Resources Conference, held April 20 and 21, 1993, at the University of Georgia, Athens, Georgia. 391-393
[21] Sommerville, Christhoper, Cohen M, Pantanella E, Stankus A, and Lovatelii A 2014 "Small-scale aquaponic food production-integrated fish and plant farming". No. 589. FAO, Fisheries and Aquaculture Technical Paper. Rome, Italy
[22] Konig B, Junge R, Bittsanszky A, Villarroel M, and Komives T 2016 On the sustainability of aquaponics. *Ecocycle*, **2**(1):26-32
[23] Delaide B, Delhaye G, Dermience M, Gott J, Soyeurt, and Jijakli M H 2017 Plant and fish productoin performance, nutrient mass balances, energy, and water use of the PAFF Box, a small-scale aquaponic system. *Aquaculture Engineering*, **78**:130-139
[24] Tyson R V, Treadwell D D, and Somonne E H 2011 Reviews opportunity and challenges to sustainability in aquaponic system. *HorTechnology*, **21**(1):6-10
[25] Graber A and Junge R 2009 aquaponic system: Nutrient recycling from fish wastewater by vegetable production, *Desalination*, **246**:147-156
[26] Green B W 2010 Effect of channel catfish stocking rate on yield and water quality in an intensive, mixed suspended-growth production system, North American Journal of Aquaculture, **72**:97-106