



## The Role of Filter with Different Media Compositions on Water Quality and Survival of *Pangasius* (*Pangasius* sp.) in Recirculation Aquaculture System

Ariska Nur Oktavia, Sri Hastuti\*, Dicky Harwanto

Department of Aquaculture, Faculty of Fisheries and Marine Science,  
Universitas Diponegoro. Jl. Prof. Soedarto Tembalang, Semarang, Jawa Tengah-50275

\*Corresponding author: [hastuti\\_hastuti@yahoo.com](mailto:hastuti_hastuti@yahoo.com)

Received 06 November 2020; Accepted 18 May 2021; Available online 30 June 2021

### ABSTRACT

The high market demand for *Pangasius* (*Pangasius* sp.) has encouraged farmers to adopt a cultivation system with high stocking densities and high feeding rates. This causes fish farming waste to increase and ammonia in the waters also increases, resulting in a decrease in water quality. One of the efforts to overcome this problem is by using Recirculation Aquaculture System (RAS). This study aimed to examine the effect of different filter media compositions on water quality and survival of *Pangasius* sp. reared in the RAS. Test fish, average weight of 4.59 g, kept for 30 days in aquarium with a density of 1.15 g.L<sup>-1</sup>. The feed given at satiation, twice a day. There were five treatments and four replications during study. The treatments were the difference composition of filter media, i.e. A (100% zeolite), B (25% net + 75% zeolite), C (50% net + 50% zeolite), D (75% net + 25% zeolite), and E (100% net). Dacron was used as a mechanical filter in all treatments. The results showed that the composition of different filter materials had a significant effect ( $P < 0.05$ ) on Survival Rate (SR), Total Amount of Feed Fed (TFF), Relative Growth Rate (RGR), and Feed Conversion Efficiency (FCE). The best performance was showed by media biofilter composition of 25% nets + 75% zeolite, with the value of VTR (Volumetric Total Ammonia Nitrogen Removal) were 55.45-66.32 g.m<sup>-3</sup>.day<sup>-1</sup>, SR was 93.75%; TFF was 124.84 g; RGR was 2.13%.day<sup>-1</sup>, and FCE was 46.87%. Various different compositions of net and zeolite as filter media on RAS were able to manage TAN below tolerance limit.

**Keywords:** catfish, dacron, filter composition, recirculation system, net, zeolite.

### ABSTRAK

Tingginya permintaan pasar akan ikan patin (*Pangasius* sp.), telah mendorong pembudidaya untuk menerapkan sistem budidaya dengan kepadatan tebar tinggi dan tingkat pemberian pakan yang tinggi pula. Hal ini menyebabkan limbah budidaya dan amoniak di perairan meningkat sehingga mengakibatkan penurunan kualitas air. Salah satu upaya untuk mengatasi masalah tersebut adalah dengan menerapkan sistem budidaya resirkulasi (*Recirculation Aquaculture System*, RAS). Penelitian ini bertujuan untuk mengevaluasi pengaruh komposisi media filter yang berbeda terhadap kualitas air dan kelangsungan hidup *Pangasius* sp. yang dibudidayakan di RAS. Ikan uji dengan berat rata-rata 4,59 g dipelihara selama 30 hari di akuarium dengan kepadatan 1,15 g.L<sup>-1</sup>. Pakan diberikan secara *ad satiation*, sehari dua kali. Penelitian ini menggunakan lima perlakuan dan empat ulangan. Perlakuannya adalah perbedaan komposisi media filter, yaitu A (100% zeolit), B (25% jaring + 75% zeolit), C (50% jaring + 50% zeolit), D (75% jaring + 25% zeolit), dan E (100% jaring). Dakron digunakan sebagai filter mekanis di semua perlakuan. Hasil penelitian menunjukkan bahwa komposisi bahan filter yang berbeda berpengaruh nyata ( $P < 0,05$ ) terhadap kelangsungan hidup (*Survival Rate*, SR), total pakan yang dimakan (*Total Feed Fed*, TFF), laju pertumbuhan relatif (*Relative Growth Rate*, RGR), dan efisiensi konversi pakan (*Feed Conversion Efficiency*, FCE). Performa terbaik ditunjukkan oleh komposisi media biofilter jaring 25% + zeolit 75%, dengan nilai pengurangan total amoniak nitrogen volumetrik (*Volumetric Total Ammonia Nitrogen Removal*, VTR) adalah 55.45-66.32 g.m<sup>-3</sup>.hari<sup>-1</sup>, SR adalah 93.75%; TFF adalah 124,84 g; RGR adalah 2,13%.hari<sup>-1</sup>, dan FCE adalah 46,87%. Berbagai komposisi jaring dan zeolit sebagai media filter pada RAS mampu mengelola TAN dibawah batas toleransi.

**Kata kunci:** lele, dakron, komposisi filter, sistem resirkulasi, jaring, zeolit.

## 1. Introduction

Pangasius is one of the important freshwater fish commodities in Indonesia. Pangasius has rapid growth and is resistant to disease and is easily cultivated (Domiszewski *et al.*, 2011). Pangasius has a fairly broad market share covering the domestic and export markets. Pangasius is a production target in national aquaculture because it is considered an economically important fish. According to the statistics of the Directorate General of Aquaculture, the consumption of catfish per capita tends to increase every year, reaching 21.9% in domestic market demand (KKP, 2018). Efforts to meet market demand are needed, namely with intensive culture systems. Intensive culture with high stocking densities and high feeding results in a rapid decline in water quality. The decrease in water quality is caused by feces and excess food waste. Feces waste and fish feed residue will produce a very toxic or toxic by-product, ammonia (Sidik *et al.*, 2002; Olmos *et al.*, 2019). The availability of water is increasingly limited, and in certain areas, there is still a shortage of clean water. The utilization of clean water is increasing. On the contrary, there are even more areas where water sources are exposed to pollution. Culture with the Recirculation Aquaculture System (RAS) system is expected to be able to conserve and utilize water more efficiently. The use of RAS systems in intensive aquaculture is important to create an optimal environment for fish (Harwanto and Jo, 2010; Enache *et al.*, 2011). The RAS system is about reuse of water, where the water coming out of the culture container is not discharged but is treated again so that it can be used again (Lekang, 2007). The RAS system aims to conserve water, and the quality of recirculated water remains controlled.

In order to improve the culture system of Pangasius, research is needed using a recirculation system with a composition of filters in the form of dacron, net, and zeolite. Research to investigate the efficiency of nets as filter media has been carried out by Kikuchi *et al.* (1994). Nurhidayat *et al.* (2012) conducted research using various compositions in the form of zeolite and bioball as filters. This study modifies the previous researches, namely the use of filters with various filter compositions in the form of dacron, net and zeolite. Dacron is a material that has holes or porous so that this material is used as a mechanical filter (Wang *et al.*, 2006). The specific surface area (SSA) of the dacron is 20 m<sup>2</sup>.m<sup>-3</sup> (Zhang *et al.*, 2016). According to Priono and Darti (2012), a mechanical filter is a tool to

separate solid material from water physically by capturing or filtering materials so that they are no longer found floating in a culture container.

The large amount of net waste resulting from fishing activities requires the use of it. The net material is expected to be used as filter material because nets that are not used are cheap and can even be obtained free of charge and easily obtained, especially in coastal areas. According to Wardhani *et al.*, (2015), nets are included in biological filters because they can be used as a place for bacteria to grow. The SSA of the nets is 35 m<sup>2</sup>.m<sup>-3</sup> (Kikuchi *et al.*, 1994). Zeolite is a chemical filter that is widely used to reduce toxic substances, especially in the absorption of ammonia, nitrites, and nitrates (Syamsiyah and Hadi, 2004; Las, 2007). The SSA of zeolites is 300 m<sup>2</sup>.m<sup>-3</sup> (Papa *et al.*, 2018; and Zhang *et al.*, 2016). Zeolites can remove ammonia from water because in the zeolite pore structure there are sodium ions instead of absorbed ammonia ions. Zeolites also have a role in the oxidation process, which is ion absorption and also as a medium for attachment and proliferation of bacteria (Nurhidayat *et al.*, 2012).

The application of the RAS system in fisheries can be applied in areas where water availability is limited so that fish culture with a recirculation system has a controlled environment, is environmentally friendly (eco-friendly), and can maintain the stability of water quality so that it can be relied upon to maintain high-density fish. The advantage of this system is that it saves water and land use. According to Rosmawati and Fia (2012), this system has many advantages, among which is that it does not require extensive land, can be applied in residential areas, and is environmentally friendly because water conditions are well controlled. Other advantages are reducing water use, saving energy because no new water changes occur, cleaning the water is easier and being able to improve the quality of aquaculture waters (Lekang, 2007; Harwanto *et al.*, 2011a,b). The application of the right filter composition will produce optimum water quality so that the cultured fish can live well with a high survival rate (Kikuchi *et al.*, 1994; Nurhidayat *et al.*, 2012; Muhtalief *et al.*, 2019). Therefore, research still needs to be done to determine the effect of the composition of dacron filters, nets, and zeolites on water quality, VTR (Volumetric TAN Removal), Survival Rate (SR), Total Amount of Feed Fed (TFF), Relative Growth Rate (RGR), and Feed Conversion Efficiency (FCE).

## 2. Materials And Methods

The fish used had an average weight of  $4.59 \pm 0.11$ g in the amount of 400 fish. Fish came from the Fish Seed Center, Ungaran, Central Java. Test fish stocked up to 20 fish per container. The density was  $1.15 \text{ g L}^{-1}$ . Fish were cultured for 30 days. Fish were acclimatized for a week so that the fish do not experience stress. The feed used was a commercial feed with 30% protein content. Feeding was carried out with a satiation method, twice a day at 08.00 and 16.00. Feeding is done by sowing the feed granules slowly. If the fish has decreased their appetite, then the feeding is stopped. Feed granules that have already been given and are not eaten will be immediately taken by siphoning and the number of granules is counted. The weight of the feed eaten is determined by the weight of the initial feed minus the number of uneaten granules multiplied by the known average granules weight.

The cultured container was aquaria, with a size of L:W:H = 60 x 40 x 40 cm, with a total of 20 aquarium. The water volume was 80 L in each container. The filter container used was 4 L volume PVC chamfer. The RAS flow rate was set at  $8 \text{ L.min}^{-1}$  or  $0.13 \text{ L.sec}^{-1}$ , resulting in six water cycles per hour. The RAS system was allowed to run for 14 days to grow enough nitrifying bacteria in the biofilter before study (Farazaki and Petros, 2019; Chung *et al.*, 2015). Water from aquaria was pumped into a filter containing dacron, net and zeolite, respectively. Then the water returns to the aquaria (Figure 1). In this RAS system, no water change is carried out. An additional 10% of the total volume is carried out once a week to replace water lost as a result of the sampling and siphoning processes.

The percentage of each filter material was calculated using the volume of filter material compared to the total volume of all filter materials in the filter container. Dacron, with SSA of  $20 \text{ m}^2.\text{m}^{-3}$ , was employed as a mechanical filter in all treatments. The length of the dacron used is 10 cm, with a thickness of 2 cm per sheet. Each filter uses 3 dacron sheets. The mesh material used is PE (Polyethylene), with a diameter of 1 mm. The filter material used were nets and zeolites with SSA of 35 and  $300 \text{ m}^2.\text{m}^{-3}$ , respectively. Zeolite used is 3-5 cm in diameter and 1-3 kg in weight. The amount of zeolite is adjusted to the ratio of the treatment given.

The method used in this study was an experimental method with a Completely Randomized Design (CRD), five treatments, and four replications. There were five treatments of the filter media composition, as followed: A

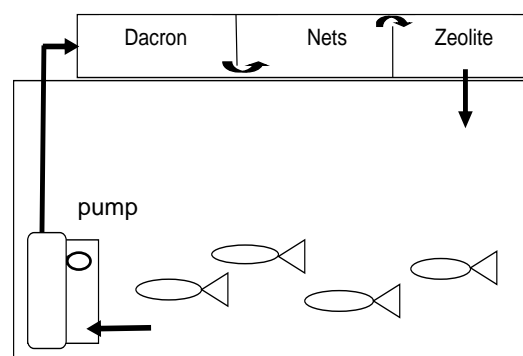


Figure 1. System Design

→ Note: (water flow)

(100% zeolite), B (25% nets + 75% zeolite), C (50% nets + 50% zeolite), D (75% nets + 25% zeolite), and E (100% net).

Methods of collecting data

### 2.1 Water quality

Water quality data measured were DO, pH, temperature, ammonia, nitrite, and nitrate. Temperature measurement is carried out 2 times a day, in the morning at 08.00 and in the afternoon at 16.00. The DO and pH measurements were carried out once a day, while ammonia, nitrite, and nitrate measurements were carried out at the beginning, middle, and end of the study. The pH measurements were carried out using a Universal Test Paper, dissolved oxygen using the Winkler titration method, temperature using an alcohol thermometer, and ammonia, nitrite, and nitrate tests using a spectrophotometer (SP-3000 plus).

### 2.2 The Volumetric TAN Removal (VTR)

The VTR calculation was performed using the formula used in the Pfeiffer and Paul study (2011), as follows:

$$\text{VTR} = Kc \times (\text{TAN}_{\text{in}} - \text{TAN}_{\text{out}}) \times Q$$

Where:

VTR	= Volumetric TAN Removal ( $\text{g.m}^{-3}.\text{d}^{-1}$ )
Kc	= conversion factor; 1.44
$\text{TAN}_{\text{in}}$	= concentration of total ammonia inlet ( $\text{mg.L}^{-1}$ )
$\text{TAN}_{\text{out}}$	= concentration of total ammonia outlet ( $\text{mg.L}^{-1}$ )
Q	= Water flow rate ( $\text{m}^3.\text{s}^{-1}$ )
V	= Volume of filter media ( $\text{m}^3$ )

Table 1. Water Quality of Pangasius Culture During Study

Parameter	Treatments (Filter Media Composition)					Tolerance value
	A	B	C	D	E	
Temperature (°C)						
08.00	28.2±0.71	28.3±0.76	28.3±0.76	28.1±0.68	28.2±0.69	27-32 <sup>(1)</sup>
16.00	29.4±0.77	28.3±0.92	29.7±0.91	29.5±0.93	29.6±0.95	
pH	7±0.0	7±0.0	7±0.0	7±0.0	7±0.0	6.5-8.5 <sup>(1)</sup>
DO (mg.L <sup>-1</sup> )	6.93±0.32	6.93±0.32	6.92±0.31	6.91±0.31	6.94±0.31	>3 <sup>(1)</sup>
TAN (mg.L <sup>-1</sup> )	0.20±0.02	0.11±0.03	0.13±0.02	0.33±0.01	0.61±0.01	<1.0 <sup>(2)</sup>
Nitrite (mg.L <sup>-1</sup> )	0.21±0.09	0.13±0.06	0.16±0.05	0.24±0.07	0.26±0.06	<1.0 <sup>(2)</sup>
Nitrate (mg.L <sup>-1</sup> )	7.53±3.08	5.41±2.5	6.29±2.61	8.59±1.97	11.49±3.26	<20 <sup>(3)</sup>

Note: Treatments: A (100% zeolite), B (25% nets + 75% zeolite), C (50% nets + 50% zeolite), D (75% nets + 25% zeolites), and E (100% net). <sup>(1)</sup>SNI 7471 (2009); <sup>(2)</sup>Losordo *et al.*, (1998); <sup>(3)</sup>Zidni *et al.*, (2017).

### 2.3 The Survival rate (SR)

The SR is the percentage of living cultured organism, which can be calculated by the formula used in the study of Dauda *et al.*, (2018), as follows:

$$SR = \frac{N_t}{N_o} \times 100\%$$

where:

- SR = survival (%)
- Nt = Number of fish at the end of study (individual)
- No = Number of fish at the beginning of the study (individual)

### 2.4 The Total amount Feed Fed (TFF)

The Total amount Feed Fed is obtained from the total amount of feed consumed by fish minus the amount of leftover feed that is not consumed by fish during the study (Dauda *et al.*, 2018).

### 2.5 The Relative Growth Rate (RGR)

The RGR was calculated by the formula used in the study of Ferosekhan *et al.* (2019) as follows:

$$RGR = \frac{W_t - W_o}{W_o \times t} \times 100\%$$

where:

- RGR = relative growth rate (%/day)
- Wt = Weight of fish at the end of study (g)
- Wo = Weight of fish at the initial of study (g)
- t = Duration of study (day)

### 2.6 The Feed Conversion Efficiency (FCE)

The calculation of FCE using the formula used in studies of Thi Da *et al.* (2012) as follows:

$$FCE = \frac{W_t - W_o}{F} \times 100\%$$

where:

- FCE = Feed Conversion Efficiency (%)
- Wt = Weight of fish at the end of study (g)
- Wo = Weight of fish at the initial of study (g)
- F = Total weight of feed given during study (g)

## Data analysis

Data of SR, TFF, RGR, and FCE were tested for normality, homogeneity and additivity. Data that was spread normally, homogeneously and additive were then analyzed for variance (ANOVA) with a 95% confidence interval to see the effect of the treatment. If the ANOVA has a significant difference ( $P < 0.05$ ), the Duncan test was performed to determine the mean value between treatments. Water quality data and VTR values were analyzed descriptively.

## 3. Result and Discussion

### 3.1 Water Quality

The results of water quality in *Pangasius* cultured for 30 days are presented in Table 1. Temperature, DO, and pH were measured daily. Meanwhile, ammonia, nitrite, and nitrate were measured on the 10<sup>th</sup>, 20<sup>th</sup>, and 30<sup>th</sup> days. In all treatments, temperatures ranged from 27-30 °C, pH values were stable at 7, DO values ranged from 6.4-7.5 mg.L<sup>-1</sup>, ammonia and nitrites were far below 1 mg.L<sup>-1</sup> and Nitrates were below 20 mg.L<sup>-1</sup>.

### 3.2 Volumetric TAN Removal (VTR)

Based on the calculations of ammonia, the VTR value varies between treatments. The VTR values from the lowest to the highest were 14.13-21.74 g.m<sup>-3</sup>.d<sup>-1</sup> (Treatment E); 21.74-29.35 g.m<sup>-3</sup>.d<sup>-1</sup> (Treatment D); 32.62-43.49 g.m<sup>-3</sup>.d<sup>-1</sup> (Treatment A); 39.14-50.01 g.m<sup>-3</sup>.d<sup>-1</sup> (Treatment

C); and 55.45-66.32 g.m<sup>-3</sup>.d<sup>-1</sup> (Treatment B). For more details, the value can be seen in Figure 2.

3.2 Survival rate (SR), Total amount Feed Fed (TFF), Relative Growth Rate (RGR), and Feed Conversion Efficiency (FCE)

The SR value in all treatments was above 85% (Table 2). The TFF values in all treatments were almost the same, ranging from 123-124 g. The lowest RGR was in treatment E (1.8% d<sup>-1</sup>), and the highest was in B (2.1% d<sup>-1</sup>). Likewise the FCE value, the lowest was in treatment E (40.9%), and the highest was in B (46.9%).

## 4. Discussion

### 4.1 Water quality

Based on observations during the study, water quality data were obtained as follows: the temperature was 28.2-29.7 °C, pH was 7, and DO was 6.4-7.5 mg.L<sup>-1</sup>. Thus, the water was suitable for use in catfish culture. This is under the provisions of the Indonesian National Standard 7471 (SNI, 2009) regarding the ideal water quality, namely temperature 27-32 °C, pH 6.5-8.5, and DO > 3 mg.L<sup>-1</sup>. Water quality is a limiting factor in aquaculture activities, so good water quality must be maintained in the recirculation system. Intensive culture with high stocking density and high feeding can increase culture wastes such as feed and metabolic product residues which can decrease water quality. Based on this research, the highest Total Ammonia Nitrogen (TAN) reduction was in treatment B, while the lowest was in treatment E. The TAN value in treatment B ranged from 0.075-0.146 mg.L<sup>-1</sup> with average 0.11 mg.L<sup>-1</sup>, while in treatment E ranged from 0.596-0.626 mg.L<sup>-1</sup> with average 0.61 mg.L<sup>-1</sup>. This range indicates that the TAN value in all treatments is still within tolerance, which is less than 1 mg.L<sup>-1</sup> (Losordo *et al.*, Harwanto *et al.*, 2011a, b). Furthermore, based on SNI (2009), ammonia (un-ionized) in *Pangasius* culture must be maintained at < 0.1 mg.L<sup>-1</sup>. The TAN value of all treatment in this study was 0.11-0.61 mg.L<sup>-1</sup>, with a pH of 7 and a temperature of 28.2-29.7 °C, so the un-ionized ammonia value was only 0.69% of TAN (Francis-Floyd *et al.*, 1990) i.e. 0.001-0.004 mg.L<sup>-1</sup>. These value were still far under limitation of SNI (2009).

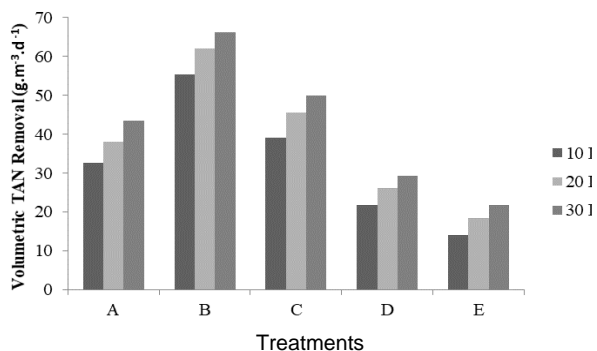


Figure 2. The Volumetric TAN Removal (VTR; g.m<sup>-3</sup>.d<sup>-1</sup>) in all treatments

Note: Treatments: A (100% zeolite), B (25% nets + 75% zeolite), C (50% nets + 50% zeolite), D (75% nets + 25% zeolites), and E (100% net)

Tabel 2. Survival rate (SR), Total amount Feed Fed (TFF), Relative Growth Rate (RGR) and Feed Conversion Efficiency (FCE) in All Treatments during Study

Variable	Treatments				
	A	B	C	D	E
SR (%)	87.5±2.9 <sup>a</sup>	93.8±2.5 <sup>b</sup>	90.0±4.1 <sup>ab</sup>	86.3±4.8 <sup>a</sup>	85.0±4.1 <sup>a</sup>
TFF (g)	123.8±0.4 <sup>ab</sup>	124.8±0.1 <sup>c</sup>	124.1±0.5 <sup>b</sup>	123.5±0.2 <sup>a</sup>	123.4±0.3 <sup>a</sup>
RGR(% d <sup>-1</sup> )	2.0±0.1 <sup>b</sup>	2.1±0.0 <sup>c</sup>	2.0±0.1 <sup>bc</sup>	1.9±0.1 <sup>a</sup>	1.8±0.1 <sup>a</sup>
FCE (%)	43.9±1.6 <sup>b</sup>	46.9±0.7 <sup>c</sup>	44.9±2.7 <sup>bc</sup>	42.5±2.3 <sup>ab</sup>	40.9±0.5 <sup>a</sup>

Note: The value of a variable on the same raw with different superscript letters indicates a significantly different value ( $P < 0.05$ )

The lowest TAN value was obtained in treatment B, since first week of cultured (0 to 10 days). The TAN in the inlet filter was 0.146 mg.L<sup>-1</sup> while in the outlet was 0.095 mg.L<sup>-1</sup>. At week 2, observations on days 11 to 20 showed a decrease in TAN, the value in the inlet filter became 0.140 mg.L<sup>-1</sup> while in the outlet was 0.083 mg.L<sup>-1</sup>. Furthermore, on week 3, days 21 to 30, the TAN value began to decrease. The inlet filter became 0.136 mg.L<sup>-1</sup>, while in the filter outlet was 0.075 mg.L<sup>-1</sup>. This is presumably due to the nitrification process which is the work of nitrifying bacteria. Nitrifying bacteria convert TAN to nitrite and then to nitrate, and certain bacteria may be able to convert nitrate into free nitrogen (N<sub>2</sub>) which is released from the system as gas (Harwanto and Jo, 2010; Thesiana and Pamungkas, 2015). The work of bacteria in the RAS is characterized by a decrease in the value of TAN. The presence of bacteria in the filter media can reduce TAN in the system by oxidizing nitrogen from metabolic waste and fish waste. This is in accordance with Dalahmeh (2013) which mentioned that nitrogen in water is in the form of nitrogen gas N<sub>2</sub>, ammonia (NH<sub>3</sub>), ammonium (NH<sub>4</sub><sup>+</sup>), nitrite (NO<sub>2</sub><sup>-</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), and organic nitrogen will be oxidized to ammonium by bacteria in water.

The highest TAN value was obtained in treatment E using a 100% net. This proves that in the absence of zeolite, the role of the filter will be less than optimal in reducing ammonia levels. zeolite can play a role in reducing TAN by absorbing it (Syamsiyah and Hadi, 2004; Las, 2007). Dacron acts more as a physical filter or is called a mechanical filter. The physical filter functions as a physical separator between solid material and water by capturing or filtering the materials, thus they are no longer found floating in the water. This is confirmed by Wang *et al.* (2006) which mentioned that dacron is a material that has holes or pores, therefore this material is

used as a mechanical filter that aims to perform mechanical filtering and remove large particles. On the other hand, the net can act as a biological filter because it can be used as a place to attach and live for bacteria (Wardhani *et al.*, 2015). It is proven that the ammonia values in treatment E were still within the tolerance limit, which means that the nitrification process has occurred in this treatment.

The lowest nitrite value during the study also occurred in treatment B (0.06-0.19 mg.L<sup>-1</sup>) which used the largest zeolite composition (75%), while the highest was at treatment E (0.21-0.32 mg.L<sup>-1</sup>) without using zeolite. Nitrite is the result of ammonia breakdown through the nitrification process. In ideal conditions, nitrite value is less than 0.25 mg.L<sup>-1</sup> (Amanda *et al.*, 2015). Furthermore, nitrite must be managed <1 mg.L<sup>-1</sup>, so it will not harmful and toxic to fish (Losordo *et al.* 1998; Siikavuopio and Saether, 2006; Harwanto *et al.*, 2011a, b). The lowest nitrate level during the study was also found in treatment B (25% net + 75% zeolite), i.e. 2.73-7.83 mg.L<sup>-1</sup>, while the highest was in treatment E (100% net), i.e. 8.31-14.83 mg.L<sup>-1</sup>. Nitrate is a nitrogen compound resulting from the breakdown of nitrite through the nitrification process. Based on Zidni *et al.* (2017), the allowable concentration of nitrate values in fish farming does not exceed 20 mg.L<sup>-1</sup>.

#### 4.2 Volumetric TAN Removal (VTR)

The VTR values in treatment B showed the highest (55.45-66.32 g.m<sup>-3</sup>.d<sup>-1</sup>), while treatment E was the lowest (14.13-21.74 g.m<sup>-3</sup>.d<sup>-1</sup>) among other treatments. This is thought to be related to the characteristics of the filter media used. If the biofilter media has a higher SSA, the nitrifying bacteria will grow more on the media so that nitrification can work more effectively (Malone and Bleacher, 2000; Harwanto *et al.*, 2011a, b; Hernawan *et al.*, 2015 ). The SSA of zeolite was

used in this study is  $300 \text{ m}^2 \cdot \text{m}^{-3}$ , while the net was  $35 \text{ m}^2 \cdot \text{m}^{-3}$ .

In addition, zeolite is not only able to act as a biological filter, but also can function as a chemical filter. Zeolite plays a role in ion absorption so that it can reduce the value of ammonia, nitrite and nitrate (Nurhidayat *et al.*, 2012). Furthermore, zeolites are not easily saturated. According to Yulianti *et al.*, (2016), zeolite becomes saturated after being used for 42 days continuously, and there is a decrease in absorption efficiency with the increasing usage period of the zeolite. However, Treatment A was not the biofilter with the highest VTR value, even though it used 100% zeolite. This is presumably because the zeolite cannot work optimally if it is not combined with the net. The net can act as a mechanical filter so that in treatment A it is assumed that many organic particles are not filtered by the net. This can interfere with the zeolite's performance. On the other hand, treatment B, which used a combination of net 25% and zeolite 75%, proved to be able to show better performance.

The higher the VTR value, the more efficient a filter media is. The range of VTR values from this study ( $14.13 - 66.32 \text{ g} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$ ) was lower than that in the study of Pfeiffer and Paul (2011), i.e.  $51 - 112 \text{ g} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$ ; Kumar *et al.* (2010), i.e.  $153 \text{ g} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$ ; and Harwanto *et al.* (2011a), i.e.  $142.6 - 193.8 \text{ g} \cdot \text{m}^{-3} \cdot \text{d}^{-1}$ . This is presumably because the biofilter media used in these studies had a greater SSA than this study so that more nitrifying bacteria grew (Malone and Beecher, 2000). Pfeiffer and Paul (2011) used Kaldnes plastic media; 10 mm in diameter which has SSA of  $500 \text{ m}^2 \cdot \text{m}^{-3}$ ; Kumar *et al.* (2010) used a 5 mm polystyrene biofilter media with SSA of  $2,236 \text{ m}^2 \cdot \text{m}^{-3}$ ; and Harwanto *et al.* (2011) used three different biofilter media separately, namely sand, polystyrene, and Kaldnes with SSA values of 7,836; 3,287; and  $500 \text{ m}^2 \cdot \text{m}^{-3}$ , respectively.

#### 4.3 Survival Rate (SR)

The SR is the ratio between fish that live at the beginning of the study and the number of fish that live at the end of the study. The SR values of Treatment A, B, C, D, and E were 87.50; 93.75; 90.00; 86.25, and 85.00%, respectively. The SR of all treatments were categorized as good. This is following the provisions of SNI (2009), the SR of catfish is more than 80%.

The SR value of the treatment B (25% net + 75% zeolite) obtained the highest ( $93.75 \pm 2.50\%$ ). This is presumably because the ammonia levels in Treatment B was very low ( $0.075$  to  $0.146 \text{ mg} \cdot \text{L}^{-1}$ ), even the lowest among other treatments. Fish survival is influenced by

some abiotic factors, one of them is ammonia. Furthermore, Harwanto *et al.* (2011b) mentioned that good environmental conditions, especially low ammonia levels, can make the fish feel comfortable and the fish have a good appetite. It is also indicating that the filter in Treatment B was worked properly and the composition of this filter is the most effective than in other treatments.

Treatment E has the lowest survival value of 85.00%. This is probably also related to the relatively high ammonia value in treatment E ( $0.596$ - $0.662 \text{ mg} \cdot \text{L}^{-1}$ ). Although the ammonia level was still in acceptable values, it seems this condition could give a negative effect on the SR. High ammonia causes fish in uncomfortable and stressed conditions. The SR value in this study is relatively equal compared to the research of Amanda *et al.*, (2015) which also used *Pangasius*, i.e. 90%. They used filter media in the form of zeolites, sand, and fibers, with an ammonia value of  $0.054 \text{ mg} \cdot \text{L}^{-1}$ . But the SR results in this study are lower than that of Pasaribu *et al.*, (2016), where the SR value was 97.80%. The study used a filter media composition in the form of sponges, zeolites, gravel, and fibers, with an ammonia value of  $0.050 \text{ mg} \cdot \text{L}^{-1}$ . The SR in this study was relatively higher when compared to the study of Rosmawati and Fia (2012). Their study on culturing *Pangasius* with a recirculation system resulted in SR of 84.94% with an ammonia value of  $0.584$ - $0.632 \text{ mg} \cdot \text{L}^{-1}$ .

#### 4.4 Total Amount Feed Fed (TFF)

The TFF is the amount of feed consumption given during the cultured period. Madinawati *et al.* (2011) reported that factors that affect the total amount feed fed are environmental conditions, such as water quality (temperature, DO, pH, and ammonia), feed quality and quantity, and the condition of the fish itself for the growth process.

The TFF of *Pangasius* with different filter compositions in the recirculation system has a significant effect. Treatment B had the highest TFF ( $124.84 \pm 0.10 \text{ g}$ ). It is assumed that the good environmental conditions with the lowest ammonia levels ranging from  $0.075$  to  $0.146 \text{ mg} \cdot \text{L}^{-1}$  make the fish comfortable and have a good appetite for fish. According to Losordo *et al.* (1998), the concentration of ammonia that fish can tolerate is less than  $1 \text{ mg} \cdot \text{L}^{-1}$ . According to Septimesy *et al.*, (2016), good water quality will increase appetite so that the amount of feed consumed is also high. While the TFF value in treatment E ( $123.44 \pm 0.29 \text{ g}$ ) was the lowest compared to all treatments. Treatment E had the

highest ammonia content (0.596-0.626 mg.L<sup>-1</sup>) among other treatments, meaning that the water quality in this treatment is the least good among the others, even though it is still within tolerance limits. According to Nurhidayat *et al.* (2012), poor water quality will make fish uncomfortable and appetite decreases so that the amount of feed consumed also decreases and the metabolic process runs less optimally.

#### 4.5 Relative Growth Rate (RGR)

The RGR of *Pangasius* with different filter compositions has a significant effect. The highest RGR was found in treatment B (2.13 ± 0.03%.day<sup>-1</sup>). This is presumably because the water quality in the culture medium remains good so that the fish can use energy for optimal growth. Water quality that is classified as good can be seen from the ammonia value ranging from 0.075-0.146 mg.L<sup>-1</sup>. The lowest RGR value for *Pangasius* was found in treatment E (1.80 ± 0.06%.day<sup>-1</sup>). This is presumably also because the ammonia content in treatment E (0.596-0.626 mg.L<sup>-1</sup>) is the highest compared to other treatments.

The RGR value in this study ranged from 1.8-2.0% day<sup>-1</sup>, relatively higher than the RGR in the study of Sefriani *et al.* (2014). Their study on *Pangasius polyuranodon* found RGR values ranging from 1.0-1.13% day<sup>-1</sup>. Although their study used a lower density (0.939 g L<sup>-1</sup>) than this study (1.15 g L<sup>-1</sup>), their FCE was relatively lower (average values of three treatments was 38%) than this study (average values of five treatments was 43.8%). This is thought to be related to the quality of the water. The pH value in their study was 6.2 which means it is not suitable for optimal *Pangasius* growth, whereas in this study it was 7 which is suitable for the optimal growth of *Pangasius*. Based on SNI 7471 (2009), the pH value for *Pangasius* cultivation is in the range of 6.5-8.5.

However, the RGR in this study is lower than the RGR in Handayani *et al.* (2014). In their research, the RGR value of *Pangasius djambal* with an initial weight of 3.5-4 g, with a density of 0.949 g L<sup>-1</sup> was 2.22-4.11%.d<sup>-1</sup>. The difference in RGR value is thought to be due to differences in stocking density of fish. If the density is lower, the RGR value will be higher. The higher the stocking density in this study (1.15 g L<sup>-1</sup>) compared to research from them resulting in higher competition in foraging for food so that growth is slower. High stocking density will result in competition in getting feed and space for movement so that it can result in differences in growth variations (Dhewantara, 2015). In addition, the RGR value in the Handayani *et al.*

(2014) is higher, presumably because of the higher feeding rate compared to this study. The feeding rate applied in their study was 2.5-10%., while in this study it was around 2.7%., since the feed eaten by fish was about 2-3 g day<sup>-1</sup>.

#### 4.6 Feed Conversion Efficiency (FCE)

The FCE in *Pangasius* with different filter compositions in the recirculation system has a significant effect. The value of FCE in each treatment, i.e. treatment A was 43.93%; treatment B was 46.87%; treatment C was 44.92%; treatment D was 42.54%, and treatment E was 40.90%. The highest FCE was found in treatment B. This was following the RGR value, where the highest RGR of *Pangasius* was found in treatment B as well, namely 2.13%.day<sup>-1</sup>. Treatment E which had the lowest FCE (40.90%), also had the lowest RGR value for *Pangasius* (1.80%.day<sup>-1</sup>). This is presumably because FCE is related to growth. The high-efficiency value causes the fish to make good use of the feed so that the fish growth rate will also be higher. Centyana *et al.*, (2014) and Rachmawati *et al.* (2017) stated that feed efficiency will always have a positive correlation with growth, if the fish can use the feed optimally, the resulting growth is also good. On the other hand, if the feed consumed is not utilized properly and growth is not optimal, it can be said that feed not efficient. The FCE value in this study (43.8% in average) is relatively higher than that in Sefriani *et al.* (2014) (38% in average). This is presumably because the pH value in their study, which was 6.2, is not suitable for *Pangasius* cultivation, namely 6.5-8.5 (SNI, 2009). Meanwhile, the pH in this study was 7.

## 4. CONCLUSIONS

The composition of filter media in a recirculation system for *Pangasius* cultured had a significant effect ( $P < 0.05$ ) on survival rate, the total amount of feed fed, relative growth rate and Feed Conversion Efficiency. The composition of 25% net + 75% zeolite as filter media (Treatment B) was performed the best for maintaining water quality to remain in optimal conditions. Treatment B had the highest VTR value per sampling, it was 55.45 g m<sup>-3</sup>d<sup>-1</sup> on day 10; 61.97 g m<sup>-3</sup> d<sup>-1</sup> on day 20; and 66.32 g m<sup>-3</sup> d<sup>-1</sup> on day 30. Treatment B also showed the highest SR (93.75 ± 2.50%); TFF (124.84 ± 0.10 g); RGR (2.13 ± 0.03%.day<sup>-1</sup>) and the FCE (46.87 ± 0.71%). However, all treatments showed that TAN could be managed at a safe value for *Pangasius* cultivation.



## REFERENCES

- Amanda, S. P., Mulyadi., U. M. Tang. 2015. Pertumbuhan dan Kelulushidupan Benih Ikan Patin (*Pangasius hypophthalmus*) dengan Sistem Resirkulasi Menggunakan Filter yang Berbeda. *Jurnal Akuakultur Indonesia*. 3(4): 1-8.
- Centyana, E., Y. Cahyoko., Agustono. 2014. Substitusi Tepung Kedelai dengan Tepung Biji Koro Pedang (*Canavalia ensiformis*) terhadap Pertumbuhan, Survival Rate dan Efisiensi Pakan Ikan Nila Merah. *Jurnal Ilmiah Perikanan dan Kelautan*. 6(1): 7-14.
- Chung, J., S. Kim, S. Baek, N. Lee, S. Park, J. Lee, H. Lee., W. Bae. 2015. Acceleration of Aged-landfill Stabilization by Combining Partialnitrification and Leachate Recirculation: A Field-scale Study. *Journal of Hazardous Materials*. (285): 436-444.
- Dalahmeh, S. 2013. Bark and Charcoal Filters for Greywater Treatment Pollutant Removal and Recycling Opportunities. [Thesis] Swedish University of Agricultural Sciences.
- Dauda, A. B., Nicholas R., W. W. Chen, I. Natrah., M. S. Kamarudin. 2018. Differences in Feeding Habits Influence the Growth Performance and Feeding Efficiencies of African Catfish (*Clarias Gariepinus*) and Lemon Fin Barb Hybrid (*Hypsibarbus Wetmorei* × *Barboides Gonionotus*) in a Glycerol-Based Biofloc Technology System Versus a Recirculating System. *Journal Aquaculture Engineering*. pp 1-33.
- Dhewantara, Y. L. 2016. Inovasi Teknologi Padat Tebar Awal terhadap Kelangsungan Hidup dan Pertumbuhan Benih Patin Hibrid Pasupati dalam Sistem Resirkulasi. *Jurnal Ilmiah Satya Minabahari*. 1(2): 1-12.
- Domiszewski, Z., Bienkiewicz, G., Plust, D. 2011. Effects of Different Heat Treatments on Lipid Quality of Striped Catfish (*Pangasius hypophthalmus*). *Acta Scientiarum Polonorum, Technol. Aliment.* 10(3): 359-373.
- Enache, I., V. Cristea., T. Ionescu., S. Ion. 2011. The Influence of Stocking Density on the Growth of Common Carp, *Cyprinus carpio*, in a Recirculation Aquaculture System. *International Journal of The Bioflux Society*. 4(2): 146-153.
- Farazaki, M., Petros G. 2019. Nitrification-denitrification of Municipal Wastewater without Recirculation, using Encapsulated Microorganisms. *Journal of Environmental Management* (242): 258–265.
- Ferosekhan, S., S.K. Sahoo, S.S. Giri, B.K. Das, B.R. Pillai., P.C. Das. 2019. Broodstock development, Captive Breeding and Seed Production of Bagrid Catfish, Mahanadi Rita, Rita Chrysea (Day, 1877). *Journal Aquaculture*. 1-33.
- Francis-Floyd, R., Watson, C., Petty, D., Pouder, D.B. 1990. Ammonia in Aquatic Systems. IFAS extension. FA16/FA031. Institute of Food and Agricultural Sciences, University of Florida. 4p
- Handayani, I., E. Nofyan, M. Wijayanti. 2014. Optimasi Tingkat Pemberian Pakan Buatan terhadap Pertumbuhan dan Kelangsungan Hidup Ikan Patin Jambal (*Pangasius djambal*). *Jurnal Akuakultur Rawa Indonesia*. 2(2): 175-187.
- Harwanto D., Jo JY. 2010 The Need of Biofilter for Ammonia Removal in Recirculating Aquaculture System. *Journal of Marine Bioscience and Biotechnology*. 4(1): 1-5.
- Harwanto D, Oh SY., Jo JY. 2011a Comparison of the Nitrification Efficiencies of Three Biofilter Media in a Freshwater System. *Fisheries and Aquatic Sciences*. 14 (4): 363-369.
- Harwanto, D., S. Y. Oh, H. S. P. Park., J. Y. Jo. 2011b. Performance of Three Different Biofilter Media In Laboratory-Scale Recirculating Systems for Red seabream Pagrus Major Culture. *Fish Aquat Sci*. 14(4): 371-378.
- Hernawan, S. K. Wahonoa, R. Maryanaa., D. Pratiwia. 2015. Modification of Gunungkidul Natural Zeolite as Bioethanol Dehydrating Agents. *Energy Procedia*. (65): 116-120.
- Kikuchi, K., H. Honda., M. Kiyono. 1994. Ammonia Oxidation in Marine Biological Filters with Plastic Filter Media. *Fisheries Science*. 60(2): 133-136.
- KKP. 2018. Data Direktorat Jenderal Perikanan Budi Daya. Diakses Tgl 18 Maret 2018.

- Kumar, V. J. R., V. Joseph, R. Philip., I. S. B. Singh. 2010. Nitrification in Brackish Water Recirculating Aquaculture System Integrated with Activated Packed Bed Bioreactor. *Water Science and Technology*. 61(3): 797-805.
- Lekang, O. I. 2007. *Aquaculture Engineering*. Blackwell Publishing, Australia, 340p.
- Losordo TM, Masser MP., Rakocy J. 1998. Recirculating Aquaculture Tank Production Systems: An Overview of Critical Considerations. Southern Regional Aquaculture Center Publication No. 451. Southern Regional Aquaculture Center, Stoneville, MI, US.
- Malone, R. F., L. E. Beecher. 2000. Use of Floating Bead Filters to Recondition Recirculating Waters in Warmwater Aquaculture Production Systems. *Aquacultural Engineering*. 22(1): 57-73.
- Muhtalief, S.N., Susilowati, T, Yuniarti, T., Harwanto D., Basuki F. 2019. Production Performance of Sangkuriang Catfish (*Clarias gariepinus* Burchell-1822) N-2 (Nursery-2) Cultured on Recirculation System with Different Filter Media. IOP Conf. Series: Earth and Environmental Science. (246): 012061.
- Nurhidayat, K. Nirmala., D. Djokosetyanto. 2012. Efektivitas Kinerja Media Biofilter dalam Sistem Resirkulasi terhadap Kualitas Air untuk Pertumbuhan dan Sintasan Ikan Red Rainbow (*Glossolepis incisus* Weber). *Jurnal Ris. Akuakultur*. 7(2): 279-292.
- Olmos, S. G., S. M. Liorens, A. T. Vidal, R. M. Ortis, G. Estruch., M. J. Cerda. 2019. Influence of Temperature, Ammonia Load and Hydraulic Loading on The Performance of Nitrifying Trickle Filters for Recirculating Aquaculture Systems. *Journal Environmental Chemical Engineering*. (7): 1-8.
- Papa, E., V. Medri, S. Amari, J. Manaud, P. Benito, A. Vaccari., E. Landi. 2018. Zeolite-Geopolymer Composite Materials: Production and Characterization. *Journal of Cleaner Production*. (171): 76-84.
- Pasaribu, B. M., Mulyadi., Usman M. T. 2016. Pemeliharaan Ikan Patin Siam (*Pangasius hypophthalmus*) dengan Sistem Resirkulasi pada Wadah dengan Bentuk yang Berbeda. *Asian Journal of Environment, History and Heritage*. 2(1): 1-9.
- Pfeiffer T. J., Paul, S. W. 2011. Evaluation of Three Types of Structured Floating Plastic Media in Moving Bed Biofilters for Total Ammonia Nitrogen Removal in A Low Salinity Hatchery Recirculating Aquaculture System. *Aquacultural Engineering*. (45): 51– 59.
- Priono, B., S. Darti. 2012. Penggunaan Berbagai Jenis Filter untuk Pemeliharaan Ikan Hias Air Tawar di Akuarium. *Media Akuakultur*. 7(2): 76-83.
- Rachmawati, D., I. Samidjan., J. Hutabarat. 2017. Peningkatan Efisiensi Pemanfaatan Pakan, Pertumbuhan dan Kelulushidupan Lele Sangkuriang (*Clarias gariepinus*) di Desa Wonosari Kecamatan Bonang, Kabupaten Demak melalui Penambahan Enzim Eksogenous Papain dalam Pakan Buatan. *Aquacultura Indonesiana*. 20(1): 248-253.
- Rosmawati., Fia S. M. 2012. Penggunaan Air pada Pemeliharaan Benih Patin (*Pangasius hypophthalmus*) dengan Sistem Resirkulasi (*Recirculation System*). *Jurnal Pertanian*. 3(2): 91-96.
- Sefriani, I., Mulyadi., Niken A.P. 2014. Effect of Different Protein Levels for Growth of Juaro (*Pangasius polyuranodon*) Using Resirculation System. *Journal of Faculty of Fisheries and Marine Science*. pp.1-11.
- Septimesy A., D. Jubaedah., A. D. Sasanti. 2016. Pertumbuhan dan Kelangsungan Hidup Ikan Patin (*Pangasius* sp.) di Sistem Resirkulasi dengan Padat Tebar Berbeda. *Jurnal Akuakultur Rawa Indonesia*. 4(1): 1-8.
- Setiawati, M., D. Jusadi, S. Laheng, M. A. Suprayudi., A. Vinasyiam. 2016. The Enhancement of Growth Performance and Feed Efficiency of Asian Catfish (*Pangasius hypotalamus*) Fed on (*Cinnamomum burmanni*) Leaf Powder and Extract as Nutritional Supplementation. *AACL Bioflux*. 9(6): 1301-1309.
- Sidik, A.S., Sarwono., Agustina. 2002. Pengaruh Padat Penebaran terhadap Laju Nitrifikasi dalam Budidaya Ikan Sistem Resirkulasi Tertutup. *Jurnal Akuakultur Indonesia*. 1(2): 47-51.

- SNI. 2009. Ikan Patin Jambal ( *Pangasius djambal* ) Produksi Kelas Pembesaran di Kolam.
- Siikavuopio SI, Saether BS. 2006. Effects of Chronic Nitrite Exposure on Growth in Juvenile Atlantic Cod *Gadus morhua*. *Aquaculture*. (255): 351-356.
- Syamsiah, S., I. S. Hadi. 2004. Adsorption Cycles and Effect of Microbial Population on Phenol Removal Using Natural Zeolit. *Separation and Purification Technology*. 3(4): 125-133.
- Thesiana L., A. Pamungkas. 2015. Uji Performansi Teknologi *Recirculating Aquaculture System* (RAS) terhadap Kondisi Kualitas Air pada Pendederan Lobster Pasir *Panulirus homarus*. *Jurnal Kelautan Nasional*. 10(2): 65-73.
- Thi Da, C., T. Lundh., J. E. Lindberg. 2012. Evaluation of Local Feed Resources As Alternatives To Fish Meal In Terms of Growth Performance, Feed Utilisation dan Biological Indices of Striped Catfish (*Pangasianodon hypophthalmus*) Fingerlings. *Journal Aquaculture*. pp. 150-156.
- Wang, L., Anhuai L., Changqiu W., Xishen Z., Dongjun Z., Rui L., 2006. Nano-Fibriform Production of Silica From Natural Chrysotile. *Journal Colloid and Interface Science*. pp.436-439.
- Wardhani, N. K., E. Sutrisno., S. Sumiyati. 2015. Penurunan Konsentrasi Bod dan Tss Pada Limbah Cair Tahu dengan Teknologi Kolam (Pond)-Biofilm Menggunakan Media Biofilter Jaring Ikan dan Bioball. *Jurnal Teknik Lingkungan*. 4(1): 1-14.
- Yulianti, D. M., T. Aminatun., Yuliaty. 2016. Pengaruh Umur Pemakaian Zeolit Alam dan Arang dalam Penyaringan Air Sumur Sistem Adsorpsi terhadap Kualitas Bakteriologis Air. *Jurnal Prodi Biologi*. 5(2): 1-6.
- Zhang, X., J. Li, Y. Yu, R. Xu., Z. Wu. 2016. Biofilm Characteristics in Natural Ventilation Trickling Filters (NVTFS) for Municipal Wastewater Treatment: Comparison of Three Kinds of Biofilm Carriers. *Biochemical Engineering Journal*. (106): 87-96.
- Zidni, I., A. Yustiati, Iskandar., Y. Andriani. 2017. Pengaruh Modifikasi Sistem Budidaya terhadap Kualitas Air dalam Budidaya Ikan Patin (*Pangasius hypophthalmus*). *Jurnal Perikanan dan Kelautan*. 7(2): 125-135.