Available online at www.worldscientificnews.com

World Scientific News

An International Scientific Journal

WSN 145 (2020) 397-408 EISSN 2392-2192

Effect of Stocking Density on Water Quality of Tilapia (*Oreochromis niloticus* Linnaeus, 1758) in Round Container with Current and Venturi Aeration System

Shalsabilla Nariswari*, Ayi Yustiati, Iis Rostini, Ibnu Bangkit Bioshina Suryadi

Fisheries Departement, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Bandung – Sumedang KM. 21, Jatinangor 45363, Indonesia

*E-mail address: shalsabilla16001@mail.unpad.ac.id

ABSTRACT

This research aims to determine the optimal stocking density for the water quality of tilapia in a round container with current and venturi aeration system. Research was conducted at the Aquaculture Laboratory Building 4th, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. The research method was carried out experimentally using the Completely Randomized Design (CRD) method consisting of three treatments with five replications, namely stocking density treatment with 15 fish, 22 fish, 30 fish using 15 L water in a container. The fish used are 3-5 cm of tilapia fry. Fish were treated for 40 days. The feed given is 5% biomass which is updated every 10 days. The parameters observed were water quality consist of temperature, dissolved oxygen (DO), pH, ammonia levels which were measured every 10 days. Based on the research results, it was concluded that the best treatment was stocking density of 15 fish/15 L in a round container with current and venturi aeration system with an average temperature of 26°C, dissolved oxygen of 5.62 mg/l, pH of 7.09, ammonia levels 0.007 mg/l.

***Keywords*:** Stocking Density, Water Quality, Tilapia, Round Container, Current, Venturi Aeration, Microbubble, *Oreochromis niloticus*

(Received 03 May 2020; Accepted 22 May 2020; Date of Publication 23 May 2020)

1. INTRODUCTION

Tilapia is a commodity that is considered promising to be cultured. The growing popularity of tilapia among consumers and the ever-increasing needs increase food production, increase the need to search alternative production for culture tilapia [1]. Increased production is followed by intensive aquaculture systems with high stocking densities in aquaculture activities. Stocking density is one of the most important factors in the production system of aquatic organisms [2]. However, high stocking densities can cause problems in the form of a decrease in environmental quality caused by organic waste from the rest of the feed and feces, the waste is generally dominated by toxic inorganic nitrogen compounds [3].

Although tilapia is environmentally tolerant, tilapia has optimal water quality to support the growth. Engineering aquaculture containers are made by modifying aquaculture containers so that they can support fish to grow by optimizing water quality. The advantage of a round container is that it provides uniformity of water quality and settling solids can be quickly carried into the middle of the container channel [4]. The advantage of the current is when increased water velocity, together with homogeneously dissolved oxygen concentration can accelerate the diffusion of oxygen at the interface of air and water, thereby producing more oxygen available [5].

The use of aeration is very necessary to meet the needs of dissolved oxygen in the waters. Especially in intensive aquaculture systems, oxygen requirements cannot be fulfilled only by natural diffusion. Therefore an artificial aeration system is necessary [6]. The venturi aeration system is capable of producing microbubbles due to the phenomenon of increased velocity in the venturi due to the difference in area and shear stress that occurs along the venturi. Air is injected into the venturi, the convergent part will experience a pressure difference which will then be dispersed through the expansion portion to a smaller size [7]. The round container with current and a venturi aeration system can affect water quality, so it can help meet the challenges of a high stocking density cultivation system. Then research needs to be done to determine the effect of different stocking densities on the growth of tilapia in a round container with a current and venturi aeration system.

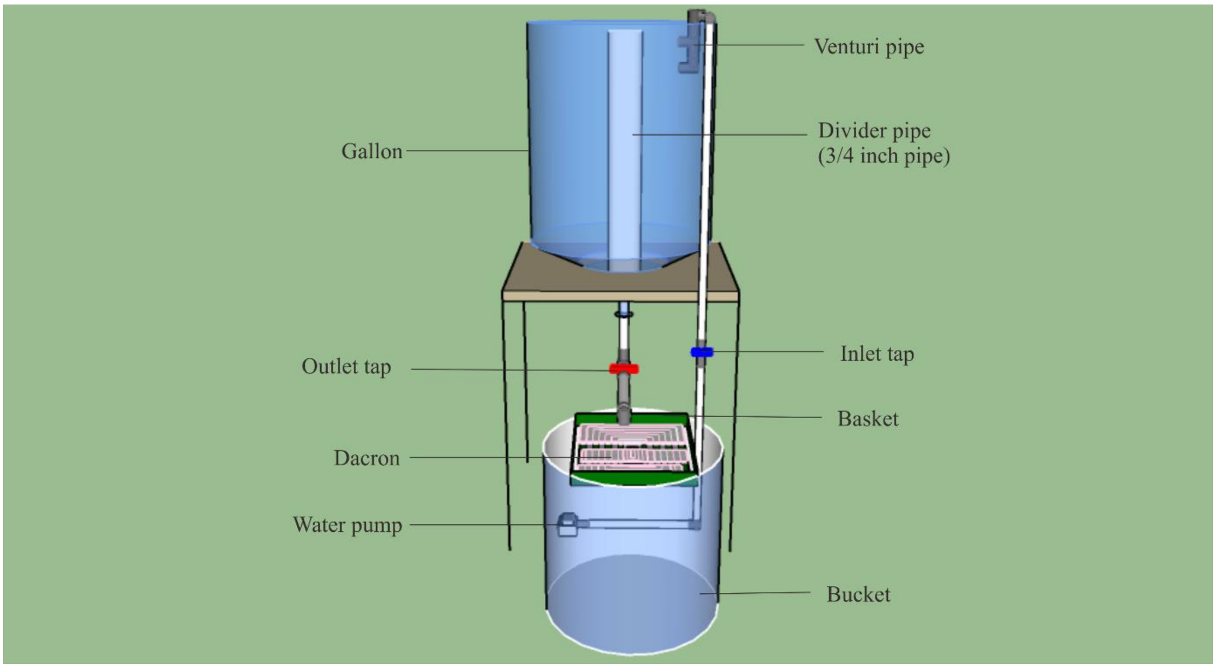
2. MATERIALS AND METHODS

The research was conducted at the Aquaculture Laboratory Building 4th Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran. The equipment used consists of 15 gallons with diameter of 26 cm × 48 cm height × 19 L volume, 15 buckets, water pumps, PVC pipes of ½ inch and ¾ inch sizes, tap sizes of ½ inch, pH meters, DO meters, thermometers, ammonia test kits, digital scales, baskets, scoop net and fiber tubs. The material used consisted of 3-5 cm tilapia fry from Balai Besar Benih Ikan Cibiru, West java, commercial feed with a protein content of 31-33%, dacron. The research method was conducted experimentally using the Completely Randomized Design (CRD) method which consisted of three treatments with five replications with different stocking densities on a round container with a venturi aeration system. This research was conducted using 0.1 ms^{-1} with the venturi aeration system and the following treatments were given:

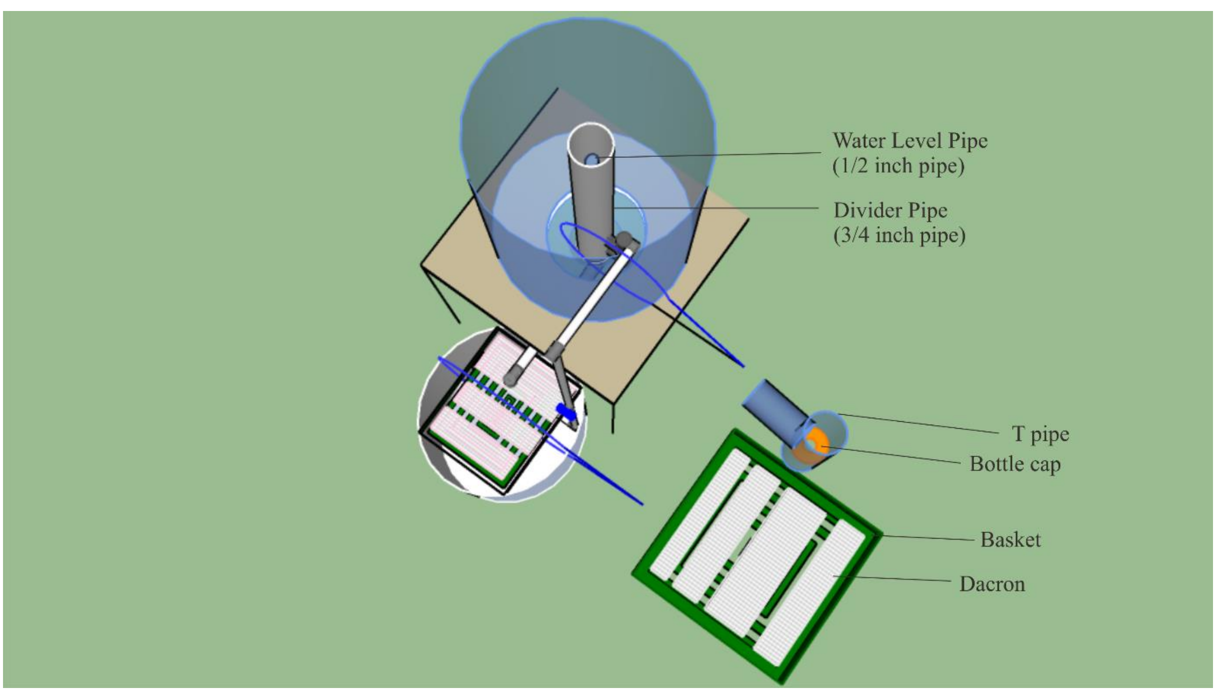
1) Treatment A: stocking density of 15 tilapia fry (100% density)

2) Treatment B: stocking density of 22 tilapia fry (150% density)
3) Treatment C: stocking density of 30 tilapia fry (200% density)

2. 1. Container Design



(a)



(b)

Figure 1. Container Design Design **(a)** Front View **(b)** Top View

In this research gallon as a round container is designed to produce a constant rotating current and expenditure of leftover feed and metabolic waste more easily through the tip of a smaller diameter gallon. In the middle of the gallon there are two pipes of different sizes, the larger pipe is outside the smaller pipe, where the larger pipe has the same height as the gallon, while the smaller pipe has the same height as the surface of the water in the gallon. Smaller pipes are made as a water level so that water does not experience shrinkage. The larger pipe at the bottom is given a cavity so that dirt can be lifted together by water and into the pipe inside it is a smaller pipe. Next the smaller pipe is connected to the end of the smaller diameter gallon which is an outlet channel in the round container (Figure 1).

Water in the round container is given a speed of 0.1 ms^{-1} with a venturi aeration system. The water used is the recirculation system, where the outlet of the container is given a tap to be balanced with the inlet of the container so that it can produce a constant speed on the maintenance media. The bottom of the round container is a bucket which was previously placed in a basket containing dacron as a physical filter. The bucket as a container for collecting water along with the rest of the feed and the rest of the metabolism is wasted through the outlet, then the impurities will settle while the water in the bucket will be pumped up through the pipe and connected to the aeration of the venturi system, then it will produce current with the venturi aeration system on the maintenance media.

2. 2. Main Research

The maintenance of the test fish was carried out for 40 days using gallons as a round container. The round container contains stocking densities that vary based on the treatment given, where treatment A container contains 15 tilapia fry, treatment B container contains 22 tilapia fry and treatment C container contains 30 tilapia fry with 15 L water each round container. The amount of feed given is adjusted to the feeding rate (FR) of 5% of tilapia biomass and adjusted to its growth once every ten days. Water quality measurements are carried out once every 10 days during fish rearing. While for knowing amount feed given, therefore the weight is calculated once every 10 days with a sampling method by taking a sample of 30% of the number of tilapia per container of maintenance and the results are included in the formula.

2. 3. Observation Parameters

The parameters observed were water quality including temperature, pH, dissolved oxygen (DO), ammonia levels. Measurement of these parameters is carried out four times during fish rearing.

2. 4. Data Analysis

Analysis of the data used is water quality data analyzed descriptively, then the parameters of temperature, dissolved oxygen, pH values are compared with BSNI (2009), while the ammonia parameters are compared with Lawson (2013).

3. RESULT AND DISCUSSION

Water quality greatly influences the growth of farmed fish. Good water quality can support optimal fish growth. Water quality plays an important role in influencing fish growth and survival [8]. Venturi aeration produces microbubbles that can help provide better water quality. Microbubble has a larger surface area compared to bubbles and hence the rate of oxygen transfer from microbubble to water is higher. Another important benefit associated with microbubbles is the slow rising speed. A slow rising speed keeps the microbubble in the water longer, allowing more time for oxygen to dissolve. Aeration with microbubbles effectively mixes water and reduces the potential for anaerobic sediment, greatly improving water quality [9].

Some water quality parameters used in the maintenance of fish for 40 days in this research are temperature, dissolved oxygen, pH, ammonia levels. The results of water quality measurements on the maintenance of tilapia fry can be seen in Table 1.

Table 1. Water Quality Measurement Results.

Parameters	Treatment			References
	A	B	C	
Temperature (°C)	26	26,07	26,10	25-30 [10]
DO (mg/l)	5,62	5,43	5,27	> 5 [10]
pH	7,09	7,11	7,2	6,5-8,5 [10]
Ammonia (mg/l)	0,007	0,012	0,023	< 0,02 [11]

3. 1. Temperature

The temperature range during the maintenance of tilapia fry is 25.74-26.44 °C in all three treatments. Based on these results, although there are changes in the maintenance temperature of tilapia fry, but the change is not too far away and is also still in the optimum limit for the maintenance of tilapia fry that is 25-30 °C [10]. Data from the temperature measurements taken once every 10 days on the maintenance media of tilapia can be seen in Figure 2.

Based on the results of the research, there are differences in temperature every 10 days, but there is not much difference. The temperature difference occurs fluctuating due to the activity of tilapia fry that affects the maintenance media. On the 20th day, treatment C had experienced a lot of mortality which caused a decrease in the number of fish, so the temperature in treatment C was not higher than the temperature of treatment B. Similarly, in treatment B which experienced a decrease in temperature on the 30th day and 40th day because mortality has happened a lot. Fish growth increases with increasing water temperatures to a certain level and then decreases at higher temperatures [12]. High temperatures will increase the metabolic process so that it is followed by an increase in metabolic waste. Respiration rate increases due to changes in environmental temperature, movement activity and frequency of eating and vice versa decreases due to increased body weight of the biota. Temperature change is a factor that can affect the rate of fish respiration, directly and indirectly, affect the solubility of some gases as well as the rate of chemical reaction in water. The rate of respiration can also be influenced by fish activity. Besides the frequency of eating also affects the rate of respiration because oxygen consumption will increase after the eating process which will increase the rate of oxygen consumption [13]. The increase in temperature affects the increase in metabolic processes at high stocking densities will be followed by an increase in metabolic waste so that it can affect water quality.

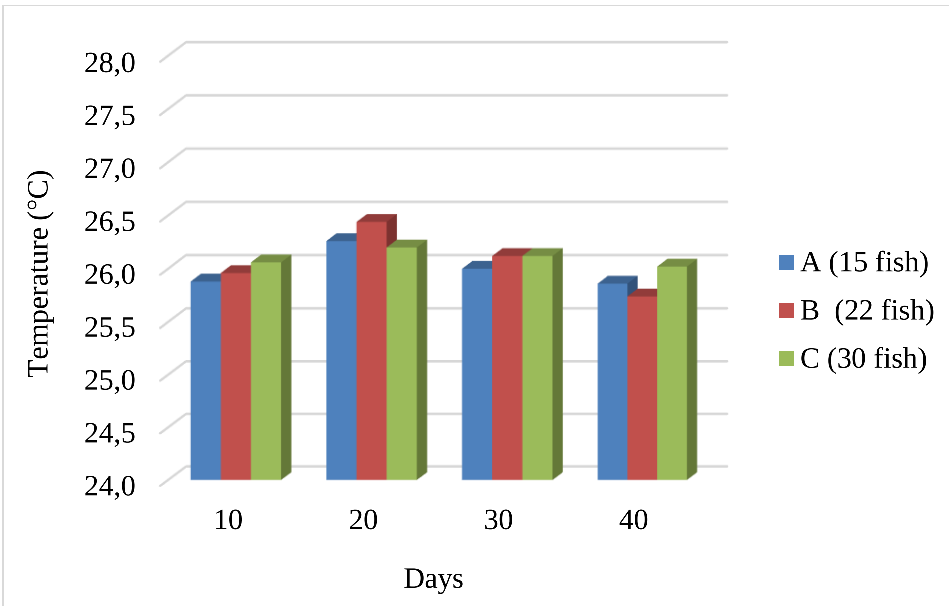


Figure 2. Temperature on Treatment Media.

The results showed that there were insignificant temperature differences in all treatments with different stocking densities, that the results obtained in the maintenance media temperature were still in the optimal range of growth of tilapia fry growth. The round container with a current and venturi aeration system can maintain the temperature to remain within the optimal range of tilapia growth. Water in a round container is usually injected tangentially into the wall, creating particles in a rotating flow that gives uniform water quality conditions [4].

3. 2. Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is one of the parameters that describe water quality. The higher of dissolved oxygen is the better the quality of the water produced [14]. Low dissolved oxygen levels affect fish growth and feed utilization. Low growth obtained under low DO conditions can be explained by the lack of oxygen available for fish growth [15]. Data from DO measurements taken once every 10 days on the maintenance media of tilapia can be seen in Figure 3.

The DO range during maintenance of tilapia fry was 4.8-6.12 mg/l in all three treatments. Based on these results, despite the changes in DO maintenance of tilapia fry fluctuating and is still in the optimum limit for the maintenance of tilapia fry which is 25-30 °C [10], but at the end of the research, treatment C has a DO of 4.8 mg/l it's under of 5 mg/l. However, the difference is not too far away and is still tolerated by tilapia fry. According to Ross (2002) at the lower limit, DO concentrations of 3 mg/l must be minimum for optimal growth of tilapia.

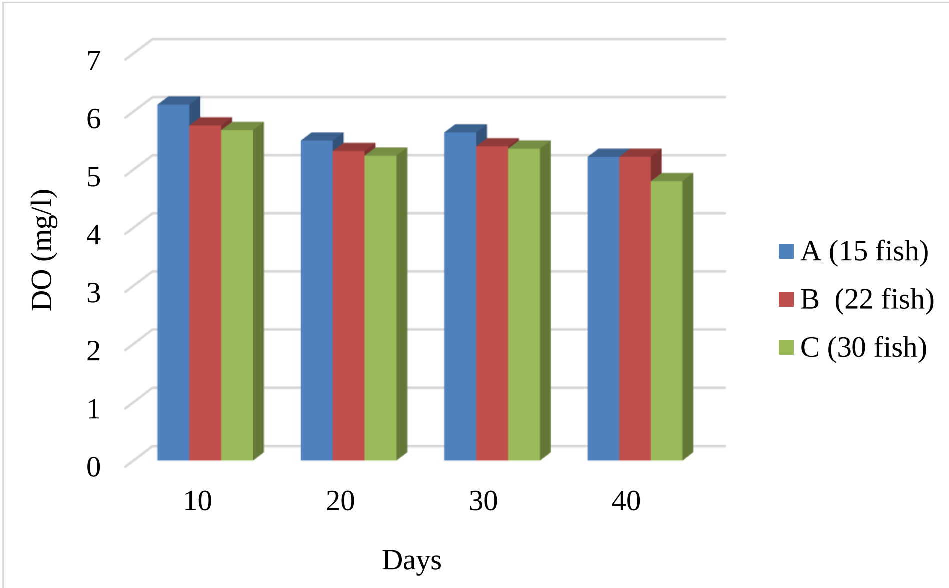


Figure 3. Dissolved Oxygen (DO) on Treatment Media

DO measurement every ten days experienced a change that did not differ greatly in each treatment due to oxygen consumption of tilapia fish which differed one of them from the amount of stocking density in the round container. Increased stocking density of fish along with an increase in oxygen consumption causes a decrease in oxygen solubility in the maintenance media. The content of dissolved oxygen plays a role in the oxidation process of waste materials and the burning of food to produce energy for the life and growth of fish. Decreased dissolved oxygen in the maintenance media, along with the amount of metabolic waste [17]. Research Duan et. al. (2011) showed that high DO concentrations increase oxygen absorption capacity, thereby reducing the proportion of metabolic energy. The proportion of metabolic energy and energy lost in nitrogen excretion is higher when at high densities. Optimal DO concentrations for fish have the ability to reduce the proportion of metabolic energy and energy loss, thereby increasing the proportion allocated to growth and lipogenesis.

The effects of venturi aeration can help maintain the availability of dissolved oxygen in water. The presence of venturi aeration shows that it can maintain the availability of dissolved oxygen in the maintenance media as indicated by the absence of DO changes drastically every ten days of measurement in all treatments with different stocking densities (Figure 3.). Venturi aeration produces microbubbles having useful characteristics, such as large gas-liquid interface areas, long residence times in the liquid phase, and rapid dissolution rates so they have the advantage of being able to dissolve oxygen in water [19].

3. 3. pH

The pH range during maintenance of tilapia fry was 6.54-7.9 in all three treatments. Based on these results, despite the change in pH of tilapia fry maintenance, the change is not too far away and is still within the optimum limit for the maintenance of tilapia fry that is 6.5-8.5 [10]. Data on the results of pH measurements taken once every 10 days on the maintenance media of tilapia can be seen in Figure 4.

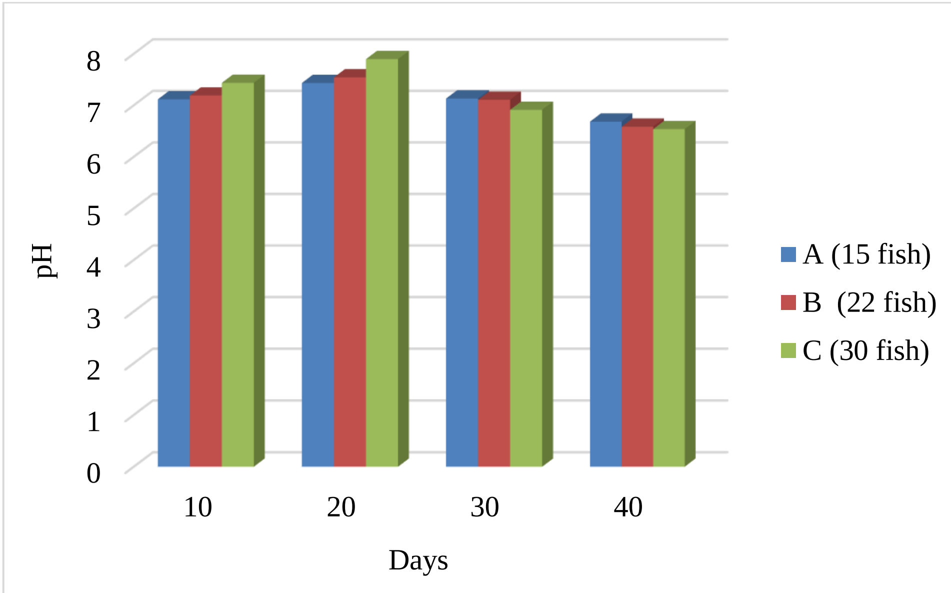


Figure 4. pH on Treatment Media

pH affects the toxicity of some chemical compounds in water such as ammonia. An increase in pH can indicate an increase in toxic ammonia. Meanwhile, the less water change volume and the longer fish maintenance time cause the water quality to decrease. Water is getting turbid due to an increase in organic waste [20]. Decomposition of organic is acidic due to the formation of organic acids. Over time, higher stocking densities will be accompanied by lower pH and dissolved oxygen [8]. Based on research results also showed that the pH after the 20th day decreased, especially in treatment C with high stocking densities. However, the research results despite a decrease in pH, but these changes are not significant. The pH of the research results shows that it is still in the optimal range for optimal growth of tilapia fry.

The round container with a current and venturi aeration system can maintain better water quality, especially pH related to dissolved oxygen. According to Boyd et. al. (2011) a common substance that causes acidity in water is CO_2. An increase in CO_2 in water will be followed by a decrease in dissolved oxygen. Therefore a venturi aeration system that can maintain the availability of dissolved oxygen can help the pH remain optimal (Figure 4.). Macro bubbles that occur in water have a large buoyancy and rise to the surface quickly, so it does not show downward movement in the water. On the other hand, microbubbles have little buoyancy, rise to the surface very slowly and remain in the water for a long time [22].

3. 4. Ammonia

Ammonia range during the maintenance of tilapia fry is 0.003-0.043 mg/l in all three treatments. Based on these results during the maintenance of tilapia fry for 40 days, the ammonia value in treatment A was still in the optimum limit of under 0.02 [11], but treatment B in the 40th day had ammonia value of 0,02 mg/l, while treatment C in the last 20 days of maintenance had an ammonia value that had exceeded the optimum limit that is, 0.026 mg/l on the 30th day and 0.043 mg/l on the 40th day. Data from the measurements of ammonia taken every 10 days on the maintenance media of tilapia can be seen in Figure 5.

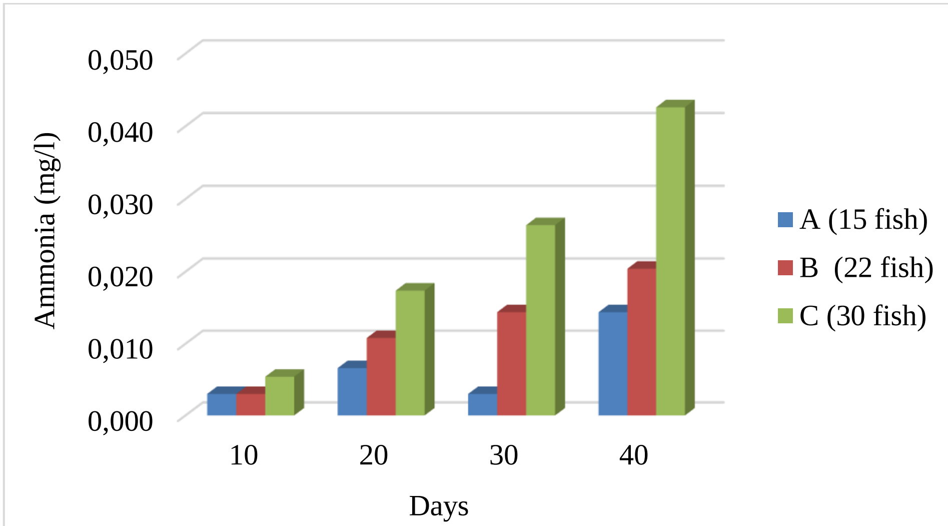


Figure 5. Ammonia value of Treatment Media

Ammonia in water is in the form of ammonia (NH_3) and ammonium (NH_4^+). Although both are toxic, the ammonia form is more toxic because these ions are uncharged and soluble in fat, so that biological membranes are more easily crossed than ammonium ions which have a charge and are hydrated [23]. The treatment C every 10 days of measurement produces the highest ammonia value, then followed by treatment B, treatment A has the lowest ammonia every 10 days of measurement (Figure 5). Feces from biota aquatic which is a waste of metabolic activity produce a lot of ammonia.

High stocking densities will produce more feed waste and metabolic waste, so that ammonia in the maintenance media will be higher (Figure 6). The influence of a round container have currents with a venturi aeration system is still unable to maintain the maintenance media to produce ammonia which is still in the optimum limit because there is an optimum stocking density limit which if it exceeds the stocking density limit, it will greatly affect the ammonia contained in the maintenance media. High levels of ammonia can also be seen from the high mortality of tilapia fry during maintenance.

(a) **(b)**

(c)

Figure 6. Dakron Conditions for Maintenance of Tilapia Fry Day 10
(a) Treatment A **(b)** Treatment B **(c)** Treatment C

A treatment with low stocking density produced the lowest ammonia among the three treatments. Whereas the maintenance media of treatment B can keep the ammonia levels within the limit of ammonia, this is allegedly because the round container has currents with venturi aeration can provide better water quality. According to Timmons et. al. (1998) the use of round containers for fish culture makes settling solids can be quickly watered through the center channel of the container. The current affects water quality because the flow of water produces water circulation, so that the waste of metabolism and feed that is not eaten can be wasted through waterways and filtered [24-27]. The venturi aeration system is also capable of producing microbubbles to provide more and smaller bubbles [7].

The result of observations from this research also showed that treatment A received a survival rate of 78%, treatment B was 60%, treatment C was 40%.

4. CONCLUSIONS

Based on the results of research it can be concluded that stocking density affects the water quality of tilapia fry maintained in a round container with a current and venturi aeration system. Stocking density of 15 fish/15 L is the best treatment by producing the most optimal water quality, with an average temperature of 26 °C, dissolved oxygen of 5.62 mg/l, pH of 7.09, ammonia levels of 0.007 mg/l.

References

[1] Daudpota, A. M., I. B. Kalhoro, S. A. Shah, H. Kalhoro, G. Abbas. 2014. Effect of Stocking Densities on Growth, Production and Survival Rate of Red Tilapia in Hapa at Fish Hatchery Chilya Thatta, Sindh, Pakistan. *Journal of Fisheries*, 2 (3): 180-186

[2] Luz. R. K., W. D. S. E Silva, R. M. Filho, A. E. H. Santos, L. A. Rodrigues, R. Takata, E. R. De Alvarenga, E. M. Turra. 2012. Stocking Density in The Larviculture of Nile Tilapia in Saline Water. *Revista Brasileira de Zootecnia*, 41 (12): 2385-2389

[3] Sukardi, P., P. H. T. Soedibya, T. B. Pramono. 2018. Production of Aquaculture of Tilapia (*Oreochromis niloticus*) Biofloc Systems with Different Sources of Carbohydrates. *Asian Journal of Innovation and Entrepreneurship*, 3 (2): 198-203

[4] Timmons, M. B., S. T. Summerfelt, B. J. Vinci. 1998. Review of Circular Tank Technology and Management. *Aquaculture Engineering*, 18, 51-69

[5] Belal, I. E. H. 2008. Water Velocity Benefits for Aquaculture. *World Aquaculture*, 15-16.

[6] Shiyang, Z., L. Gu, T. Ling, L. Xiaoli. 2013. Impact of Different Aeration Approaches on Dissolved Oxygen for Intensive Culture Ponds. *Nongye Jixie Xuebao / Transactions of the Chinese Society of Agricultural Machinery* 29(17): 169-175. DOI:10.3969/j.issn.1002-6819.2013.17.022

[7] Baylar, A., F. Ozkan, M. Ozturk. 2005. Influence of Venturi Cone Angles on Jet Aeration Systems. *Procedings of The Institution of Civil Engineers Water Management*, 158: 9-16

[8] Huang, W-B. and Chiu, T-S. 1997. Effect of Stocking Density on Survival, Growth, Size Variation, and Production of Tilapia Fry. *Aquaculture Research*, 28: 165-173

[9] Islam, M. S. and Isobe, M. 2005. Improvement of Oxygen-Deficient Water Using Microbubble Aeration Technology. *International Conference on Hydrodynamics: Hydrodynamics VI. Theory and Applications*, 429-434.

[10] BSNI. 2009. Indonesian National Standard of Production of Black Tilapia (*Oreochromis niloticus* Bleeker) Fry Spread Class. SNI 6141:2009. 16 pages.

[11] Lawson, T. B. 2013. *Fundamentals of Aquacultural Engineering*. Chapman and Hall, New York.

[12] Yoo, G. Y. and J. Y. Lee. 2016. The Effect of Feeding Frequency, Water Temperature, and Stocking Density on The Growth of River Puffer *Takifugu obcurus* Reared in A Zero-Exchange Water System. *Fisheries and Aquatic Sciences*, 19 (23): 1-7

[13] Santoso, A. D. and W. Purwantsa. 2008. Estimation of Optimum Stocking Density Based on Dissolved Oxygen Needs in Mouse Grouper (*Epinephelus cromileptes*) and Tiger Grouper (*Epinephelus fuscogutattus*). *J. Fish. Sci.*, 10 (1): 93-100

[14] Deendarlianto, Wiratni, A. E. Tontowi, Indarto, A. G. W. Iriawan. 2015. The Implementation of A Developed Microbubble Generator on The Aerobic Wastewater Treatment. *International Journal of Technology*, 5: 327-333

[15] Tawwab. M. A., A. E. Hagras, H. A. M. Elbaghdady, M. N. Monier. 2015. Effects of Dissolved Oxygen and Fish Size on Nile Tilapia, *Oreochromis niloticus* (L.): Growth Performance, Wholebody Composition, and Innate Immunity. *Aquaculture International: Journal of The European Aquaculture Society*, 23 (5): 1261-1274

[16] Ross L.G. (2000) Environmental physiology and energetics. In: Beveridge M.C.M., McAndrew B.J. (eds) Tilapias: Biology and Exploitation. Fish and Fisheries Series, vol 25. Springer, Dordrecht.

[17] Verawati, Y., Muarif, FS. Mumpuni. 2015. Effect of Stocking Density Difference on Growth and Survival of Gouramy (*Osphronemus gouramy*) Fry in the Recirculation System. *J. Mina Sains*, 1 (1): 6-12

[18] Duan, Y., X. Dong, X. Zhang, Z. Miao. 2011. Effects of Dissolved Oxygen Concentration and Stocking Density on The Growth, Energy Budget and Body Composition of Juvenile Japanese Flounder, *Paralichthys olivaceus* (Temminck et Schlegel). *Aquaculture Research*, 42: 407-416

[19] Terasaka, K., A. Hirabayashi, T. Nishino, S. Fujioka, D. Kobayashi. 2011. Development of microbubble aerator for waste water treatment using aerobic activated sludge. *Chemical Engineering Science*, 66: 3172-3179

[20] Triyatmo, B. 2003. Zeolit Maintaining Water Quality and Increasing Dumbo Catfish Growth (*Clarias gariepinus*). *GMU J. Fish. Sci*, 5 (1): 1-7

[21] Boyd, C. E., C. S. Tucker, R. Viriyatum. 2011. Interpretation of pH, Acidity, and Alkalinity in Aquaculture and Fisheries. *North American Journal of Aquaculture* 73: 403-408

[22] Endo, A., S. Srithongouthai, H. Nashiki, I. Teshiba, T. Iwasaki, D. Hama, H. Tsutsumi. 2008. DO-Increasing Effects of A Microscopic Bubble Generating System in A Fish Farm. *Marine Pollution Bulletin*, 57, 78-85

[23] Körner, S., S. K. Das, S. Veenstra, J. E. Vermaat. 2001. The effect of pH variation at the ammonium/ammonia equilibrium in wastewater and its toxicity to Lemna gibba. *Aquatic Botany*, 71 (1): 71-78

[24] Suryadi, I. B. B., M. I. Fadylah, Iskandar, A. Yustiati. The Productivity of Using Current Generating Circular Tanks for Tilapia Fingerling (*Oreochromis niloticus* (Linnaeus, 1758)) Production. *World News of Natural Sciences*, 27 (2019) 85-95

[25] Rizal A. Science and policy in the coastal zone management. *World News of Natural Sciences* 21 (2018) 1-8

[26] Junianto, Iskandar, Achmad Rizal, Windi Damayanti. The Influence of Concentration of Acetic Acid and Pepsin Enzyme in Nilem Fish Skin Collagen Extractionto the Amount of Rendement Produced. *World News of Natural Sciences* 21 (2018) 164-170

[27] Noir P. Purba, Yudi N. Ihsan, Ibnu Faizal, Dannisa I. W. Handyman, Kattia S. Widiastuti, Putri G. Mulyani, Mikhael F. Tefa, M. Hilmi. Distribution of Macro Debris in Savu Sea Marine National Park (Kupang, Rote, and Ndana Beaches), East Nusa Tenggara, Indonesia. *World News of Natural Sciences* 21 (2018) 64-76