Preliminary Study of the Effects of Air-fine (Micro/Nano) Bubbles (FB) on the Growth Rate of Tilapia in Phan District, Chiang Rai, Thailand

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Abstract— Fine (micro/nano) bubbles (FB) water could be a promising method for Thai farmers because their unique properties. In this study, we focused on the growth rate of Tilapia in Phan district area, Chiang Rai, Thailand by using air-FB water. Tilapia fishes (16 fishes/m^2) were kept either within air-FB water or within normal water with aeration system (control). Results show that air FB-water significantly promoted the average daily gain (2.00 vs 1.60 g/day) of Tilapia fish compared to control. In addition, we observed that this system can remove the contaminants in water by flotation include uneaten feed, feces and organic matter which caused turbidity of water and ammonia toxicity were decreased. Therefore, this system may be potentially effective tools for aquaculture.

Keywords—Tilapia fish, air-fine bubbles, dissolved oxygen, average daily gain, water treatment

I. Introduction

It is well-known that "Tilapia" (*Oreochromis niloticus* L.) was an outcome of the relationship between the royal families of Thailand and Japan. In March 1965, the Crown Prince of Japan presented 50 Tilapia fish to Royal Thai Family. His Majesty subsequently had 10 fishes left. After propagation, 10,000 fishes were given to the Department of Fisheries in 1966. Now, more than 220,000 tons of tilapia fish per year were farmed, which has helped create millions of jobs that shown in Fig.1.

Phan district area, Chiang Rai province, is one of the biggest Tilapia fish farming area for business in the northern Thailand. More than 43 tons per day of Tilapia fishes are exported to Northern of Thailand which leads to the net income around 900 million Baht per year or ~ 27.5 million USD [1].

However, there are several problems in this region, such as insufficient dissolved oxygen level in the early morning, raining or cloudy (Tilapia fishes need dissolved oxygen around 3 mg/L at least for growing in the fish pond) [2]. Normally, paddle wheel aerators were chosen for adding dissolved oxygen in the fish ponds like Fig. 2. However, this method cannot solve the problem when the dissolved oxygen is too low in the fish ponds especially in the early morning, which eventually results in Tilapia fish death.

Fine (micro/nano) bubbles (FB) technology is now rapidly emerging in various fields such as aquaculture, agriculture and waste water treatment [3-11]. There are several unique physical, chemical and biological properties such as large specific surface area, negatively charged surface, long stagnation, high oxygen mass transfer efficiency, strong oxidization and sterilization effects by hydroxyl radicals and so on [11]. In addition, Japanese researchers have shown that oxygen BF increase the dissolved oxygen concentration and the bubble sizes were relatively stable for 70 days [4]. It has been reported that water containing fine bubble can promote the seed germination [6]. Moreover, air-FB water was found to significantly promote the total weight of sweet fishes and rainbow trout compared with normal water [4].

In Thailand, we started to survey the effects of fine (micro/nano) bubbles (FB) technology with the private sectors since 2015, such as, highly dissolved oxygen (DO) FB water injection into fish ponds, long shelf fish preservation by

Fig. 1. Tilapia fish farming in Phan district area, Chiang Rai, Thailand.

Fig. 2. Paddle wheel aerators for adding oxygen in the fish ponds.

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oxygen-free-FB water without formalin and coconut milk and boiled shrimp sterilization by using ozone-FB water [12].

As of our previous study, we started to investigate the effects of direct injection air-FB in the fish pond (1.7 cubic meter). 100 Tilapia fish (initial weight of 30 g) were cultured either within air-FB (RMUTL – KVM20; 20 L/min and 4 bar) water or within aeration system (control) for 10 weeks. It was found that air-FB water significantly promoted the average daily gain (0.621g/day vs 0.533 g/day) compared with control (data not shown). However, when tilapia fishes were grown, there are many feces, uneaten feed and organic matter which cause high level of ammonium toxic in the fish pond. It is because of its properties in suspended solid particle flotation. So, the adjustment of FB generation pond was reorganized by adding three water distribution storage tank in recirculated system for the removal of their particles as water treatment system to improve water quality in fish pond.

In this research, we studied whether air-FB bubble water with the water treatment system can affect the growth rate of Tilapia fishes when compared with aeration system (control).

II. Methodology

In Fig. 3 shows a schematic illustration of air-fine bubble generator (RMUTL – KVM20; 20 L/min and 4 bar) and water treatment system. The FB water were produced by pressurized dissolution method. The concentration of Air-FB was found 3.4E4 bubbles/mL and the diameter of Air-FB was around 14 µm (both data were measured by Horiba LA-960). After water from the fish pond was generated, the water was sent to the 1st tank of water treatment system as shown in Fig.4. Because of the fine bubbles have a unique properties, most of the target substances were separated by floatation include feces, uneaten feed and organic matter which removed the contaminants in

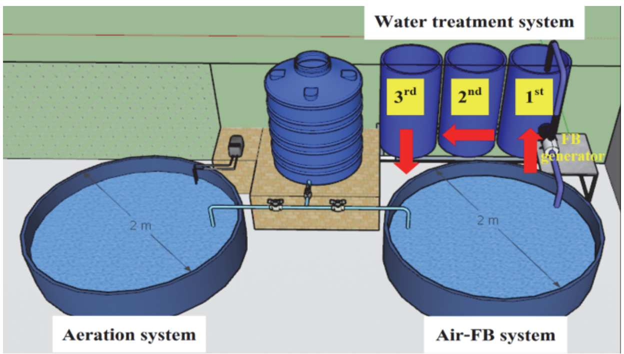

Fig. 3. A schematic diagram of aeration and FB system.

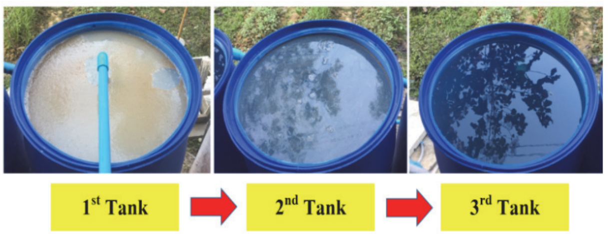

Fig. 4. Photographs of water in each tank in the water treatment system.

water in the 2nd and 3rd tank, respectively, and then water from the 3rd tank came back in to the fish pond.

In this study, Tilapia fishes were obtained from a commercial fish farm in Phan district, Chiang Rai province, Thailand. 50 Tilapia fishes (high density = 16 fishes/m^2) were cultured in 1.7 cubic meter of tap water and kept either within air-FB system (the machine was operated automatically 1 hour and 6 times/day) or within normal water (air pump working 24 hours/day). Tilapia fishes were fed 2 times per day by satiated feeding (in the morning and in the evening). Water in pond was changed once a week and once per two week for aeration and FB's pond, respectively.

The weight of all tilapia fishes of both treatments was monitored and collected every week for 6 weeks. Growth performance parameters of the harvested fish were calculated as follow:

- Average daily gain (ADG) = Weight gain (g) / Time (days)
- Specific growth rate (SGR%) = 100 x [Ln final weight (g) – Ln initial weight (g)] / time (days)

Water quality parameters consist of dissolved oxygen (DO), turbidity (NTU), oxidation reduction potential (ORP) and pH were measured at 9:00 AM every day by using Horiba U-50 series Multiparameter Water Quality Meter. Ammonia in water sample was measured by HACH DR3900 spectrophotometer (Salicylate Method).

III. Results

A. *Growth rate of Tilapia fishes*

Growth performance of Tilapia rearing in pond by using aeration and FB system as shown in Table I. At the end of experimental period, the result showed that the highest of average daily weight gain (ADG) was recorded in fish raised in water aerated by FB generator with three storage tanks (2.2±0.29 g/day), while the lowest was recorded in control (1.6±0.28 g/day). Specific growth rate (SGR) showed that FB system has higher value than aeration system about 2.18±0.37 % and 1.73±0.56 %, respectively.

B. *Water quality in the fish pond*

In this study, tap water was used for Tilapia culture in both treatments at the initial DO level of 6.61 mg/L and pH of 7.92. The FB water was prepared by FB generation before one day. Before releasing fish to start the trials, water quality was measured and recorded as shown in Fig.5-8.

DO level in the fish pond aerated by air blower as control group has higher than the pond which aerated by air-FB generator with three storage tanks about the range of 7.8-8.5

TABLE I
Growth performance of Tilapia in pond using aeration and Air-Fine bubble (FB) systems for 6 weeks

Parameters	Treatments (Mean±SD)	
	Aeration	Air-FB
Initial individual weight (g)	62.1±6.8	62.1±6.8
Final individual weight (g)	128.3±28.8	155.4±28.9
Average daily gain (g/day)	1.6±0.28	2.2±0.29
Specific growth rate (%g/day)	1.73±0.56	2.18±0.37

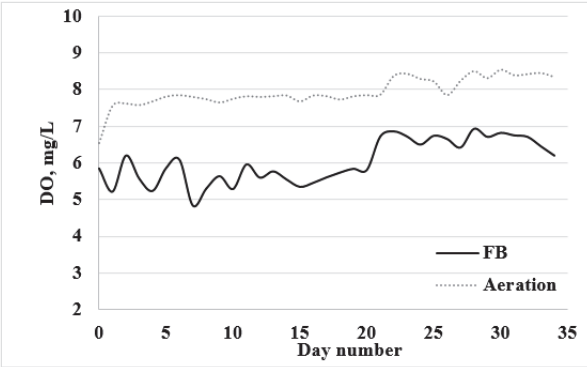

Fig. 5. Dissolved oxygen (DO) of FB and aeration system.

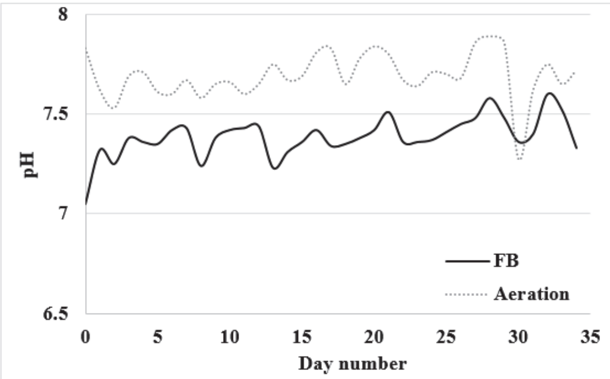

Fig. 6. pH of FB and aeration system.

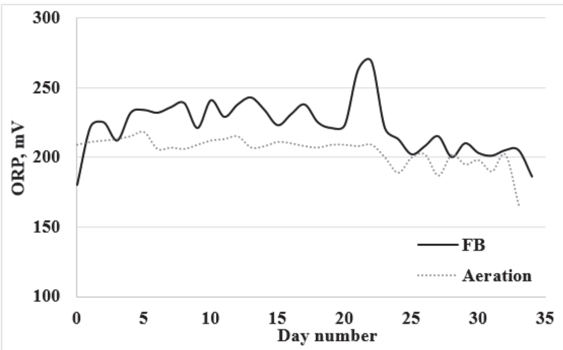

Fig. 7. Oxidation reduction potential (ORP) of FB and aeration system.

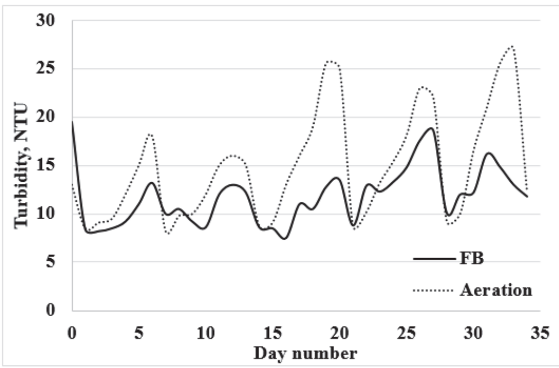

Fig. 8. Turbidity of FB and aeration system.

mg/L and 4.8-7.0 mg/L, respectively (Fig.5). The variant of DO values depended on the saturated oxygen inside water, then pattern of DO value of aeration system which worked 24 hours/day shown smaller variance than air-FB system that operated for 6 times/day. pH of water in FB's pond was lower than in aeration's pond as shown in Fig. 6.

In addition as pH was affect to amount and toxicity of ammonia form so free ammonia concentration of two systems were different.

Regarding the concentration of total ammonia (data were not shown), the initial total ammonia level of FB pond and aeration pond were 1.84 mg/L and 0.58 mg/L, respectively. After finishing the experiment, total ammonia level in FB pond was lower than the aeration pond at 4.50 mg/L and 5.03 mg/L, respectively.

In addition, Oxidation reduction potential (ORP) parameter was direct variation with water sanitation. ORP level in FB's pond water was higher than in aeration's pond throughout the experimental period. At the last week, in both ponds had been shown ORP level sharply decreasing. The result was shown in Fig. 7.

Meanwhile, Turbidity level in the fish pond showed that the FB's pond was lower than the aeration's pond **(Fig. 8)**, even the water was changed every two weeks. The turbidity of both systems obtained cycle pattern related with system water exchange. The weekly cycle of turbidity from aeration's water was slightly increased and reach to maximum level for the final point of the cycle and suddenly decreased when water exchange was performed which was related to water exchange time. In the other hand, turbidity of FB system was less variance than the control. It was show that the water treatment in FB system can reduced frequency of water exchange.

IV. Discussions

In this experiment, a novel MNB technology was considered to be efficient aerator to accelerate growth performance and to improve water quality in Tilapia (*Oreochromis niloticus*) culture. Due to its remarkable characteristic, particularly high gas dissolution capability [11] and low rising velocity under the liquid phase and the reducing frictional resistance [13], FB can maintain in the water at long duration throughout three storage tanks into fish pond.

These results revealed that growth performance of fish using FB aerator tend to be higher than air blower as the conventional aerator. According some researchers reported that FB technology can enhance the fish growth rate by improving the physiological development [11, 14].

In the experiment, it was found that water management system was necessary for Nile Tilapia fish farming and fine bubble generator could improve the water quality in the fish pond. It was notable that the suspended particles from feces and uneaten feed were penetrated on the water surface after FB generation. It is because of its properties in suspended solid particle flotation. Then their particles can be removed easily. This advantage could reduce the frequency of water exchange. Water quality parameter was reported in [15] that affect to fish growth rate. From water quality evaluation and external observation indicated that FB generator with water treatment system can keep the quality of water in the fish pond in a good condition and generate better condition for Nile Tilapia than the control so the fishes which cultured in Air-FB with water treatment system was grew faster. However, in this experiment, food intake was not controlled. The promoting effect of air-FB water combined with water treatment system on growth may be partially due to increase in oral uptake. However, it was found that there are many parameters which effects the growth rate of Tilapia fish which will discuss in the next paragraph.

Dissolved oxygen is a major important and critical parameter, requiring continuous monitoring in aquaculture production systems. DO is known to influence fish survival, fish growth and feed utilization [2]. DO concentration should be maintained above 4 mg/L for fish performance [16]. All treatments in this study were generally within the acceptable ranges for tilapia culture. Even though DO level in aeration system was slightly higher than FB system, tilapia raised in FB pond provides relatively good result with high number of average daily weight gain. As of oxygen consumption in fish increases with fish weight and water temperature [17]. Also, the excitement increases oxygen demand [18] which fish in FB pond appeared enthusiastic and hungry during FB generation.

As of total ammonia (NH_3) level, it can reduce the feeding activity, fecundity and survival of fish through various negative physiological effects by causing as phyxiation, reducing the oxygen-carrying capacity, and affecting the liver, kidneys, or immune system [19]. In this work, NH_3 toxicity was evaluated using data of NH_3 concentration in pond water, temperature and pH. Ammonia toxicity, expressed as total ammonia, in the aquatic environment increases with water pH and temperature [20-22]. All results indicated that parameter of water pH more significantly effect to NH_3 toxicity than water temperature. FB generator was generated water with lower pH than the aeration, then ammonia toxicity of FB system was less than the control.

Oxidation reduction potential (ORP) is an important parameter to measure the relative degree of oxidation and reduction in aquaculture pond. ORP in both ponds showed slight decrease due to the capacity of the reducing species increases, either organic matter (uneaten feed, fish feces and waste from living organism activities) or microorganism, with time culture period [23-24]. The organic wastes were dispensed in fish farming water and reduce transparency of water. After generating FB into the pond, particulate organic matters were raised up to water surface and were removed by floatation. Therefore, the FB's pond water was clearer and obtained higher ORP than aeration's pond.

V. Conclusions

This present study was intended as a preliminary investigation to find the efficient aerator by using Air-Fine bubbles for growth rate and water quality improvement of Tilapia culture. It demonstrated that air-Fine bubbles (FB) generator combined with circulated water treatment can promote the growth rate of Tilapia compared with aeration system. In addition, air -FB have been shown to be useful for improving some water quality by ammonia removal, reducing turbidity and raising ORP. So, application of air-FB water combined with water treatment system is an alternative method using for aquaculture.

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