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A STUDY ON MICRO BUBBLES AERATION METHOD ON WATER TURBIDITY AT AQUACULTURE EARTHEN PONDS UNDER DIFFERENT OPERATIONAL PARAMETERS

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Abstract

The experiment was established at an earthen aquaculture private farm in Kafrelshikh Government, Egypt. During 2021. To study the effect of operational variables at tube diffusion aeration system on turbidity values corresponding to Secchi disk clarity. Experimental variables under study were five air flow rates (0.1, 0.18, 0.23, 0.28 and 0.33 $m^3.h^{-1}$), three tube wall thickness (4, 6 and 7 mm), three tube depth from water surface (0.3, 0.50 and 0.70 m) and two design shapes for aeration system (circular and Longitudinal). Aeration system consist of circular tube holder, an electric single-phase compressor, three models of rubber diffusion tubes (D25-4, D25-6 and D25-7), portable galvanic dissolved oxygen meter, Secchi disk, digital LCD anemometer and thermometer and digital vernier. The results showed that, the lowest value for Secchi disk clarity were 7 cm obtained at operational conditions of 0.33 $m3.h^{-1}$ air flow rate, 0.70 m depth from water surface, 4 mm thickness of tube wall and circular shape design. While, the highest value for Secchi disk clarity were 41 cm obtained at operational conditions of 0.10 $m^3.h^{-1}$ air flow rate, 0.30 m depth from water surface, 7 mm thickness of tube wall and Longitudinal shape design. The permissible variables limits were (0.1, 0.18 and 0.23 $m^3.h^{-1}$) for air flow rate, (4, 6 and 7 mm) for tube wall thickness, (0.3, 0.50 and 0.70 m) for tube depth from water surface and both of (circular and Longitudinal) design shapes.

***Key words**: aquaculture, water turbidity, Secchi disc, fine bubbles aeration*

INTRODUCTION

Bubbling aeration, which brings water and air into close contact, is the first phase in the public health or aquaculture water treatment process. Small bubbles need more effort to reach the top, stay inside the water for longer periods of time, and give more oxygen to the water body [10].

The microbubble aeration system was developed as aquaculture technology advanced. The microbubble aeration system differs from the millimeter-sized bubble aeration system in various ways [8]. The capacity to form micro-sized bubbles, which enhanced oxygen solubility [6].

Better-dispersed gas, bigger surface area interaction with water, slower bubble rise speed, and reduced energy usage are all advantages of microbubble aeration over conventional aeration [12].

Using a blower or a compressor, oxygen or air is injected directly into a body of water in the form of bubbles. Diffusion is the mechanism by which oxygen is transferred from the bubbles to the water body across the liquid film's boundary.

Blowers or compressors are utilized to feed air to diffusers in these systems. The diffusers' little pores produce bubbles at the pond's bottom. The bubbles that were discharged at the pond's bottom are still rising through the water column.

There is a relative motion between water and bubbles during the rising. This causes water circulation by bringing water molecules into contact with air bubbles on a regular basis [19].

Furthermore, analyzing gas bubble aeration is essential for numerous engineering applications, including wastewater treatment, sterilization, hydroponics, cultured fisheries, and fast oxygen (O_2) in therapies [17].

Smaller gas bubbles, for example, have higher Laplace pressures and a longer residence period in water than bigger bubbles, which could considerably boost the O_2 transfer rate in aeration [13].

However, fouling and clogging by bio-film and tiny particles cause fine-pore diffusers to lose their original performance after installation. Fouling reduces the efficiency of oxygen transport and necessitates higher operational pressure, lowering energy performance. Several studies have been conducted on the characterization (physical properties) of the membrane diffusion and the bubbles created at the flexible orifice [11].

The porous tube wall of the flexible tube may produce fine bubbles uniformly, resulting in a bigger interfacial area and a faster oxygen transfer rate. Because of its flexibility, the tube may be simply fitted and configured on a variety of surfaces.

During aeration, the produced bubbles at the top, side, and bottom provide shear stress and a sweeping effect on the tube shape. This shear force action can reduce foulant accumulation on the tube diffuser and increase lifetime. As a result, the flexible tube diffuser's clogging and scaling problems, which are caused by the operation itself, can be regarded a benefit.

However, there are no precise methods for constructing and optimizing the flexible aeration diffuser tube that is manufactured, as well as evaluating its performance. Furthermore, the impact of various installation patterns and prediction models should be thoroughly investigated in order to recommend appropriate design requirements and operating guidelines for scaling-up into the actual system [7].

Diffusers are not commonly utilized in aquaculture ponds because bubbles rise too quickly to be fully absorbed in shallow ponds. The water depth in a typical fish or shrimp pond will be around 1.0 m, with SAE values of less than 1.0 kg.O_2/kWh. Low airflow rates via diffusers with fine pores can boost efficiency even at shallow depths, but the pores are prone to clogging and require time-consuming maintenance [4].

Turbidity in water is caused by suspended particles, which might be organic or inorganic. The inorganic ones are mostly sediments, whereas the organic ones are mostly algae, microorganisms [9]. Water quality monitoring necessitates turbidity measurements. Because of the negative consequences on ecosystems, it is quantified in natural resources [15]. The main impacts of turbidity in ecosystems are (I) reduced visibility, (II) reduced penetration of light and photosynthesis, and (III) blockage of gills and other negative physical effects on fish and eggs [18].

Increasing turbidity in fish farming reduces the performance of the fish kept two fish species alive in a range of sediment concentrations from 0 to 500 mg/l for 21 days. Their findings revealed that Erimonax monachus had the maximum SGR at 0 mg/l, while Cyprinella galactura had it between 0 and 50 mg/l [16].

At various turbidity levels red tilapia kept alive for 56 days, ranging from 0 to 500 mg/l of clay. When the amount of turbidity was reduced, the fish had a higher weight at the end of the studies. From 0 to 50 mg/l, the highest survival rates were achieved [2].

Secchi disk, is a circular white and black disk with 30 cm diameter. It’s an old tool to estimate visibility of aquaculture waters [1].

Values from 30 cm and less for turbidity in water, may lead to minimizing plankton growth and production, 30 to 60 cm satisfy for aquaculture environment, in case of 60 cm and more there are shortage in oxygen production as plankton production reduces so light enters to deeper distances [5].

The turbidity range from 30-80 cm is appropriate for aquaculture requirements; 15-40 cm is appropriate for intensive aquaculture and less than 12 cm result in problems on fish health and growth [3].

The Secchi disk readings from 30 to 40 cm were the best for the aquaculture productivity [14]. Turbidity is one of the most important factors in the production of fish in earthen farms, so using aeration appropriately is one of the solutions to increase the quality of fish.

The aims of the research was determined the optimum operational limits for fish production under different experimental variables on aeration process and water turbidity.

MATERIALS AND METHODS

The experiment was established in an earthen aquaculture private farm at Kafrelshikh Government, Egypt. As indicated in Figure 1, an earthen pond filled up with water from Burullus Lake, as a local surface water sources and other water source from agriculture and industrial drainage, the water specifications analyzed at laboratories of Faculty of Agriculture, Kafrelshikh University were shown in Table 1.

The aeration system consists of circular tube holder of 30 cm diameter from stainless steel to fix and lift tubes above bottom sediments. An electric single phase compressor model APT (SGBM9037) of 1.5 hp, 25 Lit. capacity, maximum pressure of 8 bar and maximum air delivery up to 130 L.min^{-1} used as a source of air injection with regulator valve to control airflow rate.

Three models of rubber diffusion tubes D25-4, D25-6 and D25-7 which made from rubber for AirMMax Company, China with specification are indicated in Table 2. Portable galvanic dissolved oxygen meter of model HI9147 for HANNA company, USA used for estimating on dissolved oxygen in mg.l^{-1}, water temperature in Celsius degrees and water salinity in mg.l^{-1}. Secchi disk was used for estimating water turbidity in cm.

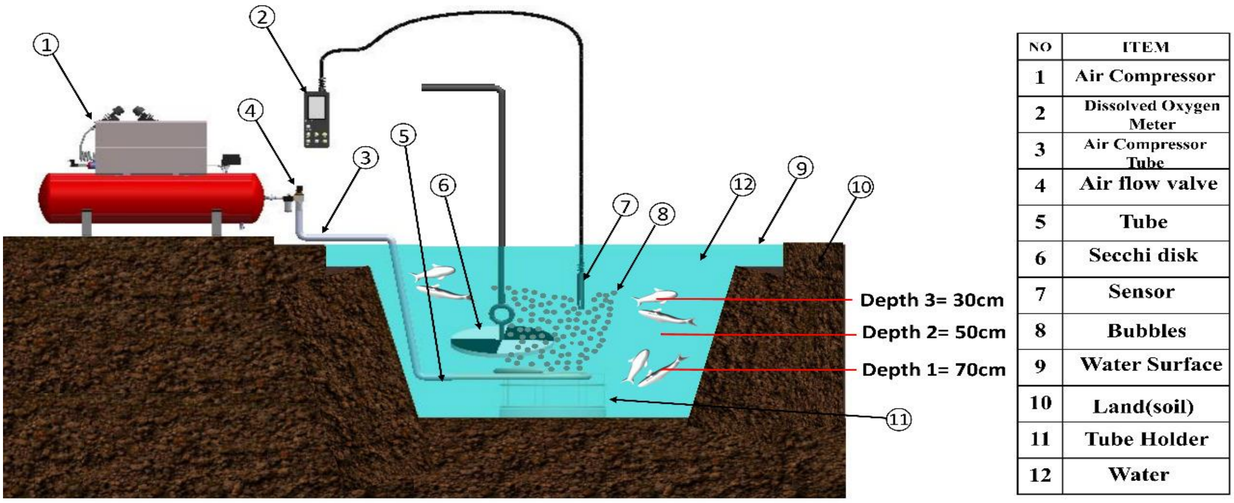

Fig. 1. Schematic diagram of the experiment.
Source: Authors' drawing.

Table 1. physical and chemical properties analysis for under study pond water

No	Test item	Value	Unit
1	Turbidity	42.0	cm
2	pH	7.36	-
3	EC	3.22	ds.m^{-1}
4	TDS	1.61	g.l^{-1}
5	Na	35.63	meq.l^{-1}
6	K	0.5	meq.l^{-1}
7	Ca	10.0	meq.l^{-1}
8	Mg	18.6	meq.l^{-1}
9	CO_3	0.00	meq.l^{-1}
10	HCO_3	10.0	meq.l^{-1}
11	CL	50.0	meq.l^{-1}
12	SO_4	4.73	meq.l^{-1}
13	Fe	Nd	mg.l^{-1}
14	Mn	Nd	mg.l^{-1}

Source: Authors' determination.

Table 2. Specification of different tubes models under study.

Model Item	Unit	D25-4	D25-6	D25-7
Outer diameter (OD)	mm	25	25	25
Inner diameter (ID)	mm	16	13	11
Wall thickness (Wall)	mm	4	6	7

Source: Catalogue determination.

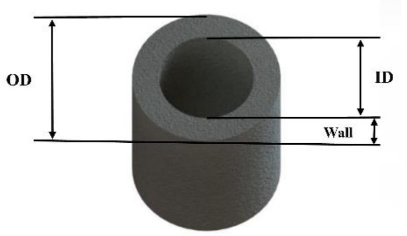

Fig. 2. Schematic diagram of rubber tube and its parts
Source: Authors' drawing.

Digital LCD anemometer and thermometer were utilized for measuring air wind speed and temperature. Digital vernier of model SM-453, Japan was used for estimating dimensions and diameters of experimental parts.

Variables under study were: (1) Five air flow rates of 0.102, 0.178, 0.229, 0.28 and 0.33 $m^3.h^{-1}$ (2) Three water depths of 0.3, 0.5 and 0.7 m. from water surface for aeration tube holder (3) Three tube wall thickness of 4, 6 and 7 mm (4) Two shapes design for aeration system position were longitudinal and circular.

RESULTS AND DISSCUSIONS

The results will be discussed under these items:

Effect of air flow rates on water turbidity

Air flow raters in rubber aeration tubes had a great effect on water turbidity as shown in Table 3 and Figures 3, 4 and 5. As indicated, inverse relationship occurred so values of Secchi disk clarity decreased with increase of air flow rates under all experimental variables.

Values for Secchi disk clarity were 38, 39, 37, 30 and 25 cm for air flow rates of 0.10, 0.18, 0.23, 0.28 and 0.33 $m^3.h^{-1}$, respectively at circular shape design, depth of 0.30 cm from water surface and 4 mm thickness of tube wall. At air flow rates of 0.10, 0.18 and 0.23 $m^3.h^{-1}$ under all treatments parameters values of Secchi disk clarity were at permissible limits for aquaculture. However, with increase values of air flow rates above 0.23 $m^3.h^{-1}$ to 0.28 and 0.33 $m^3.h^{-1}$ values of Secchi disk clarity were out of permissible limits for aquaculture causing more problems. These results may be due to the nature of pond sediments which consists of fine clay so increase of air flow rates or any excitement would load more of clay parts, decrease in visibility and increase turbidity. Permissible limits for turbidity value ranged from 30-60 cm determined by [3, 5, 14].

Effect of aeration depth from water surface on water turbidity

Depths from water surface in diffusion aeration by rubber tubes had a great effect on water turbidity as shown in Table 3 and Figures 3, 4 and 5. As illustrated, inverse relationship occurred so values of Secchi disk clarity decreased with increase of depths from water surface under all experimental treatments.

Values for Secchi disk clarity were 30, 24 and 21 cm for the depth from water surface of 0.30, 50 and 0.70 cm, respectively at circular shape design, air flow rate of 0.28 $m^3.h^{-1}$and 4 mm thickness of tube wall.

This result due to increase the effect of the air flow with closing to the clay sediments at the bottom.

Effect of tube wall thickness on water turbidity

Tube wall thickness in diffusion aeration by rubber tubes had a low significant effect on water turbidity as shown in Table 3 and Figures 3, 4 and 5.

As declared, positive relationship occurred so values of Secchi disk clarity increased with increase of tube wall thickness under majority of experimental treatments.

Values for Secchi disk clarity were 38, 39 and 40 cm for the thickness of tube wall of 4, 6 and 7 mm, respectively at circular shape design, air flow rate of 0.1 $m^3.h^{-1}$ and 0.30 cm depth from water surface.

This result compatible with previous results, as increase in wall thickness led to decrease of bubbles size and velocity so low excitement to soil.

Effect of shape design on water turbidity

Shape design in diffusion aeration by rubber tubes had a low significant effect on water turbidity as shown in Table 3 and Figures 3, 4 and 5.

As declared, values of Secchi disk clarity increased with changing shape design from circular to longitudinal under majority of experimental treatments.

Values for Secchi disk clarity were 38 and 39 cm for the circular and longitudinal shapes, respectively at air flow rate of 0.1 $m^3.h^{-1}$, 0.30 cm depth from water surface and 4 mm thickness of tube wall.

This result may due to increase the projected area at circular shape more than the longitudinal shape.

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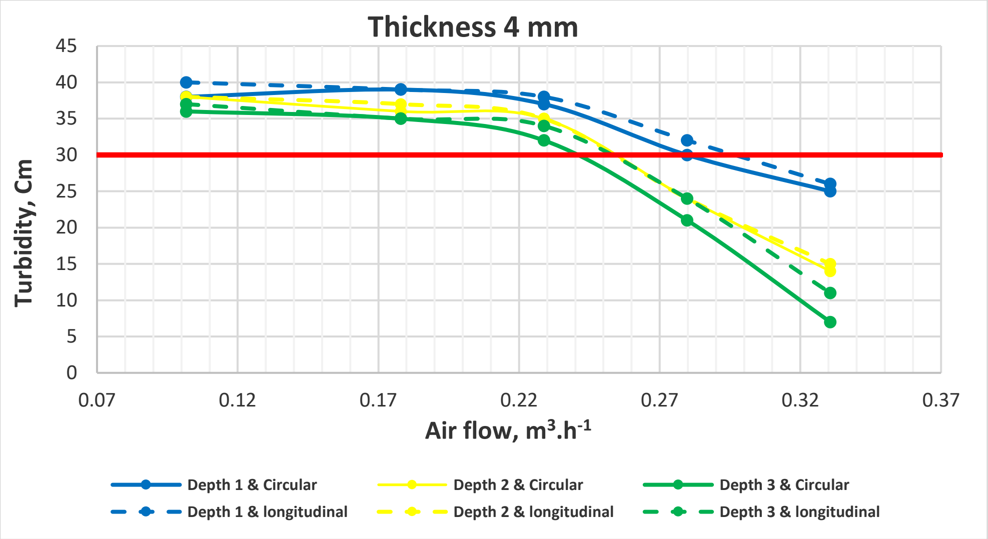

Fig. 3. Effect of air flow rate, aeration depth and shape design at 4 mm tube wall thickness on turbidity.
Source: Authors' drawing.

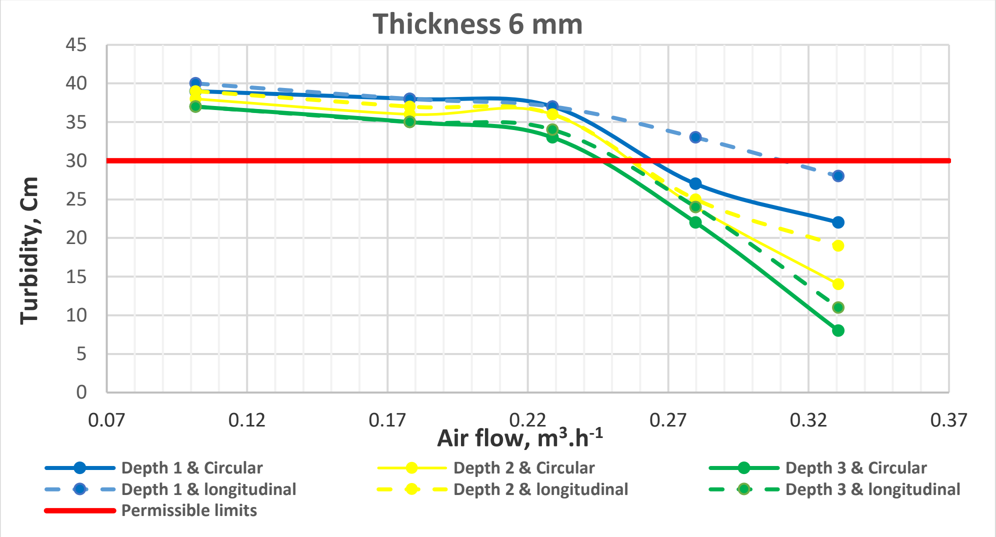

Fig. 4. Effect of air flow rate, aeration depth and shape design at 6 mm tube wall thickness on turbidity.
Source: Authors' drawing.

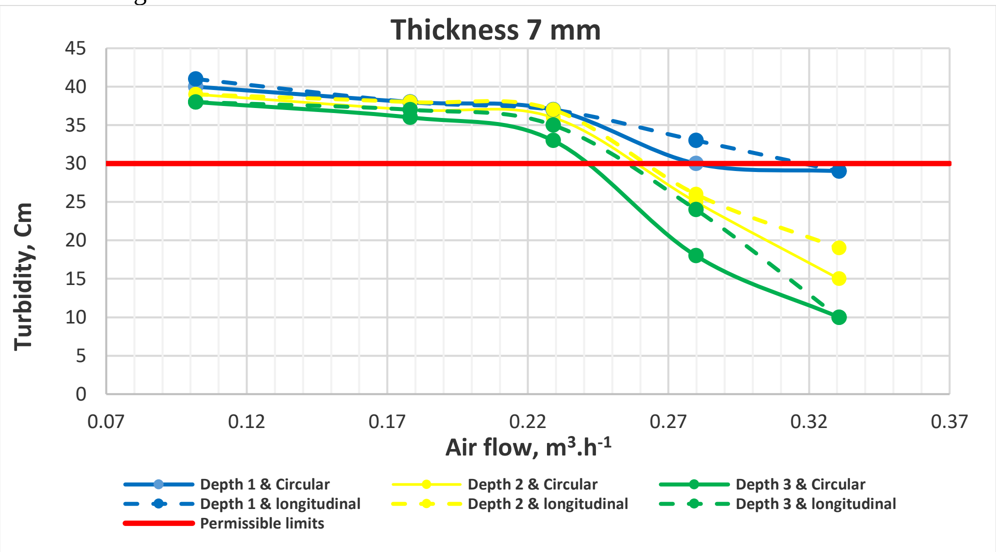

Fig. 5. Effect of air flow rate, aeration depth and shape design at 7 mm tube wall thickness on turbidity.
Source: Authors' drawing.

Table 3. Turbidity values on Secchi disk for different rates of air flow, design shape, tube thickness and depth under water surface.

Shape	Thickness, mm	4			6			7		
	Depth, m Air flow, $m^3.h^{-1}$	0.30	0.50	0.70	0.30	0.50	0.70	0.30	0.50	0.70
Circular	0.10	38	38	36	39	38	37	40	39	38
	0.18	39	36	35	38	36	35	38	37	36
	0.23	37	35	32	37	36	33	37	36	33
	0.28	30	24	21	27	24	22	30	25	18
	0.33	25	14	**7**	22	14	8	29	15	10
Longitudinal	0.10	40	38	37	40	39	37	**41**	39	38
	0.18	39	37	35	38	37	35	38	38	37
	0.23	38	35	34	37	36	34	37	37	35
	0.28	32	24	24	33	25	24	33	26	24
	0.33	26	15	11	28	19	11	29	19	10

Source: Authors' determination.

CONCLUSIONS

Turbidity in water is caused by suspended particles, which might be organic or inorganic. The inorganic ones are mostly sediments, whereas the organic ones are mostly algae, microorganisms. Water quality monitoring necessitates turbidity measurements. Because of the negative consequences on ecosystems, it is quantified in natural resources. Increasing turbidity in fish farming reduces the performance of the fish and growth. The lowest value for Secchi disk clarity were 7 cm obtained at operational conditions of 0.33 $m^3.h^{-1}$ air flow rate, 0.70 mm depth from water surface, 4 mm thickness of tube wall and circular shape design. While, the highest value for Secchi disk clarity were 41 cm obtained at operational conditions of 0.10 $m^3.h^{-1}$ air flow rate, 0.30 mm depth from water surface, 7 mm thickness of tube wall and Longitudinal shape design.

The permissible variables limits were (0.1, 0.18 and 0.23 $m^3.h^{-1}$) for air flow rate, (4, 6 and 7 mm) for tube wall thickness, (0.3, 0.50 and 0.70 mm) for tube depth from water surface and both of (circular and Longitudinal) design shapes.

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