USING NANO-CARBON PARTICLES IN SOLID WASTES TREATMENT IN FISH FARMS

Khamies A. Gabr*, Adel H. Bahnasawy, Samir A. Ali**,**

El-Sayed G. Khater*and Mohsen E. Egela ******

ABSTRACT

The main aim of this study is to investigation the possibility of using Nano-carbon particles in removing both of the settleable and suspended solid wastes from fish farms water. To achieve that, nano-carbon particles with different concentrations (0.10, 0.15, 0.20 and 0.25 % compared to control treatment) were applied to fish farm water at water depths (0.0, 0.5 and 1.0 m), times (12, 24, 36, 48 and 60 hour) and locations from the opening of the pond (inlet, middle and outlet of the pond). The settleable and suspended solids removal were determined. The obtained results indicated that the settleable solids removal increased with increasing water depth and time, where, it increased from 5.4 to 7.4 mg L^{-1} with increasing water depth from 0.0 to 1.0 m and increasing the time from 12 to 60 hour at 0.25% nano-carbon particles concentration. Using nano-carbon particles enhanced the sedimentation velocity of the solids waste, where, it increased from 4.7 to 7.4 mg L^{-1} depending on the nano-carbon particles concentrations, depths and time. The suspended solids removal from the fish pond water using nano-carbon particles at different concentrations increased with increasing water depth and decreased with time, where, it ranged from 4.8 to 7.2 mg L^{-1} depending on depth, time and nano-carbon particles concentrations.

Keywords: *Nano-carbon particles, settleable solids, suspended solids, fish farm*

1. INTRODUCTION

The effective management of solids in aquaculture is one of the major obstacles to the continued development of the aquaculture industry **(Piedrahita *et al.*, 1996)** and is often considered the most critical process to manage in aquaculture systems **(Summerfelt, 1996)**.

*** Graduate Student of Agric. Eng. Dep., Fac. of Agric., Benha Univ., Egypt**
**** Professor of Agric. Eng., Fac. of Agric., Benha Univ., Egypt**
***** Lecturer of Agric. Eng., Fac. of Agric., Benha Univ., Egypt**
****** Researcher, Agric. Eng. Res. Inst., Agric. Res. Center, Egypt**

Feed input into the system controls the production of solids and particulate matter (feces and uneaten feed). Solids and particulate matter are the major sources of carbonaceous oxygen demand and nutrient input into the water, especially if they degrade within the system. The feed portion is not assimilated by the fish excreted as an organic waste (fecal solids) and the uneaten feed consume dissolved oxygen and generate total ammonia nitrogen (TAN) when broken down by bacteria within the system **(Timmons and Ebeling, 2007 and Khater, 2012)**.

A variety of methods are currently used for solids removal in aquaculture operations (gravitational, filtration, or screening methods). Gravitational methods may result in the removal of particles that are less dense than water (e.g., dissolved air flotation), or the particles that are more dense than water (e.g., settling basins, centrifuges, hydrocyclones). Filtration or screening methods relies on particle size and particle surface properties for removal from the culture water. There are several commercial types of these filtration mechanisms, including drum filters, disk filers, triangle filters, etc. Other types of filtration systems are based on granular media beds **(Cripps and Bergheim, 2000 and Khater *et al.*, 2011)**.

Settling basins are the most common solids removal process used in flow through aquaculture systems. Properly designed and operated, settling basins can be effective in reducing suspended solids concentrations to low levels. But they must be managed carefully to achieve high nutrient removal rates **(Libey, 1993 and Merino *et al.*, 2007)**.

Recently, the use of nanoparticles for water treatment have gained the special attention due to its property being highly profitable as an adsorbents and for using for filtration purpose. Further the type Magnetic Nanoparticles (MNPs) also possesses the properties like high surface area and being the super-magnetic in nature. The magnetic property of separation is useful by applying external magnetic field to them. Thus, the MNPs are also being used for the removal of the toxic heavy metals/ elements like cations, natural organic matter, biological contaminants, and organic pollutants, Nitrates, Fluoride and Arsenic from the contaminated water. The MNPs can be synthesized by various methods like mechanical grinding etc. Among the available different technologies, adsorption by MNPs is one of the best due to its easy handling, low cost and high efficiency. The environmental fate and toxicity of a material are critical issues in materials selection and design for water treatment **(Tambe Patil, 2015)**.

Fleisther and Grunwald (2008) indicated that, the use of nanotechnology in the future is expected to expand into numerous industrial applications and help decrease production costs by reducing energy consumption, attenuate environmental pollution and increase the production efficiencies in developed countries. Moreover, nanotechnology may be a useful tool to address different social problems of developing countries such as the need for clean water and the treatment of epidemic diseases. **Binks (2007)** indicated that Nano technology is going to play an important role in addressing fundamental issues as health, energy and water.

Street *et al*. (2008) indicated that, major potential environmental benefits of nanotechnology were reported in draft nanomaterial's research strategy including. Requirement and low waste generation devices early disease detectors for preventive treatment, pollution control, and the prevention and remediation using improved systems. **Jiuhui (2008)** report that adsorption is considered as an effective, efficient and economic method to remove water contaminants.

The decomposition of solid fish waste and uneaten or indigestible feed can use a significant amount of oxygen and produce large quantities of ammonia-nitrogen. There are three categories of solid wastes, settleable, suspended, and fine or dissolved solids. There are three methods that are used to remove solids from fish culture water. These are gravity separation, filtration, and fractionation. These classifications of methodology are based on the removal mechanisms used to affect the removal (fractionation is sometimes considered as another kind of gravity separation, but it is a different principle of application so it is described separately). Large particles (larger than 100 µm) can be effectively removed by settling basins or mechanical screen filtration. However, fine particles cannot be removed effectively by either gravity separation or granular filtration methods. Granular filters are effective only in the removal of particles larger than 20 µm (**Vinci *et al.*, 2001).** Recently, nano-carbon particles are used in solid wastes removal.

The main aim of this study is to investigation the possibility of using Nano-carbon particles in removing both of the settleable and suspended solid wastes from fish farms water. To achieve that, different concentrations of Nano-carbon particles were used to remove the waste compared to the natural methods of sedimentation.

2. MATERIALS AND METHODS

The experiment was carried out at a private Company, El-Fayoum Governorate, Egypt during 2016 season to study the possibility of using Nano-carbon particles in the solids waste removal in the fish farms water.

2.1.Materials:

2.1.1. System description:

The experiment was conducted in a rectangular earth pond that used for fish culture. Dimensions of pond are 90 m long, 40 m wide and 1.25 m high. The water volume used in the pond was 3600 m^3. The pond has an inlet and outlet. The inlet for adding fresh water to fish pond, the outlet is an emergency spillway which used to remove the exceed water capacity of pond.

2.1.2. Nano-carbon particles:

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. Depending on their manufacturing process, CNTs are categorized as single-walled nanotubes and multiwalled nanotubes, respectively. Besides having a high specific surface area, CNTs possess highly assessable adsorption sites and an adjustable surface chemistry. Due to their hydrophobic surface, CNTs have to be stabilized in aqueous suspension in order to avoid aggregation that reduces the active surface. They can be used for adsorption of persistent contaminants as well as to preconcentrate and detect contaminants.5 Metal ions are absorbable by CNTs through electrostatic attraction and chemical bonding **(Rao *et al.*, 2008)**.

Furthermore, CNTs exhibit antimicrobial properties by causing oxidative stress in bacteria and destroying the cell membranes. Although chemical oxidation occurs, no toxic byproducts are produced, which is an important advantage over conventional disinfection processes like chlorination and ozonation **(Liu *et al.*, 2013)**. Table (1) shows the specifications of nano-carbon particles.

Table (1): The specifications of nano-carbon particles.

purity	More than 95%
Inner diameter	5 to 8 Nanometer
Outer diameter	20 to 25 Nanometer
Length	50 micrometer

2.2. Methods:

Tilapia nilotica fingerlings, which were used in the experiment. The daily feed rates at different fish sizes were applied according to **Rakocy (1989)** and the feed pellet diameter was prepared according to **Jauncey and Ross (1982)**. Feeding was stopped during weighing process.

Water samples were taken at the different depths (0, 0.5 and 1.0 m) and locations from the opening of the pond (inlet, middle and outlet of the pond). Different concentrations of nano-carbon particles (0.10, 0.15, 0.20, and 0.25%) were used to enhance the sedimentation velocity compared to control treatment. Water samples were collected for measuring settleable and suspended solids according to **APHA (1998)**.

3. RESULTS AND DISCUSSION

3.1. Settleable solids removal:

Table (2) shows the data of settleable solids removal at different depths and locations of fish pond using different concentrations of nano-carbon particles during time. It could be seen that the settleable solids removal increased with increasing depth and time, where, at the inlet of fish pond after 12 hours, the highest value of settleable solids removal (6.0 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.0 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (4.7 mg L^{-1}) for control. After 24 hours, the highest value of settleable solids removal (6.2 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.2 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.1 mg L^{-1}) for control. After 36 hours, the highest value of settleable solids removal (6.3 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.5 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.3 mg L^{-1}) for control. After 48 hours, the highest value of settleable solids removal (6.8 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.9 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.5 mg L^{-1}) for control. After 60 hours, the highest value of settleable solids removal (7.1 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (6.0 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.9 mg L^{-1}) for control.

Table (2): Settleable solids removal from fish pond water using nano-carbon particles with different concentration at different locations and periods.

Time (h)	Location	Depth (m)	Concentration (%)				
			control	0.10	0.15	0.20	0.25
12	Pond inlet	0.0	4.7	5.0	5.2	5.4	5.5
		0.5	4.9	5.2	5.3	5.5	5.6
		1.0	5.2	5.5	5.6	5.7	6.0
	Pond meddle	0.0	4.9	4.9	5.2	5.3	5.4
		0.5	5.1	5.2	5.4	5.6	5.8
		1.0	5.5	5.5	5.9	6.0	6.1
	Pond outlet	0.0	5.5	5.6	5.8	5.9	6.0
		0.5	5.8	5.9	5.9	6.0	6.1
		1.0	6.0	6.1	6.2	6.2	6.6
24	Pond inlet	0.0	5.1	5.2	5.4	5.5	5.8
		0.5	5.3	5.4	5.5	5.7	5.9
		1.0	5.5	5.8	6.0	6.1	6.2
	Pond meddle	0.0	5.2	5.3	5.5	5.6	5.7
		0.5	5.5	5.9	6.1	6.2	6.3
		1.0	5.7	6.0	6.2	6.3	6.4
	Pond outlet	0.0	5.7	5.8	5.9	6.0	6.1
		0.5	6.1	6.1	6.1	6.2	6.3
		1.0	6.7	7.0	7.0	7.2	7.3
36	Pond inlet	0.0	5.4	5.5	5.6	5.8	6.0
		0.5	5.5	5.5	5.7	5.9	6.2
		1.0	5.8	6.1	6.2	6.2	6.3
	Pond meddle	0.0	5.3	5.3	5.7	5.8	5.9
		0.5	6.0	6.1	6.5	6.7	6.8
		1.0	6.6	6.8	7.0	7.2	7.4
	Pond outlet	0.0	6.4	6.5	6.6	6.7	6.7
		0.5	6.7	6.7	6.9	6.9	7.0
		1.0	7.1	7.1	7.2	7.4	7.4

Table (2): Continued.

Time (h)	Location	Depth (m)	Concentration (%)				
			control	0.10	0.15	0.20	0.25
48	Pond inlet	0.0	5.7	5.9	6.1	6.2	6.3
		0.5	5.5	5.8	6.0	6.1	6.3
		1.0	6.3	6.5	6.6	6.6	6.8
	Pond meddle	0.0	5.6	5.7	5.8	5.8	6.1
		0.5	5.7	5.8	5.8	5.9	6
		1.0	6.4	6.5	6.7	6.9	7.1
	Pond outlet	0.0	6.1	6.1	6.4	6.4	6.5
		0.5	6.4	6.5	6.5	6.6	6.6
		1.0	6.8	6.9	7	7.1	7.2
60	Pond inlet	0.0	5.9	6	6.2	6.3	6.5
		0.5	5.9	6.1	6.1	6.2	6.8
		1.0	6.6	6.9	6.9	7.1	7.1
	Pond meddle	0.0	5.9	5.9	6	6.1	6.1
		0.5	6.5	6.6	6.8	7	7.2
		1.0	6.6	6.8	7	7.2	7.4
	Pond outlet	0.0	6.4	6.4	6.6	6.7	6.7
		0.5	6.7	6.7	6.9	6.9	7
		1.0	7.1	7.1	7.2	7.4	7.4

At the middle of fish pond, the results indicate that the highest value of settleable solids removal (6.1 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (4.9 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth after 12 hour. After 24 hours, the highest value of settleable solids removal (6.4 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.3 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 36 hours, the highest value of settleable solids removal (7.4 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.3 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 48 hours, the highest value of settleable solids removal (7.1 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.7 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 60 hours, the highest value of settleable solids removal (7.4 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.9 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth.

At the outlet of fish pond, the results also indicate that the highest value of settleable solids removal (6.6 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.6 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth after 12 hour. After 24 hours, the highest value of settleable solids removal (7.3 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (5.0 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 36 hours, the highest value of settleable solids removal (7.4 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (6.5 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 48 hours, the highest value of settleable solids removal (7.2 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (6.1 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 60 hours, the highest value of settleable solids removal (7.4 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest settleable solids removal (6.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth.

It could be concluded that using nano-carbon particles enhanced the sedimentation velocity of the solids waste, where, it increased from 4.7 to 7.4 mg L^{-1} depending on the nano-carbon particles concentrations, depths and time.

Multiple regression analysis was carried out to get a relationship between the settleable solids removal (SSR_{set}, mg L^{-1}), time (t, 12 – 60 hour), location (L, 0 – 90 m), depth (D, 0 – 1 m) and concentration of nano-carbon particles (C, 0 – 0.25 %). The best form obtained was as follows:

$$SSR_{set} = 4.434 + 0.020t + 0.007L + 0.733D + 2.216C \qquad R^2 = 0.894 \quad (1)$$

Where:

SSR_{set} is the settleable solids removal, mg L^{-1}

t is the time, hour

L is the location, m

D is the depth of water, m

C is the concentration of nano-carbon particles, %

3.2. Suspended solids removal:

Table (3) shows the data of suspended solids removed at different depths and locations of fish pond using different concentrations of nano-carbon particles during time. It could be seen that the suspended solids removal increased with increasing depth and it decreased with increasing time, where at the inlet of fish pond after 12 hours, the highest value of suspended solids removal (7.1 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.4 mg L^{-1}) for control. After 24 hours, the highest value of suspended solids removal (6.5 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.4 mg L^{-1}) for control. After 36 hours, the highest value of suspended solids removal (6.8 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.7 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.2 mg L^{-1}) for control. After 48 hours, the highest value of suspended solids removal (5.8 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (5.4 mg L^{-1}) for control. After 60 hours, the highest value of suspended solids removal (5.7 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (4.8 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth compared to (4.7 mg L^{-1}) for control.

Table (3): Suspended solids removal from fish pond water using nano-carbon particles with different concentration at different locations and periods.

Time (h)	Location	Depth (m)	Concentration (%)				
			control	0.10	0.15	0.20	0.25
12	Pond inlet	0.0	5.4	5.4	5.5	5.7	5.8
		0.5	5.6	5.7	5.8	5.8	5.9
		1.0	6.3	6.5	6.8	6.9	7.1
	Pond meddle	0.0	5.5	5.6	5.7	5.8	5.9
		0.5	6.4	6.4	6.6	6.7	6.8
		1.0	6.4	6.5	6.7	6.9	7.2
	Pond outlet	0.0	5.9	5.9	6.2	6.4	6.4
		0.5	6.1	6.2	6.3	6.4	6.4
		1.0	6.6	6.7	6.7	6.9	7.0
24	Pond inlet	0.0	5.4	5.4	5.5	5.5	5.7
		0.5	5.7	5.8	6.0	6.2	6.4
		1.0	6.2	6.3	6.4	6.4	6.5
	Pond meddle	0.0	5.3	5.4	5.5	5.6	5.7
		0.5	6.3	6.4	6.5	6.6	6.7
		1.0	6.2	6.4	6.6	6.9	7.0
	Pond outlet	0.0	5.6	5.7	5.8	5.8	6.1
		0.5	5.7	5.8	6.0	6.2	6.3
		1.0	6.4	6.4	6.5	6.6	6.8
36	Pond inlet	0.0	5.2	5.3	5.3	5.4	5.4
		0.5	5.3	5.4	5.4	5.5	5.8
		1.0	5.8	5.9	6.0	6.1	6.2
	Pond meddle	0.0	5.4	5.5	5.6	5.7	5.9
		0.5	6.1	6.2	6.3	6.4	6.6
		1.0	6.2	6.3	6.4	6.5	6.7
	Pond outlet	0.0	5.4	5.5	5.6	5.8	6.0
		0.5	5.6	5.7	5.9	6.1	6.3
		1.0	6.2	6.3	6.4	6.6	6.9

Table (3): Continued.

Time (h)	Location	Depth (m)	Concentration (%)				
			control	0.10	0.15	0.20	0.25
48	Pond inlet	0.0	5.4	5.4	5.5	5.6	5.7
		0.5	5.4	5.5	5.5	5.6	5.8
		1.0	5.7	5.7	5.8	5.8	5.8
	Pond meddle	0.0	4.9	4.9	5.0	5.1	5.3
		0.5	5.8	5.8	5.9	6.0	6.0
		1.0	5.9	6.0	6.0	6.1	6.2
	Pond outlet	0.0	5.2	5.2	5.3	5.4	5.5
		0.5	5.8	5.9	5.9	6.0	6.1
		1.0	5.8	5.9	6.0	6.1	6.2
60	Pond inlet	0.0	4.7	4.8	4.9	5.0	5.2
		0.5	5.0	5.1	5.2	5.3	5.5
		1.0	5.4	5.4	5.5	5.6	5.7
	Pond meddle	0.0	5.3	5.4	5.5	5.6	5.7
		0.5	5.5	5.5	5.6	5.7	5.8
		1.0	5.7	5.8	5.9	6.0	6.1
	Pond outlet	0.0	5.1	5.2	5.3	5.5	5.7
		0.5	5.4	5.4	5.5	5.6	5.7
		1.0	5.5	5.6	5.7	5.8	5.9

At the middle of fish pond, the results indicate that the highest value of suspended solids removal (7.2 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.6 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth after 12 hour. After 24 hours, the highest value of suspended solids removal (7.0 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 36 hours, the highest value of suspended solids removal (6.7 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.5 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 48 hours, the highest value of suspended solids removal (6.2 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (4.9 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 60 hours, the highest value of suspended solids removal (6.1 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.4 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth.

At the outlet of fish pond, the results also indicate that the highest value of suspended solids removal (7.0 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.9 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth after 12 hour. After 24 hours, the highest value of suspended solids removal (6.8 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.7 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 36 hours, the highest value of suspended solids removal (6.9 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.5 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 48 hours, the highest value of suspended solids removal (6.2 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.2 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth. After 60 hours, the highest value of suspended solids removal (5.9 mg L^{-1}) was obtained at 0.25% nano-carbon particles and 1.0 m depth, while the lowest suspended solids removal (5.2 mg L^{-1}) was obtained at 0.1% nano-carbon particles and 0.0 m depth.

Generally, the suspended solids removal from the fish pond water using nano-carbon particles at different concentrations increased with increasing water depth and decreased with time, where, it ranged from 4.8 to 7.2 mg L^{-1} depending on depth, time and nano-carbon particles concentrations.

Multiple regression analysis was carried out to get a relationship between the suspended solids removal (SSR_{sus}, mg L^{-1}), time (t, 12 – 60 hour), location (L, 0 – 90 m), depth (D, 0 – 1 m) and concentration of nano-carbon particles (C, 0 – 0.25 %). The best form obtained was as follows:

$$SSR_{sus} = 5.718 - 0.016t + 0.003L + 0.740D + 1.756C \qquad R^2 = 0.919 \quad (2)$$

Where:

SSR_{sus} is the suspended solids removal, mg L^{-1}

Nano-materials have unique size dependent properties related to their high specific surface area. Due to their high specific surface area, nano-adsorbents show a considerably higher rate of adsorption for organic compared with granular or powdered activated carbon **(Dhermendra *et al.*, 2008)**.

4. CONCLUSIONS

The possibility of using Nano-carbon particles in removing both of the settleable and suspended solid wastes from fish farms water was studied. The treatments under study are: nano-carbon particles concentrations (0.10, 0.15, 0.20 and 0.25 % compared to control treatment), water depths (0.0, 0.5 and 1.0 m) and locations from the opening of the pond (inlet, middle and outlet of the pond). The obtained results can be summarized as follows:

- Using nano-carbon particles enhanced the sedimentation velocity of the solids waste, where, it increased from 4.7 to 7.4 mg L^{-1} depending on the nano-carbon particles concentrations, depths and time.
- The settleable solids removal increased with increasing water depth and time, where, it increased from 5.4 to 7.4 mg L^{-1} with increasing water depth from 0.0 to 1.0 m and increasing the time from 12 to 60 hour at 0.25% nano-carbon particles concentration.
- The suspended solids removal from the fish pond water using nano-carbon particles at different concentrations increased with increasing water depth and decreased with time, where, it ranged from 4.8 to 7.2 mg L^{-1} depending on depth, time and nano-carbon particles concentrations.

5. REFERENCES

APHA (1998). Standard Methods for Examination of Water and Wastewater, American Public Health Association, American Water Works Association, Water Pollution Control Federation Washington, DC.

Binks, P. (2007). Nanotechnology & water: opportunities and challenges. Victorian Water Sustainability Seminar, May, 15, 2007. [This presents approaches to the study of nanotechnology for water issues].

Cripps, S. and A. Bergheim (2000). Solids management and removal for intensive land-based aquaculture production systems. Aquacultural Engineering, 22 (1 – 2): 33 – 56.

Dhermendra, K.T., J. Behari J. and P. Sen (2008). Application of nanoparticles in waste water treatment. World Appl. Sci. J., 3(3): 417 – 433.

Fleischer, T. and A. Grunwald (2008). Making nanotechnology developments sustainable. A role for technology assessment?. Journal of Cleaner Production, 16 (8–9): 889–898.

Jauncey, K. and B. Ross (1982). A guide to tilapia feeds and feeding. Institute of aquaculture, university of sterling, Scotland. 111 pp.

Jiuhui, Q. (2008). Research progress of novel adsorption processes in water purification: A review. Journal of Environmental Sciences, 20: 1-13.

Khater, E.G. (2012). Simulation model for design and management of water recirculating systems in aquaculture. Ph. D., Thesis, Fac. Agric., Moshtohor, Benha Univ., Egypt.

Khater, E.G., S.A. Ali, A.H. Bahnasawy and M.A. Awad (2011). Solids removal in a recirculating aquaculture system. Misr J. Ag. Eng., 28 (4): 1178 – 1196.

Libey, G. S. (1993). Evaluation of a drum filter for removal of solids from recirculating aquaculture system. In: Techniques for Modern Aquaculturre, Wang, J. K. (editors), Saint Joseph, Michigan, ASAE.

Liu, X., M. Wang, S. Zhang and B. Pan (2013). Application potential of carbon nanotubes in water treatment: a review. J. Environ. Sci. (China), 25, 1263 – 1280.

Merino, G. E., R. H. Piedrahita and D. E. Conklin (2007). Settling characteristics of solids settled in a recirculating system for California halibut (Paralichthys californicus) culture. Aquacultural Engineering, 37, 79 – 88.

Piedrahita, R. H., W. H. Zachritz, U. K. Fitzsimmons and C. Brckway (1996). Evaluation and improvement of solids removal systems for aquaculture. In Successes and Failures in Commercial Recirculating Aquaculture, editors Northeast Regional Agricultural Engineering Service (NRAES). NRAES-98, 1: 141 – 150.

Rakocy, J. E. (1989). Tank culture of tilapia. In the biology and culture of tilapia, ed. R. S. V. Pullin & R. H. Lowe-McConell-ICLARM conference proceedings 7. International center for living aquatic resources management, manila, the Philippines.

Rao, G.P., C. Lu and F. Su (2008). Sorption of divalent metal ions from aqueous solution by carbon nanotubes: a review. Separations and Purification Technology, 58, 224 – 231.

Street, A., R. Sustich, I. Duncan and N. Savage (2008). Nanotechnology applications for clean water. Solution for Improving Water Quality, Elsevier Science, 700 pp.

Summerfelt, S. T. (1996). Engineering design of modular and scaleable recirculating systems containing circular tank, microscreen filters, fluidized-sand biofilters, cascade aerators, and low head or u-tube oxygenators. In Successes and Failures in Commercial Recirculating Aquaculture, editors Northeast Regional Agricultural Engineering Service (NRAES). NRAES-98, 1: 217 – 244.

Tambe Patil, B. B. (2015). Wastewater treatment using nanoparticles. J. Adv. Chem. Eng., 5: 131.

Timmons, M. B. and J. M. Ebeling (2007). Recirculating aquaculture. Cayuga Aqua Ventures, Ithaca, NY.

Vinci, B., S. Summerfelt and A. Bergheim (2001). Solids control. In: Summerfelt, S. T. (Ed.), Presentation Notebook: Aquacultural Engineering Society Workshop: Intensive Fin-fish Systems and

Technologies. Aquaculture 2001, International Triannual Conference and Exposition of the World Aquaculture Society, January 23, Disney's Coranado Spring Resort, Orlando, FL.

الملخص العربى

استخدام جزيئات النانو-كربون فى معالجة المخلفات الصلبة فى مزارع الأسماك

خميس عبد القادر جبر*، عادل حامد بهنساوى، سمير أحمد على**،**
السيد جمعه خاطر* و محسن ابراهيم عجيله******

يهدف هذا البحث الى دراسة امكانية استخدام جزيئات النانو-كربون فى ازالة كلا من المخلفات الصلبة المترسبة والعائمة الموجودة فى مياه المزارع السمكية. وتم إجراء هذه التجربة فى مزرعة خاصة بمحافظة الفيوم لدراسة تأثير كلا من تركيز جزيئات النانو-كربون (٠.١٠ و٠.١٥ و٠.٢٠ و٠.٢٥%) وعمق المياه (٠.٠ و٠.٥ و١.٠ م) والزمن (١٢ و٢٤ و٣٦ و٤٨ و٦٠ ساعة) فى ثلاث اماكن مختلفة فى حوض الاسماك (عند المدخل ومنتصف الحوض وعند المخرج). وكانت اهم النتائج المتحصل عليها كما يلى: زاد معدل ازالة المخلفات الصلبة المترسبة بزيادة عمق الماء والزمن، حيث زادت من ٥.٤ إلى ٧.٤ مجم/لتر بزيادة عمق الماء من صفر إلى ١.٠ م وزيادة الزمن من ١٢ إلى ٦٠ ساعة عند تركيز لجزيئات النانو-كربون ٠.٢٥ %. ادى استخدام جزيئات النانو-كربون إلى تحسين سرعة الترسيب للمخلفات الصلبة، حيث زاد معدل ازالة المخلفات الصلبة المترسبة من ٤.٧ إلى ٧.٤ مجم/لتر بزيادة تركيز جزيئات النانو-كربون وعمق الماء والزمن. زاد معدل ازالة المخلفات الصلبة العائمة بزيادة تركيز جزيئات النانو-كربون وعمق الماء، كما انخفضت المخلفات الصلبة العائمة بزيادة الزمن، حيث زادت من ٤.٨ إلى ٧.٢ مجم لتر$^{-1}$ بزيادة تركيز جزيئات النانو-كربون وعمق الماء.

***طالب دراسات عليا – كلية الزراعة بمشتهر – جامعة بنها.**
**** استاذ الهندسة الزراعية - كلية الزراعة بمشتهر – جامعة بنها.**
***** مدرس الهندسة الزراعية - كلية الزراعة بمشتهر – جامعة بنها.**
******باحث معهد بحوث الهندسة الزراعية– مركز البحوث الزراعية بالدقي-الجيزة.**