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MECHANICAL FILTRATION PRETREATMENT EFFECT ON AMMONIA BIOFILTRATION PERFORMANCE INDICATORS IN FISH AQUACULTURE WASTEWATER

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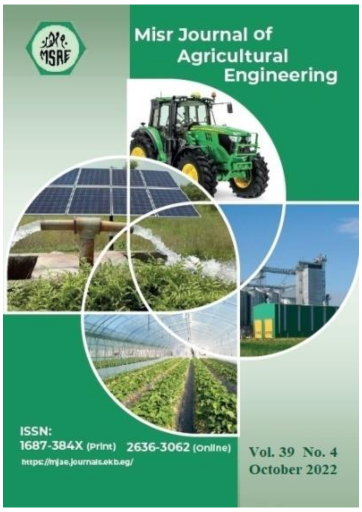

Keywords:
Biological Treatment; Ammonia; Mechanical Filter; Biofilter; Media.

ABSTRACT

Biological treatment is one of the best methods used to treat wastewater because it is environmentally friendly and costs less than chemical treatment methods. Experimental work was conducted to treat aquaculture wastewater and reuse it using white aggregate and gravel mechanical filter media and rice straw, activated carbon, plastic beads and banana peel as biofilter media. Factors under investigation were filter media type, ammonia (NH_3) concentration, HRT, measurement indicators were pH, TDS, TSS, NTU, COD, BOD, TKN. The results showed that gravel mechanical filter is better than white aggregate mechanical filter in reducing NH_3 concentration and physico-chemical parameters. NH_3 concentration in raw wastewater was 32 mg/l and reduced to 28, 25 mg/l in white aggregate and gravel mechanical filter, respectively. For gravel mechanical filter, NH_3 concentration after passing through activated carbon, rice straw, plastic beads and banana peel was 5, 9.72, 10.8 and 5.5 mg/l, respectively. Four hydraulic retention time and doses of activated carbon per liter of wastewater were used, 5, 10, 15 and 20 gm and 5, 10, 20 and 30 min. 20 min with a medium dose of 15 gm of activated carbon per liter of wastewater had the best effect on NH_3 removal. Five hydraulic retention time and doses of rice straw per liter of wastewater were used, 5, 10, 15, 20 and 25 gm and 5, 10, 20, 30 and 40 min. 30 min with a medium dose of 20 gm of rice straw per liter of wastewater had the best effect on NH_3 removal.

1. INTRODUCTION

Water covers about three quarters of the Earth's surface, and therefore it is one of the most abundant elements in nature. But about 97% of this water is the oceans and saline water bodies. More than 2% of the total remaining 3% is in a solid state, which makes its use difficult. Thus, what is available for human use only about 0.62% and it is found in ponds, rivers and groundwater. Rain is the main source of renewable fresh water, which reaches 40,000 – 45,000 km^3 per year annually. This supply must meet the needs of the world's population, which is increasing by about 85 million per year. Consequently, the per capita share of fresh water is rapidly decreasing. When natural resources are used excessively, the ecosystems from which they are obtained are negatively affected **(Turcios and Papenbrock, 2014)**. Population increasing and the development of the lifestyle in the era of rapid industrialization and urbanization led to a severe shortage of all natural resources **(Verma et al., 2012)**. Egypt ranks sixth among the top ten finfish producers from inland aquaculture by 1,091,688 T, live weight (2.6%). While it occupies the seventh place in the production of crustaceans from inland aquaculture and in farmed food fish by 5, 856 T, live weight (0.2%) and 1,097,544 T; live weight (1.6%), respectively (**Abdelbary, 2017)**. Fish aquaculture wastewater affects the living organisms in the environment due to the toxic elements it contains such as N, P, Cr and Se. It also leads to an imbalance in the aquatic ecosystem **(Abdelbary, 2016)**. With the rapid development of intensive aquaculture in recirculating systems, its impact on the environment has increased. Therefore, the need to find highly efficient ways to treat the resulting wastewater so that it can be used again has increased **(Abdelbary, 2016; Nicula et al., 2022)**.

Wastewater from fish aquaculture poses a major threat to the environment, humans and economic stability. Therefore, an appropriate method must be found to treat it **(Dadrasnia et al., 2017)**. Conventional treatment methods, whether physical, chemical or biological, are used to treat wastewater from fish aquaculture. Where the presence of massive quantities of dissolved or suspended materials in this water lead to a lack of fish production and poor water quality, thus increasing the costs of the treatment process **(Nicula et al., 2022**; **Divya, 2015)**. Treatment in which living organisms, whether plants or animals, are used is called bioremediation, in which hazardous polluting materials are degraded into non-toxic or less toxic materials. Bioremediation may occur either automatically, or there may be a need to add materials to take place effectively, such as oxygen (O_2) or fertilizers, which increase the activity of microorganisms to perform their task of breaking down pollutants. The term "bioremediators" is given to the microorganisms that are used in the biological treatment process which are beneficial microbial agents and may be yeast, bacteria or fungi **(Ranjan and Bavitha, 2014**; **Abdelbary, 2016; Aanand et al., 2017)**. The most important advantages of biological treatment are that it is less costly, environmentally friendly, and highly efficient in retaining the pollutants to be removed **(Liu et al., 2014)**. Conventional biological treatment methods provide high efficiency and continuous performance in the removal of nitrogen (N) and phosphorous (P) thus, increasing the development of fish aquaculture without the need to increase the demand for water, which is currently suffering from the problem of scarcity **(Boxman et al., 2015; Zhimiao et al., 2019; Nicula et al., 2022)**.

Nitrogenous substances are removed through nitrifying and denitrifying processes. they are removed from the wastewater of fish aquaculture traditionally by fluidized sand biofilters (FSB), bead filters (BF), Rotating biological contactors (RBC) or trickling filters (TF) **(Abdelbary, 2016; Nicula et al., 2022)**. Ammonia and ammonium are toxic to fish. Unionized ammonia (NH_3) is more toxic than charged ammonium (NH_4^+) because it is fat soluble and uncharged, making it easier to move between biological membranes. The toxic concentration of NH_3 for most types of farmed fish is 1.5 mg N/l. In theory, fish will not suffer any harm from the presence of NH_3 until this concentration (**Abdelbary, 2017)**.

Increased NH_3 concentration increases fish stress and makes it more susceptible to diseases **(Jasmin et al., 2020)**. NH_3 depends on the type and quantity of organic matter (OM) such as fertilizers and feed. However, the main component in the production of NH_3 is the protein metabolism activity of fish. The nitrite (NO_2^-) is an intermediate form between NH_3 and nitrate (NO_3^-). NO_2^- is unstable, which makes it more toxic when its concentration is above 0.5 mg/l. An increase in NO_2^- concentration leads to the death of fish because it is inferred with the O_2 carrying capacity of fish. While the last form resulting from the nitrification process is NO_3^-, which is considered less toxic than NH_3 and NO_2^-. So that the concentration of 200 mg/l of it does not affect the quality of water or fish, while a higher concentration affects fish. P is an important product of metabolism in fish aquaculture feed with N. The concentration of P increases because of uneaten feed and undigested P in the faeces, but its quantity varies according to the type of fish that is farmed, the nature of the feed and the system used in the culture **(Singh et al., 2017; Jasmin et al., 2020)**. Temperature (T), dissolved oxygen (DO), total ammonia nitrogen (TAN), NO_3^- concentration, salinity, pH, hydraulic retention time (HRT), pressure drop and inlet load are among the most important factors affecting the efficiency of N removal **(Pfeiffer and Wills, 2011; Abdelbary, 2017; Malakar et al., 2018**; **Wu et al., 2021)**.

Recirculating aquaculture systems (RAS) include 1- A means for removing large solid particles from water and resulting from fish and uneaten food waste 2- A biofilter that removes NH_3 by converting it to NO_2^- and then to NO_3^- 3- A gas exchange device to remove carbon dioxide (CO_2) produced from Fish, as well as to add the O_2 required to fish and microorganisms. RAS includes a wide range of physical, chemical, and biological interactions. Any change in system performance or water quality is known by understanding these interactions and the relationship between the fish in this system and the equipment used **(Goddek et al., 2019)**. The ability to remove N from RAS allows the expansion of fish aquaculture and allows the wastewater to be reused **(Christianson et al., 2015)**. Water quality is one of the most important elements of the success of RAS, as the removal of particles resulting from food decomposition and waste excretion is one of the elements of water treatment. DO, NH_3, biosolids, CO_2, temperature and pH are some of the water quality parameters and they can be controlled in terms of their effect on fish survival and are altered by the addition of feed. However, some other water quality parameters cannot be controlled because 1- Pollutants to be analyzed can be diluted by daily water exchange. 2 - The high price of water quality analysis. 3- Its negative effects were not observed in practice. 4- Water sources that contain them are not used **(Holan et al., 2014; Goddek et al., 2019; Su et al., 2020)**.

RAS occupies an exceedingly small area and requires less water than other forms of aquaculture and it is considered the best in the case of a water shortage **(Uzoigwe et al., 2014)**. Although the treatment of fish aquaculture wastewater depends mainly on total dissolved solids (TSS) removal, nitrification and denitrification, there are different configurations of RAS **(Wik et al., 2009)**. One of the most important components of the RAS system is the microbial communities, which play a large and key role in the degradation of OM, recycling of nutrients and treatment of diseases. Developing RAS and making it efficient, safe and productive requires an understanding of all processes whether chemical (ozonation - gas transfer - heat treatment - acidity - salinity), physical or biological (nitrification and denitrification). Although physical and chemical processes can be controlled while biological processes cannot be controlled as they depend on the interaction of microbial communities with each other **(Schreier et al., 2010; Goddek et al., 2019)**.

There are two main functions of the biofilter: 1- Determining the type and size of the medium, and 2- Determining the pretreatment unit, reactor vessel and additional process control equipment **(Abdelbary, 2016)**. Biofilters are usually used in fish aquaculture for the double oxidation process from NH_3 to NO_2^- and then to NO_3^-. The process of effectively removing NH_3 from wastewater is carried out by nitrifying microorganisms that naturally colonize on the biological filter medium. Biofilters can be either with a fixed bed (FBB) or a moving bed (MBB), as the main differences between the two types are the movement of the medium and if it is mechanical or through aeration and the ability to self-clean the biofilter with the MBB. The shear forces on the outer biofilm layer of the medium of MBB maintain it at a constant level by controlling the excessive formation of the biofilm and thus increasing the risk of system particles load. In the case of FBB, it needs regular backwashing to remove excess biofilms and accumulated matter, thus controlling heterotrophic bacteria **(Fernandes et al., 2017, Xiao et al., 2019)**.

Material of the filter medium shall have sufficient voids with a large surface area, which may be peat, compost, wood chips or peat/perlite mixture and other organic/inorganic commercial media materials. Activated carbon (AC) has been used as a medium in the biological filtration process globally for many years due to the ability of activated carbon to adsorption, as microorganisms grow on it forming a biofilm layer **(Areerachakul, 2018)**. Properties of the filter medium affect the process of removing pollutants **(Areerachakul, 2018; Malakar et al., 2018)**. Whatever the type of filter medium used in the biofilter, it must maintain the water quality within a specific range that allows the growth of fish and does not affect them negatively **(Balami, 2021)**. The presence of voids in the medium of the biofilter reduces the possibility of clogging the biofilter and therefore the flow of water continues, and the presence of pores in the medium of the biofilter leads to an increase in its surface area and thus protects bacteria from collapse and increases the acceleration of the process of maturation of the biofilter **(Boaventura et al., 2018)**.

The main goal of this research work is to examine and analyze bioremediation process as a promising necessity for alternative, energy and cost-efficient methods for wastewater treatment. Specific objectives were:

design and construct biofilter system, removing NH_3 using more than one filter medium to determine the best type of media and determining the hydraulic retention time (HRT) and dose of medium that is the best in removing NH_3.

2. MATERIALS AND METHODS

This experimental work was conducted in Biofuels Research Laboratory, Department of Agricultural Engineering, Faculty of Agriculture, Cairo University to treat aquaculture wastewater and reuse it using white aggregate (**WA**), gravel mechanical filter media (**G**), rice straw (**RS**), activated carbon (**AC**), plastic beads (**PB**), and banana peel (**BP**) biofilter media.

Wastewater Source

The fish farm at Animal Production Dept., Fac. of Agric., Cairo University was the source of wastewater. With a size of 3.5 m^3 and at a rate of 30 kg/m^3. The species of fish in the aquarium was tilapia with sizes (700-800) gm, and the fish feed used was 30% protein.

Wastewater Analysis

Parameters include pH, total dissolved solids (TDS), turbidity (NTU), chemical oxygen demand (COD), NH_3, biochemical oxygen demand (BOD), total kjeldahl nitrogen (TKN), total suspended solids (TSS), NO_3^-, NO_2^- and phosphate (PO_4) have been measured according to **(Baird et al., 2017)**. pH meter, TDS meter, turbidity meter, suction pump using filter paper grade GF/C with pore size 0.45 µm with temperature 105^o C, Kjeldahl distillation system and Spectrophotometer were used to determine pH, TDS, turbidity, TSS, NH_3 and COD, NO_2^-, NO_3^- and PO_4 respectively.

Wastewater Treatment System

The treatment system starts with a tank of wastewater with a volume of 9 liters. Wastewater passed through the mechanical filter, where two types of mechanical filters were used (white aggregate and gravel) then wastewater passed through the biofilter, where four types of biofilters media were used (rice straw, activated carbon, plastic beads and banana peel). Figures 1 and 2 show the wastewater treatment system.

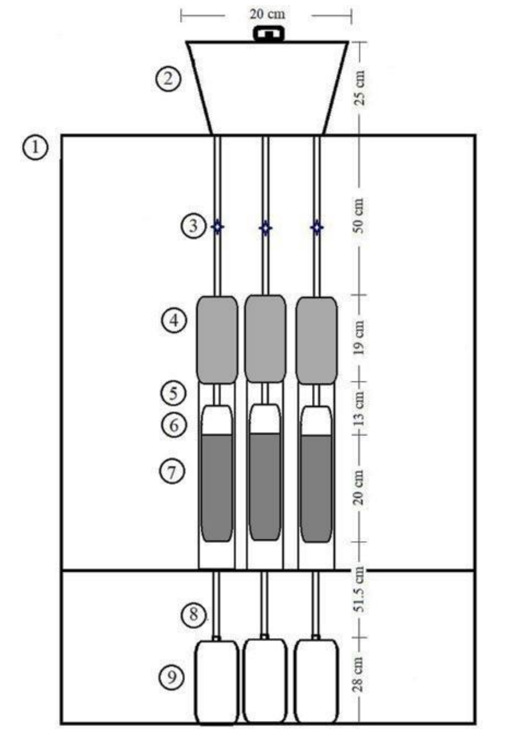

Fig.(1). Schematic diagram of an elevation view of the wastewater treatment system.

Fig.(2). Wastewater treatment system.

1	Wastewater treatment system frame.	**6**	Biofilter vessel.
2	Wastewater tank.	**7**	Biofilter medium.
3	Controller.	**8**	Exhausted (treated wastewater) outlet.
4	Mechanical filter.	**9**	Water drainage tank.
5	Water nozzle.		

The mechanical filter had a total volume of 1 liter, a height of 19 cm and a diameter of 8 cm was utilized. Porosity, flow rate and HRT (Hydraulic Retention Time) were measured for media of white aggregate (with diameter ≥ 6.3mm) and gravel (with diameter < 6.3 mm). Tables 1 and 2 show the characteristics of the different mechanical filter media. The biofilter used was 0.850 liter, with a diameter of 7.4 cm and a height of 20 cm. More than one medium for the biofilter was used as a second stage of the treatment process, which are rice straw (RS), activated carbon (AC), plastic beads (PB) and banana peel (BP) as shown in figure (3). While the concentration of NH_3 in water after passing through the WA and G mechanical filter was 28 and 25 mg/l, respectively, removal of NH_3 was measured for each medium to determine the best one. Also, the best dose of the filter medium per liter of water was determined, as well as best HRT to remove the largest proportion of NH_3 was measured.

Table (1) Porosity of mechanical filter media.

Medium Type	Medium Diameter (mm)	Replicates (%)			Average porosity (%)
WA	**≥ 6.3mm**	45.45	54.54	48.48	**48.48**
G	**< 6.3 mm**	45.45	45.45	40.90	**43.93**

Where: (WA) white aggregate and (G) gravel.

Table (2) Flowrate and H.R.T for different mechanical filter media.

	WA	G
Fill Required Time, min	3.55	3.6
	3.43	3.56
	3.45	3.5
Average, min	**3.48**	**3.55**
Q, l/min	**0.172**	**0.169**
H.R.T, min	**5.75**	**5.95**

Calculations

Hydraulic retention time (HRT) is the time that water will remain inside the biofilter and it depends on the flow rate and the volume of the biofilter. HRT is calculated using equation 1 as following **(Devinny et al., 1998, Ergas and Kinney, 2000)**:

$$HRT = \frac{\mathrm{Vf}}{\mathrm{Q}} \quad (1)$$

Where:

HRT: Hydraulic retention time (min).

Q: Flow rate (l/min).

Vf: Biofilter media volume (l).

While the percentage of pollutants removed by the biofilter is known as the efficiency of removal (R.E), whereas the mass of degraded pollutants per unit volume of filter media per unit time is known as the elimination capacity (E.C) and they were calculated using equations (2, 3) as following **(Devinny et al., 1998, Ergas and Kinney, 2000)**

$$R.E = \frac{\mathrm{Ci} - \mathrm{Co}}{\mathrm{Ci}} * 100 \quad (2)$$

$$E.C = \frac{(Ci - Co) * Q}{Vf} \quad (3)$$

Where:

R.E: The efficiency of removal (%).

E.C: Elimination capacity (mg/l. min).

Ci: Inlet concentration (mg/l).

Co: Outlet concentration (mg/l).

3. RESULTS AND DISCUSSIONS

The main characteristics of wastewater, which include pH, TDS, TSS, NH_3, NO_2^-, No_3^-, NTU, COD, BOD, TKN and PO_4 were measured. Wastewater first passed through the mechanical filter using two different media which were white aggregate and gravel, then through the biofilter with four media, which were RS, AC, BP, PB. The effect of changing HRT and dose of the AC and RS on removing the largest proportion of NH_3 was determined. The parameters of raw wastewater and water treated by white aggregate and gravel mechanical filter were measured. The concentration of wastewater parameters were 7.6 for pH, 665 mg/l for TDS, 14.6 NTU for turbidity, 93 mg/l for COD, 32 mg/l for NH_3, 51.51 mg/l for BOD, 58 mg/l for TKN, 70 mg/l for TSS, 0.15 mg/l for NO_3^-, 4.908 mg/l for PO_4 and NO_2^- was not detected. The results showed that the pH did not change after the mechanical filter also, NO_2^- was not detected, while the concentrations of other parameters for white aggregate and gravel mechanical filter media were 652, 650 mg/l for TDS, 11.2, 7.3 NTU for turbidity, 70, 47 mg/l for COD, 28, 25 mg/l for NH_3, 42, 26.5 mg/l for BOD, 52.3, 48.2 mg/l for TKN, 50, 32 mg/l for TSS and 0.15, 0.1 mg/l for NO_3^-, respectively. This confirms that gravel had a better effect than white aggregate on the removal of ammonia as well as the reduction of other parameters.

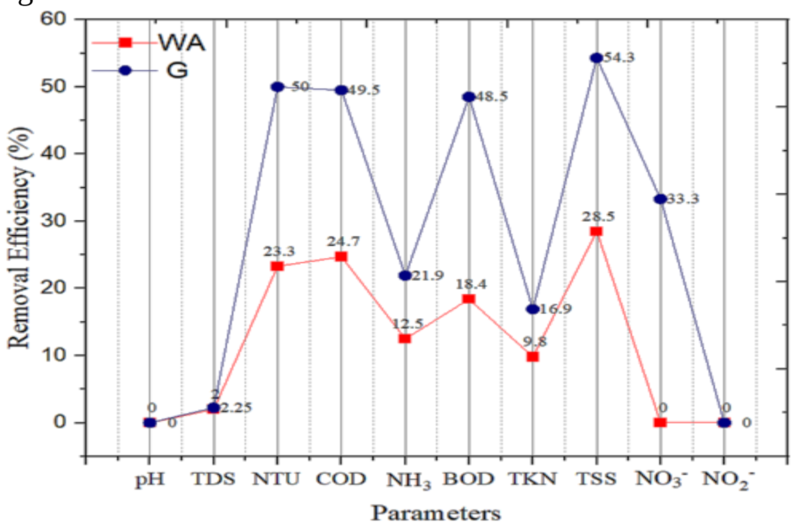

Fig.(3). Graph shows the removal efficiency (RE) of WA and G mechanical filter media.

The concentration of NH_3 in water after the mechanical filter using white aggregate and gravel media were 28 and 25 mg/l, respectively. This water passed through four different media, AC, RS, PB and BP with HRT of 30 min and 15 gm dose. When the white aggregate mechanical filter was utilized, the concentration of NH_3 after biofilter using AC, RS, PB and BP were 5.6, 10.8, 12 and 6.16 mg/l with removal efficiency (RE) 80, 61.43, 57,14 and 78 % and elimination capacity (EC) 0.75, 0.57, 0.53 and 0.73 mg/l. min, respectively. While for gravel mechanical filter medium, the concentration of NH_3 after biofilter were 5, 9.72, 10.8

and 5.5 mg/l, with RE 80, 61.12, 56.8 and 78 % and EC 0.66, 0.51, 0.47 and 0.65 mg/l. min, respectively. This proves that activated carbon showed the best results in removing ammonia, so it was used in subsequent experiments. Rice straw was also used because it is a waste to be disposed of.

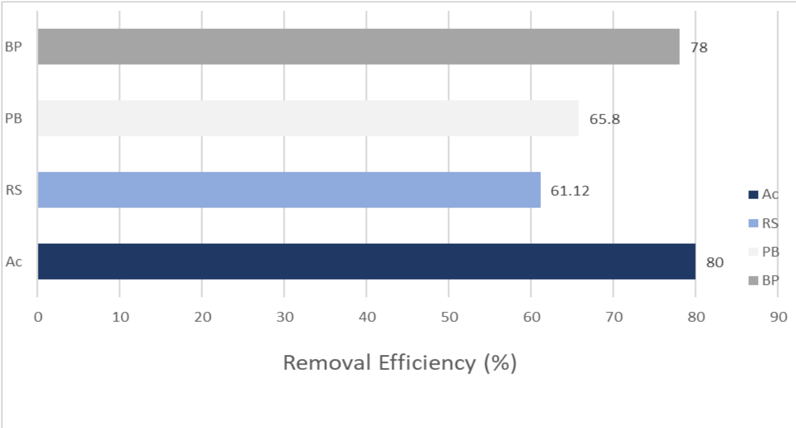

Fig.(4). Removal efficiency (RE) of biofilter media while using G mechanical filter media.

Bacteria convert ammonia (NH_3) to nitrite (NO_2^-) and then to nitrate (NO_3^-), through the nitrification process. *Nitrosomonas* was the bacteria responsible for converting NH_3 into NO_2^-, while *Nitrobacter* was responsible for converting NO_2^- into NO_3^-. An increase in the number of bacteria in a population is defined as the growth of bacterial cultures. When all the conditions and nutrients necessary for the growth of bacteria are provided, its growth takes place in four phases **(Abdelbary, 2003)**.

Four different medium doses of activated carbon were used they were 5, 10, 15 and 20 gm of activated carbon per liter of wastewater. The results showed that with HRT of 30 min, NH_3 removal efficiency was 39.6, 76, 80 and 80%, respectively. The best removal efficiency was when using a dose of 15 gm per liter of wastewater. Four HRTs were used with the dose of 15 gm of AC per liter of wastewater and they were 5, 10, 20, and 30 min. The results showed that NH_3 removal efficiency was 70, 76, 80 and 80%, respectively. The best HRT that had the greatest effect on removing NH_3 was 20 min with a medium dose of 15 gm of AC per liter of wastewater. Figures (5 and 6) show the removal efficiency using different doses and HRTs.

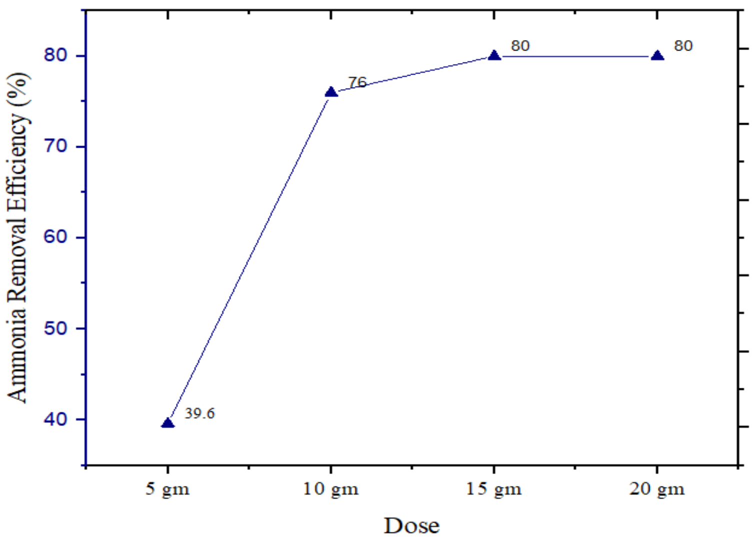

Fig.(5). Medium doses of activated carbon biofilter medium.

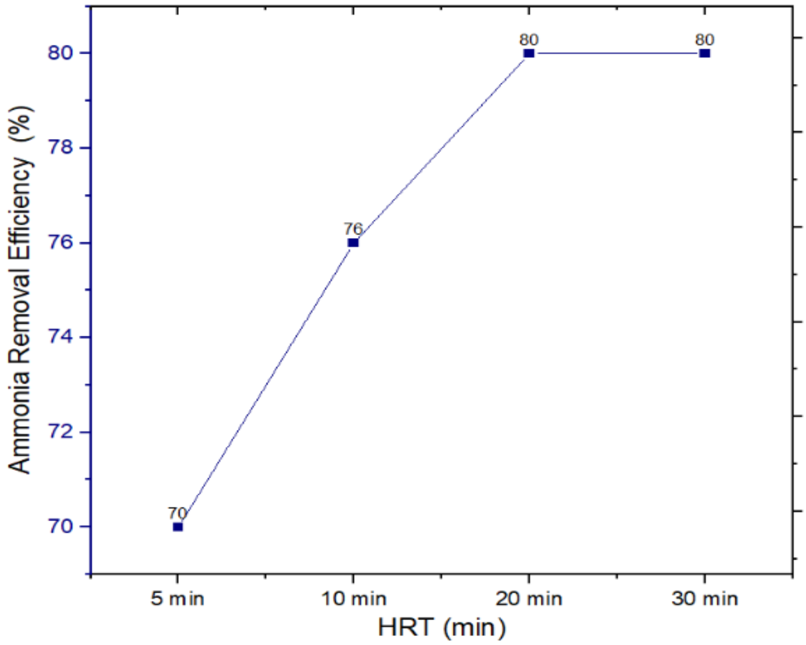

Fig.(6). HRT of activated carbon biofilter medium.

For rice straw, five doses were used and they were 5, 10, 15, 20 and 25 gm of rice straw per liter of wastewater. The results showed that with HRT of 30 min, NH_3 removal efficiency was 30, 46.4, 61.12, 62 and 62 %, respectively. Therefore, 20 gm per liter of wastewater had the best removal efficiency. Five HRTs were used with the dose of 20 gm of rice straw per liter of wastewater and they were 5, 10, 20, 30 and 40 min. The results showed that NH_3 removal efficiency was 27.2, 42, 55.2, 62 and 62.2 %, respectively. Thus, the best HRT that had the greatest ability to remove NH_3 was 30 min with a medium dose of 20 gm of rice straw per liter of wastewater. Figures (7 and 8) show the removal efficiency of rice straw at different doses and HRTs.

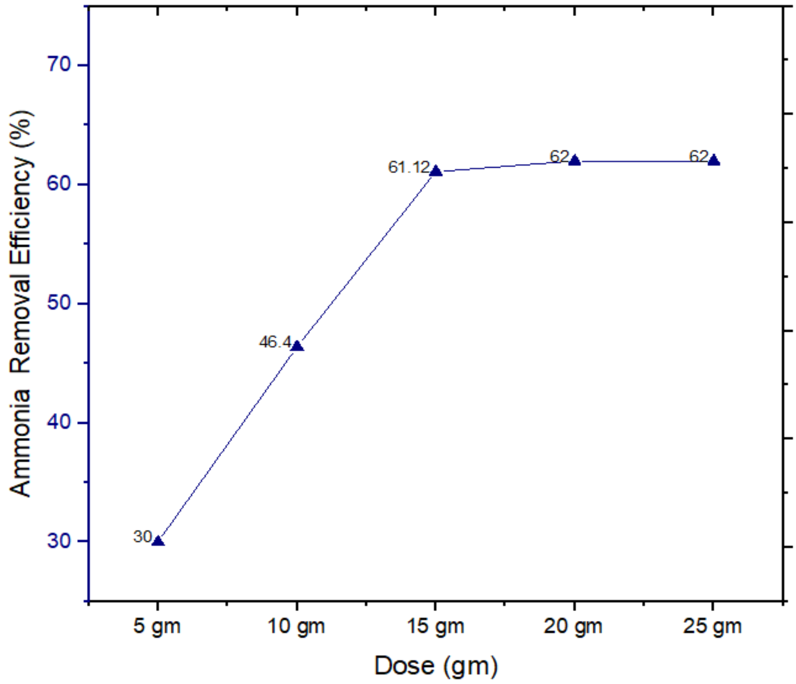

Fig.(7). Medium doses of rice straw biofilter medium.

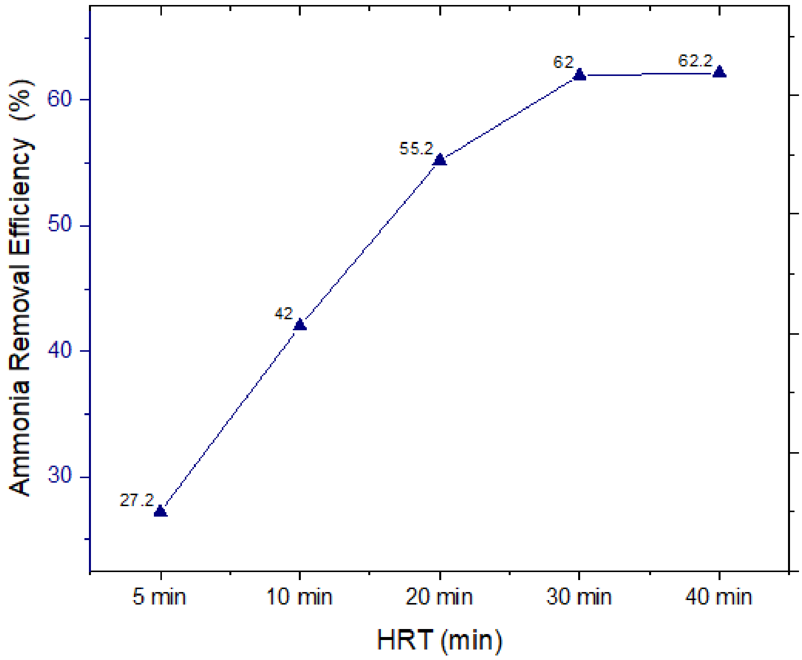

Fig.(8). HRT of rice straw biofilter medium.

The parameters of the water that was treated were measured for activated carbon and rice straw biofilter. pH did not change from 7.6 in the case of activated carbon and rice straw, the concentrations of TDS, NTU, COD, NH_3, BOD, TKN, TSS and PO_4 for activated carbon were 650 mg/l, 6 NTU, 30 mg/l, 5 mg/l, 16.5 mg/l, 16.4 mg/l, 10 mg/l and 3.647 mg/l, respectively and NO_3^-, NO_2^- were not detected. For rice straw the concentrations of TDS, NTU, COD, NH_3, BOD, TKN, TSS and PO_4 were 656 mg/l, 7.8 NTU, 38 mg/l, 9.5 mg/l, 21.6 mg/l, 21 mg/l, 16 mg/l and 2.953 mg/l, respectively when the concentrations NO_3^-, NO_2^- were not detected.

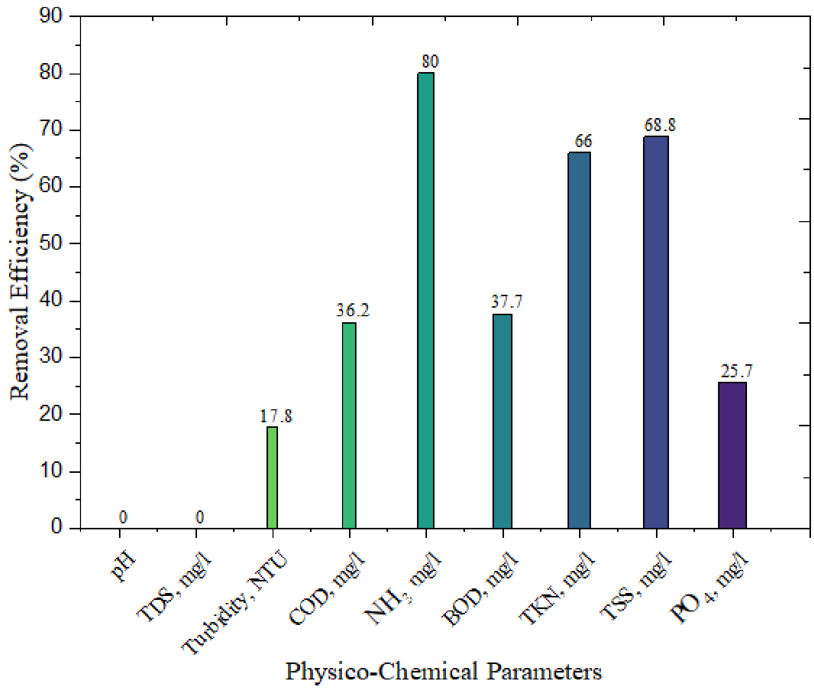

Fig.(9). Parameters of water treated by activated carbon biofilter medium.

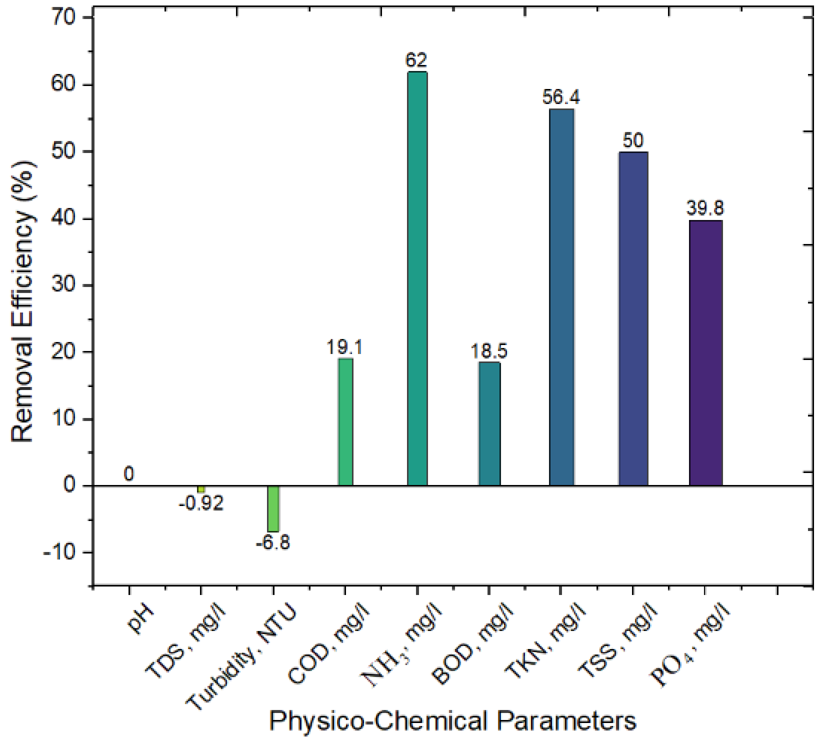

Fig.(10). Parameters of water treated by activated carbon biofilter medium.

4. CONCLUSION

A biological treatment unit was designed to treat the wastewater generated from aquaculture, and the effect of having a mechanical filter as a pre-treatment unit before passing through the biological filter was studied.

- Porosity, flow rate and hydraulic retention time of the white aggregate and gravel mechanical filter media were measured.
- Activated carbon, rice straw, plastic beads and banana peel were used as a biofilter media.
- Physico-chemical parameters for raw wastewater, water treated with white aggregate (**WA**) and gravel (**G**) mechanical filter and water treated with activated carbon and rice straw biofilter were measured.
- Gravel and activated carbon had the best effect on ammonia removal.
- Different doses of activated carbon and rice straw biofilter were used to select the best dose of biofilter media in removing ammonia.
- 20 min with a medium dose of 15 gm of activated carbon per liter of wastewater had the best effect on ammonia removal.
- 30 min with a medium dose of 20 gm of rice straw per liter of wastewater had the best effect on ammonia removal.

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تأثير المعالجة المسبقة بالترشيح الميكانيكي على مؤشرات أداء الترشيح الحيوي للأمونيا الناتجة من مياه صرف المزارع السمكية

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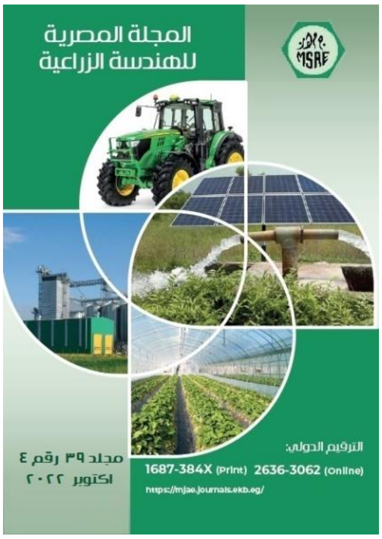
الملخص العربي

المعالجة البيولوجية من أفضل الطرق لمعالجة مياه الصرف الصحي. تم إجراء هذه التجربة في معمل الوقود الحيوي، قسم الهندسة الزراعية، كلية الزراعة، جامعة القاهرة لمعالجة مياه المزارع السمكية لإعادة استخدامها وذلك باستخدام الركام الأبيض والحصى كوسائط ترشيح ميكانيكي والكربون المنشط وقش الأرز وقشر الموز والخرز البلاستيكي كوسائط ترشيح حيوية. العوامل قيد الدراسة هى نوع وسائط المرشح، تركيز الأمونيا، زمن الاحتفاظ الهيدروليكي، وكانت مؤشرات القياس هي pH، DS ، TSS، NTU، COD، BOD، TKN. كان الحصى أفضل من الركام الأبيض في تقليل الأمونيا والعوامل الكيميائية الفيزيائية. كانت الأمونيا في مياه صرف المزارع السمكية ٣٢ مجم/لتر وتم تقليلها إلى ٢٨ و ٢٥ مجم/لتر في الركام الأبيض والحصى، على التوالي. بالنسبة لمرشح الحصى الميكانيكي، كانت الأمونيا بعد المرور على الكربون المنشط وقش الأرز والخرز البلاستيكي وقشر الموز هي ٥ ، ٩,٧٢، ١٠,٨ و ٥,٥ مجم/لتر، على التوالي. تم استخدام أربع جرعات من الكربون المنشط لكل لتر من مياه الصرف وأربع ازمنة احتفاظ هيدروليكي وهم ٥ ، ١٠ ، ١٥ و ٢٠ جرامًا و ٥ ، ١٠ ، ٢٠ و ٣٠ دقيقة. ٢٠ دقيقة بجرعة ١٥ جم من الكربون المنشط لكل لتر من مياه صرف المزارع السمكية كان لها أفضل تأثير على إزالة الأمونيا. تم استخدام خمس جرعات من قش الأرز لكل لتر من مياه الصرف وخمس فترات احتفاظ هيدروليكي وهم ٥ ، ١٠ ، ١٥ ، ٢٠ ، ٢٥ جرامًا و ٥ ، ١٠ ، ٢٠ ، ٣٠ ، ٤٠ دقيقة. ٣٠ دقيقة بجرعة متوسطة ٢٠ جم من قش الارز لكل لتر من مياه الصرف الصحي كان لها أفضل تأثير على إزالة الأمونيا.



الكلمات المفتاحية:
المعالجة البيولوجية؛ الأمونيا؛ المرشح الميكانيكي؛ المرشح الحيوي؛ الوسائط.