 Egypt J. Chem. **Vol. 65,** No. SI:13B, pp. 1221 - 1229 (2022)

Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

Using Polyethylene Bio Media as A New Floated Media in a Biological Aerated Filter (BAF) to Treat Primary Effluent Wastewater

Reem A. Elhalafawy [a*] A. M. Hassanain [b] and Rehab El Hefny [c]

[a] *Department of Civil Engineering, Faculty of Engineering at Shoubra, Benha University, Cairo, Egypt*
[b] *Lecturer of Sanitary and Environmental Engineering, Department of Civil Engineering, Faculty of Engineering at Shoubra, Benha University, Cairo, Egypt.*
[c] *Assistant Professor of Sanitary and Environmental Engineering, Department of Civil Engineering, Faculty of Engineering at Shoubra, Benha University, Cairo, Egypt*

Abstract

A Biological aerate filter (BAF) is considered one of the most important applications used in wastewater treatment. Therefore, in this study, we were looking forward to discovering its ability to treat primary sedimentation tank effluent utilizing Polyethylene floated media called bio-media as a biological filter media, which is considered the novelty point of this research. This study and investigations operated for several months with a designed pilot plant installed and designed in Zenin Wastewater Treatment Plant located in Egypt. During the operation study of the BAF system, dissolved oxygen (DO) and flow rate with different hydraulic retention times (HRT) were studied. All these parameters were measured to investigate the ability of the BAF with polyethylene bio media on removal rates of chemical oxygen demand (COD), biological oxygen demand (BOD), and total suspended solids (TSS). The result showed that the optimum HRT was 72 minutes with the DO equal to 4.67±0.2 mg/l for COD and BOD removal rates; it yielded the largest removal efficiency of COD and BOD_5 68.08 % and 69.18%, respectively. While the optimum HRT was 24 minutes with the DO equal to 4.67±0.2 mg/l for TSS removal efficiency, it recorded maximum removal efficiency up to 70.40 %.
Keywords: Bio media; Biological aerated filter; Dissolved oxygen; Floated media; Hydraulic retention time; Polyethylene.

1. Introduction

Filtration is one of the foremost vital treatment preparations utilized in water and wastewater treatment; it is utilized to decontaminate the surface water for consumable use. In wastewater treatment, the main reason for filtration is that filtration achieves effluent with a high-quality efficiency. So, it can be reused for a different reason and protect the environment from the bad impact of untreated wastewater. Wastewater passes through three stages during the treatment process: primary treatment, secondary treatment, and tertiary treatment. Usually, the filtration process is utilized in the secondary wastewater treatment stage if used as a Conventional method. Still, recently the filtration process has been developed to be used as an advanced treatment called tertiary treatment. This does not prevent it from being used as a secondary treatment stage. Even though conventional treatments are, for the most part, dependable, they present various disadvantages: poor efficiencies in some cases, capacity, odor, flies, and space prerequisites. To improve the biological treatment, as one of the traditional methods used, wastewater treatment plants should be more conservative, low in operational expense, and stable inactivity while simultaneously limiting the commotion and smell and space prerequisites to create high proficiency. One of the advanced processes that used biological treatment and microorganisms will be discussed in this research, called biological aerated filters (BAFs). The term BAF came from a combination of air and the filtration activity of the microorganisms. A BAF comprises a medium that treats carbonaceous and nitrogenous matter utilizing biomass settled to the media and capturing the suspended solids within the media. BAF may be an adaptable reactor that gives a little impression choice at different stages of

*Corresponding author e-mail: reem.el-halafawy@eng.mti.edu.eg
Receive Date: 22 April 2022, , **Revise Date:** 08 June 2022, **Accept Date:** 21 June 2022
DOI: 10.21608/EJCHEM.2022.135354.5951

wastewater treatment (Verma et al. 2006). The microorganisms attached to the medium; consisting of a slim layer called biofilm; to accomplish its mission of degrading the organic matter, and that's happened by affording it a perfect medium to life; hence using of media was so necessary, so the choice of the media type is very important in the biofilm layer formation. In addition to that, it will affect all the biological processes, which will be mentioned later. Originally, using media in bio-filter was developed using rock or slag as a filter media, that's was first introduced in England in 1893 with trickling filter application in wastewater treatment. However, at present, various types of plastic media are used(Chaudhary et al., 2003). Each type has its own characteristics according to density, void ratio, roughness, specific surface area, etc. These specifications somehow affect the treatment efficiency, which will be mentioned later according to our utilized media (polyethylene bio media).

1.1. Historical brief about BAFs

For approximately one hundred years, the (BAFs) were used through wastewater treatment; they were working either in down-flow or up-flow pressure-driven conditions (Canler et al., 1994). The BAFs are compact units that combine filtration and aerobic -anoxic--anaerobic biodegradation (Rogalla et al.; 1994, Rogalla and Sibony; 1992). It reminds the primary well-known treatment methodology in America up to 1970.

DR. Alexander Mueller was the first one who proved that sewage might be decontaminated by the microorganisms living in a filtration column as the primary trial to treat sewage out of the common implies, and that was in 1865. In 1868 sir Edward Frankland started to think about filtration execution in research facility columns stuffed with media extending from coarse rock to peaty soil. The execution of the test was measured and gave great results, and didn't record any disappointments. (Hatem et al. 2009). The bio-filter medium is intermittently washed to evacuate suspended solids held amid the media and delivered inside the filter bed. Within the mid- 20th century, noteworthy advancements happened with the joining of plastics-based backed media.

A wide variety of BAFs which used floated media as filter media have been investigated, whether it is up-flow or down-flow. The Biostyr process is also an up-flow system which first introduced in Denmark. The media packing in this type of system is floating because it has a specific density less than the wastewater density; this media packing is polystyrene beads (Safoniuk, 2004). The media are roughly the same measure; the media utilized was 3.6 mm, which gives a huge specific area zone (>1,200 m2/m3 or 400 ft2/ft3) for biomass formation on the surface and retention of suspended solids. (Le Tallec et al., 1998).This research aims to investigate the efficiency of a Floated biological aerated filter with polyethylene biological media as a based biological media in removing organic compounds present in the wastewater. These bio-media provide a favorable environment for beneficial Bactria; aerobic and anaerobic bacteria are the two main necessary bacteria for wastewater treatment.

2. Experimental

This study's main objective was to evaluate the performance of (BAF) using a filling medium called bio-media as a filter media on primary sedimentation tank effluent wastewater to degrade the organic compounds with the lowest cost and save the land area used in traditional methods. This application was used to evaluate the efficiency of the bio-media in (BAF) as a secondary treatment measure. The reactor used in the experimental program was designed and installed at Zenin Sewage Treatment Plant in Giza, Egypt. It was designed to be operated 24 hours a day, from January 2021 to June 2021. Zenin Sewage Treatment Plant, located in Giza, Egypt, was constructed in 1990. It depends on activated sludge utilized aeration tank in its framework, which is due to the increasing intensity of the effluent. (Hanafy et al. 2019).

2.1. Characteristics of Wastewater

The characteristics of primary effluent wastewater, which is utilized to feed the designed reactor BAF, are presented in table (1)

2.2. Designed Reactor Description

In the present study, the designed BAF model was constructed to simulate a BAF using floating media, as its density is less than wastewater density, to investigate the experimental plan and the aim of this research.

Table 1: Characteristics of influent wastewater (primary sed. Tank effluent)

Property	Ranges for 1st run	Ranges for 2nd run	Ranges for 3rd run	Ranges for 4th run	Ranges for 5th run	Ranges for 6th run	Ranges for 7th run	Ranges for 8th run	Ranges for 9th run
BOD	150-170	73-183	115-156	110-225	120-161	130-155	137-159	131-170	131-173
COD	220-330	220-344	217-319	215-360	235-332	279-323	239-341	240-326	221-340
TSS	143-180	106-157	171-230	130-153	140-163	115-156	125-149	140-180	137-159
PH	7.05-7.45	7.04-7.51	6.82-7.3	7-7.5	7.29-7.35	7-7.25	7.58-7.7	7.13-7.7	7.01-7.3
Temp.	22-26	24.2-26	23-25	24-25	29-35.5	26-29	25-27.8	26.5-28	27.9-29.5

The reactor model was made of a metal box with a 0.35 m3 capacity, as the reactor dimension is 1*0.5*0.7 m with a thickness of 10 mm. The reactor was designed to receive the primary effluent treated wastewater using a submerged pump model V750 with a maximum head equal to 11 m and a maximum flow of 300 l/min (international Co. for trading and supplies, Egypt). It was installed in the primary settling tank to raise the wastewater to the storage tank. This storage tank is circular with 84 cm diameter and 84 cm height. It was used to deliver the influent wastewater to the BAF after setting the required flow rate. The excess sludge was drained through the tab, which was positioned at 2 cm from the base of the filter. On the other hand, another tab is positioned at 12 cm from the filer base to take the treated wastewater samples.

Another two devices that complete the bio-filter reactor were installed in the system. The first device is the diffuser system used to inject air into the reactors. It is installed at the 15 cm height from the base of the filter to ensure maximum aeration for the floated media, which contain the biofilm responsible for degrading the organic compounds. This diffuser works to keep microorganisms in reactors in air condition. The second device is a small reservoir which is later filtered to collect the wastewater. The flow rate was controlled using control valves. An installed control valve also controlled the airflow.

2.3. properties of the material used in the designed reactor (BAF)

Bio-media was used in the aerated filter reactor with a filling ratio of 40% of the total volume of the water to be treated (Safoniuk, 2004). This bio-media was made from Polyethylene (Alandalus Company located in Obour city), which has a bulk density = 0.93 g/cm^{3,} making it float as it is less than wastewater density (1.1 g/ cm^3). This with the wide specific surface area up to 13.1495 m2/g according to BET test measured in National Research Centre located in Egypt, high porosity up to 90 %, weight is equal to 2.1531 gm., media height is 16 mm with a diameter equal to 22 mm, and its structure shape is a cylinder with external fines, as shown in fig. (1) and fig. (2). Our media has various important characteristics such as ease of installation, low sensitivity to shock loading, high surface area, and a high percentage of voids. Hence, it provides a clog-free operation, makes bio-reactors extremely compact, and has longer media life as it can be washed and reused easily. The full pilot is shown in figure (3).

2.4. Operating Procedure and Experimental Plan

The experimental plan was conducted at Zenien Wastewater Treatment Plant laboratory through nine arrangements (Table 2). Samples were usually collected from 9 a.m. to 1 p.m. and then transferred directly to the laboratory for analysis. The wastewater was pumped into the BAF model until it reached a level of 50 cm from the bottom of the filter. That happened after placing the media in the filter and calculating the designed flow rate according to the plan line, which will be displayed later.

Fig 1 Polyethylene Bio-media

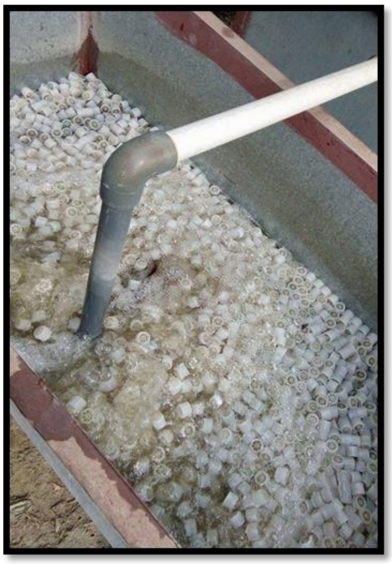

Fig 2 Floated media with the diffuser system in the designed reactor.

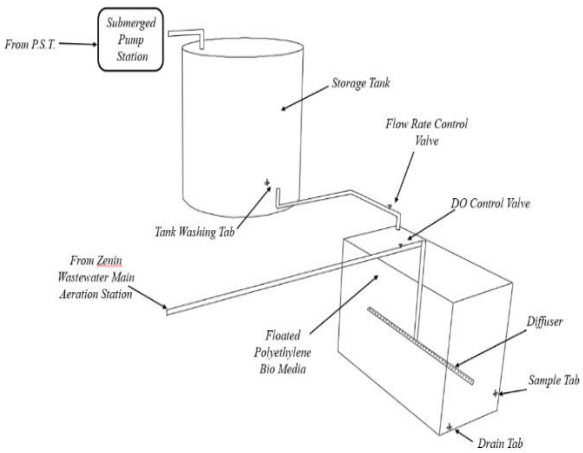

Fig 3 The Experimental Model of the Designed Reactor.

The filter is continuously operated 24 hours a day and for 15 to 30 days as a basic and important step to form the biofilm necessary to start the treatment process. Soon after placing ceramic rings in the BAF as a filter media, the wastewater flowed over the filter media until it was completely immersed. A submerged aerated filter was operated for 15 to 30 days for biofilm formation and development as a startup period (Aslam et al., 2017) to ensure active growth for the biofilm (A. Imran et al., 2016). There are two main factors considered as a key point of this study as they affect the results: factor (a) the hydraulic retention time (HRT) and factor (b) dissolved oxygen (DO). Therefore, different values of (DO) (2.53±0.2 mg/l, 3.17±0.33 mg/l, and 4.67±0.2 mg/l) were employed other than another value of the (HRT) (24 mins, 36 mins, and 72 mins), to make a study plane to determine the optimum value for (DO) with the HRT, which achieves the maximum efficiency of the process. Nine runs were carried out in this study; in each run, the HRT and the DO values were exchanged, as shown in table (2).In addition, the role of filter washing cannot be denied as a very important factor affecting the treatment process and its efficiency. Therefore, the filter was usually washed almost daily with effluent treated wastewater diluted with water for a period ranging from a quarter of an hour to a half of an hour, which helps prevent clogging of the media used and raises the efficiency of the process. Soon after setting all the parameters according to the study plane, influent and effluent treated wastewater were analysed and measured according to the standard methods of wastewater treatment examination (APHA-2005). There are three main measured contaminates in this study, which are chemical oxygen demand (COD), biological oxygen demand (BOD), and total suspended solids (TSS). Also, our analysis included PH values and the temperature in our analysis to determine all factors and characteristics that may affect the result, as shown in table (2).

3. Results and Discussion

The collected, treated effluent samples were analyzed for different wastewater treatment parameters to determine the outlined data. The characteristics mentioned in table (1) show the values ranges of the effluent primary sedimentation tank contaminates COD, BOD, and TSS.

3.1. Performance of the BAF model for the First arrangement at DO= 2.53±0.2 mg/l:

This arrangement was divided into three runs:

Run1: the flow rate was 5 m^3/d, and the equivalent HRT is 72 minutes

Run2: where the flow rate was 10 m^3/d, and equivalent HRT is 36 minutes

Run 3: where the flow rate (Q) was 15 m^3/d and HRT was 24 minutes.

3.1.1. According to COD Removal:

This figure indicates the COD removal efficiency when the DO has been kept at 2.53±0.2 mg/l. The maximum removal efficiency in this arrangement was 40.45%, which was obtained in the first run (Run 1), while the flow rate was set at 5 m3/d with corresponding HRT= 72 minutes. This result was obtained on the third day, the start of the experiment. This may be due to the higher HRT than the other runs, which gave more contact time between the biofilm and the organic matter in the wastewater, which helped raise the efficiency (Aslam et al. 2017). On the other hand, the minimum removal efficiency obtained was in run 3, with 24.45%. This occurs on the last day of this arrangement; the lack of the HRT can explain it.

Table 2: The Study Plan

Arrangement No.	**Study plan**	Property									fwhm (V)[a]
		Flow Rate (Q)	HRT	DO	COD	BOD	TSS	Temperature	PH		
		(m3/d)	(mins)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	°C	_		
Arrangement No.1	Run(1)	5	72	2.53±0.2	√	√	√	√	√		-
	Run (2)	10	36	2.53±0.2	√	√	√	√	√		0.103
	Run (3)	15	24	2.53±0.2	√	√	√	√	√		-
Arrangement No.2	Run (4)	15	24	3.17±0.33	√	√	√	√	√		0.112
	Run (5)	10	36	3.17±0.33	√	√	√	√	√		-
	Run (6)	5	72	3.17±0.33	√	√	√	√	√		0.121
Arrangement No.3	Run (7)	5	72	4.67±0.2	√	√	√	√	√		
	Run (8)	10	36	4.67±0.2	√	√	√	√	√		
	Run (9)	15	24	4.67±0.2	√	√	√	√	√		

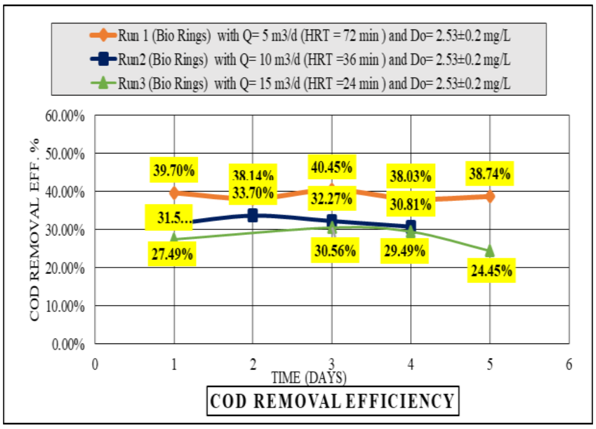

Fig 4 COD Removal Efficiency for Arrangement no.1

3.1.2. According to BOD Removal:

Fig no (5) shows the BOD removal efficiency through the arraignments no.1, when the used DO was 2.53±0.2 mg/l. The maximum removal obtained was 39.35%, obtained in run no.1 at HRT=72 minutes. While the minimum removal efficiency recorded was 25.53 %, recorded in the run.no3. It is noticeable from the figure that the efficiency started to increase slightly in the first run, until it reached the highest efficiency on the third day of the run, under the same conditions. That may return to the change in the degrees of the dissolved oxygen ratios resulting from the change in temperature for each day. It was found that (DO) values were changeable through the experiment. It increases with the increase in the temperatures.

1. Conclusions

The conclusions section should come in this section. The intermediate removal efficiency was recorded in run 1 (48.78%). This result was achieved on the second day of the first run. The percentage of removal of suspended solids in the same run under the same conditions varies; it rises at times and descends at other times. It may be due to the percentages of the contaminants present in the wastewater entering the system (Gaber et al. 2020), which will affect the treatment process. This explains the slight change in the treatment rates per day for the same run. The minimum removal efficiency of this arrangement ranged from 30.56% on the third day of the first run, in which the HRT is equal to 72 minutes, to 30.57% on the fourth day of the second run (Run 2), in which the HRT is equal to 36 minutes. Finally, it recorded 30.99% on the fourth day of the third run (Run 3). These results contradict the scientific fact that the longer HRT, the higher the treatment efficiency. The interpretation of these results may be due to two important factors. The first, as mentioned previously, is that the intensity of the wastewater has a role in the treatment efficiency. In contrast, the second reason is the change in the percentage of dissolved oxygen.

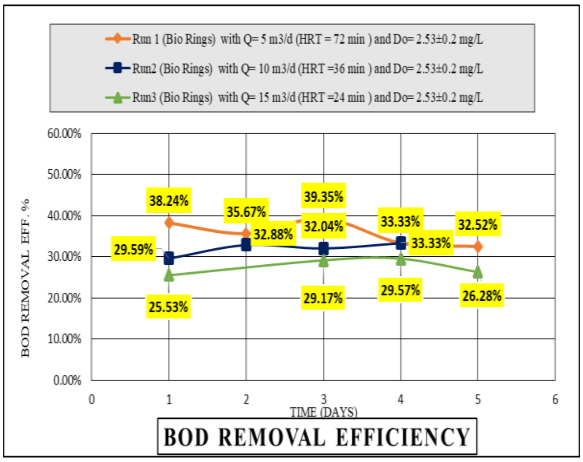

Fig 5 BOD Removal Efficiency for Arrangement no.1

3.1.3. According to TSS Removal:

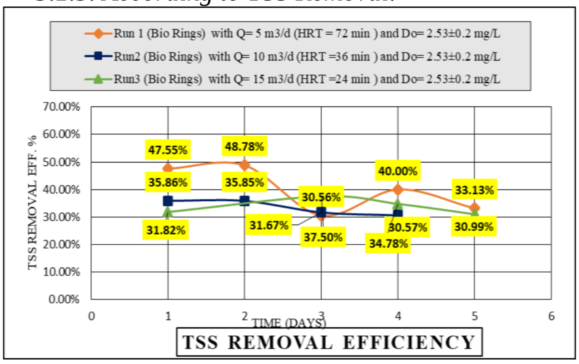

Fig 6 TSS Removal Efficiency for Arrangement no.1

3.2. Performance of the BAF model for the second arrangement at DO= 3.17±0.33 mg/l:

This arrangement was divided into three runs:

Run 4: The flow rate (Q) was 15 m^3/d, and HRT was 24 minutes.

Run 5: The flow rate was 10 m^3/d, and the equivalent HRT was 36 minutes.

Run 6: the flow rate was 5 m^3/d, and the equivalent HRT was 72 minutes.

3.2.1. According to COD Removal:

The COD removal efficiency is shown in fig (7), which ranges from 42.91%, as a minimum value, to 56.63%, as a maximum value. This maximum value was obtained in run (6), where the HRT = 72 minutes on the sixth day in the run. This can be explained by the maturity of the biofilm layer, which matures more with time and with the presence of a strong influential factor such as the remaining time factor, which has an effective role in improving the efficiency of removal. On the other hand, the minimum value was recorded in run (4), where the HRT= 24 minutes. In general, it can be said that the average removal percentage in the whole arrangement obtained under dissolved oxygen DO =3.17±0.33 mg/l was equal to 49.3% approximately.

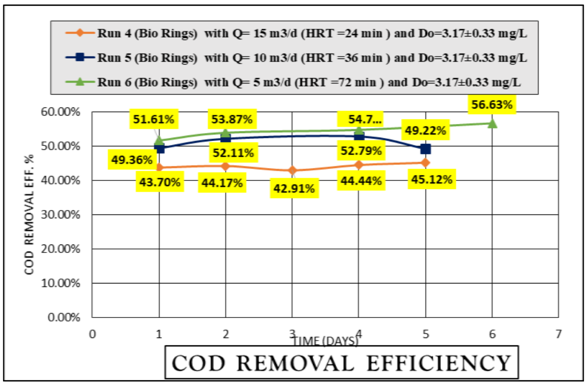

Fig 7. COD Removal Efficiency for Arrangement no.2

3.2.2. According to BOD Removal:

The figure shows that the BOD removal efficiency ranges from 41.07% to 57.69%. As shown in Figure (8), the average overall efficiency of the entire arrangement at an operating DO rate = 3.17 ± 0.33 mg / L corresponds to 49.07%. It shows that the maximum removal was recorded in Run (6) on the fourth day after the operation, at an operating flow rate of 5 m3 / d and HRT = 72 minutes. This recorded result is probably due to the high organic decomposition of organic matter due to the long HRT and the formation of biofilm layers on the daily development of the polyethylene bio-media used (Raj SA et al., 2008). It was observed that the BOD removal efficiency in (Run 4 and Run 5) was lower than in Run 6; this is because HRT is an important factor that affects BAF, as the contact time between wastewaters and biofilm is long. Note that the treatment efficiency was higher in the second arrangement than in the first one because of the dissolved oxygen ratio, as it was set at 3.17 ± 0.33 mg / L in the second arrangement and (2.53 ± 0.2mg / l) in the first one. This higher percentage of DO created suitable aerobic conditions for bacteria, which helps to support. It strengthened the biofilm layer, which is considered an important and powerful factor in the treatment process. The more mature the biofilm layer is and exposed to suitable conditions, the higher the treatment removal efficiency rates.

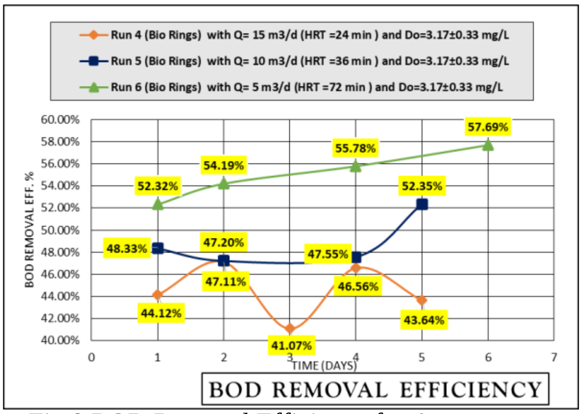

Fig 8 BOD Removal Efficiency for Arrangement no.2

3.2.3. According to TSS Removal:

The TSS maximum removal efficiency recorded was 70.63%, based on the illustrated Fig (9). This result was obtained on the second day of run no 5, while the HRT=36 minute's underflow rate Q= 10 m^3/d. But it is worth noting here that the second-highest percentage of removal was 70.51%, which was achieved in run no 6, where the HRT was equal to 72 minutes, with a very slight difference in the percentage removal had been noticed. This contradicts the scientific facts that say that; the longer HRT, the greater the percentage of removal. This may be due to the HRT factor, which is one of the most important factors influencing removal results. Other factors may affect the results to give different results, such as the intensity of the wastewater strength before treatment; the higher the concentration of pollutants present in the wastewater, the lower the treatment efficiency.

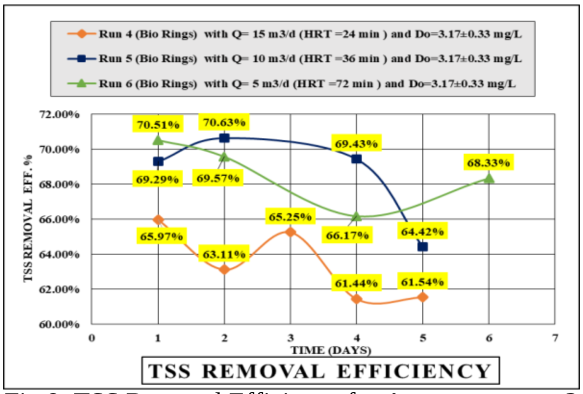

Fig 9 TSS Removal Efficiency for Arrangement no.2

3.3. Performance of the BAF model for the Third arrangement at DO= 4.67±0.2 mg/l:

This arrangement was divided into three runs:

Run 7: the flow rate was 5 m^3/d, and the equivalent HRT is 72 minutes

Run 8: where the flow rate was 10 m^3/d, and equivalent HRT is 36 minutes

Run 9: where the flow rate (Q) was 15 m^3/d and HRT was 24 minutes

3.3.1. According to COD Removal:

As the figure showed, the COD removal efficiency ranged from 57.01% to 68.06 %. The removal percentages ranged between the two mentioned values. The highest value achieved in run 7 was using HRT equal to 72 minutes, while the lowest value was achieved in run 9 using HRT= 24 minutes. On the other hand, run 8 achieved removal percentages in the middle between the two other runs. It was found that the results recorded some values that are higher than logic, where it recorded higher removal rates than its counterpart in run 7, and this contradicts the scientific facts which state that, due to the increase in HRT (72 minutes), the contact time between the biofilm and the liquid will increase, which give more time to bacteria to degrade the organic substance. This is what should happen in run 7 overrun 8. This may be because many factors affect the efficiency, such as the temperature and the contaminate percentage. The temperature directly relates to the DO ratio; when it increases, the DO increases, and the treatment efficiency increases. While the contaminates, percentage present in wastewater has an inverse relation with the treatment removal efficiency, as the higher the contaminates, the lower the efficiency.

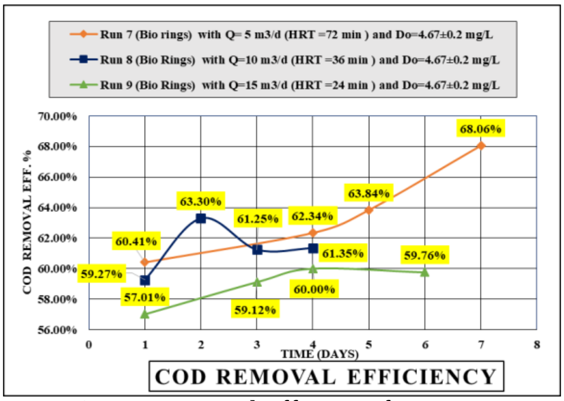

Fig 10 COD Removal Efficiency for Arrangement no.3

3.3.2. According to BOD Removal:

This figure investigates the effect of the high ratio of DO 4.67±0.2 mg/l, with different values of HRT and flow rates. The BOD maximum removal efficiency obtained was 69.18% at flow rate = 5 m^3/d and hydraulic retention time (HRT) = 72 mins on the fifth day. While the minimum removal efficiency noticed in arrangement no.3 was at run 9 with 57.58 %. Higher BOD removal efficiencies were recorded in this arrangement compared to the other arrangements. This may happen due to the higher DO ratio obtained for gaining aerobic conditions in the biofilm layer, which helps bacteria live and accomplish its mission of degrading organic matters. Also, the biofilm layer has a big role in the treatment efficiency. It developed and matured over time, which gave a suitable condition with the aid of the polyethylene bio media. This bio-media can conduct biofilm that thickens over time. In addition to that, filter washing from time to time plays a role in improving the results as it keeps the system clean and removes sludge from filters. This explains the slight difference in removal performance in the same run as it depends on which day the filter gets washed.

3.3.3. According to TSS Removal:

Figure (12) shows that the TSS maximum removal efficiency obtained was 71.07 %. This result was obtained on the second day in run (9), with flow rate = 15 m^3/d and hydraulic retention time =24 minutes as an operating parameter. In addition to that, the second maximum result obtained was 70.40%. Here it has been noticed that the difference in these two results is too small, and in fact, the first result (71.07%) was not logical according to the HRT obtained in run (9). But as mentioned before, many other reasons could affect the result.

On the other hand, the minimum removal efficiency for TSS was 61.67 at run (8) with flow rate = 10 m^3/d and HRT = 36. This is contrary to scientific constants because the minimum result should be obtained in run 9 as the HRT in this run is less than that in run 8. This may be due to the effect of the difference in organic load on the tributaries of test 8 being more efficient and higher than the effect of the time difference (HRT) in particular, especially when the difference in HRT between the two series was only 12 minutes.

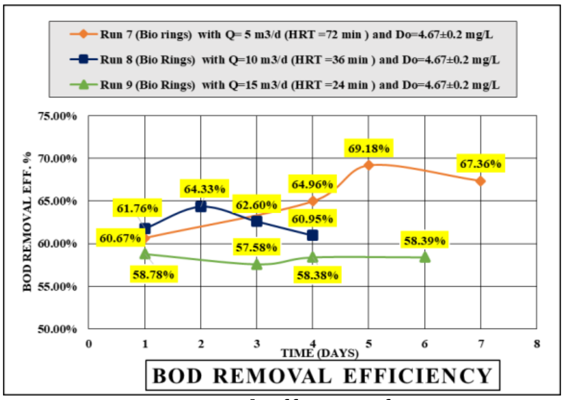

Fig 11 BOD Removal Efficiency for Arrangement no.3

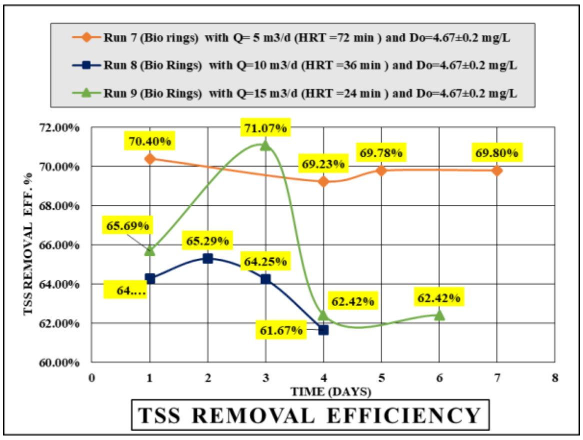

Fig 122 TSS Removal Efficiency for Arrangement no.3

4. Conclusion and Recommendations:

4.1. Conclusions:

Based on the experimental study executed in this research and according to the effluent recorded result, the following conclusions were observed:

1. Polyethylene bio-media gave good results due to the fact that it treated wastewater in the secondary treatment phase
2. Floated Polyethylene bio-media with BAF application obtained good results in COD removal; it can reach an efficiency removal rate

up to 68.06% at DO = 4.67±0.2 mg/l, flow rate = 5 m^3/d, and HRT= 72 minutes

3. Floated Polyethylene bio-media with BAF application obtained good results in BOD removal. It can reach an efficiency removal rate up to 69.18% at DO = 4.67±0.2 mg/l, flow rate = 5 m^3/d, and HRT= 72 minutes.
4. The maximum removal efficiency recorded in the BAF utilizing polyethylene bio media for TSS was 71.07 % at DO = 4.67±0.2 mg/l with flow rate = 15 m^3/d and HRT= 24 minutes. That happened because of the effect of the other factors as mentioned in the discussions.
5. The optimum dissolved oxygen utilized to obtain good removal efficiency was 4.67±0.2 mg/l.
6. The optimum flow rate utilized to obtain good removal efficiency was 5 m^3/d as it recorded better results than other flow rates.
7. The optimum HRT utilized to obtain good removal efficiency was 72 minutes in most of the runs.
8. The performance of the floated BAF is better than the conventional systems according to saving in the area since it does not need a final settling tank, odor, flies, and effluent results.

4.2. Recommendations:

The following recommendations can be further examined to achieve and enhance results and get the most out of the BAF application:

1. Polyethylene bio-based material has been proven to be a buoyant filter medium, so multiple experiments with different applications and different raw materials can obtain the optimal conditions and parameters.
2. The use of polyethylene bio-media as a filter media gave good results. However, it is considered a floating material because its density is less than the density of wastewater. This reduced the efficiency of treatment because specific surface areas exposed to contact with wastewater are less than if all media were submerged in water, so it is recommended to place the media inside an iron cage or any container prevents the media from floating and forces it to be all submerged in water, thus making all the specific surface area of the media utilized.
3. Periodic filter flushing effectively improved results, so backwashing is recommended to compare the two flushing methods.
4. This experimental study was done on secondary treatment, so it is highly recommended to use the application as tertiary treatment as advanced biological treatment; it will give better results as expected.
5. Improve the efficiency of the floated BAF by adding chemicals, which will enhance the efficiency of the system

5. ACKNOWLEDGMENTS:

The authors would like to thank the teamwork of the Zenien sewage treatment plant and the laboratory for their help and cooperation in carrying out this work.

6. **References**

[1] Aslam, Mian M.Ahson, et al.(2017). “Performance Evaluation of Trickling Filter-Based Wastewater Treatment System Utilizing Cotton Sticks as Filter Media.” Polish Journal of Environmental Studies 26(5): 1955–62.

[2] APHA, (2005). No Title. American Public Health Association/American Water Works Association/Water

[3] Canler JP and Perret, JM (1994). Biological aerated filters: assessment of the process based on 12 sewage treatment plants. Wat. Sci. Tech., 29 (10-11), 13-22.

[4] Chaudhary, Durgananda Singh, et al. (2003). “Biofilter in Water and Wastewater Treatment.” Korean Journal of Chemical Engineering 20(6): 1054–65.

[5] Gaber, Mohamed Fawzy, et al. (2020). “PERFORMANCE EVALUATION OF AERATED MODIFIED TRICKLING FILTER FOR ADVANCED TREATMENT OF SECONDARY.” 11(11): 1238–47.

[6] Hanafy, Radwa, et al. (2019). “Upgrading Conventional Activated Sludge System Using Bio-Media: A Case Study of Zenin Wastewater Treatment Plant, Egypt.” Civil and Environmental Research 11(1): 29–38.

[7] Mohamed, Hatem, et al. (2009). “PERFORMANCE ASSESSMENT OF DIFFERENT MEDIA FOR A BIOLOGICAL FILTER WITHIN LOW COST WASTEWATER TREATMENT UNIT.” FACULTY Of Engineering Ain Shams University ENGINEERING IN, Thesis.

[8] IMRAN A., ZAHID M.K., MUHAMMAD S., MUHAMMAD H.M., HAFIZ U.F., MOHSIN A., ABDUL N. (2016) Experimental study on Maize Cob trickling filter-based wastewater treatment system: design, development, and performance evaluation. Pol. J. Environ. Stud. 25 (6), 2265, 2016. DOI: 10.15244/pjoes/63657

[9] Le Tallec X., A. Vidal and D. Thornberg (1998): Upflow biological filter: Modelling and simulation of the filtration. Application of models in water management. Aquatek ‘98, Amsterdam, Sept. 1998. To be published in Wat. Sci-Tech

[10] RAJ S.A., MURTHY D.V.S.(2008). Synthetic dairy wastewater treatment using cross flow medium trickling filter. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering. 357, 2008. http://dx.doi.org/10.1080/109345299093768411 nvironment Federation, Washington DC.

[11] Rogalla F., Lamouche A., Specht W. And Kleiber B. (1994). High rate aerated biofilters for plant upgrading, Wat. Sci. Tech, 29, p 207-216.

[12] Rogalla F., Meunier G., Penillard P. And Pedersen, P. (1992). Aerated biofilters: ten years old and full of future, Advanced Techniques for wastewater Treatment, Ghent - October 8, 1992.

[13] Safoniuk, M. (2004). Wastewater Engineering: Treatment and Reuse (Book). In Chemical engineering (Issue 7, pp. 10–11).

[14] Verma, M. et al. (2006.) "Aerobic Biofiltration Processes - Advances in Wastewater Treatment." Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management 10(4): 264–76.