International Journal of Engineering Research Updates

Journal homepage: https://orionjournals.com/ijeru/

ISSN: 2783-0187 (Online)

(RESEARCH ARTICLE)

Best application of low-cost enhancement treatment for agricultural drain wastewater

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International Journal of Engineering Research Updates, 2022, 03(02), 032–039

Publication history: Received on 11 September 2022; revised on 18 October 2022; accepted on 20 October 2022

Article DOI: https://doi.org/10.53430/ijeru.2022.3.2.0056

Abstract

This study aimed to apply a new technique of treatment inside stream using polyethylene sheets strips as a very cheap method for enhancing the quality of agriculture wastewater to meet the irrigation reuse needs. The study was carried out on a pilot plant that was constructed by EU research project named "drains water quality enhancement" inside Faqous Wastewater Treatment plant nearby Bahr El Bakar agricultural drain in El Sharqiyah Governorate, Egypt.

Polyethylene strips were used as in stream media treatment where the operation program was made to determine the best positioning for applied serial lines to achieve the target water quality for reuse purposes, The study used four intervals first was 30 cm in channel 2 ,the second was 70cm in channel 3, the third was 100cm in channel 4 ,and the fourth was 150 cm in channel 5 to get the best enhancing efficiency and the removal ratios for Biochemical Oxygen demand (BOD), Chemical Oxygen demand(COD) & Heavy metals (HM). Each channel contains six serial curtain lines to determine the study parameters.

The results showed that the first interval 30 cm achieved removal ratios 44.6 %for BOD, 27 %for COD, and 41.7% for HM, while interval 70 cm produced removal ratios 46 %for BOD, 27.7 %for COD, and 43.3% for HM, for the third interval 100 cm the study get the removal ratios 51.6 %for BOD, 30 %for COD, and 46 % for HM, and finally for interval 150 cm the resulted removal ratio were 52.6 %for BOD, 30.5 %for COD, and 48 % for HM.

The study proved that the curtain lines interval should be equal to or more than double the water depth in the stream to achieve higher removal efficiency in all measured parameters.

Keywords: Agricultural Wastewater treatment; New treatment techniques; In stream treatment procedure; Artificial bio reactor; Polyethylene strips

1 Introduction

Water means life. In the last decades more countries have water scarcity problems. Every day human beings perform a remarkable variety of activities involve the use of water, often in very large quantities. Water is needed in all industrial activities, in agriculture and for domestic purpose.

With the population growth, the civilization progresses the enlarging in industrial and agricultural aspects the water needs had been increased.

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Water scarcity for Egypt is highly impressed due to its limited water resources that raised the need for wastewater treatment and reuse. The agricultural wastewater was the bigger amount and the lower polluted one that made the treating of it, the most easily and cheap wastewater to be reused specially for irrigation needs.

The in-stream treatment methods are the easiest and low cost treatment procedures could be applied for agricultural wastewater treatment. This study applied one of the in-stream treatment methods to determine the best application methodology for it as mentioned here after.

2 Literature Review

The treatment method selection depends on several factors as type of pollution, characteristics of effluent, average and peak flows, the required degree of treatment, the amount of treated wastewater required, the treatment target, energy consumption, operational, maintenance cost, the geography of the land and the served area [1].

Khalifa, A.K, et al, discovered that the application of plastic media in Wastewater channel increased removal of TSS and BOD efficiency. The tube media achieves higher organics removal because of higher specific surface area, and void ratio. The advantage of use plastic media is its capability to allow substantial biological slime growth because of high surface area, improvement of oxygen transfer because of high void spaces and its low weight allowed deeper filter [2].

A study made in 2020in a pilot channel on drain wastewater source used plastic media with square shape with thickness of 50,80, 110 &140 cm applied in parallel channels with fixed channel width and water depth concluded that the removal ratio of BOD and COD increased from 88.4 % to 91% with media thickness increase [3].

El Nadi, M. H., and Abdalla, M.A.F. proved the success of use the agricultural waste as cheap adsorbent in treatment of agricultural drains wastewater polluted from industrial wastewater open the door for the existing drains to be easily treated with minimum cost and no effect on their profiles and saving the environment from heavy metals harm pollution [4].

El Haefny, Z.A.M. et.al, proved the success of the use of agricultural waste (rice husk) as biodegradable media for in stream agriculture wastewater treatment. Also, the study showed that the agricultural waste was the best for this in stream treatment technique compared with plastic media boxes media and naturally rotating paddles that applied in their study, technically and financially [5, 6].

Abdel Momen, M. M., et. al, used the polyethylene strips for preliminary treatment or polishing for the wastewater. This study proved that the values of BOD, COD, TSS and VSS removal ratios were varied according to the surface roughness for the used polyethylene sheets. The rough surface media had granted the best efficiency for the measured parameters removal compared with the two other applied polyethylene sheets with smooth surface [7].

Abdel Momen, M. M., used the polyethylene strips in the effluent channel of wastewater treatment plant and proved that the system is successfully improved the effluent quality by 10- 15 % and committed to be used in Egypt specially, the polyethylene sheets strips are very economical solution [8].

Soliman, R.A., et. al, showed the success of the polyethylene strips in removal of pollutants inside stream as a very cheap method for improving the efficiency of agriculture drains wastewater to meet the irrigation reuse needs [9].

This study aimed to determine the best positioning for applied serial lines of polyethylene sheet strips curtains to achieve the target water quality for reuse purposes.

3 Material and methods

The used material (polyethylene strips) for this study was previously used for enhancement the wastewater characteristics of sewage properties at effluent of the wastewater treatment plant in Egypt. The study was carried out on a pilot plant that was constructed by EU research project named “drains water quality enhancement”. The pilot was built inside Faqous Wastewater Treatment plant held nearby Bahr El Bakar agricultural drain in El Sharqiyah Governorate, Egypt. Polyethylene strips were used as instream media treatment where the operation program was made to determine the best positioning for applied serial lines to achieve the target water quality for reuse purposes.

The study used four intervals first was 30 cm in channel 2, the second was 70cm in channel 3, the third was 100cm in channel 4, and the fourth was 150 cm in channel 5 to get the best enhancing efficiency and the removal ratios for BOD, COD, HM were measured. Each channel contains six curtain lines to determine the possibility of reapplication and the maximum possible removal efficiency.

Different samples were taken daily to measure BOD, COD, HM, according to the Standard methods for water and wastewater examinations edition 22nd [10]. The samples are taken before putting the polyethylene strips, at the mid between two lines, and after 1meter from the last strip line.

Figures 1,2,3 shows the pilot and the polyethylene sheets strips used for treatment inside pilot channels.

Figure 1 The pilot photo

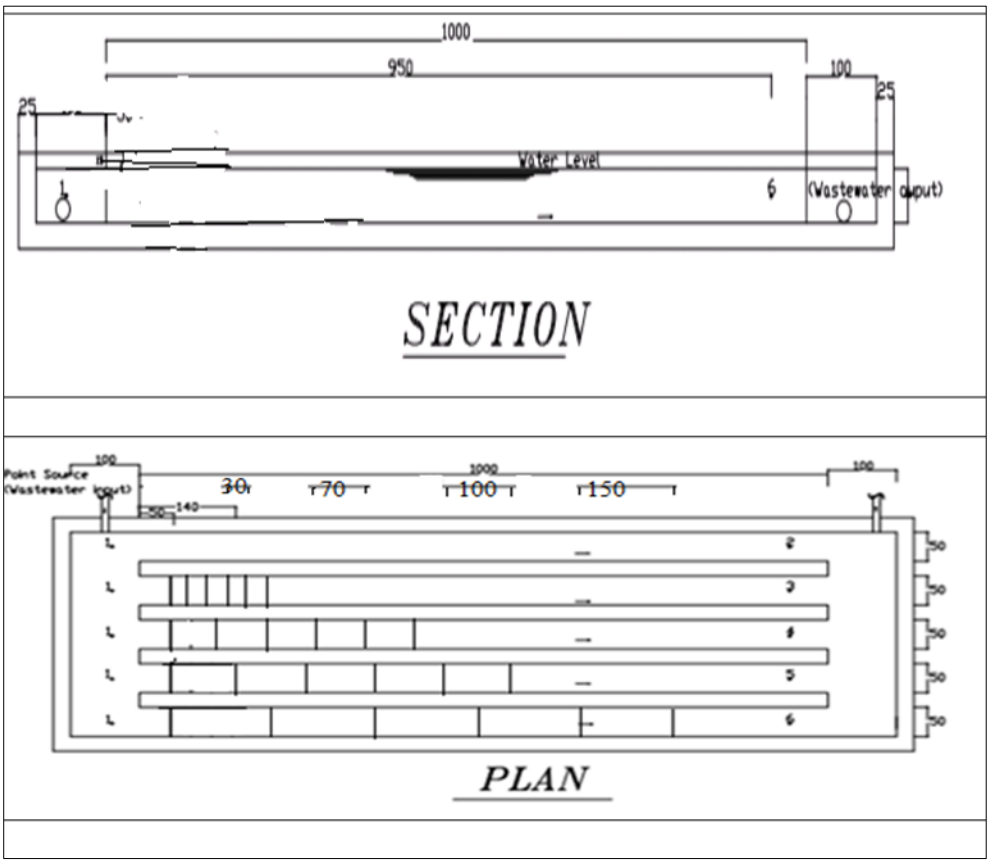

Figure 2 The pilot

Figure 3 Polyethylene sheets strips

4 Results and discussion

The results of the work done due to the operation of the pilot plant that used the polyethylene strips as bio media reactor in stream during the study period are discussed briefly, considering the changes found in different parameters affecting the removal process of the media.

4.1 BOD

Table (1) and figure (4) present the strips lines effect on BOD removal along the channel.

Table 1 Average BOD in the five channels

Channel	Distances (m)						
	0	0.5	1.0				
1	486	486	486				
	0	0.65	0.95	1.25	1.55	1.85	3.00
2	486	423	380	346	312	295	270
	0	0.85	1.60	2.30	3.00	3.70	5.05
3	486	417	370	335	307	282	262
	0	1.00	2.00	3.00	4.00	5.00	6.50
4	486	410	365	325	290	260	235
	0	1.25	2.75	4.25	5.75	7.25	9.00
5	486	408	361	320	285	255	230

From the previous results, it was observed that the BOD in the first channel without any polyethylene strips was 486 ppm, in the second channel after putting six lines of polyethylene strips with 30 cm interval the removal ratio was 44.4%,in the third channel after putting six lines of polyethylene strips with 70 cm interval the removal ratio was 46%, in the fourth channel the removal ratio was increased by 15-11% after each line of polyethylene strips until reached to 51.6% after the sixth line of strips with 1m interval, in the fifth channel the removal ratio was increased by 16-12% after each line of polyethylene strips until reached to 52.6% after the sixth line of strips with 1.50 m interval.

It was concluded that polyethylene strips had a good efficiency in BOD removal, and when the interval distance between Polyethylene lines strips increased, the removal efficiency increased, the removal efficiency in the fourth and fifth channels was higher than the removal efficiency in the second and third channels because the velocity of the flow decreased in the distance between strips lines and returned to its steady state flow when the interval distance increased that gave the chance for action to take place on the next line almost the same as the first line. This could be appeared at the interval length is double or more than the water depth of the stream.

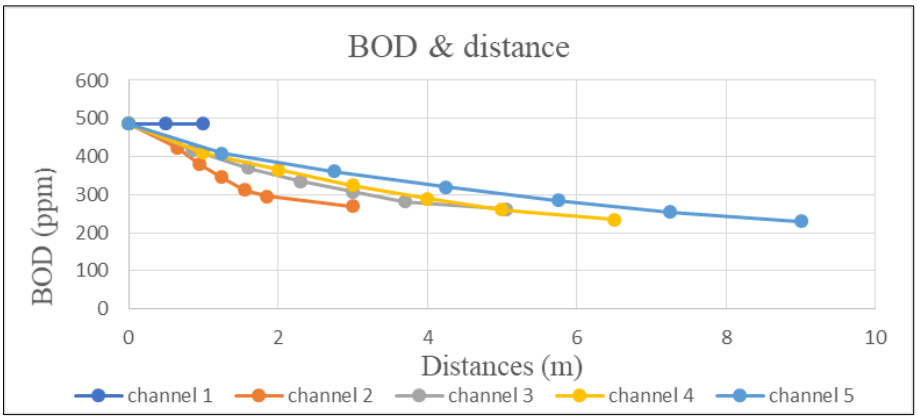

Figure 4 Effect of strips lines on BOD removal along the channel length

4.2 COD

Table (2) and figure (5) show strips lines effect on COD removal along the channel.

Table 2 Average Results of COD in the different channels

Channel	**Distances (m)**						
	0	0.5	1.0				
1	1160	1160	1160				
	0	0.65	0.95	1.25	1.55	1.85	3.00
2	1160	1020	956	908	864	861	846
	0	0.85	1.60	2.30	3.00	3.70	5.05
3	1160	1014	946	899	859	848	838
	0	1.00	2.00	3.00	4.00	5.00	6.50
4	1160	989	930	880	835	831	811
	0	1.25	2.75	4.25	5.75	7.25	9.00
5	1160	987	926	875	830	826	806

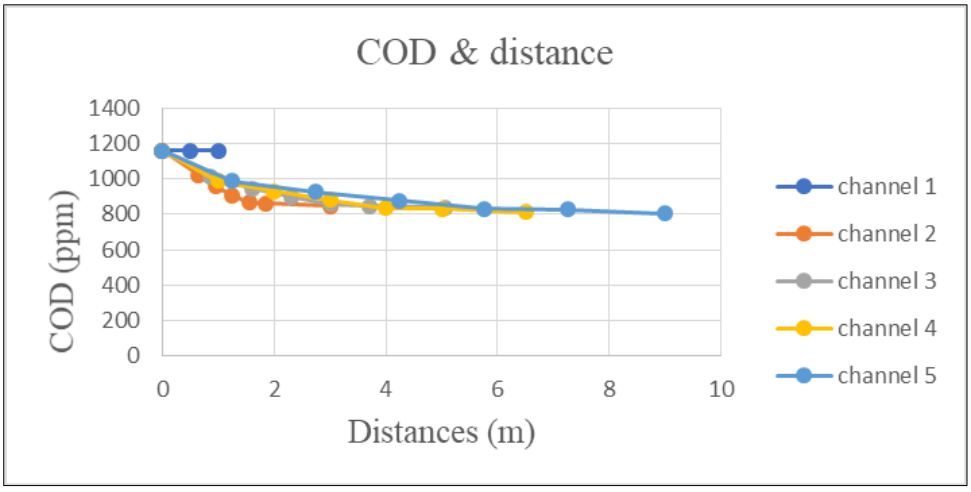

Figure 5 Effect of strips lines on COD removal along the channel length

From the previous results, it was observed that the COD in the first channel without any polyethylene strips was 1160 ppm, in the second channel after putting six lines of polyethylene strips with 30 cm interval the removal ratio was 27%, in the third channel after putting six lines of polyethylene strips with 70 cm interval the removal ratio was 27.7%, in the fourth channel the removal ratio was30% after the sixth line of strips with 1m interval, in the fifth channel the removal ratio was 30.5% after the sixth line of strips with 1.50 m interval.

It was concluded that polyethylene strips had a good efficiency in COD removal, and when the interval distance between Polyethylene lines strips increased, the removal efficiency increased, the removal efficiency in the fifth channel was higher than the removal efficiency in other channels because the velocity of the flow decreased in the distance between strips lines and returned to its steady state flow when the interval distance increased that gave the chance for action to take place on the next line almost the same as the first line. This could be appeared at the interval length is double or more than the water depth of the stream.

4.3 HM

Table (4) and figure (6) illustrate strips lines on HM removal along the channel length.

Table 4 Average Results of HM in the different channels

Channel	Distances (m)						
	0	0.5	1.0				
1	1.27	1.27	1.27				
	0	0.65	0.95	1.25	1.55	1.85	3.00
2	1.27	1.15	1.06	1.04	1.00	0.99	0.74
	0	0.85	1.60	2.30	3.00	3.70	5.05
3	1.27	1.14	1.05	1.02	1.00	0.97	0.72
	0	1.00	2.00	3.00	4.00	5.00	6.50
4	1.27	1.14	1.04	1.02	0.99	0.96	0.71
	0	1.25	2.75	4.25	5.75	7.25	9.00
5	1.25	1.13	1.04	0.97	0.94	0.91	0.66

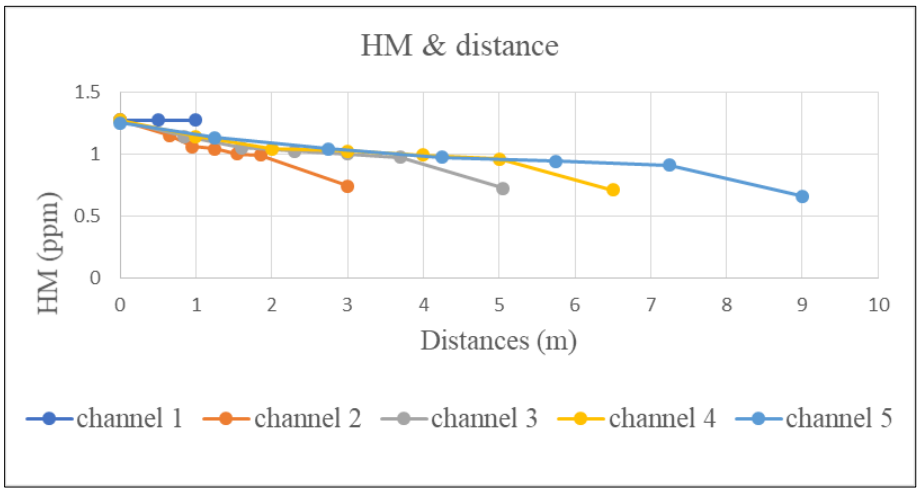

Figure 6 Effect of strips lines on HM removal along the channel length

From the previous results, it was observed that the HM in the first channel without any polyethylene strips was1.27 ppm, in the second channel after putting six lines of polyethylene strips with 30 cm interval the removal ratio was 41.7%,in the third channel after putting six lines of polyethylene strips with 70 cm interval the removal ratio was 43.3%,

in the fourth channel the removal ratio was 44% after the sixth line of strips with 1m interval, in the fifth channel the removal ratio was 48% after the sixth line of strips with 1.50 m interval.

It was concluded that polyethylene strips had a good efficiency in HM removal, and when the interval distance between Polyethylene lines strips increased, the removal efficiency increased, the removal efficiency in the fifth channel was higher than the removal efficiency in other channels because the velocity of the flow decreased in the distance between strips lines and returned to its steady state flow when the interval distance increased that gave the chance for action to take place on the next line almost the same as the first line. This could be appeared at the interval length is double or more the depth of water in the stream.

5 Conclusion

Polyethylene strips had a good efficiency in agricultural wastewater instream treatment which can remove BOD, COD and HM with removal ratio 52.6, 30.5 and 48% respectively after six lines of Polyethylene strips in the fifth channel with 1.50 m interval.

The removal ratio increased when the interval distance between strips lines increased to 1.50m which was 2.5 times of the depth, it was very convenient to the channel dimensions that gave channel the chance to return to its steady state flow and decrease its velocity.

If the distance between strips lines was equal the depth as it was in the second channel, the removal ratio of BOD, COD and HM was low (44.4, 27, 41.7 %) respectively because it did not have the chance to return to its steady state flow because the distance was small, and the velocity increased.

It was concluded that the interval distance 1.50 m of Polyethylene strips was the optimum distance of BOD, COD and HM removal because the velocity of the flow decreased in the distance between strips lines and returned to its steady state flow when the interval distance increased that gave the chance for action to take place on the next line almost the same as the first line.

The study proved that the curtain lines interval should be equal to or more than double the water depth in the stream to achieve higher removal efficiency in all measured parameters.

Compliance with ethical standards

Acknowledgment

Gratefully thanks to the staff of Faqous WWTP for their help and cooperation to complete this research specially the laboratory staff and the plant manager.

Disclosure of conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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