Journal of Al-Azhar University Engineering Sector

Vol. 17, No. 64, July 2022, 858 - 866

IN STREAM POLLUTION CONTROL FOR AGRICULTURAL DRAINS WATER USING PLASTIC MEDIA

El Hefny, Z. A. M.M.[1]*, Samy, GH. M.[1], El Nadi, M. H.[2], Nasr, N. A. H.[2] & Hagras. M. A. S.[1]

[1] Irrigation & Hydraulic Eng. Dept., Civil Eng., Faculty of Eng., ASU, Cairo, Egypt.

[2] Public Works Eng. Dept., Civil Eng., Faculty of Eng., ASU, Cairo, Egypt.

*Corresponding author's E-mail: zainabweg.2018@gmail.com

Received: 26 March 2022 Accepted: 13 April 2022

ABSTRACT

Water bodies are facing many problems in Egypt due to the direct disposal of both raw domestic and industrial wastewater depending on the stream self purification. With the increase of pollution amounts the stream self purification takes long distance and period to recover the stream that affected by the repeating disposals which made the stream polluted along its length.

This study covered the use of plastic media inside stream as a low cost bioreactor packing media that increased dissolved oxygen by 48.88% decrease COD and BOD by 75.8% % & 81.4% % respectively. It is also decrease total dissolved solids and turbidity by 51.5% & 87.2% respectively which helped to minimize the distance needed for self - purification process in water bodies through a less distance than required.

التحكم في تلوث التيار لمياه المصارف الزراعية باستخدام الوسائط البلاستيكية

زينب ع.م.م. الحفني[١] ، غادة م. سامي[١] ، محمد الحسيني النادي[٢] ، ناني ع.ح. نصر[٢] ود. مني ع.س. هجرس[١]

[١] قسم هندسة الري والهيدروليكا – قسم الهندسة المدنية – كلية الهندسة - جامعة عين شمس – القاهرة – جمهورية مصر العربية.

[٢] قسم هندسة الأشغال العامة – قسم الهندسة المدنية – كلية الهندسة - جامعة عين شمس – القاهرة – جمهورية مصر العربية.

* البريد الإلكتروني للمؤلف الرئيسي: zainabweg.2018@gmail.com

الملخص

تواجه المسطحات المائية العديد من المشاكل في مصر بسبب التخلص المباشر من مياه الصرف الصحي المنزلية والصناعية الخام اعتمادًا على التنقية الذاتية للمجري. ومع زيادة كميات التلوث ، تستغرق التنقية الذاتية للمجري مسافة طويلة وفترة زمنية لاستعادة المجري لصلاحية نوعية المياه به للاستخدام الذي تأثر بالتخلص المتكرر مما أدى إلى تلوث المجري بكامل طوله.

غطت هذه الدراسة استخدام الوسط البلاستيكي داخل المجري كمفاعل حيوي منخفض التكلفة أدى إلى زيادة الأكسجين المذاب بنسبة ٤٨,٨٨٪ وتقليل COD و BOD بنسبة ٧٥,٨٪ و ٨١,٤٪ على التوالي. كما أنه يقلل من إجمالي المواد الصلبة الذائبة والعكارة بنسبة ٥١,٥٪ و ٨٧,٢٪ على التوالي مما ساعد على تقليل المسافة اللازمة لعملية التنقية الذاتية في المسطحات المائية إلي مسافة اقل من خمسين % منها في حالة عدم استخدامه.

INTRODUCTION

There are various sources for drain water contamination. The sources are either direct or indirect sources such as industrial effluent, sewage or wastewater effluent ,direct run off, oil spillage, dumping garbage also it could be the change in water temperature, chemical composition, also air and soil pollution [1].

The ability of the stream to restore itself from pollutants called self-purification which is a natural process that involves chemical, physical and biological actions working at the same time together. The polluted water affects negatively the self-purification of the water stream itself. It leaves contaminant sediments that lead to the contamination of the whole stream bed and the emergent of odor and cause the algal bloom on the surface of the stream. And finally, it will affect the color and the shape of the stream [2].

The reuse of agricultural drainage becomes essential to be a non-conventional water resource. This is by improving the quality of the heavily polluted agriculture drainage water to be suitable for irrigation practices. The enhancement process used bio-reactors to achieve sustainability and cost-effective treatment technique and also to be safe for the environment and the human health [1].

The idea of the use of plastic media treatment biomedia in stream was raised to achieve good treatment with huge water quantities and very low construction and operation costs that could achieve the fasting of self purification and minimize distance required to remove the pollution and encourage the reuse purposes from this water. Unfortunately, the reuse of the polluted drainage water has the potential of causing serious problems of soil degradation, reduction in crop productivity and quality, and human health hazards [1].

The treatment of agricultural drainage water presents a challenge due to the complex chemical characteristics of most drainage waters [2]. There are various types of treatment process and techniques for agricultural drainage. The treatment is divided to procedures and technique.

In this study the inside stream treatment procedure is applied. The treatment improves the natural self-purification action to treat the whole volume of the drain flow. In the opposite of previous methods this solution does not need any land for the treatment for it is made inside the stream body to encourage the natural self-purification action or enhance the water quality to ease the self-purification to take very short distance after this treatment. This also, minimizes the treatment cost to its lower value [4]

Several methods of treatment could be applied inside stream all of them depends on the biodegradation concept for removal of pollutants. One of the lowest cost of these methods is the application of the plastic media inside the stream.

LITREATURE REVIEW

The application of bio-reactors is a unique treatment method to enhance the water quality. It's known worldwide as natural technologies. The bio-treatment is an innovative and sustainable method using cheep processes to improve water quality. Applying the plastic media as bio reactor is the most innovative method of these procedures [5].

A research made to remove heavy metals from wastewater, proved that the plastic media have the role of adsorbents for the Elimination of heavy metals. The heavy metal ions such as copper, cadmium, mercury, zinc, chromium and lead ions do not degrade into harmless elements. Studies on the treatment of effluent using the plastic media showed high efficiency in heavy metals adsorption from a stream. In addition to that the usage of this treatment technique has a low cost and is relatively connected to the low cost of plastic media [4].

Several studies applied the plastic media direct as an adsorbent in the treatment of industrial wastewater of low amounts before its disposal in the environment to minimize the treatment cost and get very cheap solution for environment protection without increasing the manufacturing cost that reflect on the industry success [5]. These applications were for different purposes as its application as biodegradable material for encourages the biological action to take place inside the stream or for heavy metals removal or generally enhancing the water quality [6].

Using plastic media in agricultural drainage for its treatment is one of the suitable techniques. The plastic media act as a natural adsorption media for heavy metals and other elements. It's considered a management procedure for controlling pollution from surface runoff that is contaminated by chemicals in fertilizer, pesticides, animal slurry, crop residues or irrigation water. Water flows from one end to another over the surface, and the effluent comes out from the other end suitable for irrigation needs [6].

El Nadi, et al., [5] used Biomass plastic media from crushed solid wastes as filter bio-media for wastewater treatment. It was tested for the removal efficiencies of the sewage parameters TSS, COD, BOD, N and P variable media thickness and constant flow. The study results showed that the removal efficiencies were positively proportional with media length. The study proved that tested cheap plastic media was effective media for wastewater treatment.

Abdel Rahman, W.H.,[7] applied of aqua life unit that consisted of submersible pump took water from the drain after sewage disposal point by 2m and deliver it inside a submerged rectangular box filled with plastic balls as a biodegradable media to treat drains water after sewage disposal in el Kafr El Ghab village in Damietta Governorate. The results was the quality improve for all pollutant measured parameters by 80-90 % that cancel the disposal of sewage effect on the drain water approximately.

Khalifa, et al., [8] discovered that the application of plastic media inside stream increased removal efficiency of TSS and BOD by range varied between 65 and 86% due to the inflow load, media length and void ratio of applied media.

Plastic media contribute in enhancement of water quality. The presence of the plastic wastes such as plastic balls, crushed plastic wastes, plastic boxes with different shapes, plastic corrugated sheets and plastic developed small random shapes in a polluted water body's shows enhancement in water quality regarding heavy metals to be ready for reuse [2].

MATERIAL AND METHODS

The study was carried out on a pilot plant that was built inside Faqous Wastewater Treatment plant held nearby Baher El Baqar agricultural drain in El Sharkiyah Governorate, Egypt. The pilot consisted from five parallel channels simulates drain streams each with dimensions 40 cm width, 70 cm wall depth and 10 m length. They started and ended with two crossing channels as feeding and disposing channels each with the same depth and width 1.0

m. this pilot fed by agricultural drain water using a submersible pump erected inside the drain above the bed by 50 cm delivered through 4 inch force main pipe to the feeding crossing channel that distribute water on the five longitudinal main channels.

The channels effluent collected in the disposal crossing channel that drained to the agricultural drain by 6 inch. The applied solutions are put in four from the five parallel channels after its starting edge by 0.5 m with variable lengths from 0.5 to 1.40 m.

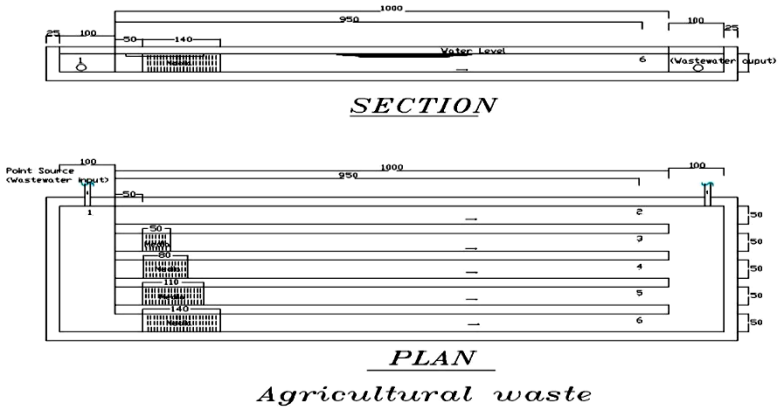

Figure (1) Plan and Section of the Applied Pilot

Table (1) Plastic media application procedure

Channel No.	Treatment Method	Applied Plastic Media
CH1	Without treatment	
CH2	Plastic media length50 cm	
CH3	Plastic media length80 cm	
CH4	Plastic media length110 cm	
CH5	Plastic media length140 cm	

Erecting Plastic bio-media as treatment unit after water channel inlet by 0.5 m with different lengths as showed in table (1)

Four different sampling locations were applied by taken three samples for each during the day for all channels. The first group at 9.00 am in the morning, the second at 1.00 pm after noon and the third at 6.00 pm in the evening to simulate the variation during the day and the average reading in each location simulates the day measuring for this location. Before starting the treatment run one preparation week was made to prepare the pilot for the treatment. The samples locations were, at inlet, inside channel after Plastic media media by1 meter, at channel Middle after 5m from channel beginning and at channel outlet after 10 m from channel beginning.

All measurements were made according to the American standard methods for water &wastewater Examinations [9] in the Faquos WWTP laboratory. The measured parameters are taken for all samples, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and heavy metals (HM),

RESULTS AND DISSCUTION

The first run used plastic media with size of channel width and water depth and variable length ranged between 50, 80, 110 &140cm one for each channel from 2 to 5 and left first

channel without any media as buffer. The run covers period of six weeks from first of feb2020 to fifth of March 2021.

Figure (2) and table (2) illustrate DO average variations in plastic media experiment for all channels from distance zero to distance ten meter.

Table (2) Average DO Variations

Distance (m)	Raw water	Effluent water				
		Ch1	Ch2	Ch3	Ch4	Ch5
0	0.9	0.9	0.9	0.9	0.9	0.9
1 m after media	0.9	0.9	1.3	1.4	1.5	1.6
5	0.9	0.9	1.2	1.3	1.4	1.5
10	0.9	1.0	1.4	1.5	1.5	1.5

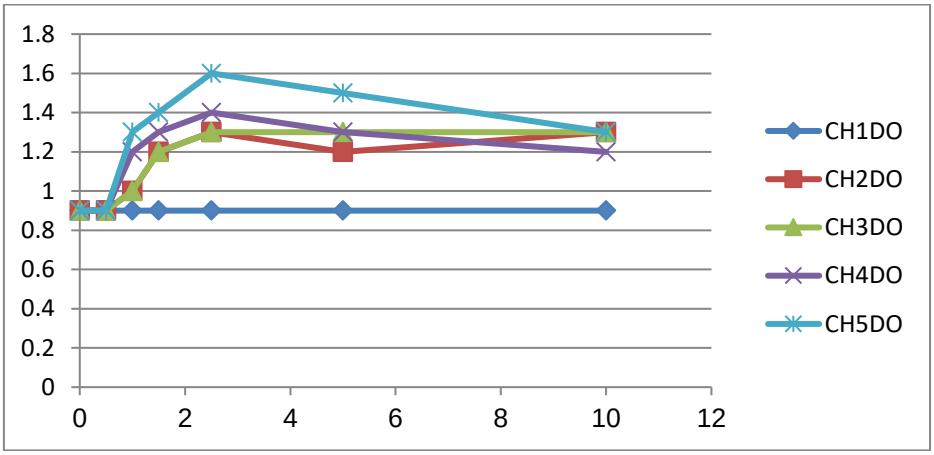

Figure (2) Average Effluent DO

In general **DO** increased due to the passage in the plastic media from 0.9 mg/l to1.3-1.6mg/l according to the plastic media length at distance one meter from the media with increase ratio between 44.42% and 77.7% for the water velocity increase during its passage through the media voids that helps air dissolving in water

After 5 meters from channel start DO increased to 1.2mg/l in ch2, 1.3 mg/l in ch3, 1.4mg/l in ch4 and 1.5 mg/l in ch5 with decrease ratio 8.8%, 7.14%, 6.6% and 6.25%. This was due to the biological action consumed DO with lower dissolving for additional air needed for this action specially the decrease of organics lead to bacterial death that produce new organics consumed DO with bacterial action, leading to decrease DO in water.

After 10 meters DO increased to 1.4 mg/l up to1.5mg/l with increased ratio to 16.6, 15.3% and7.14%.The ratio was increase again due to the self-purification inside the stream.

It is clear from the results that the greater length of plastic media has a direct effect in increasing DO in water after one meter from media used for treatment that minimize the required length for the stream water to be treated and suitable for reuse**.**

Figure (3) and table (3) show BOD average Variations in plastic Media Experiment for all channels from distance zero to distance ten meter.

Table (3) Average BOD Variations

Distance (m)	Raw water	Effluent water BOD				
		Ch1	Ch2	Ch3	Ch4	Ch5
0	485	485	485	485	485	485
1after media	485	485	340	220	150	75

5	485	485	**400**	**280**	**190**	**95**
10	485	485	**320**	**250**	**180**	**90**

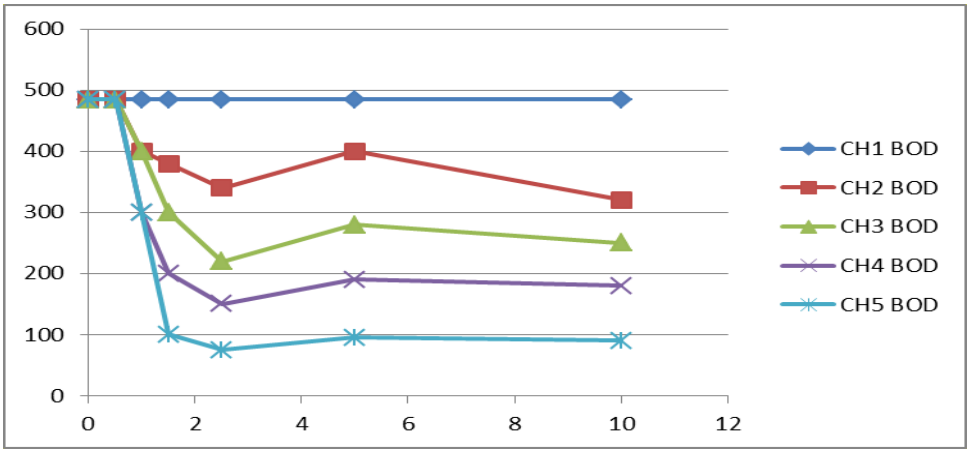

Figure (3) BOD Daily Variations

It was found that, BOD decreased with plastic media in general from 485mg/l to 340-75 mg/l according to the length of the media and the distance after it with removal ratio from 29.8% to84.5%. For the water velocity increase during its passage through the media voids that helps air dissolving in water and encourage the attached growth bio action to take place inside the media

After 5 meters from channel start BOD increased to 400mg/l in ch2, 280mg/l in ch3, 190mg/l in ch4 and 95mg/l in ch5 with increase ratio were 17.6%, 27.2%, 26.6% and 26.6 % respectively. This was due to the biological action consumed BOD with the decrease of organics lead to bacterial death that produce new organics consumed BOD with bacterial action, leading to increase BOD in water.

After 10 m the ration was increase again due to the self-purification. It is clear from the results that the greater length of plastic media has a direct effect in increasing BOD.BOD was increased to 320mg/l in ch2 ,250mg/l in ch3,180 mg/l in ch4 and 90 mg/l in ch 5 with removal ratio were 20%,10.7%,5.2% and 5.2 %.

Figure (4) and table (4) present COD average variations in plastic media experiment for all channels from distance zero to distance ten meter

Table (4) Average COD Variations

Distance (m)	Raw water	Effluent water COD				
		Ch1	Ch2	Ch3	Ch4	Ch5
0	1200	1200	1200	1200	1200	1200
1 m after media	1200	1200	**950**	**750**	**680**	**300**
5	1200	1200	**970**	**770**	**700**	**310**
10	1200	1200	**900**	**700**	**600**	**290**

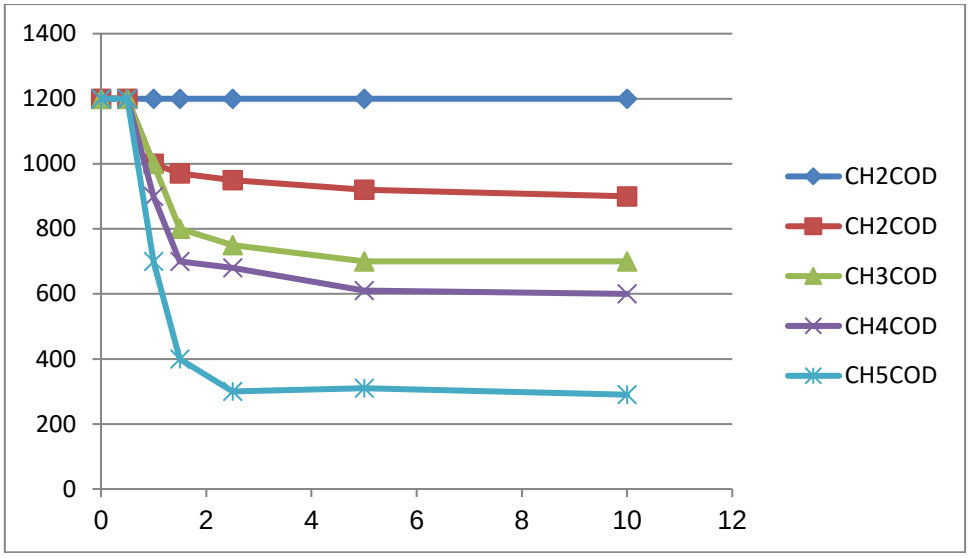

Figure (4) COD Daily Variations

From the results obtained, it was found that **COD** decrease with plastic media in general from1200mg/l to 950- 300 mg/l according to plastic media length with distance one meter from the media with removal ratio between 20.8%, 37.5% to75%. For the water velocity increase during its passage through the media voids that helps air dissolving in water and encourage the attached growth bio action to take place inside the media

After 5 meters from channel start COD increased to to970mg/lit ch2, 770mg/l in ch3, 700mg/l in ch4 and 310mg/l in ch5 with increase ratio were 2.10%, 2.6%, 2.9% and 3.3% respectively. This was due to the biological action consumed COD with the decrease of organics lead to bacterial death that produce new organics consumed BOD with bacterial action, leading to increase COD in water.

After 10 meters COD decreased to 900 mg /l in ch2, 700mg/l in ch3, 600mg/l in ch4 and 290 mg/l in ch5.with average removal value 7.2% and removal ratio between 9% and 14.2% and 6.6% due to the self-purification action in the stream

Figure (5) and table (5) illustrate TSS average Variations in Agricultural Waste Media Experiment for all channels from distance zero to distance ten meter.

Table (5) Average TSS Variations

Distance (m)	Raw water	Effluent water TSS				
		Ch1	Ch2	Ch3	Ch4	Ch5
0	550	550	550	550	550	550
1 m after media	550	550	380	300	240	110
5	550	550	360	280	210	80
10	550	550	350	240	200	70

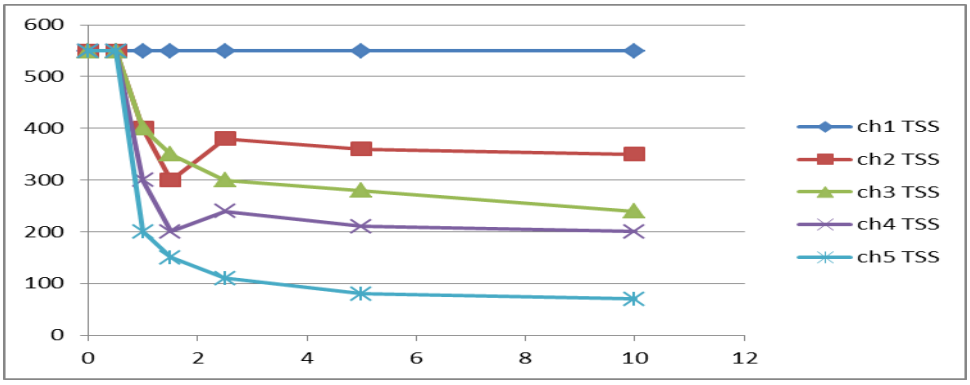

Figure (5) Average TSS Variations

In this study, it was found that TSS decreased in general from 550 mg/l to 380 mg/l to 110 mg/l according to the length of media after one meter from it, with average removal ratio 30.9% to 80%. This may be because the media filtration and adsorption effect with some elements.

After 5 meters TSS decreased to 360mg/l in ch2, 280 mg/l in ch3, 210mg/l in ch4 and 80 mg/l in ch5 with removal ratio were 5.2%,6.6%,12.5% and 27.2% respectively. It cleared that after 5m the TSS was decreased because of the sudden drop in flow velocity after the media that helps the TSS settling.

After 10 meters TSS decreased to 350 mg /l in ch2, 204 mg/l in ch3, 200mg/ l in ch4 and 70 mg/l in ch5.with removal ratio between 2.7%, 14.2%, 4.7%, % and 12.5%. The ratio was increase again due to the self-purification.

It is clear from the results that the greater length of agriculture waste has a direct effect in increasing TSS in water

Table (6) show HM average Variations in Agricultural Waste Media Experiment for all channels from distance zero to distance ten meter.

Table (6) Average HM Variations

Distance (m)	Raw water	Effluent water HM				
		Ch1	Ch2	Ch3	Ch4	Ch5
0	1.5	1.5	1.5	1.5	1.5	1.5
1 m after media	1.5	1.5	1.3	1.3	1.4	1.4
5	1.5	1.5	1.4	1.39	1.3	1.3
10	1.5	1.5	1.3	1.2	1.2	1.2

Heavy Metals decreased in general from1.5mg/l to 1.3-1.4mg/l according to the length of the media with distance one meter from the media with removal ratio from 13.3%to6.6% for the voids of media increase the dissolved air that oxidized HM also the adsorption action take place between the media and HM.

After 5 meters HM decreased to 1.4mg/l in ch2, 1.39 in ch3,1.3mg/l in ch4 and ch5 with removal ratio were 7.6%,6.9% and 7.14% respectively. It cleared that after 5m the HM was decreased because of HM oxidation by DO with the water flow.

After 10 meters HM decreased between 1.3 mg /l in ch2, 1.2 mg/li n ch3, ch4 and ch5.with removal ratio between 7.1% and7.6%. The ratio was due to the chemical oxidation self-purification action.

It is clear from the results that the greater length of agriculture waste has the higher direct effect in increasing HM removal from water.

CONCLUSIONS

The study concluded that the application of the plastic media in stream help in the treatment of the agricultural drains water for reuse purposes with very cheap and easy operated solution as the plastic media.

1. Using plastic media method increase removal ratio of BOD by 81.4 %, also increase removal ratio of COD by 75.8% that decrease the required distance for drain water recovery by the same ratio to be between 20-25% maximum from the case without this media application.
2. The dissolved oxygen percentage is high for the turbulence flow occurred through the media with the higher velocity in media voids and due to the plastic media acts as a bio-reactor make it a unique treatment method to enhance the water quality for the increase in the removal rate of the BOD, TSS, HM & COD.
3. Using plastic media can be applied in agricultural drains to improve quality with low cost in operation and maintenance.

REFERENCES

1. "The Dangerous of Domestic and Industrial Wastewater Discharge into Stream;" Reported done by "Public Work Minster". Jan. 1996.
2. Metcalf & Eddy, Inc.. “Collection, Treatment, and Disposal.” McGraw-Hill International Editions, USA, 1991.
3. R. Hranova, “Diffuse pollution of water resources” university of Botswana, Gabronee, Botswana, 2006.
4. Ahmed, S.D., Fadl, S.F.& Ramly, G.C., “Applications for Quality Improvement Inside Streams”, JWRC, V 4, No.#, pp 134-140, June 2011.
5. El Nadi, M.H., Khalifa, A.K., El Monayeri, D.S.D. & Abdel Rahman, W.H., “Improvement Of Biodegradation Enhancement Technique By Bio Media Use In Water Streams.”, Ain Shams Univ., Faculty Of Eng., 1st Intr. Conf. For Environmental Engineering, April 2005.
6. El Khouly, M.S., El Nadi, M.H., Hataba, A., Habib, M.S., “Improvement of Environmental Impact of Sewage Disposal in Water Stream Bodies.”, Ain Shams Univ., Institute for Environmental Studies and Research, Journal of Environmental Science, vol. 6, No. 3, June, 2004.
7. Abdel Rahman, W.H., “Developing The Aqualife System To Suit Hot Climate.”, M.Sc. Thesis Menofiya University, Shebin El Kom Faculty of Eng., Shebin El Kom, Egypt, July 1995.
8. Khalifa, A.K., El Monayeri, D. S. D., El Nadi, M. H. ,Abdel Rahman, W.H., “Enhancement Of The Stream Self-Purification After Wastewater Disposal.”, Ain Shams Univ., Faculty of Eng., Scientific Bulletin, vol. 39, No. 4, December 2004.