International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams

Hamdy Ibrahim Aly[1], Mohamed Shaaban Negm[2], Enas Sayed Ahmed Wahb[3], Mahmoud M. S. El Khouly[4]
[1]Professor of Sanitary Engineering, Faculty of Engineering, Ain Shams University, Cairo, Egypt
[2]Professor of Sanitary Engineering, Faculty of Engineering, Ain Shams University Cairo, Egypt
[3]Associate Professor of Sanitary Engineering, Faculty of Engineering, Ain Shams University Cairo, Egypt
[4]Post Graduate Student, Sanitary Engineering, Faculty of Engineering, Ain Shams University Cairo, Egypt

Abstract— *The primary objective of this study is upgrading the existing WTPs by setting up an additional primary unit at the inlet of the WTPs which handles water flows from Ismailia canal to provide a safe drinking water source effluent. Three experimental runs were conducted to make a comparison between the three types of filters media. The first from agricultural solid wastes (Ag. SW), the second from broken hard stone (BHS) and the third from granular activated carbon (GAC), each used in separate, or in series or dual media. The research concluded that the (GAC) filter media as a separate media is capable to remove (26%) from TDS, (89%) from COD, (100%) from BOD and (100%) from nitrates.*

I. Introduction

Egypt is facing complications and challenges correlated to water. The limited share of rainfalls, the deeply ground water and the rapid growth of population while River Nile remains as the only main water source.

River Nile was of high water quality, as the polluted stream reaches Cairo, deterioration occurs especially at the Delta region due to the disposal of municipal, agricultural drainage and industrial effluents with decreasing flows.

Water purification at the end of canals and streams using traditional treatment techniques is not appropriate owing to the new polluted characteristics. This study is carried out at Ismalia canal which represents the most distal downstream of River Nile. It also acts as agricultural drain for the surrounding agricultural zone.

II. Literature Review

Natural organic matter (NOM) include humic substances, hydrophilic acids and organic compounds. NOM has no direct measurement, but total organic carbon (TOC) can be considered a reasonable indicator of organic content. River Nile water quality results indicate high TOC concentration ranging from 5.5 to 8 mg/L for years 2010 and 2011 which violates the U.S. Drinking Water Standard of 5.0 mg/L, M.Reda-2012.

Water Color, Odor and Taste are common water quality problems. Odor and Taste are emitted from agricultural and industrial activities such as animal farms, waste disposal, pulp and water mills, and various chemical industries. Many biological methods used for odor and taste treatment, Krzysztof Barbusinski-2017.

Reynolds -1996, stated that activated carbon (AC) is a natural material with surface properties that are both hydrophobic and oleophilic (which means, they “hate” water but “love” oil), when flow conditions are suitable, dissolved chemicals in water flowing over the carbon surface bound to the carbon surface in a thin film by either chemical or physical attraction (Van der Waals forces) while the water passes on.

Granular activated carbon (GAC) is regularly utilized for expelling organic constituents and disinfectants in water supplies. This not only enhances taste and minimizes wellbeing risks; it secures other water treatment units, for example, reverse osmosis membranes and ion exchange from conceivable harm because of oxidation or organic fouling. (Frank De Silva 2000).

The adsorption procedure is as a rule broadly utilized by different specialists for the expulsion of heavy metals from waste streams and activated carbon has been as often as possible utilized as an adsorbent. In spite of its broad use in the water and wastewater treatment techniques it remains a costly material.

GAC can be utilized as a media of rapid gravity filters, Slow Sand filters and fixed pressure rated filters. Today, GAC is the standard for the treatment of surface sourced drinking water and polluted ground water in Europe. GAC enhances the nature of drinking water by expelling: Taste and odor forming (compounds, for example, MIB and geosmin), Pesticides including side effects (e.g. atrazine), Color, Trihalomethanes and other sterilization results (DBP expulsion), Algal poisons, Chlorinated hydrocarbons and other volatile organic compounds (VOC expulsion), Endocrine disturbing mixes (EDC expulsion) and other miniaturized scale poisons, Pharmaceutical and individual care items (PPCP expulsion).

GAC for drinking water treatment needs a porous structure to permit the adsorption of an extensive variety of organic pollutants including particular mixture pollutants and natural organic matter. The GAC should likewise have a reasonable measure of transport pores which permit the atoms to be transported to the adsorption destinations. The adsorption limit with respect to drinking water applications is exceptionally hard to measure by lab assessment.

There are three available methods for regeneration: thermal, steam and chemical regeneration. Thermal is commonly used, It consists of three basic steps which are drying (at 100 ºC) for 15 minutes period during which the water retained in the carbon is evaporated, baking (at 800ºC) for 5 minutes period during which the adsorbed material is

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, “Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams,” *International Research Journal of Advanced Engineering and Science,* Volume 4, Issue 4, pp. 242-251, 2019.

pyrolyzed and the volatile portions are driven off and finally activating (> 800 ºC) for 10 minutes period during which the adsorbed material is oxidized and the carbon reactivated.

Powder activated carbon (PAC) is utilized as a part of consumable water creation. These powders are produced using bituminous coal and are accessible in enormous packs, sacks or in mass. The late utilization of powdered activated carbon in blend with ultrafiltration membranes has turned into an option and powerful innovation for the evacuation of organic compounds in drinking water. Carbon has created items with particular attributes for this sort of utilization.

Powdered activated carbon improves chemical coagulation water treatment process and enhances the organic pollutants removal efficiency. (Tseng- 1991).

Suitability of powdered activated carbon for enhancing the reduction in heavy metals concentration (Agata Rosinska-2016).

The optimum dose of PAC and coagulant dose can be determined by "Jar testing" (David 1993). (El-Zayat-2013) mention in their study, that use of agricultural solid waste to create profitable items has opened space in Egypt to minimize environmental solid dangers coming from burning agricultural solid wastes, activated carbon delivered locally from cotton stalks was used for the expulsion of target heavy metal pollutants from water and wastewater.

The biggest value of adsorption limit was for lead. Then, copper and after that cadmium. Multicomponent metal adsorption tests demonstrated an opposition for the accessible surface destinations.-Adsorption limits in the mixture were diminished from their single-solute qualities for all metals.

Clark-1989, reported that adsorption efficiency decreases over time, the "spent" carbon, is removed and sent for re-activation treatment. This is done primarily with GAC because PAC particles are too small to be effectively re-activated. This process allows for recovery of approximately 70% of the original carbon.

Although PAC has high adsorption capacity which is 2 to 3 times less expensive than GAC and can be easily applied and does not need a special unit, but it can be only applied on small scale and it is only used for one cycle.

Although GAC has higher cost than PAC and needs a special unit, but it has higher degree of produced water purity than PAC and can be used multiple times.

III. MATERIAL AND METHODOLOGY

This study was applied established on direct filtration phenomenon as pretreatment step to upgrade the existing WTPs that are fed by Ismailia Canal. The work was done using three different filter media of agricultural solid wastes (Ag SW), broken hard stone (BHS), and granular activated carbon (GAC). The first pilot plant is displayed in figure (1).

The suggested pretreatment unit was erected at faculty of engineering, Ain Shams University at laboratory of Sanitary Engineering. Two bench pilot plants (units) were erected to be operated for several months (November 2015 – May 2016) to achieve the study targets.

In the first pilot plant, an agriculture solid waste (Ag. SW), a broken hard stone(BHS), and granular activated carbon (GAC) as filter media in plastic column 10cm in diameter and height 67 cm and 30 cm depth of filter media.

In the second pilot plant which is shown in figure (2), the filter was a plastic column 10cm in diameter and a height of 200 cm with 60 cm filter media depth (GAC), 30 cm of supporting media (BHS) and 80 cm raw water depth. Flow rate (Q) = 11 l/s and the rate of filtration = 120 m^3/m^2/day

The laboratory measured parameters such as TSS, COD, BOD, and Nitrate were measured according to (The Standard American Method for the examination of water and wastewater)

IV. OPERATION PROGRAM

The study was conducted on three groups to determine the most suitable filter media capable to remove the pollution. The chosen depth and size of filter media were taken from the previous experimental records. The used flow system is batch flow (fill and draw) system. Several runs were conducted as shown in figure (3).

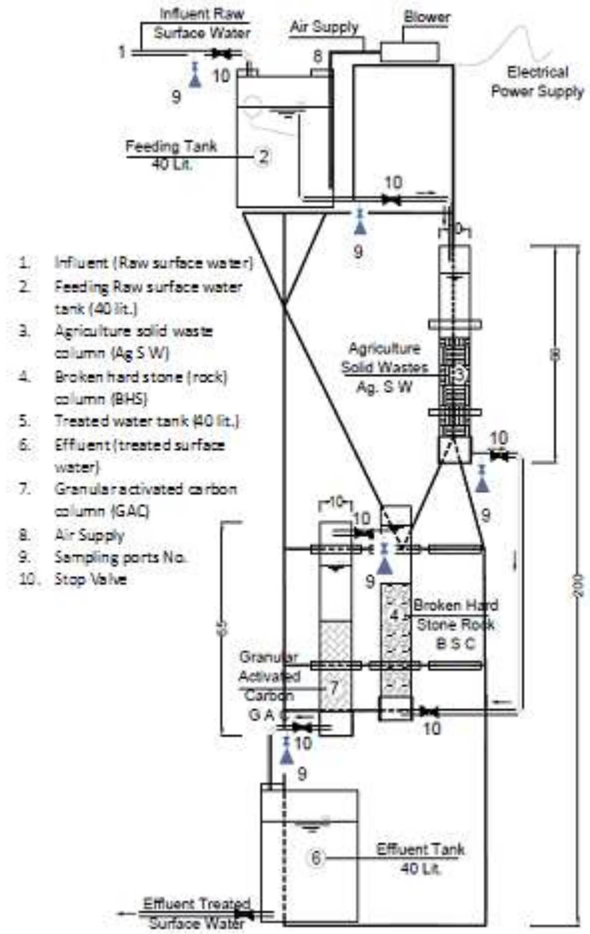

Figure (1) Schematic diagram of first bench pilot plant

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

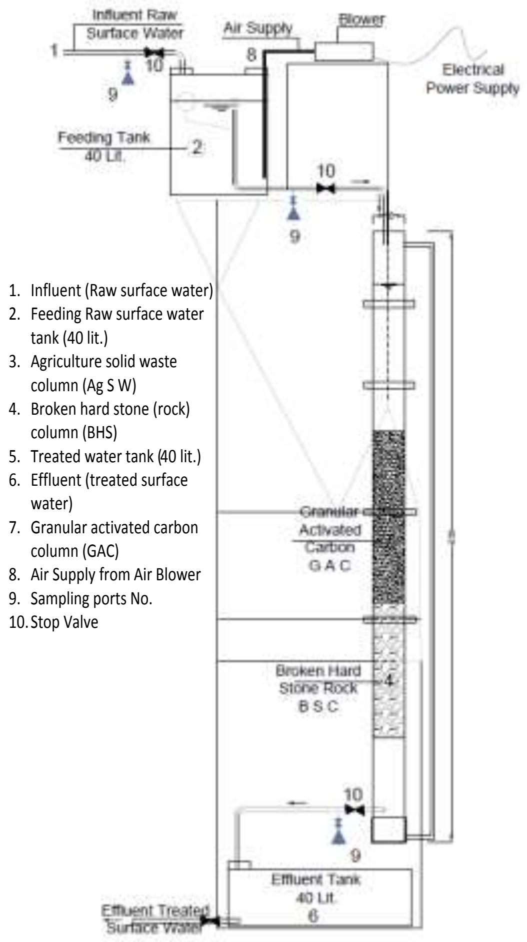

Figure (2) Schematic diagram of second bench pilot plant

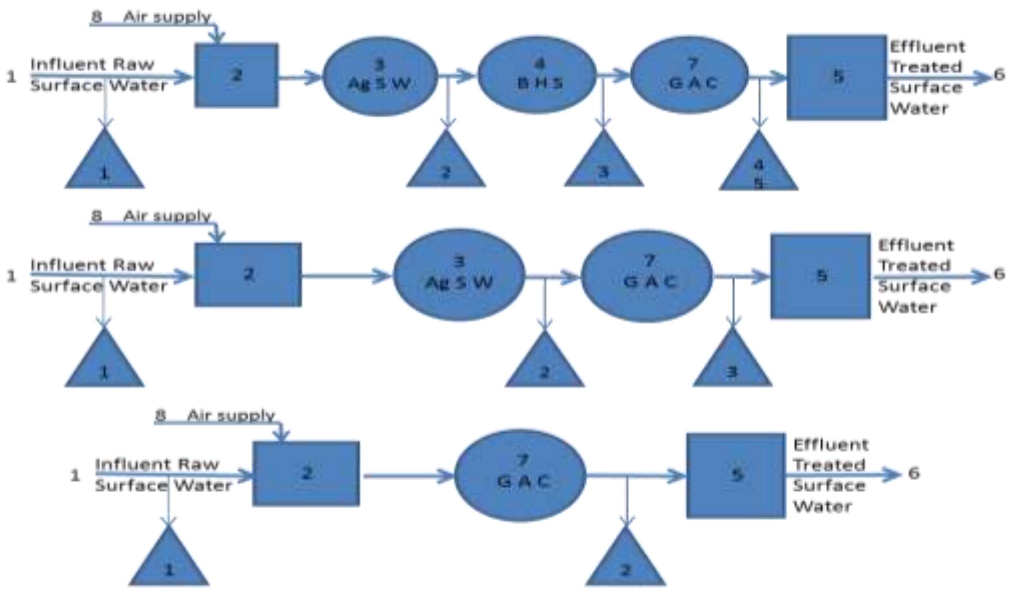

Figure (3) Flow diagram for the conducted runs

V. Results and Discussion

1) *Experimental Results for first run group*

A bench pilot plant scale used in the first run consist of:

A. Feeding influent storage tank (2) with capacity 40 liters for raw surface water from Ismailia canal at El-Ameria water treatment plant was supplied with air.

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

B. Filter Column (3) with agriculture solid waste (Ag SW) media.
C. Filter Column (4) with broken hard stone (BHS) media.
D. Filter Column (7) with granular activated carbon (GAC) media.
E. Effluent tank (5) with capacity 40 liters. The above diagrammatic process is shown in figure (4).

The following tables (1), (2), (3) show the physical, chemical and biochemical properties of influent surface water and pretreated water. Figures from (5) to (7) show the removal ratios of the measured parameters for the three groups in the first run.

1.1) Discussion

The main aim for applying air to inlet raw water is mixing to inhibit settling of SS during experimental interval. Moreover, air oxidizes part of DS to SS and also oxidizes part of organic pollutants which enhances the treatment process.

Both media (Ag SW) and (BHS) are capable to decrease pollutants (TSS & TDS) to less extent not more than 10%. The results were reasonable for removing approximately 50% of organic pollutants which retain on the pores between filter media or particles adsorb on the surface of filter media. Adsorption characteristics of both (Ag. SW) and (BHS) media is neglected.

The addition of (GAC) media filter improved the Removal ratio of (TSS) up to 90% that is due to the adsorption characteristic of (GAC).It also enhanced the reduction of (COD & BOD) up to 100% due to adsorption and absorption properties of (GAC) that makes the (GAC) to be considered as the most suitable filter media that can be capable of removing the various pollutants found in raw water

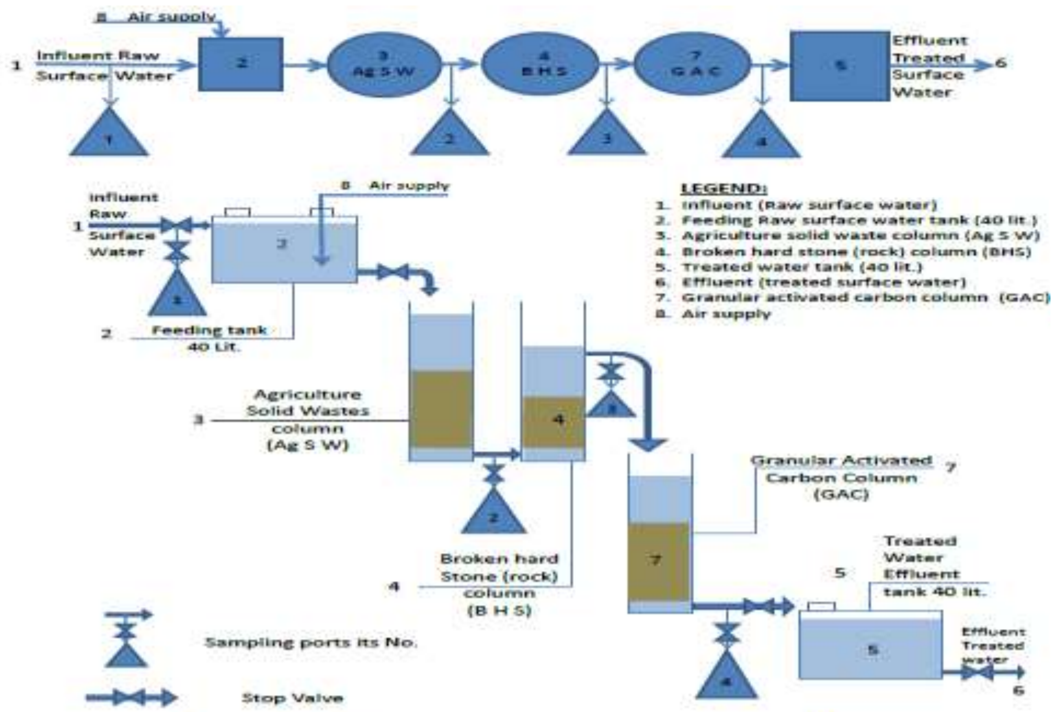

Figure (4) Treatment process of first pilot plant (1st run)

Table (1) Analysis for First group run (December 2015)

No.	Parameters	Sample (1)	Sample (2)		Sample (3)		Sample (4)	
			T	R.R%	T	R.R%	T	R.R%
1	TDS ppm	278	232	16.55	194	30.22	178	35.97
2	TSS ppm	15	8	46.67	6	60	2	86.67
3	pH Value	7.7	7.75	7.7		7.7		7.6
4	C.O.D ppm	18	8	55.56	6	66.67	3	83.33
5	B.O.D ppm	12	4	66.67	3	75	0	100
6	Nitrate ppm	2.4	0	100	0.13	94.58	0.63	73.75

Table (2) Analysis for First group run (February 2016)

No.	Parameters	Sample (1)	Sample (2)		Sample (3)		Sample (4)	
			T	R.R%	T	R.R%	T	R.R%
1	TDS ppm	180	135	25	135	25	135	25
2	TSS ppm	10	3	70	2	80	0	100
3	pH Value	7.5	7.66	7.69		7.67		8.5
4	C.O.D ppm	11	4	63.64	2	81.82	0	100
5	B.O.D ppm	7	2	71.43	1	85.71	0	100
6	Nitrate ppm	0.18	0	100	0	100	0	100

Table (3) Analysis for First group run (March 2016)

No.	Parameters		Sample (1)	Sample (2)		Sample (3)		Sample (4)	
				T	R.R%	T	R.R%	T	R.R%
1	TDS	ppm	240	221	7.92	216	10	214	10.83
2	TSS	ppm	14	4	71.43	4	71.43	1	92.86
3	pH Value		8	8	7.95		7.93		8.33
4	C.O.D	ppm	21	5	76.19	5	76.19	4	80.95
5	B.O.D	ppm	8	2	75	1	87.5	0	100
6	Nitrate	ppm	0	0	0	0	0	0	0

Note: T = Treated sample analysis R.R% = Removal Ratio

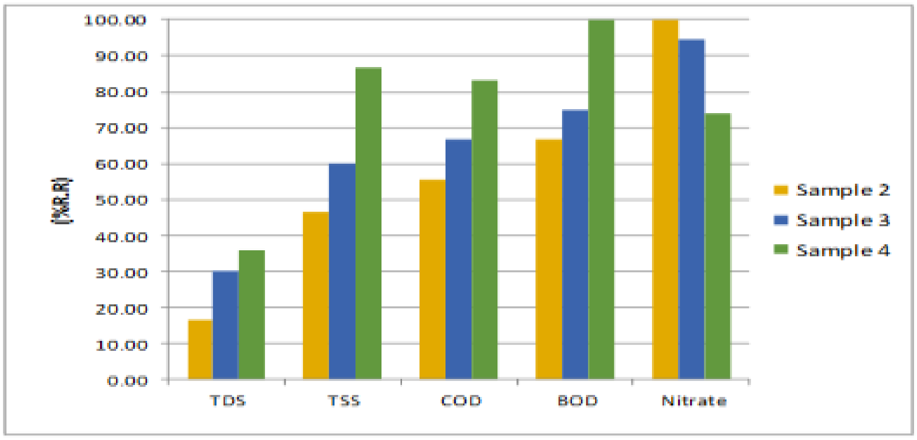

Figure (5) Removal ratio of measured parameters for first run (December 2015)

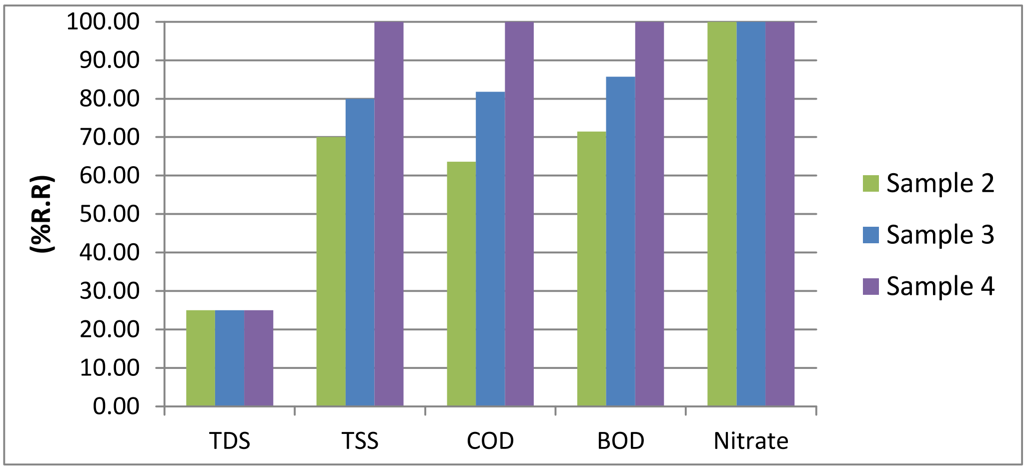

Figure (6) Removal ratio of measured parameters for first run (February 2016)

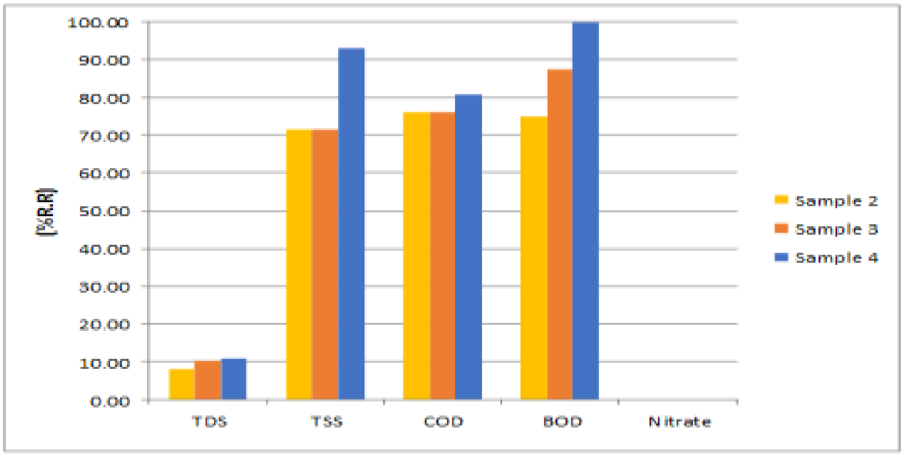

Figure (7) Removal ratio of measured parameters for first run (March 2016)

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

2) Experimental Results for second run group

A bench pilot plant scale used in the SECOND run consists of:

1. Feeding influent storage tank (2) with capacity 40 liters for raw surface water from Ismailia canal at ELAMERIA water treatment plant was supplied by air using a small blower (8).
2. Filter Column (3) with agriculture solid waste (Ag. S W) media.
3. Filter Column (7) with granular activated carbon (GAC) media.
4. Effluent tank with capacity 40 liters. This experimental bench pilot (columns and tanks) are shown in figure (2).

The following tables (4), (5), (6) represent the physical, chemical and biochemical properties of influent surface water and after pre-treated water. Figures from (9) to (11) show the removal ratios of the measured parameters for the three groups in the second run

2.1) Discussion

For the second run, it was obvious that aerated raw water could be treated by passing through (Ag SW) media that capable of removing 70% from TSS and (70-80)% from (COD & BOD) which shows that (Ag. SW) can be considered to be a low cost filter media in the pretreatment step.

The following (GAC) filter media can make a polishing step and gives water free from organic pollutants due to its adsorption and absorption properties.

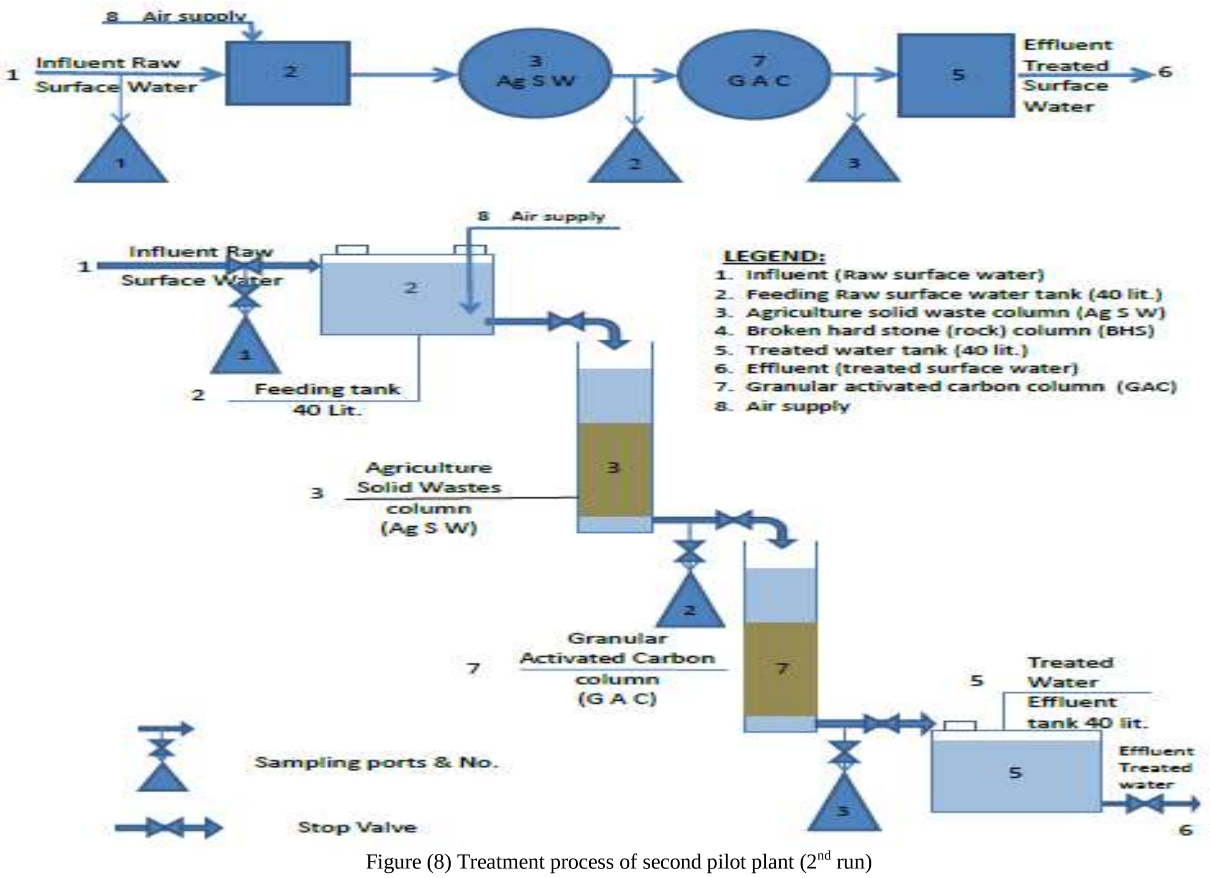

Figure (8) Treatment process of second pilot plant (2nd run)

3) Experimental Results for third run group

A bench pilot plant scale used in the third run consists of:

1. Feeding influent storage tank (2) with capacity 40 liters for raw surface water from Ismailia canal at ELAMERIA WTP was supplied by air using a small blower (8).
2. The upper zone of the Column reactor (7) with filter media from Granular Activated Carbon (GAC).
3. The lower zone of the Column reactor (4) with filter media from broken hard stone (BHS) used as support layer and under drainage media.
4. Effluent tank with capacity 40 liters. These experimental bench pilot columns and tanks dimensions and details are shown in figure (12).

The experiment bench pilot plant was operated till getting stable conditions characteristics of the samples represents for surface raw water and after pre-treatment.

The following tables (7), (8), (9) and figures from (13) to (15) show the physical, chemical and biochemical properties of influent surface water and pretreated water.

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

Table (4) Analysis for second group run (December 2015)

No.	Parameters		Sample (1)	Sample (2)		Sample (3)	
				T	R.R%	T	R.R%
1	TDS	ppm	278	194	30.22	178	35.97
2	TSS	ppm	15	6	60	2	86.67
3	pH Value		7.7	7.88		8.02	
4	C.O.D	ppm	18	7	61.11	3	83.33
5	B.O.D	ppm	12	4	66.67	0	100
6	Nitrate	ppm	2.4	0.1	95.83	0	100

Table (5) Analysis for second group run (February 2016)

No.	Parameters		Sample (1)	Sample (2)		Sample (3)	
				T	R.R%	T	R.R%
1	TDS	ppm	180	138	23.33	130	27.78
2	TSS	ppm	10	2	80	0	100
3	pH Value		7.5	7.6		7.5	
4	C.O.D	ppm	11	3	72.73	0	100
5	B.O.D	ppm	7	1	85.71	0	100
6	Nitrate	ppm	0.1	0	100	0	100

Table (6) Analysis for Second group run (March 2016)

No.	Parameters		Sample (1)	Sample (2)		Sample (3)	
				T	R.R%	T	R.R%
1	TDS	ppm	240	205	14.58	205	14.58
2	TSS	ppm	14	5	64.29	1	92.86
3	pH Value		8	7.93		8.33	
4	C.O.D	ppm	21	6	71.43	5	76.19
5	B.O.D	ppm	9	1	88.89	0	100
6	Nitrate	ppm	0	0	0	0	0

Note : T = Treated sample analysis   R.R% = Removal Ratio

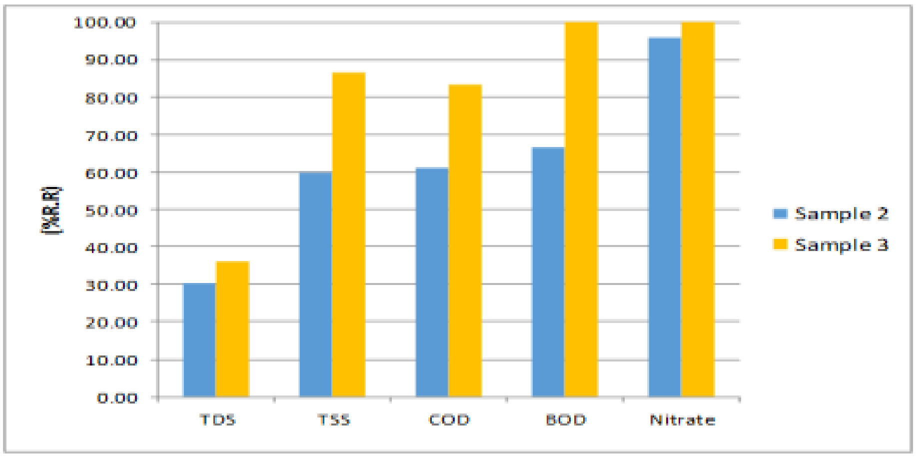

Figure (9) Removal ratio of measured parameters for 2nd run (December 2015)

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

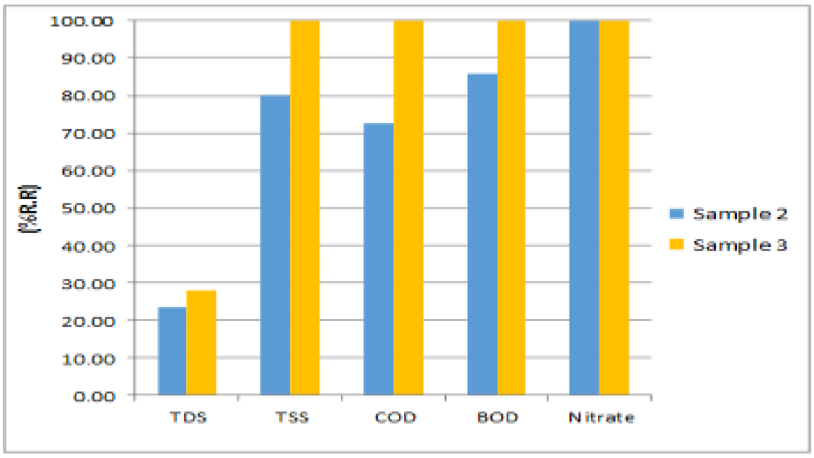

Figure (10) Removal ratio of measured parameters for 2nd run (February 2016)

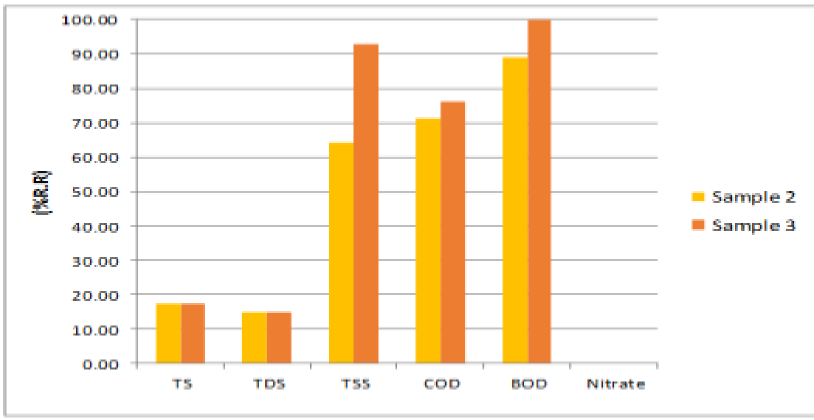

Figure (11) Removal ratio of measured parameters for 2nd run (March 2016)

3.1) Discussion

The third run proved that using (GAC) as filter media is an effective way to remove organic pollutants (COD, BOD & Nitrates) and also reduce (TDS) to great extent.

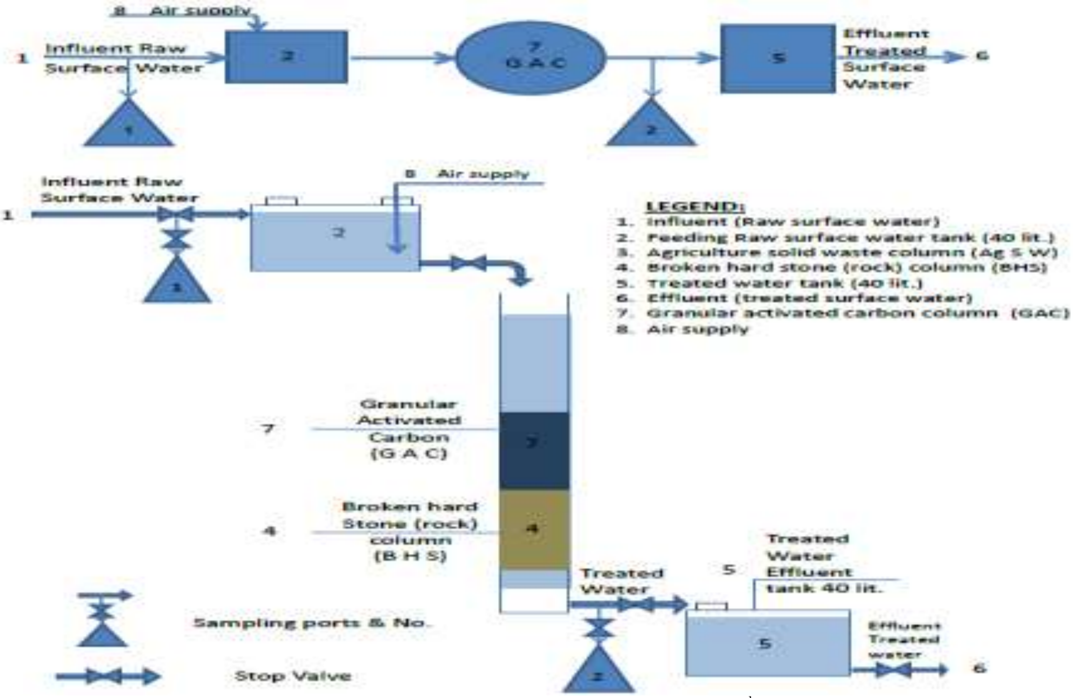

Figure (12) Treatment process of second pilot plant (3rd run)

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

Table (7) Analysis for 3rd run (December 2015)

No.	Parameters	Sample (1)	Sample (2)	
			T	R.R%
1	TDS ppm	260	192	26.15
2	TSS ppm	9	3	66.67
3	pH Value	7.96	7.7	
4	C.O.D ppm	17	5	70.59
5	B.O.D ppm	9	3	66.67
6	Nitrate ppm	2.05	0.13	93.66

Table (8) Analysis for 3rd run (February 2016)

No.	Parameters	Sample (1)	Sample (2)	
			T	R.R%
1	TDS ppm	180	140	22.22
2	TSS ppm	10	0	100
3	pH Value	7.47	7.67	
4	C.O.D ppm	18	2	88.89
5	B.O.D ppm	12	0	100
6	Nitrate ppm	0.8	0	100

Table (9) Analysis for 3rd run (March 2016)

No.	Parameters	Sample (1)	Sample (2)	
			T	R.R%
1	TDS ppm	213	197	7.51
2	TSS ppm	12	0	100
3	pH Value	7.85	7.95	
4	C.O.D ppm	15	2	86.67
5	B.O.D ppm	9	0	100
6	Nitrate ppm	0.5	0	100

Note : T = Treated sample analysis R.R% = Removal Ratio

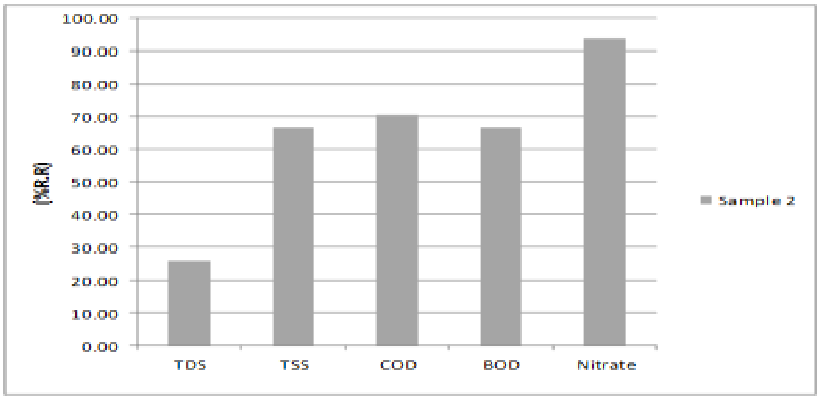

Figure (13) Removal ratio of measured parameters for 3rd run (December 2015)

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, "Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.

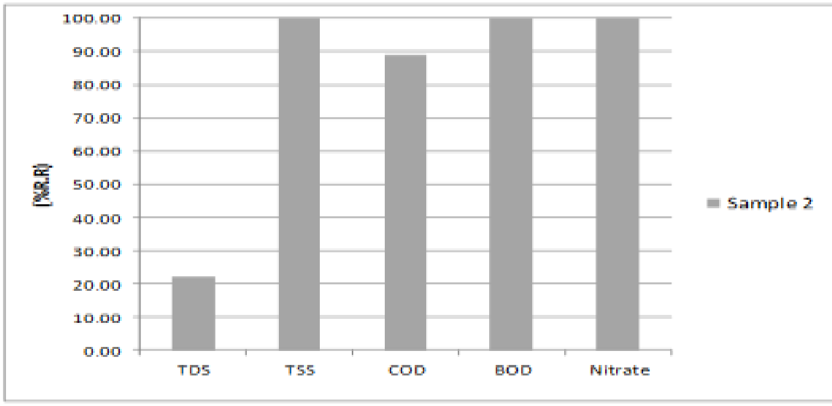

Figure (14) Removal ratio of measured parameters for 3rd run (February 2016)

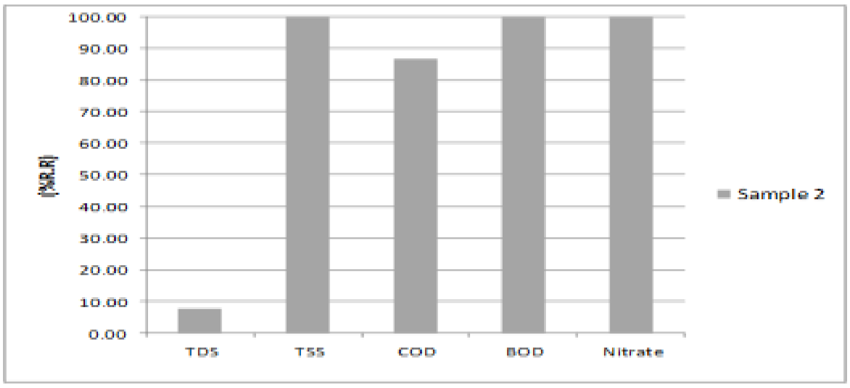

Figure (15) Removal ratio of measured parameters for 3rd run (March 2016)

VI. CONCLUSION

Egyptian WTPs on River Nile and its main branches (canals) are facing lack of efficiency due increasing concentration of types of pollutants, which cannot be treated by traditional treatment methods used in WTP as mentioned before. The study suggest pretreatment units to recover the actual polluted raw water and enhance the treatment process of existing WTPs.

1- The first step is applying air to inlet raw water to oxidize part of DS to SS and also oxidizes part of organic pollutants which enhances the treatment process.
2- The second step is direct filtration with different media. Both filter media (Ag SW) and (BHS) are capable to decrease pollutants (TSS & TDS) not more than 10% and remove approximately 50% of organic pollutants which retain on the pores between filter media or particles adsorb on the surface of filter media. Adsorption characteristics of both (Ag. SW) and (BHS) media is neglected.
3- The addition of (GAC) media filter improved the Removal ratio of (TSS) up to 90% that is due to the adsorption characteristic of (GAC).It also enhanced the reduction of (COD & BOD) up to 100% due to adsorption and absorption properties of (GAC).
4- The researcher used GAC as a single filter media before the WTP. The (GAC) filter media is capable to remove (26%) from TDS, (89%) from COD, (100%) from BOD and (100%) from nitrates.

The study concluded That (GAC) is considered as the most suitable filter media that can be capable of removing the various pollutants found in raw water. GAC absorbs natural organic compounds, taste and odor compounds and synthetic organic chemicals in raw water.

REFERENCES

[1] Reda M.R.,(2012). “Control of Trihalomethanes (THMs) Formation by Proper Prechlorination System in Water Treatment Plants”, M.Sc. Thesis Ain Shams University.
[2] Krzysztof Barbusinski, K.K, D.K, K.U, VK. “Biological Methods for odor treatment” journal of cleaner production 152,223-41p, May, 2017
[3] Reynolds T.D., and Richards P.A (1996). “Unit Operations and Processes in Environmental Engineering”, 2nd Edition. PWS Publishing Co., New York, NY. Water Treatment Technology, Fact Sheet.
[4] Frank De silva, 2000, “Activated carbon filtration”, published in water quality products magazine, January, 2000.
[5] Agata Rosińska, 2016, “Enhancement of coagulation process with powdered activated carbon in PCB and heavy metal ions removal from drinking water”, Desalination and Water Treatment Journal Volume 57, 2016 - Issue 54.
[6] David W, 1993, “Coagulation and flocculation in water and wastewater treatment”, The World Health Organization.
[7] Mohamed El Zayat and Edward Smith, 2013, “Removal of Heavy Metals by Using Activated Carbon Produced from Cotton Stalks”, Environmental Engineering Program, the American University in Cairo.
[8] Clark, Robert M,(1989). “Granular Activated Carbon: Design, Operation, and Cost”. Lewis Publishers.
[9] APHA, AWWA and WEF, 2005, “Standard method for examination of water and wastewater”, American Public Health Association, Washington D.C.

Hamdy Ibrahim Aly, Mohamed Shaaban Negm, Enas Sayed Ahmed Wahb, and Mahmoud M. S. El Khouly, “Upgrading Existing WTPs to Remove an Excess of Organic Matter in Water Streams,” *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 4, pp. 242-251, 2019.