Application of New Filtration Media In Wastewater Treatment For Irrigation Purpose

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Abstract- The present study deals with treatment process applied on wastewater using biological method such as sequencing batch reactor (SBR). A 12-hour aeration cycle were applied in SBR unit. In addition, the effluent of SBR unit filtered through varied media filter such as sand or pottery scraps. Each type experimented individually. The aeration cycle consists of 11-hour actual aeration and 1 hour for settling phase. The raw wastewater samples were griped from wastewater treatment plant at New Cairo, Egypt. Two-stage (reactor and filter) laboratory scale model were designed. Results indicated the great ability of pottery scraps filter with SBR 12-hour cycle for improving of the physicochemical parameters. The removal percentage of COD, BOD, TSS, TKN and TP are 79.26, 69.94, 69.12, 76.67 and 48.94 respectively. Treatment of wastewater using SBR technology with filtration by pottery scraps is an effective, cheap and eco-friendly technology.

Keywords – SBR, Biodegradation, Pottery Scraps and Filtration

I. Introduction

Water is an essential source of life, but the main environmental problem facing humankind globally is its low quantity besides its pollution so finding best ways to treat water, especially wastewater, as it constitutes a threat to the surrounding environment and its use in the field of agricultural irrigation, especially after the Egyptian governorate trends to the new irrigation law of year 2020.

Wastewater is assessed as domestic, industrial and agricultural consistent with its source. Domestic wastewater is one among the current environmental issues everywhere the planet. Sewage water originates from domestic sources and contains varying amounts of industrial wastewater. Domestic wastewater is laden with different kinds of inorganic and organic compounds that limit its direct use for irrigation. There are many sources for pollutants founding in the sewage effluent like house hold activities.

Indirect re-use of wastewater as agricultural water is also viewed as a coveted resource, where consumption of fresh water grows to accommodate for supply and demand. Primary re-use of wastewater as farm water requires drainage from a direct source from a wastewater treatment plant, while indirect re-use of wastewater is the pumping of treated wastewater into a system that conveys irrigation water.[1]

The quality of wastewater treatment plant (WWTP) effluent controls direct wastewater re-use, while indirect wastewater re-use quality control is complicated because it relies on both the hydrological properties of the wastewater source and the quality of the treated wastewater effluent[2].Indirect irrigation drainage quality must be closely regulated in order to avoid pollution of the soil. Accumulation of substances in soil voids is detrimental to growing crops and induces microbial contamination and soil degradation.[3]

World biological approaches such as up-flow Anaerobic Sludge Blanket Reactor (UASB), activated sludge process (ASP), and sequencing batch reactor (SBR).[4] Organic compounds and solids can be extracted from the wastewater by using SBR reactor. This process consists of five stages: fill, react, settle, withdrawal and idle. This process had the potential to treat a huge influent size, low cost, lower operator interactions required, and very high removal performance and cushy service. It may also be used as a nitrification-denitrification operation; the stages between filling and drawing are controlled by mixed oxygen (O2). Therefore, a frequent shift in the concentricity of oxygen, substrates and inorganic nutrients may be added to the process.[5] Biological methods are typically prescribed for wastewater treatment to minimize organic compounds as they have economic benefits over chemical oxidation.[6]

The sequencing batch reactor (SBR) is the most widespread and flexible biological process used worldwide for the secondary treatment of residential, urban and industrial wastewater. Over time, several changes to the SBR are made to increase the efficiency of treatment in compliance with strict effluent requirements.[7]

II.Material and Methods

2.1 Sample Collection

Wastewater was collected from a WWTP at New Cairo, Egypt. The containers filled through plastic vessel; the containers are prepared to be transferred to workplace to process the wastewater. Three plastic containers were collected with 20 liters for each one. Samples were collected and transferred to national research center for the experiments. The samples were taken twice from the plant.

2.2. Pilot Description

A pilot was made by an aeration tank with dimensions of 30*30*60 cm with total volume of 54 litters and working volume of 45 litters considering 5 cm freeboard. The first tank was equipped with air tubes placed at the bottom of the reactor which pump the air inside the tank. Also, the tank contains two taps placed outside the tank, one placed at 15 cm high to collect the treated samples and the other placed at the bottom. Followed by a filtration tank with dimensions of 30*30*60 cm with one tap placed outside the tank placed at bottom to collect the filtered samples. Figure no. (1) Shows the schematic diagram of the pilot.

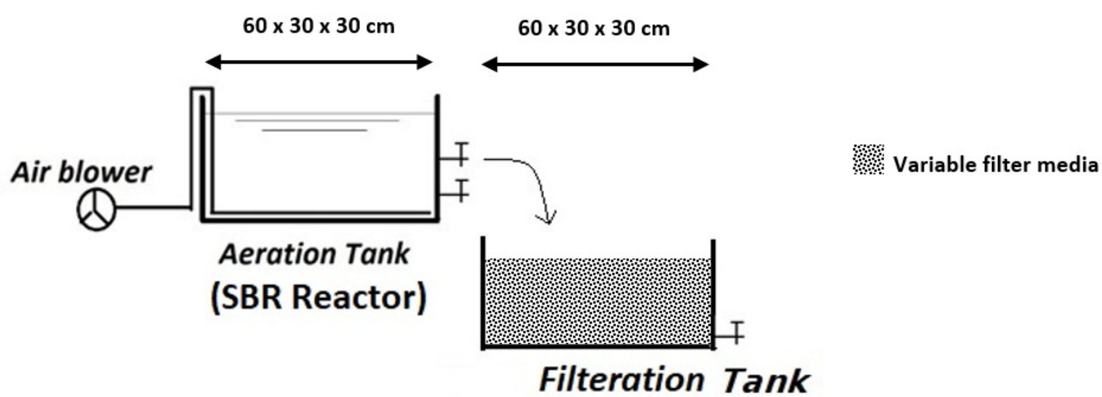

Figure 1. Components of the SBR model

2.3. Experimental Run Description

The aeration tank filled with raw wastewater. The proposed SBR cycle was 12-hour application. The aeration stage consists of 11 hour and settling stage of 1 hour. After the aeration tank the effluent will be filtered through a variable filter media. The approaches used in treatment are summarized as follow:

- 12-hours cycle which consists of aeration stages consume 12 hours then the settling stage consumes 1 hour. The sample was taken when the SBR cycle finished. The effluent will be filtered through sand filter. A second sample will be taken after filtration stage.

- 12-hours cycle which consists of aeration stages consume 12 hours then the settling stage consumes 1 hour. The sample was taken when the SBR cycle finished. The effluent will be filtered through pottery filter. A second sample will be taken after filtration stage.

2.4. Chemical and Physical Analysis

Characterization of raw and treated wastewater was carried out through measuring some physicochemical parameters. These parameters were biological oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), pH, Total Kjeldahl Nitrogen (TKN) and Total phosphorus (TP). All these parameters were measured according to the standard methods for examination of water and wastewater APHA2010 at the national research center.[7]

III. Experiment and Result

3.1. Characterization of Raw Sample

Two Samples had been taken from the wastewater, and tested at the National Research Center to know the rate of pollutants and pathogens in it. The characteristics of the tested wastewater are given in Table (1).

Table -1 Raw Wastewater Samples

Parameters	Raw sample 1	Raw sample 2
COD (mg/l)	360	352
BOD (mg/l)	172	163
pH	7.6	7.4
TSS (mg/l)	144	136
TKN (mg/l)	37	30
TP (mg/l)	5.6	4.7

Table (1) shows the values for measured physicochemical parameters of raw wastewater to evaluate and determine the efficiency of wastewater treatment process. The raw wastewater was moderate polluted according to the physiochemical parameters value. In this study, pH of raw wastewater ranged from (7.4–7.6). The values of pH are suitable to bacteria to be active. TSS average concentrations was less than those reported by some researchers 176-343 mg/L.[8] Also, raw wastewater showed low values of organic matter fraction expressed as COD and BOD5. The value of BOD concentrations lower than reports by some researchers (180-525) mg/L. Also, the COD values lower than reported by some researchers (400-1295) mg/L. The values of BOD5 are attributed to the existence of organic maters and microorganisms.[8]

Raw wastewater showed high concentrations of organic matter fraction expressed as COD and BOD which derives primarily from human being lifestyle. The high values of TKN which derives primarily from social Practices such as institutional and commercial.

3.2. Results of Treatment Trials

Table (2) shows the final results of all trials of treatment of raw wastewater. All the results were compared with the Egyptian standards for reusing the treated wastewater in irrigation purposes. As shown in table (2) the final results of the all trials used in wastewater treatment were less than the Egyptian standards for reusing the treated wastewater in irrigation purposes.

Table -2Final Results of All Trials of Wastewater Treatment

Parameters		COD (mg/l)	BOD (mg/l)	pH	TSS (mg/l)	TKN(mg/l)	TP (mg/l)
first Trial	Raw sample 1	360	172	7.6	144	37	5.6
	After SBR cycle of 12 hr. 1st trial	215	100	7.5	114	21	4.4
	After sand filtration (1st trial)	86	51	7.4	46	9.8	2.9
	Removal efficiency %	76.11	70.35	------	68.06	73.51	48.21
second Trial	Raw sample 2	352	163	7.4	136	30	4.7
	After SBR cycle of 12 hr. 2nd trial	206	92	7.4	94	13	3.8

	After pottery filtration (2nd trial)	**73**	**49**	**7.4**	**42**	**7**	**2.4**
	Removal efficiency %	**79.26**	**69.94**	**-----**	**69.12**	**76.67**	**48.94**
Law 48 year 1982		**100**	**60**	**6-9**	**60**	**----**	**10**

Generally, raw wastewater showed higher average values of physicochemical parameters than the permissible limits of treated wastewater reuse in irrigation purposes according to the Egyptian guidelines. The all trials show the physiochemical parameters law than the Egyptian standards, but the second trial was the more efficient than the other.

3.2.1 Chemical oxygen demand (COD)

The experiment result with SBR system indicate that COD decreased significantly from the first trial to the second trial. The obtained results in Table (2) showed that wastewater had a relatively high average concentration of COD (352-360 mg/l). During the total operational period, high COD removal was achieved in the system by applying the trial of 12-hour SBR cycle with pottery filtration and the removal efficiency approaches to 79.26 %. At other studies almost the same removal efficiency for COD by applying SBR treatment method.[9]

The removal of COD can be explained due to the activity of the aerobic bacteria which activated at the aeration phase which decompose the organic compounds into inorganic compounds which settle at settling phase. Also, the settling phase can make the anaerobic action to decompose the hard-organic materials to be transformed to settleable materials. At the filtration phase a same trickling filter effect had been done here to reduce the influent COD values such that the bacteria attached to the surface of pottery scrabs and start to decompose the residual organics which cause the COD values decreases.[9]–[11]

At the first trial when using the sand filter the reduction in COD value can be explained due to the formation on dirt skin covers the filter top layer. The bacteria attached to this layer and starts to treat the filter influent. This layer takes a little long duration thus the removal efficiency decreased.[12], [13]

3.2.2 Biochemical oxygen demand (BOD)

Wastewater is made up of a mixture of organic and inorganic compounds. Organic compounds refer to compounds that are carbon-based that contain fecal matter. These large organic compounds are readily broken down by bacteria in the septic system.However, this mechanism involves oxygen to split up large molecules into smaller molecules and ultimately into carbon dioxide and water.The amount of oxygen needed for this process is known as the demand for biochemical oxygen. BOD removal efficiency approach to 69.94% during applying the trial of 12-hour SBR cycle with pottery filtration to the wastewater. Treatment of wastewater through the use of SBR process has been reported by many research workers [9]–[11], [14]–[17] All these studies indicate a BOD5 removal of 80 to 90% for the effluent concluding SBR method as highly recommended for the purpose. The deference between the achieved removal efficiency due to the high influent concentration compared to the other studies[18], [19]. The removal of BOD can be explained due to the activity of the aerobic bacteria which activated at the aeration phase which break down the organic compounds into inorganic compounds which settle at settling phase. Also, the settling phase can make the anaerobic action to decompose the hard-organic materials to be transferred to settleable materials. At the filtration phase a same trickling filter effect had been done here to reduce the influent BOD values such that the bacteria attached to the surface of pottery scrabs and start to decompose the residual organics which cause the BOD values decreases.[9]–[11]. Also, when the sand used as a filter media the values of BOD value decreased due to the formation of the dirt skin where the bacteria attached and decompose the organic compounds.[12], [13] *3.2.3 Total suspended solids (T.S.S)*

Total suspended solids include all particles suspended in water that do not move through the filter. The TSS removal rate was varied during the deferent treatment trials. The higher removal percentage achieved when applying the trial of 12-hour SBR cycle with pottery filtration to the wastewater and reaches the 69.12% removal efficiency. High TSS in the water body may also mean higher concentrations of bacteria, nutrients, and metals in the water. The main issue when using recycled water is the potential risk to human health, the standards are usually based on microbial content. It was clear that raw wastewater contains high values of suspended matters measured by either TSS or turbidity. TSS ranged from (136-144 mg/l). At other studies a removal efficiency achieves a 98.2% by applying SBR treatment method[20]–[22]. But it noticed that the TSS concentration was less than in this study. At other studies the removal efficiency varied from 82-90%. The efficiency achieved the minimum required value for the environmental law of reuse the treated wastewater for irrigation purpose. Also, this percentage may increase when the settling phase duration increase.[22]

The filtration using sand or pottery scrabs was almost the same effect where the solids go to stuck into the gelatinous layer formed around the pottery scrabs or the dirt skin covers the sand. And both ways make the solids retained and the TSS concentration decreases.

3.2.4Total Kjeldahl Nitrogen (TKN)

The data was obtained by analyzing the effluent samples at laboratories of national research center and also tested for the removal performance. It was found that conversion of ammonia to nitrite and nitrate occurred successfully within the process of SBR treatment which led to decrees the value of TKN. Where Total Kjeldahl Nitrogen TKN varied at raw samples from 30-37 mg/l. After applying the trial of 12-hour SBR cycle with pottery filtration to the wastewater and reaches the 76.67% removal efficiency. The efficiency removal of Classical reactor decreases from 70% to 50% as mentioned in other studies. Also, the value of TKN decreased due to because the anoxic phase has been used and transformed all Nitrogen – nitrate to Nitrogen – gas and this occurred at the settling phase where the aerators turned off at which the oxygen concentration depleted.[23]

The filtration through the sand media decreases the TKN value due to the aerobic environment in the sand filter is evident from the conversion rate of NH 4-N to nitrate nitrogen (NO3-N) that leads to decrease the TKN value. While when using the pottery scrabs filter media the size of aerobic environment is larger than the sand filter so the conversion rate is faster and more efficient.[24]

3.2.5Total phosphorus (TP)

Phosphorus, in substances present in wastewater, is neither toxic nor a health threat. Phosphorus, on the other hand, is a part of several cell structures and the metabolism of animals and plants. Phosphorus occurs in sewage in its most highly oxidized forms and is therefore not an oxygen consuming substance. Nevertheless, phosphorus is a “problem” because in an aquatic environment, it is generally a limiting factor for the development of organisms. The total phosphorus removal average within 48.94 %. Where the value of TP varied from 4.7 mg/l to 2.4 mg/l after applying the 12-hour SBR cycle with pottery filtration treatment trial. But it’s noticed the value of the raw wastewater TP samples ranged from 4.7 mg/l to 5.6 mg/l which is lower than the law limitation of reusing the treated water in irrigation purpose from the beginning of treatment trials. At other studies a removal efficiency achieves ranged from 53% to 70% by applying SBR treatment method.[25]. Phosphorous is removed from a wastewater either through microbial uptake, or adsorption onto the biomass; therefore, SRT plays an important role in the removal of TP [26]. There is a study recommend a 20-day SRT. The low SRTs of 2, 2.7, and 4 days were likely the cause of incomplete phosphorous removal. [26]. The SRT at this study is lower than recommended by a previous study[26] due to low TP concentration for the raw wastewater.

IV.CONCLUSION

Sequencing batch reactor (SBR) is a feasible treatment technology forwastewater especially where limitedspace restricts the use of other biologicalmethods. According to the results achieved by the experimental program it’s concludes that:

- The raw wastewater sample has high polluted properties due to the different life style behavior such as municipal, commercial and institutional process.
- Using biological treatment by 12-hour SBR cycle followed by sand filter reduces the water properties by overall percentage 67.25%.

- Using biological treatment by 12-hour SBR cycle followed by pottery filter reduces the water properties by overall percentage 67.78%.
- Using biological treatment by 12-hour SBR cycle followed by pottery filter reduces the water properties significantly.
- A comparison was made between the results of the different treatment trials used in wastewater treatment and the Egyptian standards for irrigation or disposal in to drains.
- The final results of the treated wastewater by the two approaches were less than the Egyptian standards of treated water for irrigation purpose. But the second approach with pottery filter media was the more efficient than the other approach.
- The second approach was selected as a best choice for treatment of wastewater as a result of using a pottery filter such we consider the pottery scrabs an environmental waste.
- From the obtained results it is concluded that it is necessary to use a pottery filter after 12-hour SBR cycle for wastewater treatment to achieve best final properties of treated wastewater were matching with the Egyptian specification of treated water for irrigation purpose.

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