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Research paper

Sequencing batch reactor combined with coarse filter for domestic wastewater treatment

Hameedah M. Maatoq [1] *, Wisam S. Al-Rekabi [1], Sarmad A.Abbas [1]

[1] *Department of Civil Engineering Engineering, College of Engineering, University of Basrah, Basrah*
**Corresponding author E-mail: wisam.neaamah@uobasrah.edu.iq*

Abstract

SBR is a system of treatment that relies on activated sludge and consists of a group of processes occurring in the same tank to obtain a wastewater treatment. In this study, the SBR combined with the filter has been applied to treat domestic wastewater in Basra city. The treat-ment unit consists of a domestic wastewater collection tank (250 L), an SBR tank with dimensions of (60x50x30) cm. this tank contains a mixer, diffuser for aeration, and an open hole at a height of (0.15 cm) for the discharge of treated water to the filter which consists of tank (60x70x30) cm. and two layers of gravel, the first layer with a diameter (2/5 – 6/5) mm. and the second layer with a diameter (6/5 – 9/5) mm. with the thickness of 7cm for each layer. The results of removal pollutants for domestic wastewater (COD, BOD, PO4, SO4, and NO3), for SBR alone, were (93%, 93%, 52%, 10, and 65%) respectively and for SBR combined with filter for the same pollutant, the removal values were as follows (97%, 96%, 56% 29%, and 70%) respectively.

Keywords: *SBR, Filter; Nutrient Removal; Domestic Wastewaters; Biological Treatment.*

1. Introduction

Due to water scarcity, increasing population, industrial progress, and increasing welfare in most parts of the world, the quantities of wastewater have been increased dramatically, so it was necessary to research means of treating wastewater for use in agriculture and cooling factories [1]. SBR technology was first used in 1914 [2] throughout the twentieth century and this technology has gained great popularity because it has both operational advantages and flexibility. Additionally, the automation of the SBR process made its adoption much easier and supported the advancement of this technique. Research in SBR began in 1970 [3]. Irvine and Davis, 1970 [3] in conjunction with the improvement of the new discontinuity process (eg.Goronszy, 1979 [4]. One advantage of this batch system it's that it can be easily modified to continuous concentration fluctuations of pollutants [5]. In fact, the mass balance of the batch system describes the irregular behavior resulting from the normal changes in the flows of volume and pollutants concentration [6]. With the increasing use of micropro-cessor-based programmable logic controllers (PLC) and the increasing efficiency of these technologies, SBR processing technology has become increasingly popular. SBR wastewater treatment can produce sewage that is better than the secondary treatments are flexible and can perform a wide variety of fluctuations in hydraulic and organic flow.
The work of Norcross [7] and Ketchum [8] on the design and physical characteristics of sequencing batch reactors is essential for under-standings the characteristics of SBR. The first deals with the mechanical technological aspects of control of the SBR design. The second clearly describes the physical SBR system and describes the methods used to improve the design rationale necessary to achieve various treatment goals. The second international sequencing batch reactor technology seminar was held in Narbonne, France. July 2000, demon-strate the compatibility of this technology. Various articles in articles on sequencing batch reactor technology reflect a significant number of articles in this field and the system's ability to adapt to this great change.
Horkins et al. [9] conducted comprehensive comparative research between continuous systems such as SBR. This study aims to use SBR combined with a filter to treat domestic wastewater in Basra city, (Al-Junaina) by removing pollutants (COD, BOD, PO_4, SO_4, and NO_3).

2. Materials and methods

2.1. The contraction units

The main parts of the built unit are the settling tank, SBR reactor, including (mixer, pumps, control rooms, aeration system) and coarse filter as shown in figure (1).

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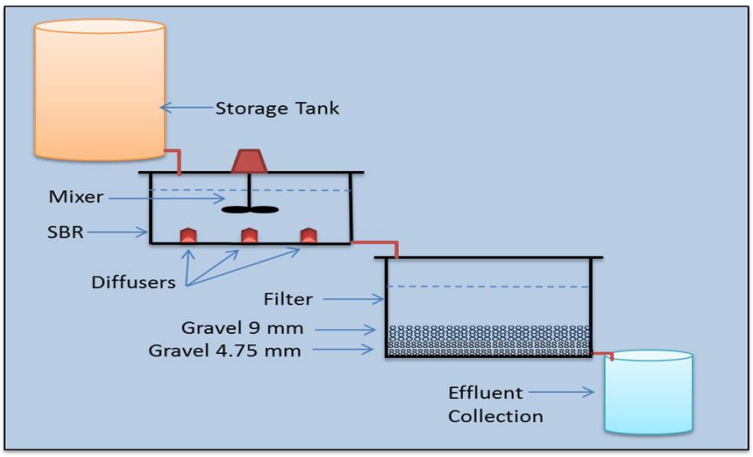


Fig. 1: Schematic Diagram of Constructed Unit.

2.2. Domestic wastewater

Raw wastewater is discharged from the manhole in Basra city (Al-Junaina region) and gathered in the collection tank which represents the source of the influent raw wastewater in the SBR reactor.

2.3. The methodology of the experimental work

Collection of sludge seeds from the main Baghdad treatment plant (Al-Dora treatment plant) and loading with a plastic drum (20L). The seeds are added to the SBR reactor after domestic wastewater is added and the SBR is operated through five stages: Filling, Aeration, Mixture, Sedimentation, and Draw, finally the wastewater effluent from SBR enters the filter and passes through the gravel layers slowly.

2.4. Analytical methods

Generally, the entire test was done in the sanitary laboratory in the department of civil engineering at the University of Basrah by using a spectrometer Dr5000. And some of the tests used BOD devices, ovens, sensitive scales, and digital devices. BOD checked method by Oxidirect instrument manual [10], COD (standard methods for water and wastewater) [11], PO_4, SO_4, and NO_3 (Dr 5000 spectrometer procedures manual [12].

3. Results and discussion

The experimental period for various operational cycle modes proceeded in both sequence batch reactor (SBR) and filter as indicated in the figure (2).

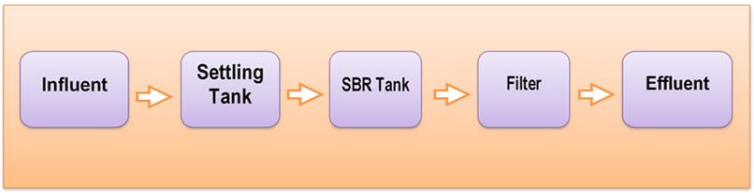


Fig. 2: Expermental Process.

Operations optimization is used to get the best cycle mode in the reactor which produces the best results. This process was carried out in cycle modes (1st to 4th), each treatment has its own set of parameters. The specification for each cycle is explained in the following paragraphs. The experiment began between February and September of 2020. The temperature range was (21 - 30) C°, which is appropriate for living sludge organisms, and it was operated in four-cycle modes as described in figure (3).

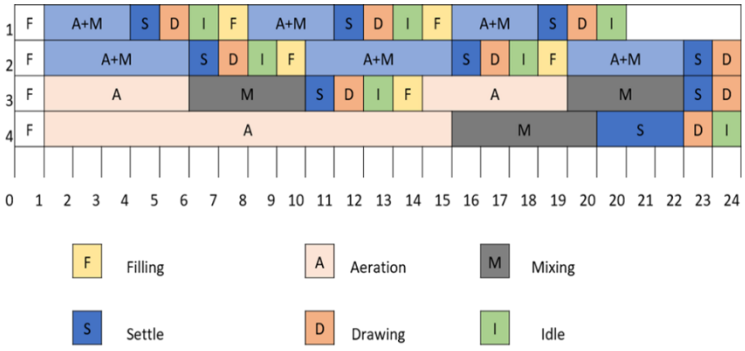


Fig. 3: SBR Operation Cycle Modes.

3.1. SBR Performance during Startup Period

The initial concentration of MLSS is 678 mg/l by applying aerobic conditions continuously at 24h with adding raw wastewater, after 7 days' notice the concentration of MLSS was raised to 1013 mg/l. after that, the sludge is acclimated to the sequence of aerobic and anoxic conditions. In this period we fill the SBR with raw wastewater and apply 15h aeration conditions, then the settled microorganism is used for the next treatment cycle. Figure (4) describe the growth of biomass concentration in term of MLSS during this period. The period of startup finished when the removal rate of pollutants becomes stable and happens after 30 days of the deference process maximum removal rate of COD during this stage was 85% figure (5) shows the rate of COD removal during this period.

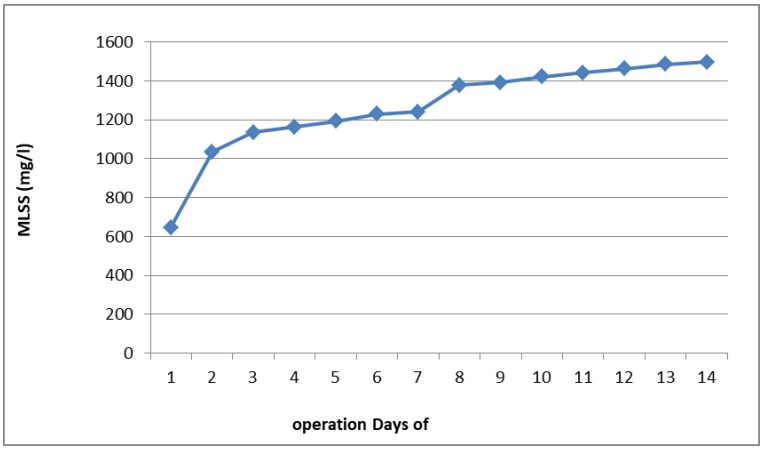


Fig. 4: Variation of MLSS Concentration During the Start-up Period.

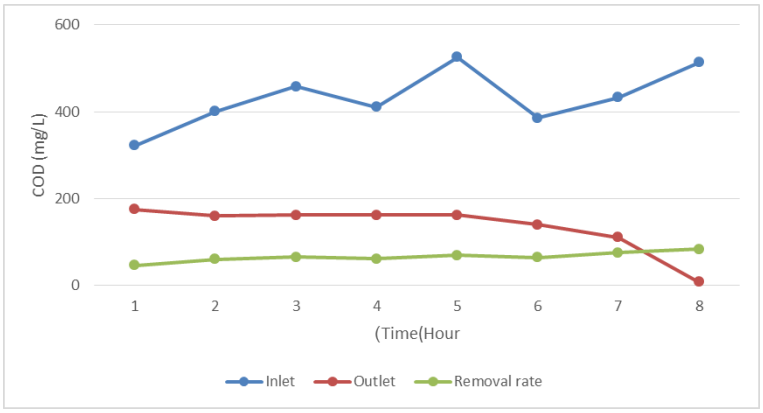


Fig. 5: Profile of COD Removal Rate During the Startup Period.

3.2. Results for operation period

3.2.1. Removal of COD

The effects of the aeration phase on the removal of COD were studied in various cycles modes of operation figure (3), with low dissolved oxygen (0.6 mg/L to 1.2 mg/L). COD was one of the most important pollutants in domestic wastewater throughout the experimental work. The average value of the influent for COD was (395.5 mg/l). the removal efficiency of COD was in SBR through four-cycle operation modes were (83%, 88%, 93%, and 92%) respectively and through combined SBR with filter for the same stage were (86%, 91%, 97%, and 95%) as shown in figure (6). Under low DO, COD oxidization is unaffected. In each cyclic mode of SBR activity, COD removal efficiency was more than 80 % as shown in Figure (6), and COD effluent concentration is reduced to a lower concentration. Due to the dilution in the reactor and the biological activated sludge adsorption, COD removal occurred predominantly in the first hour. Since the performance of the SBR for COD degradation is High (The efficiency of SBR removal is high), while coarse filter for COD removal is not completely carried out (filter removal efficiency is low). It means that the result of the coarse filter for COD degradation rate depends on the quality of COD influent that comes from SBR. When the COD of the SBR effluent is highly concentrated, the coarse filter for the efficiency of COD removal will increase accordingly. On the reverse, the removal efficiency of the coarse filter will decrease accordingly when the COD of the effluent SBR is at a low concentration.

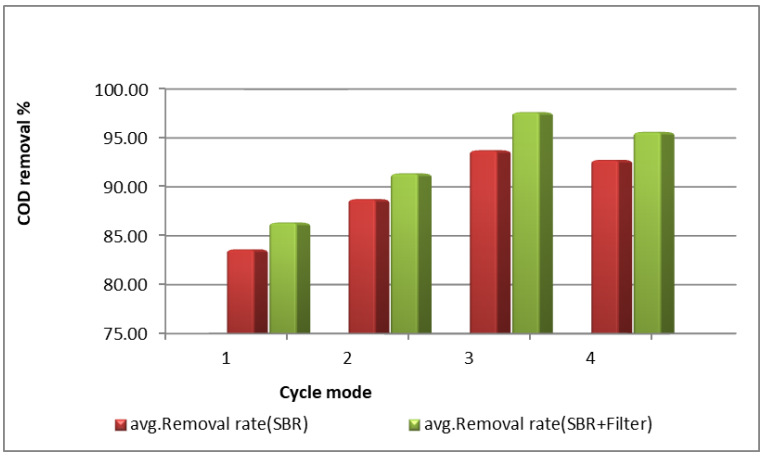


Fig. 6: COD Removal Efficiency by SBR & SBR + Filter.

3.2.2. Removal of BOD

The BOD in domestic wastewater was monitored throughout the work. The total average influent BOD was approximate)283.76 mg/l(. the removal of BOD through (the first, second, third, and fourth) stages were (88%, 92%, 93%, and 925) respectively and through SBR with filter, the removal rate for the same stages were (89%, 94%, 96%, and 93%) as shown in figure (7). The BOD test is based on the fact that in the case of abundant oxygen, the oxidation and cracking of the organic compounds will continue through the vital activity of the bacteria until the organic waste ends completely, and during that, three important activities occur, the first is the oxidation of part of the organic compounds and gives new compounds to obtain energy for preservation and the second in conjunction with that transformed some of the organic wastes of new cells are used in that energy that has been released and the third is when the concentrations of organic matter decrease to the maximum degree, the cells begin to feed on their stock of stimulated life and earthly security, strategies for controlling organic compounds in what is called respiration or endogenous respiration, cells die and remain from the non-amendable tissues Cell debris. We should also expect that the BOD value is less than COD. The reason for this is that many organic compounds that are difficult to biologically oxidize such as lignin are chemically oxidized and the inorganic materials that are oxidized will increase the phenotypic value of the organic matter content of the sample; Also, some substances can be toxic to bacteria that oxidize in BOD test; Also, high values of COD may be due to some inorganic materials that interact with the chromate! All these reasons explain why the BOD value is less than COD.

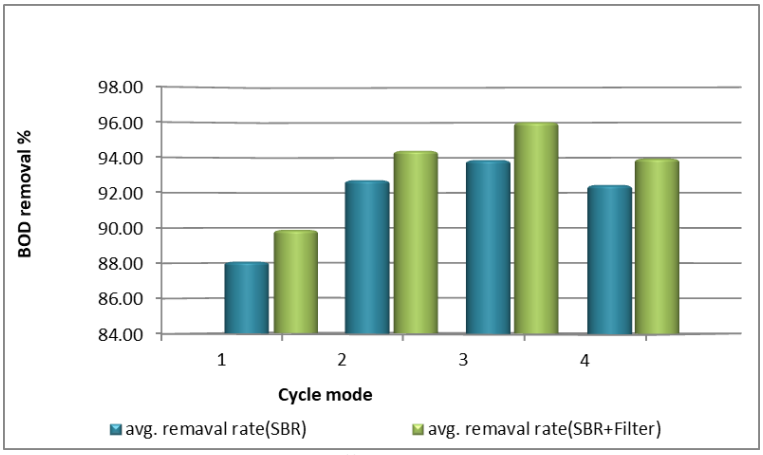


Fig. 7: BOD Removal Efficiency by SBR & SBR + Filter.

3.2.3. Removal of (NO3N)

Nitrate removal efficiencies for SBR operating cycle modes (1st, 2nd, 3rd, and 4th) were (93%, 75%, 65%, and 33%) but for SBR with filter, the efficiencies removal for the same cycle were (93%, 82%, 70%, and 37%) as shown in figure (8). The reason for this removal is biological nitrification, which is a term describing a two-step biological process in which * NH4 - N is oxidized to nitrite NO2 and then oxidized to NO3 in order to reduce the concentration of ammonia toxic to the aquatic organism. Two groups of autotrophic bacteria carry out the nitrification process: Nitrosomonas oxidizes ammonia to nitrite NO2 and Nitrobacter oxidizes nitrite NO2 to nitrate NO3, The nitrates are converted to nitrogen gas in a subsequent step called denitrification.

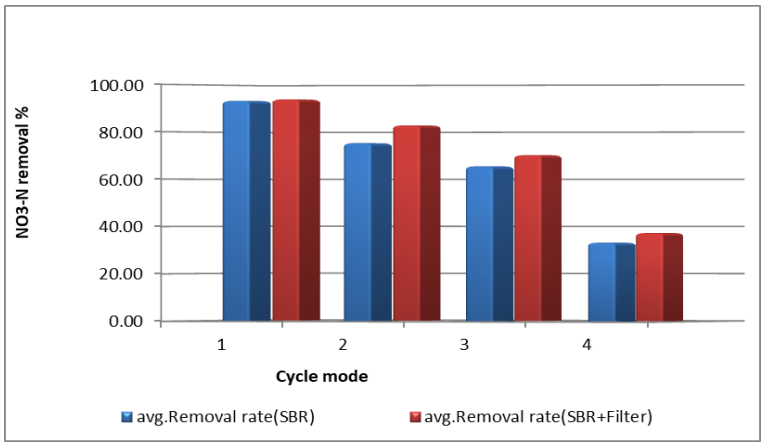


Fig. 8: NO_3N Removal Efficiency by SBR & SBR + Filter.

3.2.4. Removal of PO4

The phosphate removal efficiencies were (57%, 67%, 52%, and 59%) in the (first, second, third, and fourth) modes and for SBR with filter were (61%, 68%, 56%, and 62%) for the same cycle as shown in figure (9). One of the prerequisites for the phosphating process is subjecting the sludge with the wastewater to an aerobic/anaerobic cycle, and successively, the micro-organisms capable of storing phosphorous in their biomass in the form of a complex phosphate (Poly-P) multiply by division. Once the phosphate collector and the rest arrive Microorganisms into the antenna environment, most of the easily oxidized organic materials will move into the phosphate-storing bacteria, and when the organic materials are oxidized, the resulting energy is used to synthesize polyphosphates and form new cells that are the cells responsible for removing phosphorous in the system.

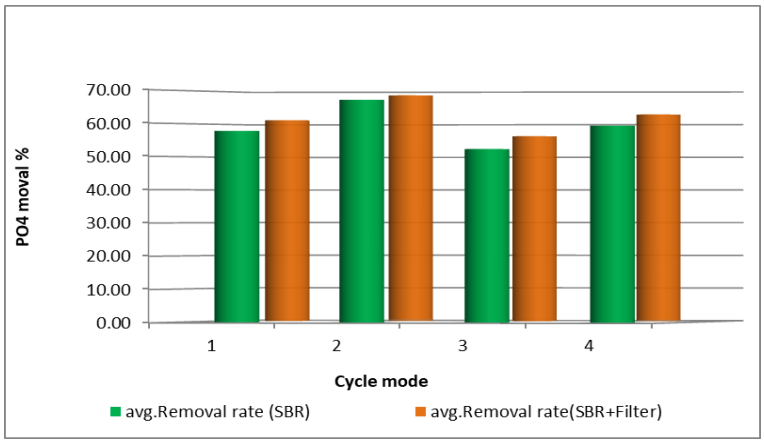


Fig. 9: PO_4 Removal Efficiency by SBR & SBR + Filter.

3.2.5. Removal of SO4

Sulfate removal efficiencies for SBR operation cycle modes (first, second, third, and fourth) were (16%, 17%, 10%, and 9%) respectively and SBR with filter the removal efficiencies were (25%, 26%, 20%, and 25%) for the same operation cycle modes as shown in figure (10). The reason for obtaining these percentages may be the need for the sulfate removal bacteria (sulfide reducing bacteria, SRB) these bacteria are used as acceptors by hydrogen and organic substances as donors of electrons and sulfate.

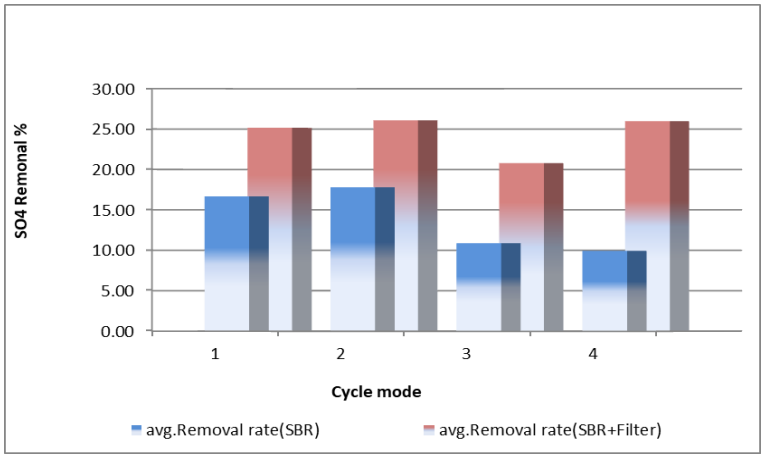


Fig. 10: SO_4 Removal Efficiency by SBR & SBR + Filter.

3.2.6. Removal of total suspended solid (TSS)

The removal of average effluent concentration TSS in the first cycle mode was (157.83mg/l), the second cycle mode was (133.75mg/l), and in the third cycle mode the average effluent concentration was (172.42mg/l), and (163.14mg/l) for the fourth cycle mode. The average effluent concentrations for SBR with filter for the fourth cycle mode were (52.5%, 47.75%, 67.85%, and 49.7%) mg/l, respectively as shown in figure (11).
The reason for the increase in of concentration TSS in SBR was the sedimentation time as the sedimentation process requires a longer time or the presence of bacterial cells in the effluent produced.

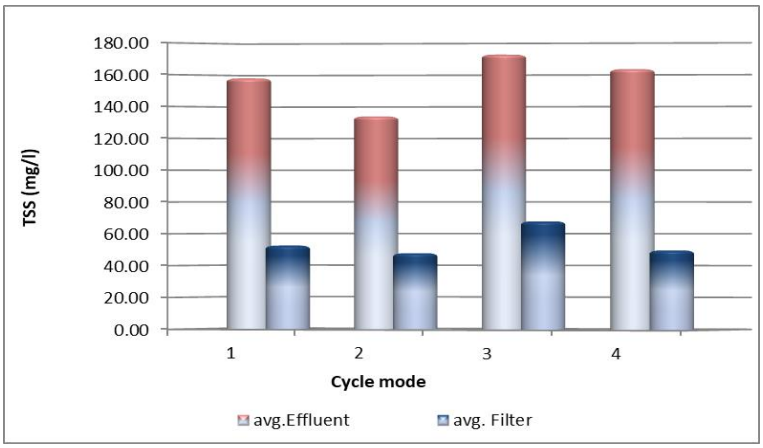


Fig. 11: Average Value of TSS in SBR & SBR + Filter.

4. Conclusions

In four operating cycle modes (first, second, third, and fourth), domestic wastewater was treated using a batch reactor and a filter. The following conclusions are drawn from the current stage's testing and results:

1) The sequencing batch reactor (SBR) system can successfully treat Al-Basra municipal wastewater and obtain a high pollutant removal rate
2) The results indicate that SBR with the filter is more efficient than SBR alone at removing pollutants (COD, BOD, PO4, SO4, and TSS).

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