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Nutrients Removal from Domestic Wastewater in Basrah City (Southern Iraq) using Combined A^2/O Bio Contact Oxidation Technology

Husham T. Ibrahim[1*], *Ali H.* Al-Aboodi[1], and *Sarmad A.* Abbas[1]

[1]Department of Civil Engineering, College of Engineering, University of Basrah, Basrah, Iraq

Abstract: The nutrients removal from domestic wastewater in Basrah City (Southern Iraq) by using the technology of up flow A^2/O Bio Contact Oxidation with bypass flow was studied in this research. The treatment system was designed in order to treating 100 L/day of domestic wastewater by using a laboratory scale Anaerobic-Anoxic-Aerobic Moving Bed Biofilm Reactors (MBBRS) in series form with effective volume equal to 15 L, 15 L, and 30 L respectively. Kaldnes polyethylene media (K1) was used in this study in order to achieve attached biofilm process with filling ratio equal to 30% for both anaerobic/ anoxic MBBRS, and with filling ratio 50% for aerobic MBBR .After the biofilm was developed in the carriers the system was operated under internal recycle ratio equal to 100%, bypass ratio equal to 40%, and under 3 different external recycle ratio (25%, 50%, and 100%). The experimental results showed that the optimal value of the external recycle ratio was equal to 50 %, which the average values of removal efficiencies of COD, NH_4^+-N, TN and TP were equal to 98.15 %, 97.16%, 82.12%, and 93.39 % respectively. Under the condition of the optimum value of external recycle ratio the average concentration of the dissolved oxygen in both anoxic and aerobic reactors were equal to 0.151 mg/L, and 3.57 mg/L respectively, and the temperature of water was controlled in the range of 35^o C in the anaerobic reactor and in the range of 30^{o}C in both anoxic and aerobic reactors by used temperature controlled.

1 Introduction

The increased of world population by each year, and urbanization, caused to increase the quantity of wastewater with decreasing in the available area to build additional wastewater treatment plants, also the limitation of discharge for various pollutants especially for nutrients (TN, and TP) was became more stringently .So it's important to find alternative and new technology to treating the wastewater especially for nutrients such as nitrogen and phosphorus instead of conventional activated sludge processes which presented many

* Corresponding author: drhushamibrahim@gmail.com

shortcomings like the sludge rising, sludge bulking, higher retention time requirement, and end up to large reactors volume [1-3].

In general, Iraq has suffered from a shortage of surface water resources for more than a decade due to the high degradation in the levels of the Tigris and Euphrates rivers, low rainfall and high temperature degree, as well as high pollution in river water due to the direct connection of rainwater networks with the sewage networks and discharged most of the wastewater to the main and sub-rivers due to the lack of sewage treatment plants. Therefore, it is necessary to seriously thinking in order to study the suitability of modern technologies used in the treatment of sewage water to treat wastewater in Iraq by establishment of new sewage treatment plants operating with the latest international technologies to provide a new source of water resources that can be used for the purposes of both irrigation and Drinking.

Bio-contact oxidation technologies (Fixed biofilm reactors, Membrane reactors, Moving bed biofilm reactors, and Hybrid reactors) was introduced in order to face all the challenges in the conventional activated sludge processes. The process of biofilm was proved to be more dependable than suspended growth systems for both nitrogen and organic carbon removal without any problems in the system of suspended growth, and the effective cost of the nitrogen removal can be achieved by using biofilm reactors in compact form [4,5] .There are many researchers investigating the ability of the biofilm processes to treating wastewater, they concluded that the main disadvantage of this process is the possibility of obstruction of the biofilm media [6-12].

Nam et al, (2000) [13], used laboratory scale anaerobic/anoxic/aerobic fixed film reactors in series form with internal recycle ratio (flow from the aerobic reactor to the anoxic reactor) and external recycle ratio (flow from final settling tank to the anaerobic reactor) equal to 50% from the influent flow to treating 34 L of synthetic wastewater by operated the system under three bypass flow ratio.The results of this study demonstrated that this fixed film system was useful to enhancing the nutrients removal from synthetic wastewater, and the optimum value of the bypass flow ratio was equal to 40%.

The most famous Bio Contact Oxidation technology that was presented from the last years for treating different types of wastewater under the conditions of biofilm processes that take advantages of both suspended and attached growth systems without clogging problem is the Moving Bed Biofilm technology [14-17].The first MBBR was introduced in Norway in 1990, in 1999 this process became popular with more than ninety facilities in seventeen countries in Europe and United State of America [18,19].Now there are more than six hundred plants operating under the process of MBBR in fifty countries [20].

The main idea of the MBBR process is operating the treatment system under continuous flow process with combine the attached and suspended biomass processes with theirs advantages by growing the biofilm on a small high density plastic carrier elements with a large surface area, those carriers are kept in suspension and continuous movement along in the processes by aeration and/or mixing, thus improving the processing performance of the reactors and make this process more ideal under very high load with little sensitive to load variation [18, 21-23] The main advantages of the MBBR process are [24] :

1- The reactors volume is totally mixing without any unused or dead part.

2- The head loss is small and there is no need for biomass recycling.

There are many researchers interested in studying the technique of MBBR bases to treat different types of wastewater such as fish farming wastewater [25], landfill leachate [26], paper industry wastewater [27], cheese factory wastewater [11], dairy wastewater [15, 28], and domestic wastewater [2, 3, 10, 29-35], all these researches presented the MBBR technique as the most useful and economical method to treating all the types of wastewater especially for nutrient removal.

The main objective of this research is to study the ability of the technology of A^2/O Bio Contact Oxidation with bypass flow for domestic wastewater treatment in Basrah City (Southern Iraq) and present this technology as an alternative and more successful method for simultaneous organic and nutrients removal from domestic wastewater by operating this process under internal recycle ratio (from aerobic MBBR to anoxic MBBR) equal to 100% from the influent flow, bypass ratio (part from the influent flow feeding directly to the anoxic MBBR) equal to 40%, and operating the system under 3 different external recycle ratio (25%, 50%, and 100% from the influent flow, which the treated water was fed from the final settling tank to the anaerobic reactor) in order to investigate the optimum value of external recycle ratio give the best removal efficiencies.

2 Materials and methods

2.1 Experimental setup

In this research, the experiments was started in early of July 2017 to the end of September 2017, experiments were designed and conducted by using one unit of a laboratory scale Anaerobic-Anoxic-Aerobic reactors in series form in order to treating 100 L/day for domestic wastewater in Basrah City (Southern Iraq) under the processes of up flow A^2 /O Bio Contact Oxidation with bypass flow in order to achieve simultaneous removal of organic carbon and nutrients. This unit consist of square primary clarifier (made of glass 75 cm × 75 cm × 50 cm), square anaerobic reactor (made of glass 25 cm × 25 cm × 30 cm) with effective volume equal to 15 L, square anoxic reactor (made of glass 25 cm × 25 cm × 30 cm) with effective volume equal to 15 L, square aerobic reactor (made of glass 35 cm × 35 cm × 30 cm) with effective volume equal to 30 L, and square final settling tank (made of glass 75 cm × 75 cm × 50 cm).The aeration system in aerobic reactor was consist of 2 fine bubble bar type diffusers fixed at 5 cm from the bottom of reactor, aeration was achieved by using air compressor with a capacity of 150 L/min. The aeration supply in the aerobic reactor was controlled at a constant rate of 15 L/min over the total period of operation. The propeller mixer was installed in both anaerobic and anoxic reactors in order to keep the biofilm carriers in the case of continuous movement within the reactors.

Kaldnes polyethylene media (K1) with density equal to 0.93 g/cm^3 and effective specific area equal to 500 m^2/m^3 was used in this study in order to achieve attached biofilm process with filling ratio equal to 30% for both anaerobic and anoxic $MBBR_S$, and with filling ratio 50% for aerobic MBBR. Small sized sieve with opening diameter approximately equal to 2 mm was used in order to retain the media elements inside the reactors. The K1 media characteristics used in this research are shown in Table 1.

Table 1. K1 media characteristics.

Parameter	Value
Dimension (mm)	25×10
Surface area (m^2/m^3)	500
Filling ratio (%)	15-65
Density (g/cm^3)	0.93
Number/m^3	150,000

2.2 Operation procedure

Seed sludge was taken from Hamdan Wastewater Treatment Plant which located in Basrah City (Southern Iraq) and screened with a sieve in order to ensure that it is free from inorganic materials, after the seeding sludge was aerated for three days, mixing with raw domestic wastewater by ratio of 50% and filling 50% of the reactors volume. After that the system will be startup by operated the reactors under batch mode for three weeks. During this operation mode, all the reactors were filled with period equal to 4 hours, mixed liquor was aerated in aerobic reactor with gas/water ratio equal to 5/1 and mixing in both anaerobic and anoxic reactor for 16 hours, settling time period equal to 2 hours, then 50% from the water was discharged for 2 hours. At the end of startup period the biofilm was grew in the carriers elements, which the total concentration of mixed liquor suspended solids (total MLSS) in anaerobic, anoxic, aerobic reactors reached to 2316 mg/ L, 2710 mg/L, 3180 mg/L respectively.

After the biofilm was developed in the carriers the system was operated under continuous up-flow with total HRT equal to 14.4 hours, internal recycle ratio (from aerobic MBBR to anoxic MBBR) equal to 100% from the influent flow, and bypass ratio (part from the influent flow feeding directly to the anoxic MBBR) equal to 40% in order to improving the denitrification processes. The improving of phosphorus uptake was done by operated the system under 3 different external recycle ratio (25%, 50%, and 100% from the influent flow), which the treated water was fed from the final settling tank to the anaerobic MBBR. During this operation mode the aeration system was operated under gas/water ratio equal to 5:1 (The average concentration of dissolved oxygen in both anoxic and aerobic reactors were equal to 0.152 mg/L, and 3.59 mg/L respectively), and the temperature of water was controlled in the range of 35o C in the anaerobic reactor and in the range of 30oC in both anoxic and aerobic reactors by used temperature controller. Fig.1 shows the schematic diagram of the up flow A2/O Bio Contact Oxidation process which used in this study.

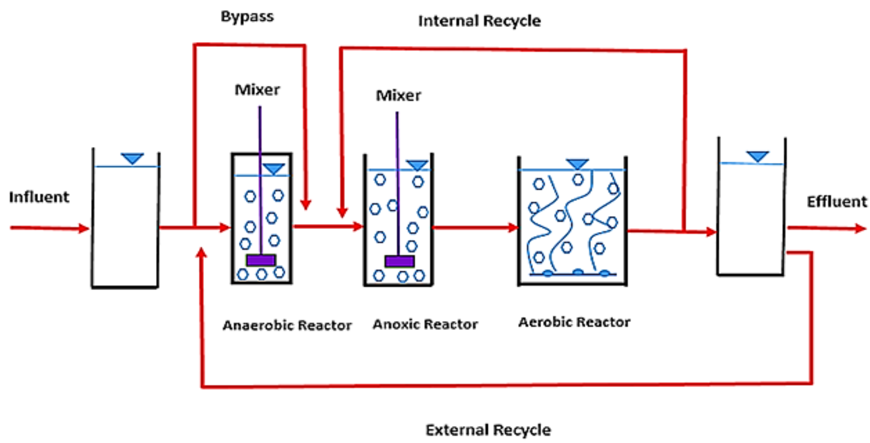

Fig.1. Schematic diagram of the up flow A^2/O MBBR.

The samples of COD, NH_4^+-N, TN, and TP were taken from the influent and effluent of the system twice a week and the tests were done according to the standard methods which described in American Public Health Association 21^{th} Edition (2005) [36].The attached biomass in the bio-media elements was measured according to the method used by (Andreottola et al., 2000 a & b; Jahren et al., 2002; Helness, 2007) [27,33,34,37].

2.3 Expected performance

Generally, the mechanism of biological nitrogen removal depending on the combination of two main processes namely Nitrification-Denitrification processes. Nitrification process can be define as the ammonium oxidation under aeration condition by using oxygen as electronic acceptor, this process can be classified into either Fully Nitrification process (which ammonium oxidation to nitrite and then oxidation nitrite to nitrate) or Partially Nitrification processes (which ammonium oxidation to nitrite only) depending on the concentration of dissolved oxygen [38-40]. The concentration of dissolved oxygen is a very important factor affecting on the nitrification process [41-43].The level of dissolved oxygen for partially nitrification process is in the range of 0.5-1.5 mg /L, while for fully nitrification process is more than 2 mg/L [41,44,45].In the other hand Denitrification process can be define as the very important process in the nitrogen removal by using nitrate and nitrite as electronic acceptors instead of oxygen under anoxic or/and anaerobic condition ,which the concentration of dissolved oxygen must be less than 0.5 mg/L [39,46,47]. The increase of the nitrification rate in aerobic reactor lead to increasing the nitrate which enters the anoxic reactor, finally more denitrification and COD removal will be achieved.

Part from the NH_4^+ -N will be removed in both anaerobic and anoxic reactors under the process of Anaerobic Ammonium Oxidation (Anammox Process), which ammonium is directly converted to dinitrogen gas using nitrite as the electronic acceptor without any need of carbon source or oxygen with producing of small amount of nitrate(approximately 10%).

NO_2^- is not only an electronic acceptor for NH_4^+ -N oxidation, but it is also as an electronic acceptor for carbon dioxide reduction [48-51].Also part from the TP will removed in anaerobic and anoxic reactors under the process of Phosphate Denitrification, which the Denitrifying Phosphate Accumulating Organisms remove some of the phosphate by using nitrate as electronic acceptor and consumed some of the COD and NH_4^+ -N [2, 3, 52, 53]. The dissolved oxygen in the aerobic reactor will be consumed by a competition between COD removal bacteria (Heterotrophic Organisms),TP removal bacteria (Phosphate Accumulating Organisms), and Nitrification bacteria (Autotrophic Organisms), while the COD will be consumed by a competition between both Phosphate Accumulating and Heterotrophic Organisms [2,3,39].

3 Results and discussion

In this study the lab scale Anaerobic-Anoxic-Aerobic reactors in series form was designed and constructed in order to treating 100 L/day for domestic wastewater in Basrah City (Southern Iraq) under the processes of Fully Nitrification-Denitrification continuous up flow A^2 /O Bio Contact Oxidation with bypass flow in order to achieve simultaneous removal of organic carbon and nutrients by operating the system under internal recycle ratio equal to 100% from the influent flow, bypass ratio equal to 40% from the influent flow, gas/water ratio equal to 5:1, and under 3 different external recycle ratio (25%, 50%, and 100% from the influent flow) in order to investigate the optimum value of external recycle ratio which give the best removal efficiencies. The performance data of treating system were presented in Table 2&3, and shown in Fig. 2 to Fig.6.

During experiment period and under the condition of continuous flow the influent concentration for COD, NH 4+ -N, TN, and TP were in the range of 140.3 mg/L - 356.7 mg/L (Average = 262.88, Standard Deviation = 77.17), 27.5 mg/L - 47.6 mg/L (Average = 35.78, Standard Deviation = 7.09), 25.2 mg/L – 50.2 mg/L (Average = 38.64, Standard Deviation = 8.25), and 2.1 mg/L – 4.6 mg/L (Average = 3.44, Standard Deviation = 0.82) respectively. The average concentration of dissolved oxygen in both anoxic and aerobic reactors were equal to 0.152 mg/L, (Standard Deviation = 0.012), and 3.59 mg/L (Standard Deviation = 0.189) respectively.

Under the first running mode (External recycle ratio = 25% from the influent flow) the influent concentration for COD, NH 4+ -N, TN, and TP were in the range of 162.9 mg/L – 311.4 mg/L (Average = 222.65, Standard Deviation = 69.44), 27.5 mg/L – 43.7 mg/L (Average = 32.85, Standard Deviation = 7.55), 28.9 mg/L – 49.3 mg/L (Average = 38.98, Standard Deviation = 8.44), and 2.1 mg/L – 4.5 mg/L (Average = 3.16, Standard Deviation = 1.04) respectively. During this mode the total removal efficiency for COD, NH 4+ -N, TN, and TP were in the range of 88.5 % – 94.06 % (Average = 91.13, Standard Deviation = 2.42), 82.8 % – 91.53 % (Average = 87.06, Standard Deviation = 3.57), 67.65 % – 75.25 % (Average = 70.6, Standard Deviation = 3.4), and 82.89 % – 89.11 % (Average = 85.65, Standard Deviation = 2.62) respectively, while the average concentration of dissolved oxygen in both anoxic and aerobic reactors were equal to 0.141 mg/L (Standard Deviation = 0.004), and 3.59 mg/L (Standard Deviation = 0.156) respectively.

Under the second running mode (External recycle ratio = 50 % from the influent flow) the influent concentration for COD, NH 4+ -N, TN, and TP were in the range of 266.4 mg/L – 345.8 mg/L (Average = 310.55, Standard Deviation = 34.3), 34.1 mg/L – 45.6 mg/L (Average = 39.3, Standard Deviation = 4.75), 25.2 mg/L – 46.8 mg/L (Average = 37.08, Standard Deviation = 8.93), and 2.91 mg/L – 4.37 mg/L (Average = 3.56, Standard Deviation = 0.68) respectively. During this mode the total removal efficiency for COD, NH 4+ -N, TN, and TP were in the range of 97.67 % – 98.53 % (Average = 98.15, Standard Deviation = 0.37), 94.72 % – 98.07 % (Average = 97.16, Standard Deviation = 1.63), 77.38 % – 88.95 % (Average = 82.12, Standard Deviation = 5.09), and 90.03 % – 96.44 % (Average = 93.39, Standard Deviation = 2.91) respectively, while the average concentration of dissolved oxygen in both anoxic and aerobic reactors were equal to 0.151 mg/L (Standard Deviation = 0.004), and 3.57 mg/L (Standard Deviation = 0.311) respectively.

Under the third running mode (External recycle ratio = 100 % from the influent flow) the influent concentration for COD, NH 4+ -N, TN, and TP were in the range of 140.3 mg/L – 356.7 mg/L (Average = 255.45, Standard Deviation = 102.83), 28.9 mg/L – 47.6 mg/L (Average = 35.2, Standard Deviation = 8.75), 28.3 mg/L – 50.2 mg/L (Average = 39.88, Standard Deviation = 9.66), and 2.47 mg/L – 4.6 mg/L (Average = 3.6, Standard Deviation = 0.87) respectively. During this mode the total removal efficiency for COD, NH 4+ -N, TN, and TP were in the range of 92.23 % – 95.28 % (Average = 93.93, Standard Deviation = 1.51), 87.2 % – 92.65 % (Average = 90.74, Standard Deviation = 2.45), 68.9 % – 77.29 % (Average = 74.45, Standard Deviation = 3.77), and 81.3 % – 92.78 % (Average = 88.05, Standard Deviation = 4.83) respectively, while the average concentration of dissolved oxygen in both anoxic and aerobic reactors were equal to 0.164 mg/L (Standard Deviation = 0.01), and 3.62 mg/L (Standard Deviation = 0.092) respectively.

The results illustrated that when the external recycle ratio increased from 25% to 50% the average values of total removal efficiencies for COD, NH 4+ -N, TN, and TP were increased by 7.7 %, 11.6 %, 16.32 %, and 9.04 % respectively, while the average values of total effluent concentration for COD, NH 4+ -N, TN, and TP were decreased from 18.55 mg/L (Standard Deviation = 1.61) to 5.7 mg/L (Standard Deviation = 0.9), from 4.08 mg/L (Standard Deviation = 0.55) to 1.07 mg/L (Standard Deviation = 0.49), from 11.35 mg/L (Standard Deviation = 2.05) to 6.53 mg/L (Standard Deviation = 2.29), and from 0.44 mg/L (Standard Deviation = 0.08) to 0.24 mg/L (Standard Deviation = 0.11) respectively. When the external recycle ratio increased from 50 % to 100 % the average values of total removal efficiencies for COD, NH 4+ -N, TN, and TP were decreased by 4.49 %, 7.08 %, 10.3 %, and 6.06 % respectively, while the average values of total effluent concentration for COD, NH 4+ -N, TN, and TP were increased from 5.7 mg/L (Standard Deviation = 0.9) to 14.35 mg/L (Standard Deviation = 2.75), from 1.07 mg/L (Standard Deviation = 0.49) to 3.15 mg/L (Standard Deviation = 0.53), from 6.53 mg/L (Standard Deviation = 2.29) to 9.95 mg/L (Standard Deviation = 1.4), and from 0.24 mg/L (Standard Deviation = 0.11) to 0.45 mg/L (Standard Deviation = 0.28) respectively.

The External recycle ratio in the range 25% - 100 % did not significantly affect on the average values of total removal efficiencies for COD, NH 4+ -N, TP and the average values of total effluent concentration for COD, NH 4+ -N, and TP could meet with many discharge standard of pollutants for treated wastewater in the world. While the effect of external recycle ratio is clear on the TN removal where the average value of total effluent concentration for TN could meet with many discharge standard of pollutants for treated wastewater in the world only when the external recycle ratio is equal to 50 % from the influent flow. Finally the results show that the optimum value of external recycle ratio which give the best removal efficiencies for COD, NH 4+ -N, TN, and TP is equal to 50 % from the influent flow.

Table 2. The Performance Data of Treating System.

External Recycle Ratio	COD			NH_4^+-N			TN			TP		
	Influent (mg/L)	Effluent (mg/L)	Removal Efficiency (%)	Influent (mg/L)	Effluent (mg/L)	Removal Efficiency (%)	Influent (mg/L)	Effluent (mg/L)	Removal Efficiency (%)	Influent (mg/L)	Effluent (mg/L)	Removal Efficiency (%)
25	162.90	16.30	89.99	32.30	4.20	87.00	40.50	13.10	67.65	3.41	0.52	84.75
25	311.40	18.50	94.06	27.90	4.80	82.80	37.20	11.70	68.55	2.62	0.37	85.88
25	172.10	19.80	88.50	43.70	3.70	91.53	28.90	8.40	70.93	4.50	0.49	89.11
25	244.20	19.60	91.97	27.50	3.60	86.91	49.30	12.20	75.25	2.10	0.36	82.86
50	345.80	6.70	98.06	34.10	1.80	94.72	37.40	6.40	82.89	3.09	0.11	96.44
50	327.20	4.80	98.53	45.60	0.90	98.03	46.80	9.70	79.27	4.37	0.35	91.99
50	266.40	6.20	97.67	39.20	0.85	97.83	25.20	5.70	77.38	2.91	0.29	90.03
50	302.80	5.10	98.32	38.30	0.74	98.07	38.90	4.30	88.95	3.86	0.19	95.08
100	356.70	17.40	95.12	28.90	3.70	87.20	36.10	8.70	75.90	3.60	0.26	92.78
100	140.30	10.90	92.23	47.60	3.50	92.65	50.20	11.40	77.29	4.60	0.86	81.30
100	198.70	13.70	93.11	35.10	2.80	92.02	44.90	10.90	75.72	3.74	0.41	89.04
100	326.10	15.40	95.28	29.20	2.60	91.10	28.30	8.80	68.90	2.47	0.27	89.07

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Table 3. The Average Performance of Treating System.

External Recycle Ratio	COD			NH_4^+-N			TN			TP		
	Average Influent (mg/L)	Average Effluent (mg/L)	Average Removal Efficiency (%)	Average Influent (mg/L)	Average Effluent (mg/L)	Average Removal Efficiency (%)	Average Influent (mg/L)	Average Effluent (mg/L)	Average Removal Efficiency (%)	Average Influent (mg/L)	Average Effluent (mg/L)	Average Removal Efficiency (%)
25	222.65	18.55	91.13	32.85	4.08	87.06	38.98	11.35	70.60	3.16	0.44	85.65
50	310.55	5.70	98.15	39.30	1.07	97.16	37.08	6.53	82.12	3.56	0.24	93.39
100	255.45	14.35	93.93	35.20	3.15	90.74	39.88	9.95	74.45	3.60	0.45	88.05

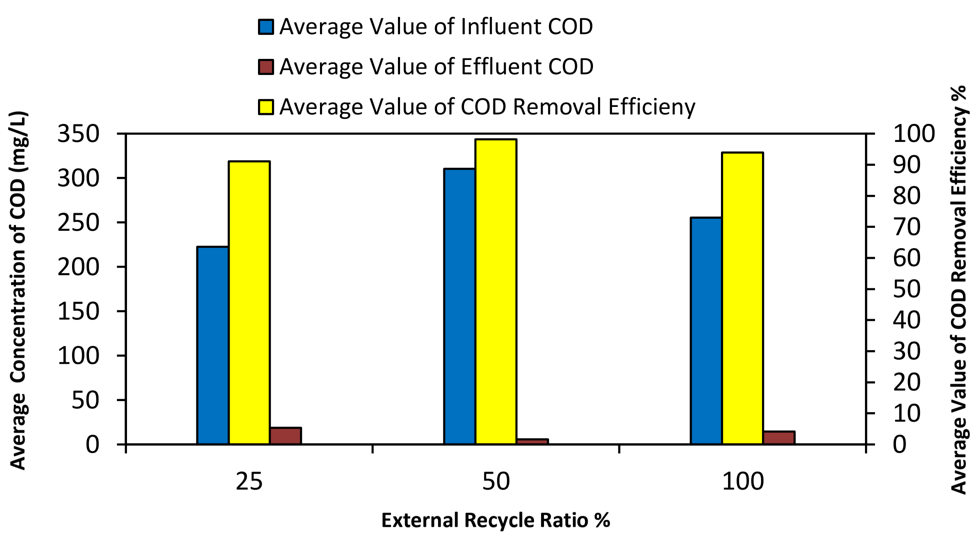

Fig. 2. Effect of External Recycle Ratio on the COD Removal

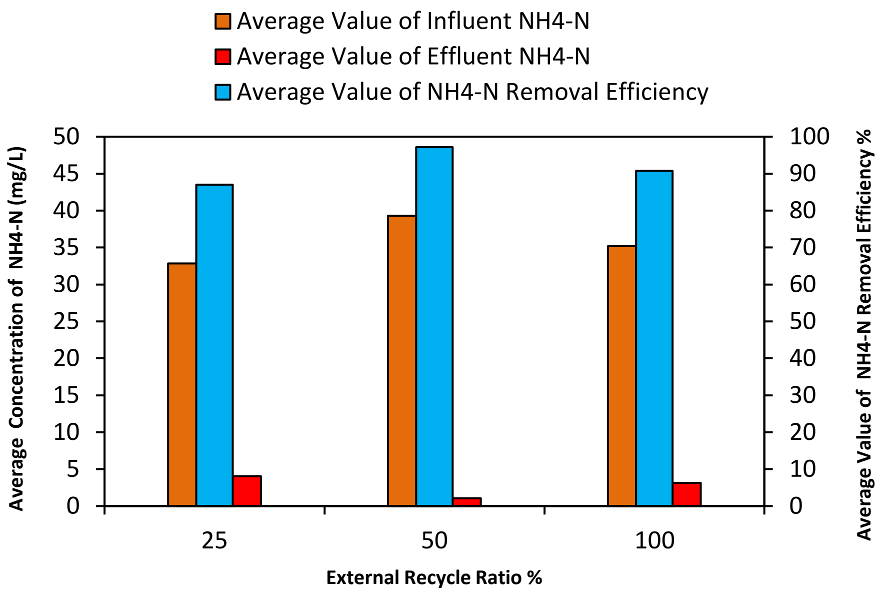

Fig. 3. Effect of External Recycle Ratio on the NH_4^+ -N Removal

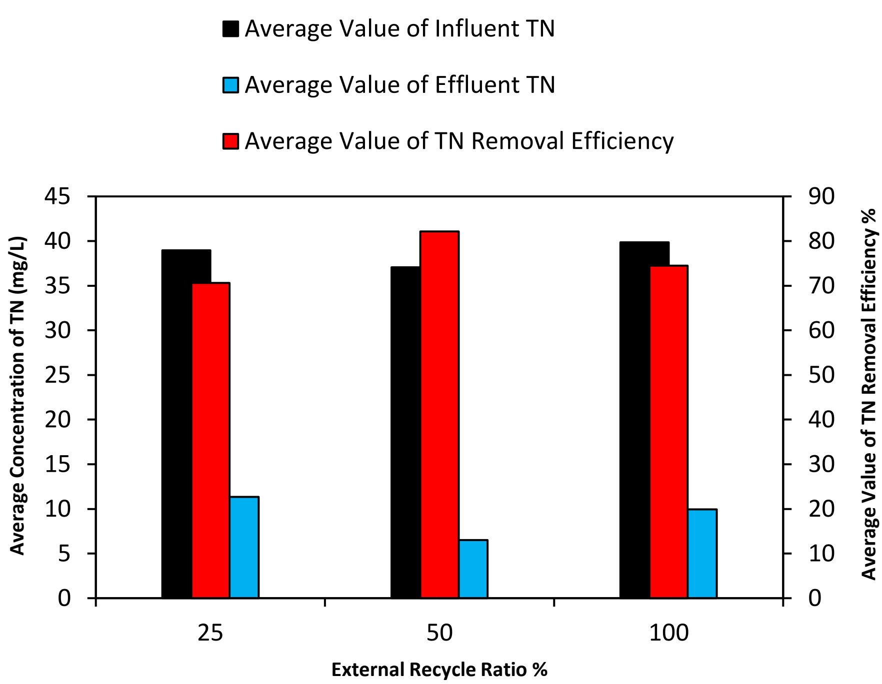

Fig. 4. Effect of External Recycle Ratio on the TN Removal

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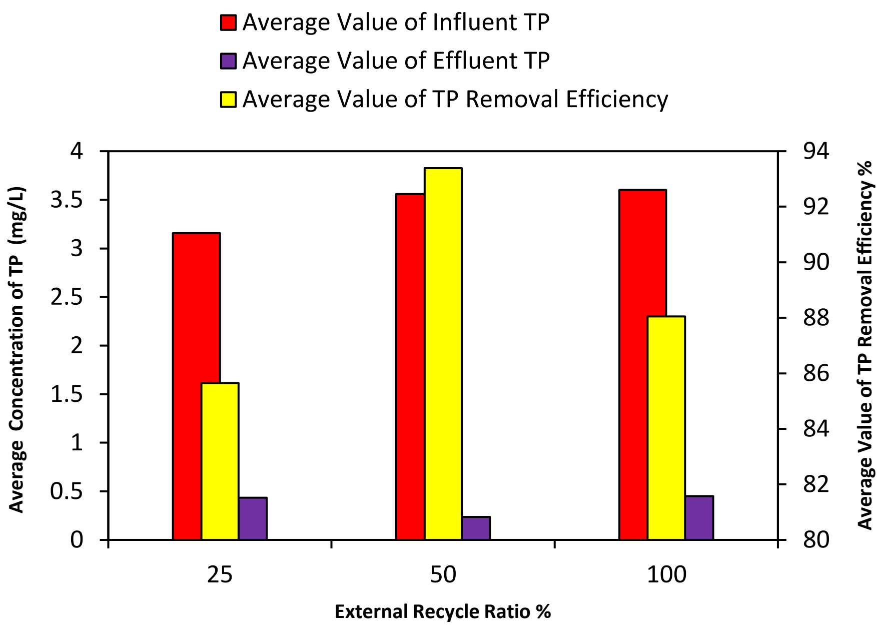
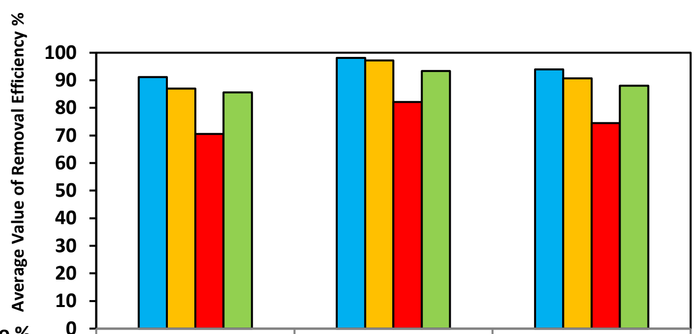


Fig. 5. Effect of External Recycle Ratio on the TP Removal



External Recycle Ratio %	25	50	100
Average Value of COD Removal Efficiency	91.13	98.15	93.93
Average Value of NH4-N Removal Efficiency	87.06	97.16	90.74
Average Value of TN Removal Efficiency	70.60	82.12	74.45
Average Value of TP Removal Efficiency	85.65	93.39	88.05

Fig. 6. Effect of External Recycle Ratio on the Average Values of Total Removal Efficiencies for COD, NH_4^+-N, TN, and TP

4 **Conclusion**

According to the experiment results the following conclusions can be reached:

1. The gas/water ration with value equal to 5:1 was efficient in making the treating system work under the process of Fully Nitrification-Denitrification by controlling the concentration of the dissolved oxygen in aerobic reactor in the range of 3.27 mg/L- 3.92 mg/L.
2. When the External Recycle Ratio increased from 25% to 50% the average values of total removal efficiencies for COD, NH_4^+ -N, TN, and TP were increased by 7.7 %, 11.6 %, 16.32 %, and 9.04 % respectively.
3. When the External Recycle Ratio increased from 50 % to 100 % the average values of total removal efficiencies for COD, NH_4^+ -N, TN, and TP were decreased by 4.49 %, 7.08 %, 10.3 %, and 6.06 % respectively.
4. The External Recycle Ratio in the range 25% - 100 % did not significantly affect on the average values of total removal efficiencies for COD, NH_4^+ -N, TP and the average values of total effluent concentration for COD, NH_4^+ -N, and TP could meet with many discharge standard of pollutants for treated wastewater in the world.
5. The effect of external recycle ratio is clear on the TN removal where the average value of total effluent concentration for TN could meet with many discharge standard of pollutants for treated wastewater in the world only when the External Recycle Ratio is equal to 50 %.
6. The optimal value of the external recycle ratio was equal to 50 %, which the average values of removal efficiencies of COD, NH_4^+-N, TN and TP were equal to 98.15 %, 97.16%, 82.12%, and 93.39 % respectively. Under the condition of the optimum value of external recycle ratio the average concentration of the dissolved oxygen in both anoxic and aerobic reactors were equal to 0.151 mg/L, and 3.57 mg/L respectively.
7. The technology of Fully Nitrification-Denitrification Up Flow A^2 /O Bio Contact Oxidation with Bypass Flow with internal recycle ratio equal to 100% from the influent flow, bypass ratio equal to 40%, and external recycle ratio equal to 50 % was very sufficient and useful for simultaneous removal of organic carbon and nutrients from domestic wastewater in Basrah City (Southern Iraq).

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