Original Article

Investigation of Wastewater Treatment Plant Behavior for Residential Community within 1 Year

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Abstract

Aim: The effluent generated from wastewater treatment plant (WWTP) is a mixture of several chemicals, including, salts, chemical solvents, strong acidic, and alkaline so the study aimed to investigate the performance and characterization of the WWTP in a residential community to evaluate within the limits of the design of the plant. **Methods:** For the studying performance of (WWTP), the samples were collected before interred the treatment unit (influent) and after exiting from the treatment unit (effluent) in 24 plastic bottles for each time during 1 year, and used for analysis as chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solid (TSS), PO_4, nitrate, chlorine, hydrogen sulfide, and oil, and grease (O and G) parameters and investigated the efficiency of remove to BOD, COD, TSS, and O and G. **Results:** Results showed the removal efficiency of BOD, COD, TSS, O and G and PO_4 in the WWTP as 91%, 82.8%, 83.5%, 67.4%, and 64.7%, respectively, from June 7, 2018, to December 16, 2018. The experimental results indicated that the period from January to March demonstrates the best removal efficiency of COD. Furthermroe, it indicated that suddenly changing amounts in influent had an adverse decrease in the efficiency of biological systems. **Conclusions:** The performance of SBR was good which was reflected in the final effluent. The finding may back to cumulating high parameter amounts that inhibit microorganism activities when all nutrients were low in the wastewater that wanted to microorganism's growth. The results proved the solubility of effluent to be discharged on the sewer system and used for irrigation purposes (based on its characteristics).

Keywords: Assessment, biochemical oxygen demand, chemical oxygen demand, domestic wastewater, sequence batch reactor

Introduction

Water crisis deficiency in Iraq country is a major problem of the economy, the mainly agricultural field because Iraq still depends on the agricultural field. The water size problem is considerable, and if this problem is not clear today, it will be dangerous and difficult in the future.[1-4] Wastewater flow to the surface water may expose it to pollution risk with various organisms (bacteria, parasites, and other organisms) as well as to precipitation and thus the development of the anaerobic conditions; however, the considerable concern back to rapid algal growth development in these waters.[5] Algae growth is a development process in water resulting in elevating the biological activity in water. The water and this growth are features of water grasse's presence in rising amounts. The organism's death leads to the accumulation and then precipitation and oxidation, resulting in dissolved oxygen available water consumption and the development of anaerobic situations at the depth associated with a foul smell.[6] Algal growth speed elevated nutrient loads related to the final sewage discharged occurring from wastewater treatment plants (WWTPs).[7]

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A typical residential wastewater treatment system is a centralized municipal-sized plant that processes wastewater to set discharge limits to safeguard human health and the environment. Despite this, 10% of wastewater produced in the United States is treated in small systems that receive wastewater from single and multiple homes and small business enterprises.[8] The majority of these minor systems have no discharge restrictions. Onsite treatment is a stable – and increasing – component of the wastewater industry, far from vanishing into the annals of history.[9] This is seen as a gift by some and a curse by others. Historically, and in most instances today, onsite treatment has relied on "lowest common denominator" technology. The very simplest, lowest-cost, and least-monitored systems are often the only ones permitted.[10-12]

As a result of this strategy, there are recurrent instances of insufficient human health and environmental protection, sometimes widespread and sometimes for long periods. With so many recent technology advancements in onsite treatment, it is time to rethink its function, but how should this evaluation be conducted? One method is to describe its value, function, and obstacles to achievement in the context of sustainable development. A sustainability assessment considers a wide variety of factors such as shifting demographics, values, and natural resources.[3,4,13]

At present, the system of activated sludge is the major utilized in wastewater treatment in the universe, resulting in its high efficiency. In the process of activated sludge, hanging biomass is responsible for decreased chemical and other pollutants.[14] Depending on the project, activated sludge reactors can decrease phosphorus, nitrogen, and organic matter. Various configurations have developed over the years, including the sequencing batch reactor (SBR).[15]

The description of wastewater and activated sludge was utilized to regulate and optimization of present processes. Chemical oxygen demand (COD), like a basis for measurements of organic matter, has replaced biochemical oxygen demand (BOD)-like initial parameters in wastewater. The significant aspect of the description of organic matter is the fractionation due to its degradation rate.[16,17] Activated sludge design has the potential to concern efficiencies of treatment and the costs of plant operation.

The current investigation aims to study the characterization and performance of the WWTP for residential communities within 1 year. Standard explanation investigation that has been recorded over 1 year, were analyzed and utilized parameters such as hydrogen sulfide (H_2S), NH_3, COD, BOD, total suspended solids (TSS), SO_4, PO_4, NO_2, nitrate (NO_3), chlorine (Cl), alkalinity, and oil and grease (O and G) to explore the removal efficacy of O and G, Cl, PO_4, TSS, COD, BOD.

Materials and Methods

Description the plant

The type of wastewater entering the plant is domestic wastewater collected from a Residential Community with a quantity of 600 m^3/day, and the principal work of the plant is depending on the biological treatment system. Which consist from a pump station 2, 10, and 8 m width, length, and depth respectively to pump the wastewater to the plant, screen chamber 0.9, 8, and 1 m width, length and depth, respectively, to remove large size floating materials, O and G (0.9, 1.5 and 3.5) m width, length and depth, respectively, to remove excessive O and G from the wastewater, equalization tank (10, 4, and 8) m width, length and depth, respectively, to control or adjust the system pH, three units of sequence batch reactor (SBR) 2.4, 13, and 2.8 m width, length, and depth, respectively, under four cycle per day consist (2 h feeding time then 4 h blower time include 2 h with the feeding time, 1 h settling time and 1 h discharge time) to remove colloidal and soluble organic solids by aerobic and anaerobic oxidation, to remove excessive nitrogen and phosphorus content from wastewater by nitrification-denitrification, ultraviolet disinfection, and sludge pressing system as demonstrated in Figure 1.

Parameters needed

Before testing the quality of WWTP effluents, potential parameters should be identified for the successful interpretation of the experimental results obtained. The quality of WWTP effluents can generally be assessed by monitoring the most popular parameters such as COD, BOD, TSS, PO_4, NO_3, Cl, H_2S, and O and G.

Sampling technique

In this study, a series of samples were taken from the influent and effluent of WWTP to detect the influent and effluent quality fluctuations. A total of 576 samples were taken during the sampling period of January 7, 2018–December 16, 2018. At an average of two samples per month. The samples were collected in 24 plastic bottles and immediately refrigerated at 4°C. Wastewater chemical analysis was applied according to (Standard Method for the Examination of Water and Wastewater) at the environmental laboratory of the Civil Engineering Department at Al-Qalam University College, Kirkuk, Iraq.

Sampling locations

For the studying performance of (WWTP), the samples were collected before interred the treatment unit (influent) and after exiting from the treatment unit (effluent) for each period during 1 year, and used for analysis as COD, BOD, TSS, PO_4, NO_3, Cl, H_2S, and O and G parameters. The station is located in the southern part of the Noor City complex on the Sulaymaniyah-Erbil Road with coordinates (35.50650832503494, 44.408096353055235) as shown in Figure 2 which includes wastewater treatment for the role of the residential complex in Noor City, which has a population of 2600 people, with a capacity of 600 m^3/day. The treatment unit (PT) in Noor City is a sewage treatment plant that is designed to render the brackish water harmless after having dealt with the "biological treatment" system.

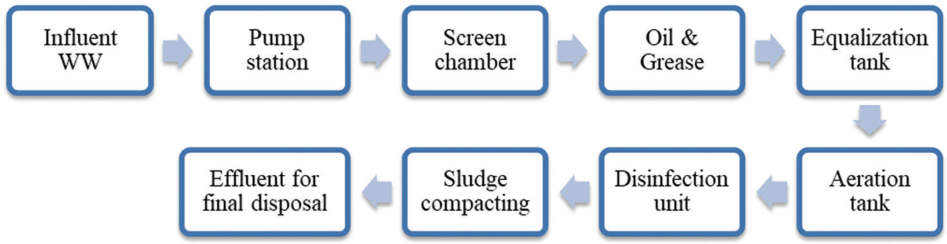

Figure 1: The processing steps of the wastewater treatment plant

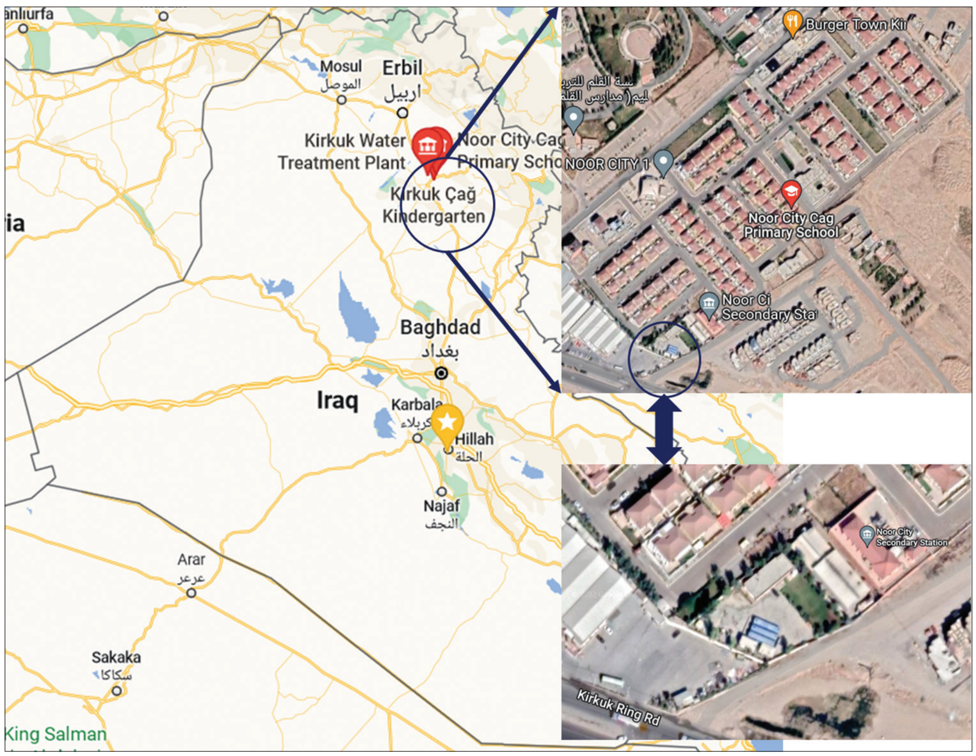

Figure 2: Location of the wastewater treatment plant

Ethical approval

Ethical approval for this study (Ethical Committee No. 1) was provided by the Ethical Committee in Al-Noor Residential Community, Kurkuk, Iraq on 1 July 2015.

Experimental Results and Discussion

The experimental results of the WWTP for a residential community are shown in Figure 2. These results represent the wastewater characteristics at the plant during the sampling period of January 7, 2018, to December 16, 2018.

Characterization study results of influent in total wastewater as average values were COD = 447.7 mg/L, BOD_5 = 250.3 mg/L, TSS = 234.1 mg/L, PO_4 = 9 mg/L, NO_3 = 4.9 mg/L, Cl = 107.3 mg/L, O and G = 64.5 mg/L, and H_2S = 12.6 mg/L.

Results

The obtained results are revealed in Tables 1 and 2.

Discussion

The impact of BOD, COD, TSSs, Phosphate (PO_4), NO_3, Cl, H_2S amount in feed water on the performance biological reactors in WWTP was investigated.[18]

Biochemical oxygen demand, chemical oxygen demand, and total suspended solid values

Figures 3 and 4 demonstrat the performance of sequence batch reactors (SBR) on BOD, COD, and TSS values for influent and effluent.

As shown in Figure 3, the range value of BOD, COD, and TSS was observed in influent (90–685) mg/L, (188–813) mg/L, and (76.5–12) mg/L, respectively, while the result presented in Figure 4, indicated for the decreasing the range value of BOD, COD, and TSS was observed in effluent (5–40) mg/L, (30–228) mg/L, and (10–93) mg/L and the maximum reduction values were in November 13, November 13, and August 5, respectively.

Table 1: The inlet and outlet results for biochemical oxygen demand, chemical oxygen demand, total suspended solid, nitrate, and hydrogen sulfide

Date	BOD (40 mg/L>)		COD (100 mg/L>)		TSS (60 mg/L)		NO_3 (50 mg/L)		H_2S (3 mg/L)	
	In	Out	In	In	Out	In	In	Out	In	Out
January 7, 2018	296	20	492	6.2	22.6	6.2	6.2	22.6	17	11
January 22, 2018	250	23	338	0.3	5	0.3	0.3	5	25.5	9.4
February 6, 2018	310	10	584	5	18.75	5	5	18.75	9.2	4.8
February 11, 2018	340	10	452	9	30.5	9	9	30.5	20	3.97
March 1, 2018	90	10	188	0.2	3.5	0.2	0.2	3.5	7.5	6.8
March 4, 2018	280	20	316	2	10	2	2	10	20.6	5.1
April 8, 2018	230	10	384	6.3	39.25	6.3	6.3	39.25	22	7.7
May 6, 2018	100	40	220	1.2	5	1.2	1.2	5	5.1	8.3
May 23, 2018	296	20	492	3.1	22.6	3.1	3.1	22.6	17	8.2
June 10, 2018	230	10	524	4	22.25	4	4	22.25	20	8.1
July 1, 2018	180	20	260	2.25	2.75	2.25	2.25	2.75	13.6	8.6
July 4, 2018	200	30	520	8.3	38	8.3	8.3	38	8.8	7.4
July 22, 2018	120	12	444	3	20.7	3	3	20.7	16.7	10.2
August 5, 2018	296	34	456	1.1	2.25	1.1	1.1	2.25	14.5	5.6
August 13, 2018	241	14	440	0.5	12	0.5	0.5	12	2.3	10
September 9, 2018	194	10	546	1	2.3	1	1	2.3	2.2	1
September 16, 2018	315	19	440	3.2	8	3.2	3.2	8	3	8.6
September 23, 2018	205	34	428	8.3	40	8.3	8.3	40	10.4	1.7
October 16, 2018	250	5	489	13.5	43.5	13.5	13.5	43.5	22.9	7.7
October 23, 2018	180	10	410	15.5	38.8	15.5	15.5	38.8	2	9.2
November 4, 2018	369	36	468	10.5	30.5	10.5	10.5	30.5	9.7	3.3
November 13, 2018	685	10	813	2	28	2	2	28	12.6	10.3
November 26, 2018	190	10	396	6.4	34	6.4	6.4	34	12.3	16.5
December 16, 2018	160	23	644	4.8	33.25	4.8	4.8	33.25	7.1	11.2

BOD: Biochemical oxygen demand, COD: Chemical oxygen demand, TSS: Total suspended solid, NO_3: Nitrate, H_2S: Hydrogen sulfide

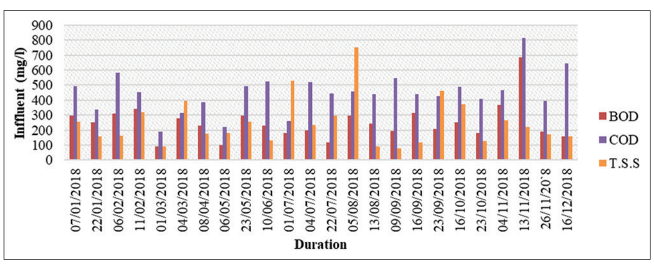

Figure 3: The values of influent for biological oxygen demand, chemical oxygen demand and total suspended solids. COD: Chemical oxygen demand, BOD: Biochemical oxygen demand, TSS: Total suspended solid

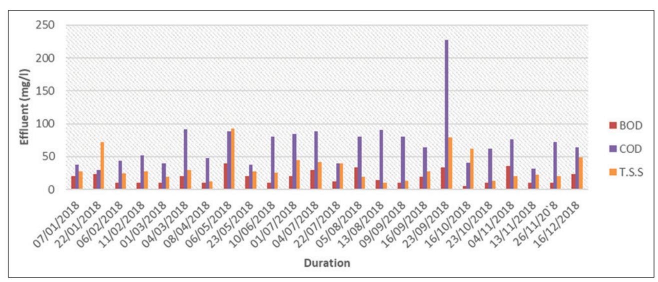

Figure 4: The values of effluent for biological oxygen demand, chemical oxygen demand, and total suspended solids. COD: Chemical oxygen demand, BOD: Biochemical oxygen demand, TSS: Total suspended solids

The TSSs concentration decreased after existing from treatment unit and the final TSS concentrations in the effluent were within the Iraqi discharge limitations (60 mg/L),[19] except in January, August, and September the samples from the treatment unit not within the limitations, this may be due to the low air pressure used for design.[20] As shown in Table 1, the removal efficiency of TSS in the plant was 83.5%.

The COD concentration decreased after the existing treatment unit because reaction time plays a role in COD reduction. This may be due to the oxidation of the suspended solids in the water with the increase in the reaction time, thus releasing a large number of soluble compounds.[21] and the final COD concentrations in the effluent were within the Iraqi discharge limitations (100 mg/l),[19] except in September the sample from treatment unit not within the limitations, and the removal efficiency of COD for the plant was presented in Figure 5 as 82.8%.

The reduction in the BOD concentration after existing from treatment unit related to the biological or secondary treatment of primary effluent involves passing the effluent into large aeration tanks where constant stirring and agitation are done followed by pumping out of the air. This allows a magnified growth of aerobic microorganisms into masses called flows. These microorganisms then utilize a lot of oxygen to break down the organic matter present in the effluent. This results in a significant decrease in the BOD of the effluent). The final BOD concentrations in the effluent were within the

Iraqi discharge limitations (40 mg/l).[19] The plant had a BOD removal efficiency of 91% as presented in Figure 5.

It can be noticed from the figures that the changing climate harmed reactors' performance. The BOD and COD amount in effluent reached 228 mg/l and 34 mg/l respectively on September 23 may be attributed to temperature changes in orbit micro which organisms' activities when the wastewater is not rich in all nutrients required for bacteria growth.[18]

Oil and grease, chlorine, and PO_4

Figures 6 and 7 show the performance of sequence batch reactors (SBR) on O and G, Cl values for influent and effluent. Figure 6 shows the range value of O and G, Cl and PO_4 in influent 17.8–282 mg/L, 43–134 mg/L, and 75–363 mg/L, respectively, while the result presented in Figure 7 indicated a decreasing in the range value of O, G, and Cl with increasing the range value of SO_4 in the effluent (4.4–82) mg/L, (38–116) mg/L, and (114–328) mg/L. The maximum reduction values for O and G and Cl were in October 16 and September 16 respectively, while the maximum raising values for PO4 was achieved on 13 August due to the higher detention time in the extended aeration reactor.[18]

The reduction in the O and G concentration for effluent related to the treatment unit gravity separators, and the final O and G concentrations in the effluent that was not within the Iraqi

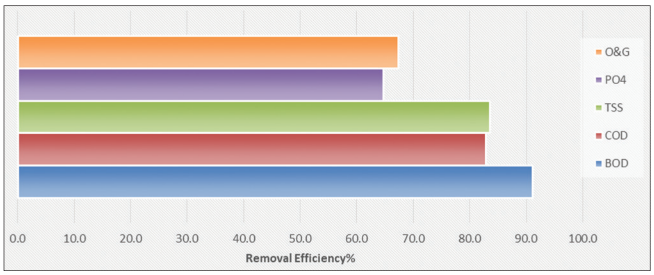

Figure 5: The removal efficiency of biological oxygen demand, chemical oxygen demand, total suspended solids, PO_4, and oil and grease in the wastewater treatment plant. BOD: Biological oxygen demand, COD: Chemical oxygen demand, TSS: Total suspended solids, O and G: Oil and grease, PO_4: Phosphate

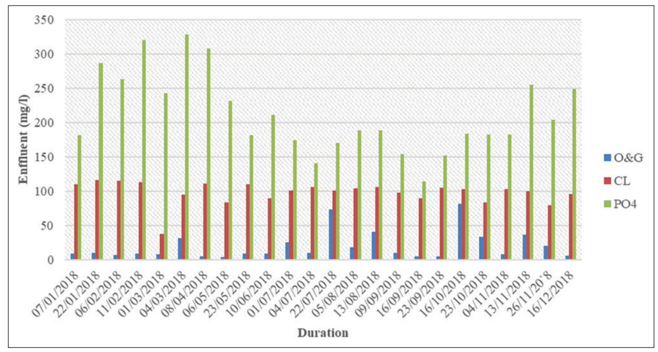

Figure 6: The values of influent for oil and grease, chlorine, and PO_4. O and G: Oil and grease, CL: Chlorine, PO_4: Phosphate

Table 2: The inlet and outlet results for chlorine, phosphate and oil and grease

Date	CL (600 mg/L)		PO_4 (1400 mg/L)		O and G (10 mg/L)	
	In	Out	In	Out	In	Out
January 7, 2018	128	110	363	182	75	8.7
January 22, 2018	133	116	212	287	34.8	9.6
February 6, 2018	122	115	270	263	40.8	7.08
February 11, 2018	106	113	255	320	170	9.4
March 1, 2018	43	38	228	243	24	8.4
March 4, 2018	90	95	288	328	71.2	31.9
April 8, 2018	102	111	300	308	60	5
May 6, 2018	95	84	166	232	40	4.4
May 23, 2018	128	110	363	182	75	9
June 10, 2018	103	90	204	211	26	8.8
July 1, 2018	92	101	167	174	83	25
July 4, 2018	123	106	110	141	28	9.6
July 22, 2018	110	101	93	170	92	73
August 5, 2018	112	104	89	189	43	18
August 13, 2018	120	106	75	189	73	
September 9, 2018	123	98	149	154	36	
September 16, 2018	128	90	182	114	48	
September 23, 2018	123	105	106	152	44	
October 16, 2018	134	103	110	184	282	
October 23, 2018	91	84	83	183	42	
November 4, 2018	92	103	164	183	50	
November 13, 2018	102	100	121	255	56	
November 26, 2018	78	79	204	204	37	
December 16, 2018	97	96	221	249	17.8	

O and G: Oil and grease, CL: Chlorine, PO_4: Phosphate discharge limitations (10 mg/l)[21] may be due to the poor performance of the treatment unit, which related to the low saturation pressure used in pressurization tank. In addition, Figure 5 showed the removal efficiency of O and G as 67.4%. While the incretion in PO_4 concentrations was related to the high amounts of phosphoric acid added to the aeration tank as a source of nutrients (1980).[22]

Nitrate and hydrogen sulfide

Figures 8 and 9 show the performance of sequence batch reactors (SBR) on decreasing H_2S values for influent and effluent.

As shown in Figure 8, the range value of NO_3 and H_2S were observed in influent (0.2–15.5) mg/L, and (2.2–25.5) mg/L, respectively, while the result presented in Figure 9, indicated the decreasing range value of H_2S were observed in the effluent (1–16.5) mg/L, and the increasing the range value of NO_3 (2.25–43.5) mg/L.

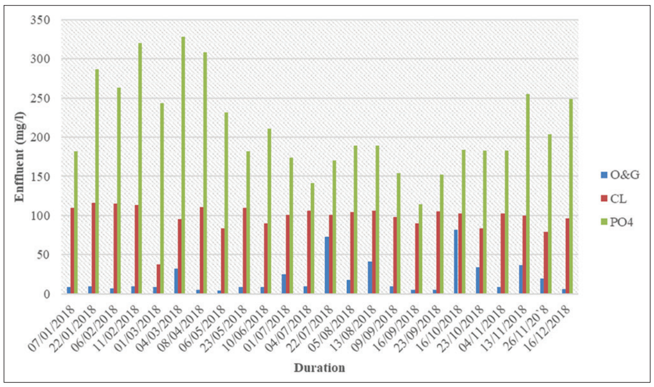

Figure 7: The values of effluent for oil and grease, chlorine and PO_4. O and G: Oil and grease, CL: Chlorine, PO_4: Phosphate

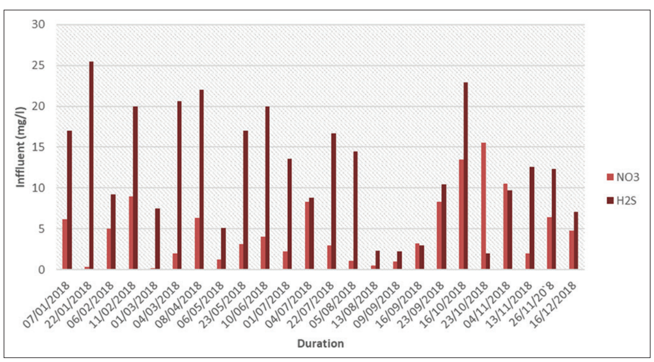

Figure 8: The values of influent for nitrate and hydrogen sulfide. NO_3: Nitrate, H_2S: Hydrogen sulfide

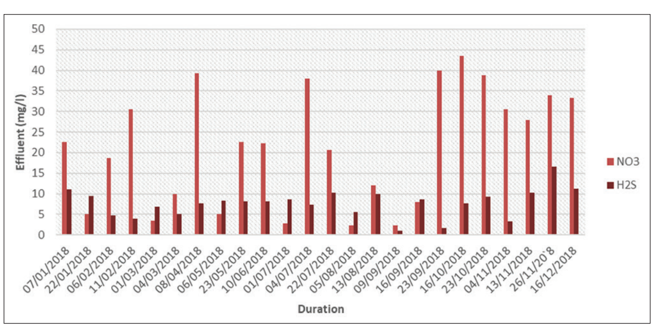

Figure 9: The values of effluent for nitrate and hydrogen sulfide. NO_3: Nitrate, H_2S: Hydrogen sulfide

The H_2S concentration decreased after the existing treatment unit and the final concentrations in the effluent were not within the Iraqi discharge limitations. This is due to the sulfate production from the degradation of the organic matter in the treatment units. While the increase of NO_3 concentrations was expected due to the higher detention time in the extended aeration reactor.[18]

Conclusions

This study investigated the treatment feasibility of domestic wastewater containing various amounts of BOD, COD, TSS, PO_4, CL, O and G, H_2S removal by three biological reactors (sequence batch reactors [SBR]). Furthermore, the performance of the three reactors has been evaluated.

The performance of SBR was good which was reflected on the final effluent. The final TSS, BOD and COD concentrations in the effluent were within the Iraqi discharge limitations while the final O and G and H_2S concentrations in the effluent were not within the Iraqi discharge limitations.

Results showed the removal efficiency of BOD, COD, TSS, O and G, and PO_4 in the WWTP as 91%, 82.8%, 83.5%, 67.4%, and 64.7%, respectively.

The finding might refer to the accumulation of parameter amounts that inhibit microorganisms' activities when the wastewater is not rich in all nutrients needed for bacteria growth, so they proved the solubility of effluent to be discharged on the sewer system and used for irrigation purposes (based on its characteristics).

Acknowledgments

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Nil.

Conflicts of interest

There are no conflicts of interest.

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