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Modelling and Simulation of Al-muamirah Wastewater Treatment Plant by GPS-X Software

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Abstract

Mathematical modelling has emerged as a critical tool for long-term wastewater management, particularly for simulating complicated biological processes. This study focuses on modelling and simulating of Al-muamirah wastewater treatment plant whose system is an oxidation ditch using GPS-X simulator to investigate the plant performance among four scenarios in different conditions. Samples were measured weekly over eight weeks, which were taken from the treatment plant's influent and effluent wastewater. The contamination parameters tested for these samples were the biochemical oxygen demand (BOD), the chemical oxygen demand (COD), and the total suspended solids (TSS). COD and TSS coefficients were chosen in the model because calibration values close to their true values were reached, while the true value of the BOD was not reached, so it was not taken as a calibration parameter. The results showed that the values of COD and TSS in the effluent wastewater were; 47 mg/L and 9 mg/L for the first scenario, 57 mg/L and 73 mg/L for the second scenario, 66 mg/L and 14.97 mg/L for the third scenario, 74 mg/L and 42 mg/L for the fourth scenario, respectively. The concentrations of pollutants in the effluent wastewater remained within the acceptable limits (less than 100 for COD) and (less than 40 for TSS). This is an indication of the good performance efficiency of the treatment system used in the plant and the adequacy and suitability of its design capacity.

Keywords: GPS-X, Wastewater treatment, Modelling, Simulation, BOD, COD, TSS.

1. Introduction

The components that make up a community's wastewater flow, as well as variations in the utilized collection technology determine the wastewater properties. Typical domestic wastewater is discharged from homes, businesses, institutions, and public facilities. Sanitary wastewater is another term for domestic wastewater [1]. Domestic wastewater treatment and reuse are now necessary for commonalty health, environmental safeguard, water supplies contamination prevention, reuse of wastewater after treatment for industry and farming purposes. This is critical due to the growing population and the shortage of water supplies [2, 3]. When wastewater contaminants such as nitrogen and phosphorus reach freshwater resources, they can cause eutrophication and decrease the quality of the water [4, 5]. Physical, biological, and chemical wastewater treatment technologies have significantly advanced in tandem with the advancement of biological technology. Biological wastewater treatment is the most essential and crucial element of wastewater treatment facilities because it eliminates biodegradable organic wastes and suspended particles (WWTPs). Biological treatment technologies are the most popular domestic wastewater treatment methods because of their ease of use and adaptability, low operating and maintenance costs, and high efficiency [6, 7].

The oxidation ditch system is considered a modification of the traditional activated sludge process that uses a closed ditch-like aeration tank to remove organic carbon, nitrogen, and phosphorus in alternating anoxic-oxic zones within the looping channel [8]. Because of its simple construction, low capital and maintenance expenses, high and flexible capacity, and minimal sludge generation, oxidation ditches (ODs) are frequently employed in wastewater treatment [9]. Oxidation ditches take up a lot of space, use a lot of energy, and generate uneven sludge deposits [10]. Oxidation ditches compete with other activated sludge methods when it comes to eutrophication control [11]. There are several different types of oxidation ditches, such as integrative oxidation ditches, oval oxidation ditches, and carrousel oxidation ditches. Correspondingly, several aeration devices come in a variety of forms, including spinning brushes, spinning disks, and surface aerators. They all can introduce oxygen into the oxidation ditch. The amount of oxygen in the oxidation ditch varies depending on how far away is the aeration equipment. [12].

Mathematical models are useful for simulating biological, chemical, and physical processes in oxidation ditches where nitrification and denitrification occur under complex alternating anoxic and aerobic conditions [13]. For example, the Activated Sludge Model (ASM) forecasts wastewater treatment plant effluent water quality and biomass output [14]. Operators of WWTPs can use specialized software such as GPS-X, STOAT, SIMBA, WEST, and BioWin to apply mathematical models [15]. GPS-X (version 8.0), which is a modular, multi-purpose modelling environment for the simulation of municipal and industrial wastewater treatment facilities, is the utilized modular software in this study. It was developed by Hydromantis Environmental Software Solutions Inc [16]. GPS-X facilitates dynamic modelling and simulation with a sophisticated graphical user interface.

In recent years, a great deal of modifications and improvements have been made to simulate the GPS-X program. Thus, some global and local researchers investigated the GPS-X program's ability to model and simulate any part or whole wastewater treatment plant to achieve their study objectives by simulating a complete mix batch reactor and optimizing the number of batch runs to treat a high concentration of COD [17]. They found that the calibrated model gives accurate results that simulate the real results. El-Hoz and Gerges [18] studied the wastewater treatment plant simulation by using the GPS-X program. The results showed that the capacity, operating efficiency, and quality of effluent discharge could be improved by properly improving the existing facility. Viegas [19] made a great deal of scenarios to model a wastewater treatment by using GPS-X including rearrangement to the diffusers inside the aeration tank. Accordingly, he found a suitable way of arrangement that reduces the consumption of energy by about 35% with the same removal efficiency. Arif et al., [20] conducted a study to present three alternative processes by using GPS-X including; complete mix activated sludge with nitrogen removal, complete mix activated sludge with nitrogen removal and membrane bioreactor. The results showed a good agreement between the designed and simulated values. Also, Shamkhi [21] presented a study that used GPS-X to predict the combination of the enhanced biological phosphorus removal (EBPR) and chemical phosphorous precipitation processes to remove phosphorus from wastewater. The results revealed that using a dosing approach for both wastewater and side streamlines provided a better phosphorus removal option in terms of effluent quality and alum usage. Nasr et al.[22] conducted a study to modelling and simulation of WWTP plant as a Sequencing Batch Reactor (SBR) system by utilizing a GPS-X simulator. The results showed that the microbial denitrification process represented through anoxic conditions is highly recommended to remove nitrates and nitrites during the treatment of activated sludge and prevent the accumulation of the filamentous sludge. Jasim [23] used a GPS X modelling technique to design treatment units for of Al-Hay wastewater treatment plant. It was found that there is a typical enhancement in the total suspended solids and solids by increasing the simulation time. The results also showed that the suspended solids in mixed liquor (MLSS) are correlated with the sludge age that is related to the observed yield. As well, the retention time was found to be equaled to 27.7 days. Abdel Kader [24] conducted a comparison study between sequencing batch reactor SBR and conventional activated sludge AS to investigate the performance and treatment capability of both systems under different cases of operation by utilizing GPS-X. The results showed that, the ability of SBR and AS systems differ from each other in removing the total nitrogen TKN concentration and the total ammonia NH3+ concentration.

The aim of this study is to modelling and simulation of Al-Muamirah WWTP by using the GPS-X program with four scenarios under different conditions. The plant is located in Hilla city in the province of Babylon. Up to our knowledge, this study is considered the first one on the modelling and simulation of Al-Muamirah WWTP and by this program in the region.

2. Case Study

Al-Muamirah WWTP is located in the south of Babylon Province, Iraq (32.425821 N, 44.472889 E) (Figure 1). The system used in this plant is an oxidation ditch system. The treatment plant's building was completed in 2019, and it began working in the same year. The plant serves a population of around 970,000 residents. The treatment plant's discharge capacity is 107,000 cubic meters per day. The average input flow to the treatment plant is 30000 m^3/d. The construction of treatment plant consists of screens, a lift station, an oil and grit removal chamber, two oxidation ditches, and four tanks for sedimentation. Squeezing devices and drying beds are used in the sludge dewatering and thickening system. Chlorine is used to disinfect the effluent at the end of the process. Two kinds of screens are used to separate solid waste and large materials from wastewater: coarse and fine. The grit chamber unit removes fats using a physical mechanism and contains two sand removal basins. The oxidation ditch consists of three basins; closed basin that represents the anaerobic treatment stage which is the first stage of the removal of nitrates and a portion of phosphorus by anaerobic bacteria, an open basin that represents the aerobic treatment stage, which is the second stage of the nitrate removal process and at this stage gas is released Nitrogen, and aeration tank that consists of two main basins of ovoid form and each one equipped with five oxygen addition motors and ten submersible mixers that reduce sedimentation in the basin, add oxygen and develop aerobic bacteria. A secondary sedimentation device is used after the aeration unit to settle the suspended solids and flocs in the output wastewater. The plant has 4 sedimentation basins with a diameter of 45 m for each basin. These basins are used to separate the treated water from the sludge. Then the treated water is disposed of outside the treatment plant and the sludge is later treated and disposed of. In the chlorination unit, chlorine is added to the treated water to kill microorganisms and microbes [25].

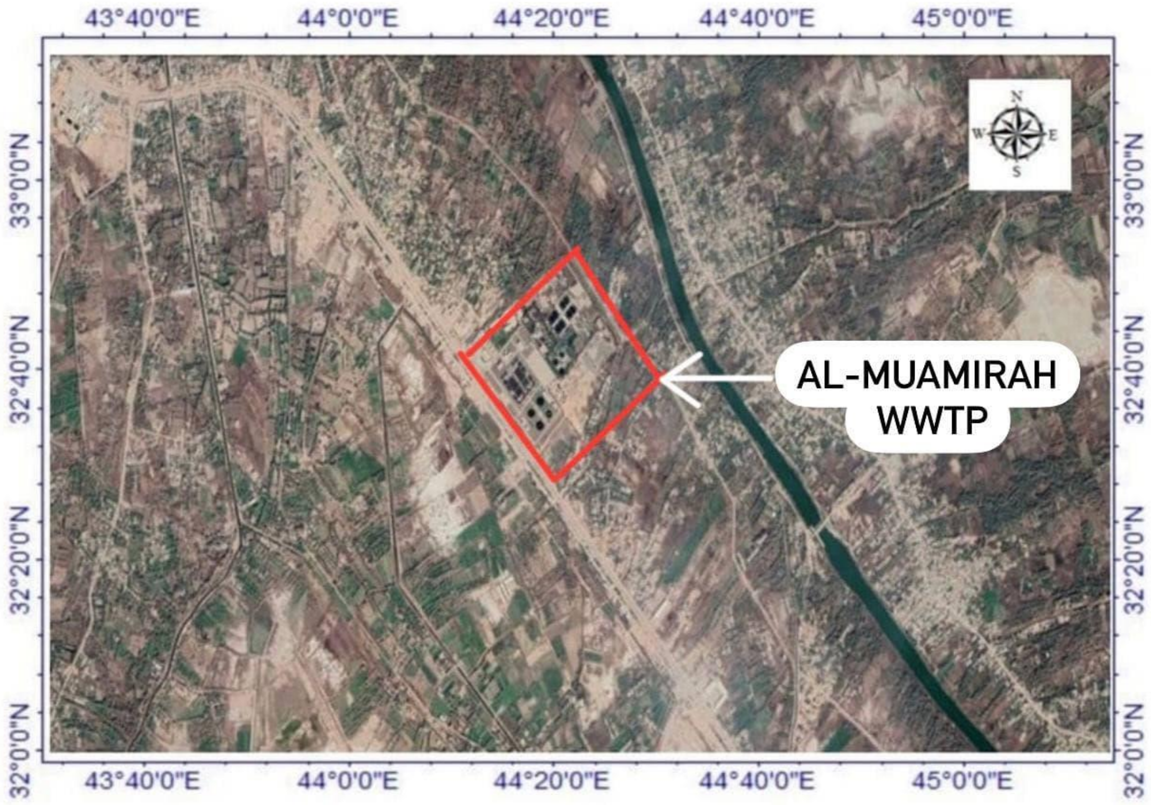

Figure 1 An aerial view of the Al-Muamirah WWTP

3. Methodology

3.1 Sampling and Data Testing

Samples were measured weekly for eight weeks (2/1/2021-20/2/2021) in which a total of eight samples were taken from the treatment plant's outflow of wastewater, as shown in Figure 2. The contamination parameters tested for these samples were BOD5, COD and TSS. Water and wastewater testing standards were followed during the experiments [26]. To assure the quality of analytical data provided, the accuracy and precision of the plant's and operations' performance are checked against WWTP standard values. The samples were measured in the Al-Muamirah plant laboratory located inside the plant. The required protocols for the sampling process were considered by selecting the appropriate depth, the time of sampling, the equipment used, and the transport to the laboratory.

Figure 2 Wastewater sample from exit point (OUT)

- **Total Suspended Solid (TSS)**

The TSS test is done by filtering a certain volume of water and then drying it at 100° C until the accomplishing weight stability, and calculating the content of suspended solids per liter. TSS is measured by using a Spectrophotometer – Hach- DR2800.

- **Biochemical oxygen demand (BOD)**

In the laboratory, BOD is defined as the amount of oxygen consumed by the bacteria and other microorganisms that analyze the organic materials in the water under aerobic conditions at a temperature of 20 ° C for five days. This experiment was conducted by using an electronic device (hach BOD Trak).

- **Chemical oxygen demand (COD)**

COD is the amount of oxygen consumed to analyze or oxidize organic carbon materials, whether they are biodegradable or not by a strong oxidizing agent such as potassium chromate anode. The COD is measured using Spectrophotometer.

3.2 Modeling of Al-Muamirah WWTP by GPS_X

Engineers and scientists in the environmental sector have been used modelling and simulation for many years and all the models are frequently steady-state rather than dynamic. There has been considerable progress in constructing models for the processes employed in a typical municipal or industrial facility in wastewater engineering [18]. Model building, model calibration, scenario development, simulation, and result interpretation are the primary processes in creating a GPS-X model as it will come later. It should be noted that calibration of the model is the most crucial phase; since a simulation model must include all physical processes of the full-scale plant and be run comparably to the plant, it is mimicking to correctly evaluate its functioning. Hydromantic Environmental Software Solutions, Inc.'s GPS-X software version is utilized in the present study as follows:

3.2.1 Building of Al-Muamirah WWTP Layout

Since GPS-X creates dynamic process models based on a graphical depiction of unit processes, the first step was to create a graphical representation of Al-Muamirah WWTP. The WWTP process flow diagram was built by selecting items (process unit icons) from the process table (GPS-unit X's process library) and connecting them through flow pathways, as shown in Figure 3.

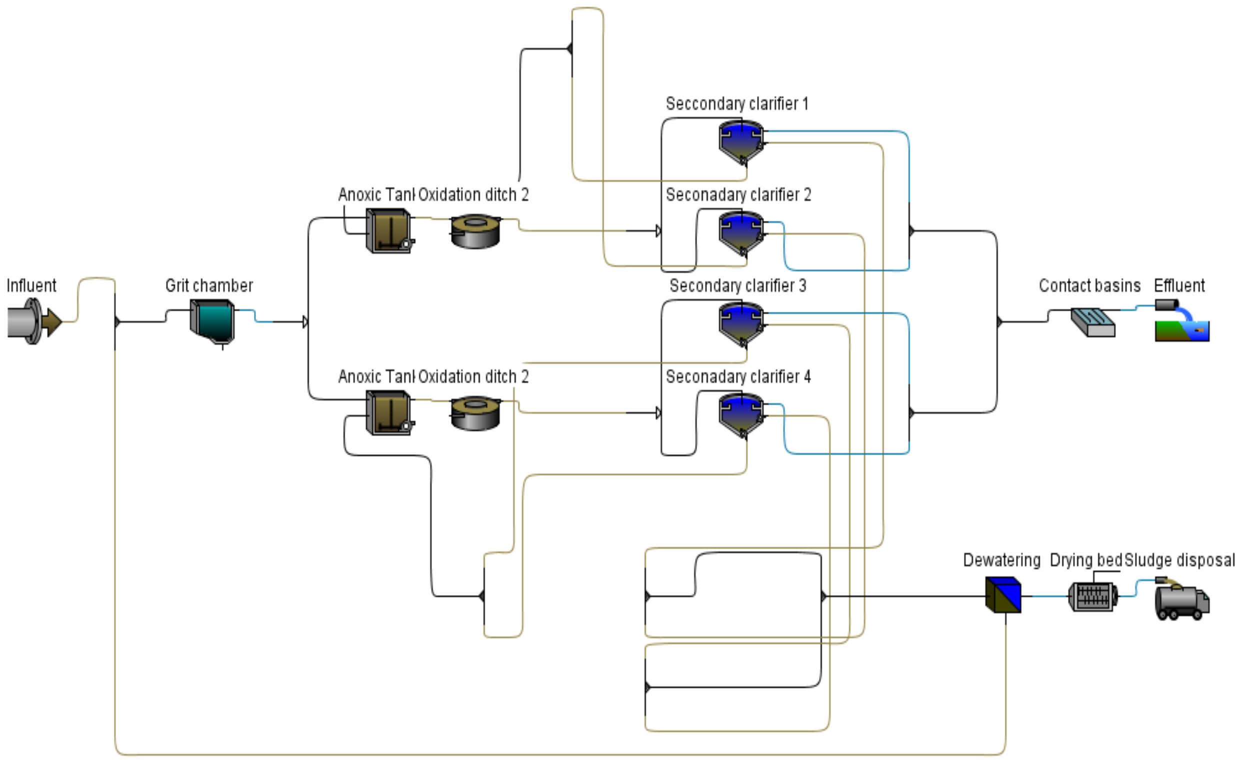

Figure 3 Model building by GPS-X

3.2.2 Selection of the Library

It is important to choose a library that is more appropriate for the entire WWTP facility. A library is a collection of wastewater treatment components with built in state variables. Each of GPS-six X's libraries contains default values and formulas for calculating state variables. Since there was an interest in modelling comprehensive - carbon, nitrogen, phosphorus, and pH, (mantis3lib), library is comprised of fifty-six (56) state variables that were chosen for this study.

3.2.3 Influent Wastewater Characteristics

GPS-X program includes adding the parameters of characteristics of the influent wastewater entering the plant in detail. The characteristics are entered in each scenario according to their respective values.

3.2.4 Input Physical and Operational Data

Some physical and operational variables of plant units are changed according to the scenario, while others are constant in all cases. Tables 1 and 2 show the values of variables entered in the model.

Table 1 Input variables values (influent wastewater)

Unit	Variable	Input Value
Influent Wastewater	Flow	Varied according to the scenario
	Total suspended solids	Varied according to the scenario
	Biological oxygen demand	Varied according to the scenario
	Chemical Oxygen demand	Varied according to the scenario
	Total phosphorus	$6gP/m^3$
	Ammonia nitrogen	$15gN/m^3$
	Ortho-phosphate	$5gP/m^3$
	VSS/TSS ratio	$0.17gVSS/gTSS$
	nitrate	8.2

Table 2 Input variables (treatment units)

Process unit	Physical parameter	Value	Operation parameter	Value
Grit removal	-	-	Grit production per-flow	20 mg/L
Anoxic tank	Max volume	11400 m^3	-	-
	Tank Depth	6.5 m	-	-
Oxidation ditch	Max volume	50000 m^3	Aeration Method	Diffused air
	Tank Depth	6.5 m	-	-
	Channel length	900 m	-	-
Secondary clarifier	Water depth at center	6 m	-	-
	Feed points from the bottom	4 m	-	-
	Surface area	1590 m^2	-	-
	Water depth at the sidewall	4.5 m		-
	Clarifier type	Sloping Bottom	Underflow rate	Varied according to the scenario

3.2.5 Validation and Calibration of the Model

After completing the construction of the model within the GPS-X program environment, the model performance is calibrated by using weekly observed concentration values of BOD, COD, and TSS parameters for influent and effluent wastewater that obtained from the experimental work conducted during the plant operation under the design requirements for two months extended from 2/1/2021 to 20/2/2021, as shown in Table 3. It is worth to mention that it is very necessary to verify the validity of the model through a calibration process using a real data plant.

Table 3 Weekly observed concentration values of COD, BOD, and TSS parameters for influent and effluent wastewater of Al-Muamirah WWTP from 2/1/2021 to 20/2/2021

Test No.	COD		BOD		TSS	
	IN	OUT	IN	OUT	IN	OUT
1	281	65	118	11	192	9
2	325	52	167	12	275	10
3	282	49	143	9	285	9
4	151	45	121	11	122	8
5	182	61	118	8	143	11
6	213	39	136	10	173	9
7	148	30	98	7	136	10
8	341	38	139	8	194	7

These values were used as input values for the characteristics of influent wastewater in the model that was run in the steady-state, and the model results were compared with the actual results. After that, some parameters were corrected to achieve a maximum match between the model and the reality. Table 4 shows the parameters that have been calibrated.

Table 4 Calibrated parameters in the model

Calibrated fractions	Default	Calibrated
Soluble inert fraction of COD	0.05	0.172
Readily biodegradable fraction of COD	0.2	0.352
Particulate inert fraction of COD	0.13	0.063
Colloidal fraction of slowly biodegradable COD	0.15	0.9
Ammonium fraction of soluble TKN	0.9	0.8
N content of soluble inert material	0.05	0.08

3.2.6 Applied Scenarios

After completing the correction process of the model, the selected scenarios are applied to determine the response of Al-Muamirah WWTP to each scenario. In this study, four scenarios were built depending on two variables. The first variable was the influent wastewater flow rate entering the plant while the second variable was the number of duty (working) secondary sedimentation tanks in the plant. The following is the details of these scenarios:

- Scenario one (actual): This scenario represents the situation of Al-Muamirah WWTP under normal operational conditions. The influent wastewater flowrate entering the plant was 30000 m^3/day, and the number of duty (working) secondary sedimentation tanks was four tanks.
- Scenario two (virtual): The second scenario depending on a half capacity of secondary sedimentation tanks with maximum values of influent concentrations that are obtained from experimental works. The influent wastewater flowrate entering the plant was 30000 m^3/day and

the number of duty (working) secondary sedimentation tanks was only two tanks because the amount of the influent entering the plant (30000 m^3/day) was much less than the plant's maximum capacity (107000 m^3/day). In addition, using two sedimentation tanks will reduce the cost of energy consumption and maintenance of these tanks.

- Scenario three (predicted): For this scenario, the input effluent wastewater flowrate entering the plant was estimated at 65000 m^3/day, which is the expected value after completing the construction of the first conveyor line of Hilla sewer. In this scenario, all four sedimentation tanks are proposed to be operated.
- Scenario four (predicted): For this scenario, the amount of the entering influent was estimated at 107000 m^3/day after completing the construction of the second conveyor line of Hilla sewer. This influent flow rate is the maximum capacity of the plant and all four sedimentation tanks are assumed to be operated.

Table 5 presents the values of input parameters of four scenarios.

Table 5 Characteristics of input parameter in the scenarios

Input parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Q, m^3/day	30000	30000	65000	107000
Return sludge, m^3/day	18000	18000	36000	60000
WAS, m^3/day	400	400	600	900
Total COD, mg/L	241	341	341	341
TSS, mg/L	190	260	260	260
BOD, mg/L	130	185	185	185
Total TKN, mg/L	40	40	40	40
Total phosphorus, mg/L	6	6	6	6
Ammonia, mg/L	15	15	15	15
Nitrate, mg/L	8.2	8.2	8.2	8.2

4. Results And Discussion

▪ Scenario One

Figure 4 shows the plant's response in the first scenario, which is a real scenario that represents the reality of the plant during two months of operation in which the actual samples were taken and tested. The results showed that the steady-state values of the COD and TSS in the effluent-treated wastewater were 47 mg/L and 9 mg/L, respectively. These values are within the Iraqi standards which are less than 60 mg/L and 100 mg/L for TSS and COD, respectively. The Hydraulic Retention Time (HRT) in the secondary sedimentation tank was 16 hours during this scenario. It is considered a very long period that allows the sedimentation of the highest possible percentage of sludge, and this explains the reason for the presence of a very small concentration of TSS in the plant effluent. This value of HRT leads to a decrease in the surface overflow rate (SOR) and the solid loading rate (SLR) that were 4.6 $m^3/day/m^2$ and 38.1 $Kg/day/m^2$, respectively. This can assist in improving the efficiency of the plant in the removal process, despite the fact that the plant detains high sludge quantities that must be dealt with.

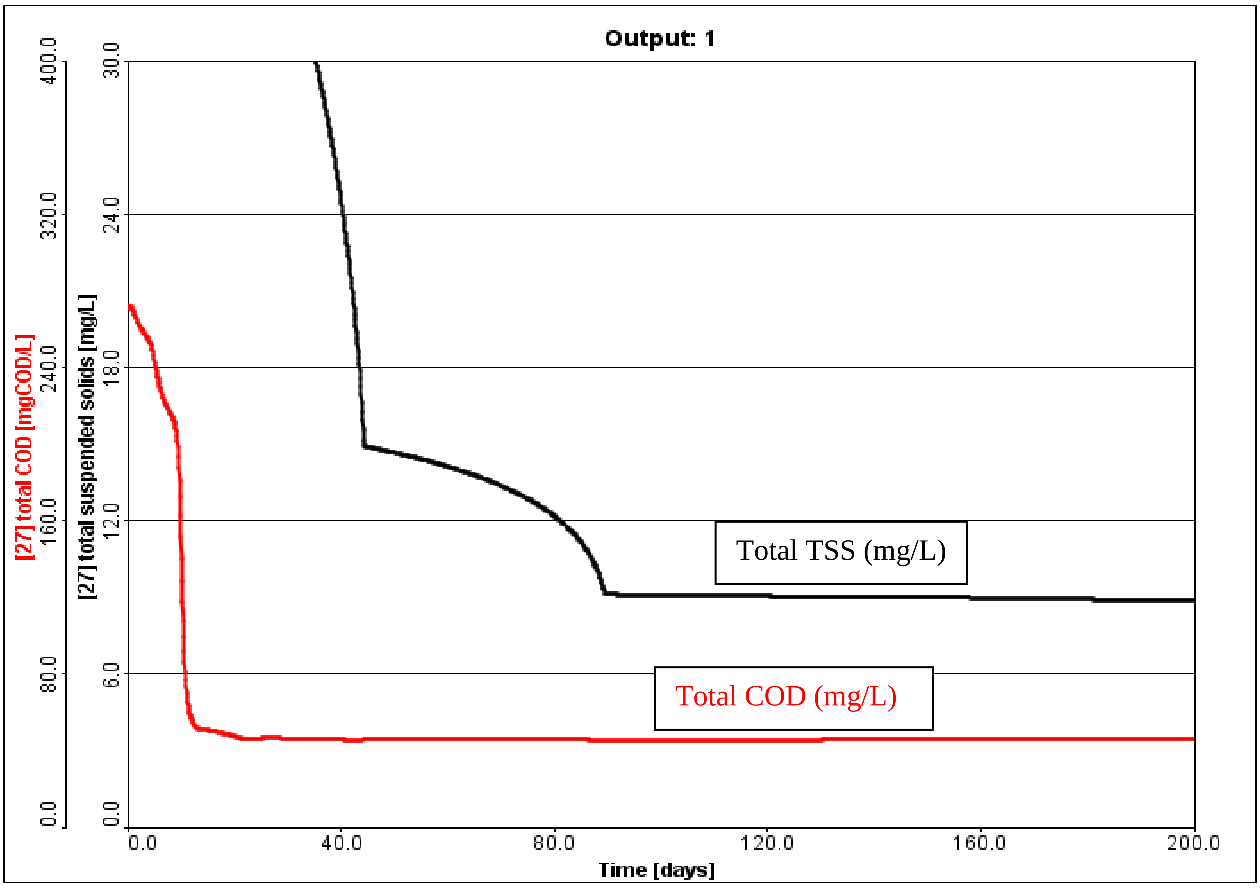

Figure 4 Response of the plant under the first scenario.

- **Scenario Two**

Figure 5 shows the response of the plant under the second scenario. The results showed that the steady-state value of the TSS in the effluent treated wastewater was 57mg/L, which is within the limits of the Iraqi standard that is less than 60 mg/L, but it is a high value and represents a critical case. The results also showed that the steady-state value of the COD was 73 mg/L, which meets the requirements of the Iraqi standard that specified the permissible value of TSS in the effluent treated wastewater to be less than 100 mg/L, but it is also a high value. The value of HRT reduced to 8 (by half compared to the first scenario). Thus, the values of the surface overflow rate and the solid loading rate increased to 9.3 and 73, respectively. These changes led to the deterioration of the plant's performance significantly in this scenario, as the removal efficiency decreased to a critical degree, taking into account that the values of the pollutants entering the plant were considered at their highest values in this scenario. This increase in pollutant concentrations from their values in the first scenario is due to two reasons: The first reason is the maximum value of each pollutant in the influent treated wastewater that was obtained from the experimental work was used instead of the average value of each pollutant as in the first scenario. The second reason is the decrease in the number of secondary sedimentation basins (using half the capacity of secondary sedimentation basins). Therefore, the surface overflow rate increased to 9.3 m/day, as well as the solid loading rate increased to 73 kg/m^2/day, and this increase leads to a decrease in the efficiency of the plant.

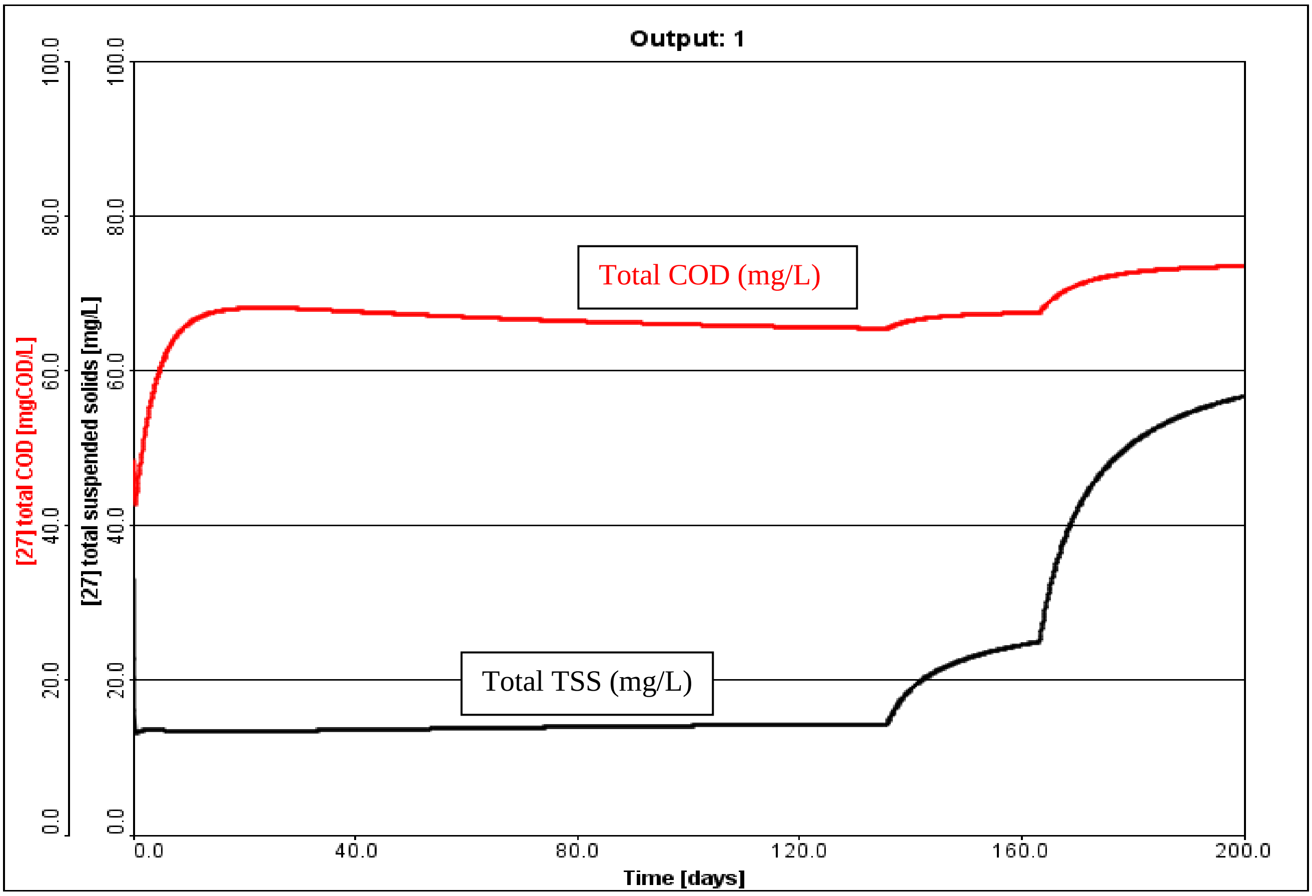

Figure 5 Response of the plant under the second scenario

- **Scenario Three**

Figure 10 shows the response of the plant under the third scenario. The results showed that the steady-state value of COD and TSS in the effluent treated wastewater were 66 mg/L (less than 100 mg/L) and 14.7 mg/L (less than 60 mg/L), respectively, which are within the Iraqi standard, but the value of COD is considered a high value.

The values of the HRT (7.6h), the surface overflow rate (10 m/day) and the solid loading rate (71kg/m^2/day) are close to what they were in the second scenario. However, it is noticed that the percentage of TSS removal is improved, and this may be related to the amount of returned sludge from the secondary sedimentation tank to the aeration tanks in which the change in the amount of the influent wastewater flowrate leads to a change in the amount of return activated sludge (RAS) and waste activated sludge (WAS) The concentration of COD also remained close to what it was in the second scenario due to the stability of HRT, surface overflow rate and solid loading rate at certain values.

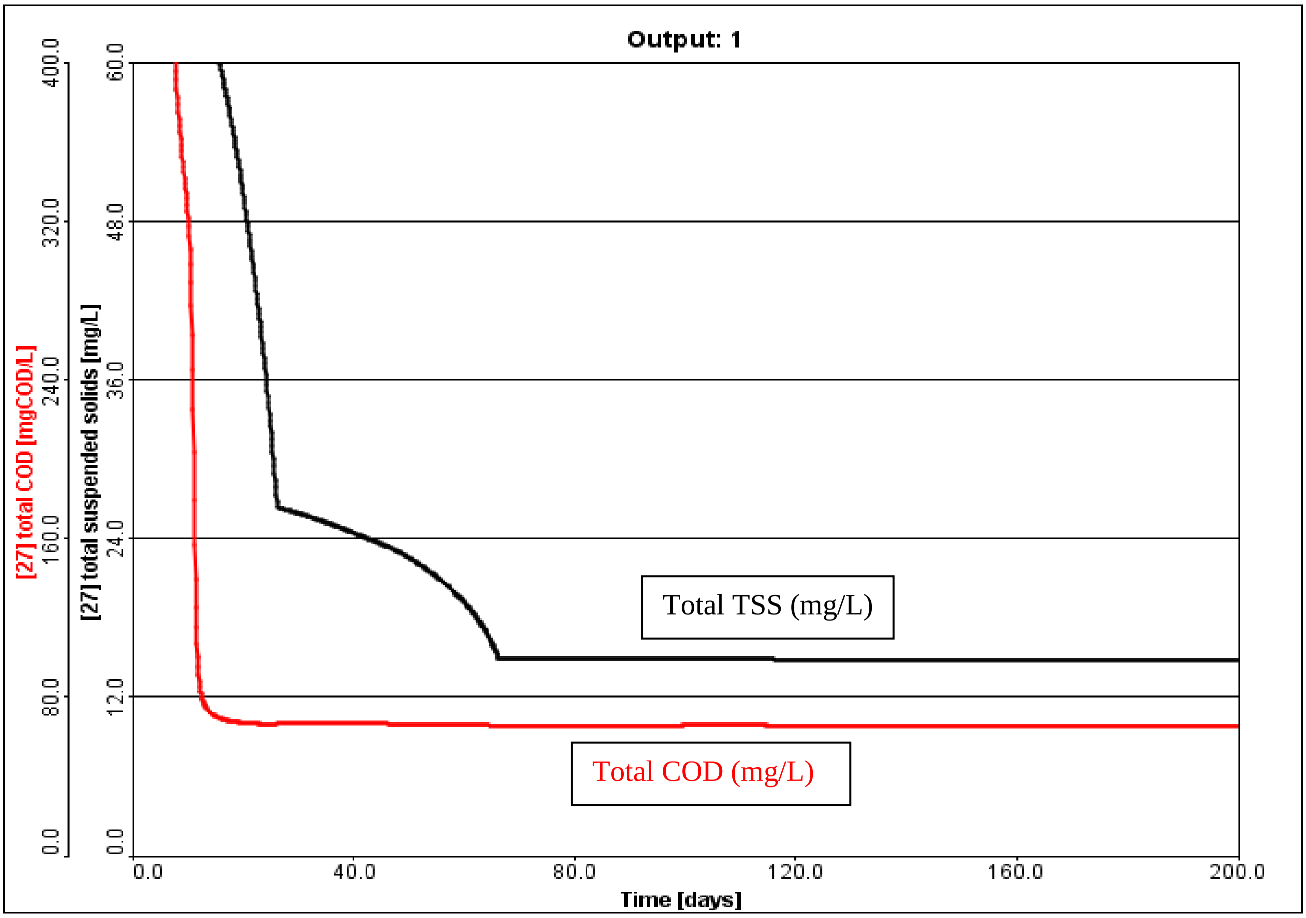

Figure 6 Response of the plant under the third scenario

- **Scenario Four**

There is a clear increase in the amount of TSS and COD parameters in the liquid waste compared to the same parameters in the third scenario. Despite this increase, the values of these parameters did not exceed the limits of the Iraqi standards. The concentration value of COD and TSS in the effluent treated wastewater were 74 mg/L (less than 100 mg/L) and 42 mg/L (less than 60 mg/L), all of these values are considered high values. The HRT value in this scenario was reduced to 4.6, this led to increasing the surface overflow rate and the solid loading rate to 16.5 and 106, respectively. Considering the concentrations of influent pollutants and the amount of the returned sludge, The HRT, surface overflow rate, and solid loading rate in this scenario led to a significant decrease in the removal efficiency of the plant compared to the first scenario. Nevertheless, the concentrations of effluent pollutants remained within the acceptable limits, and this is an indication of the efficiency of the treatment system used in the plant and its design capacity.

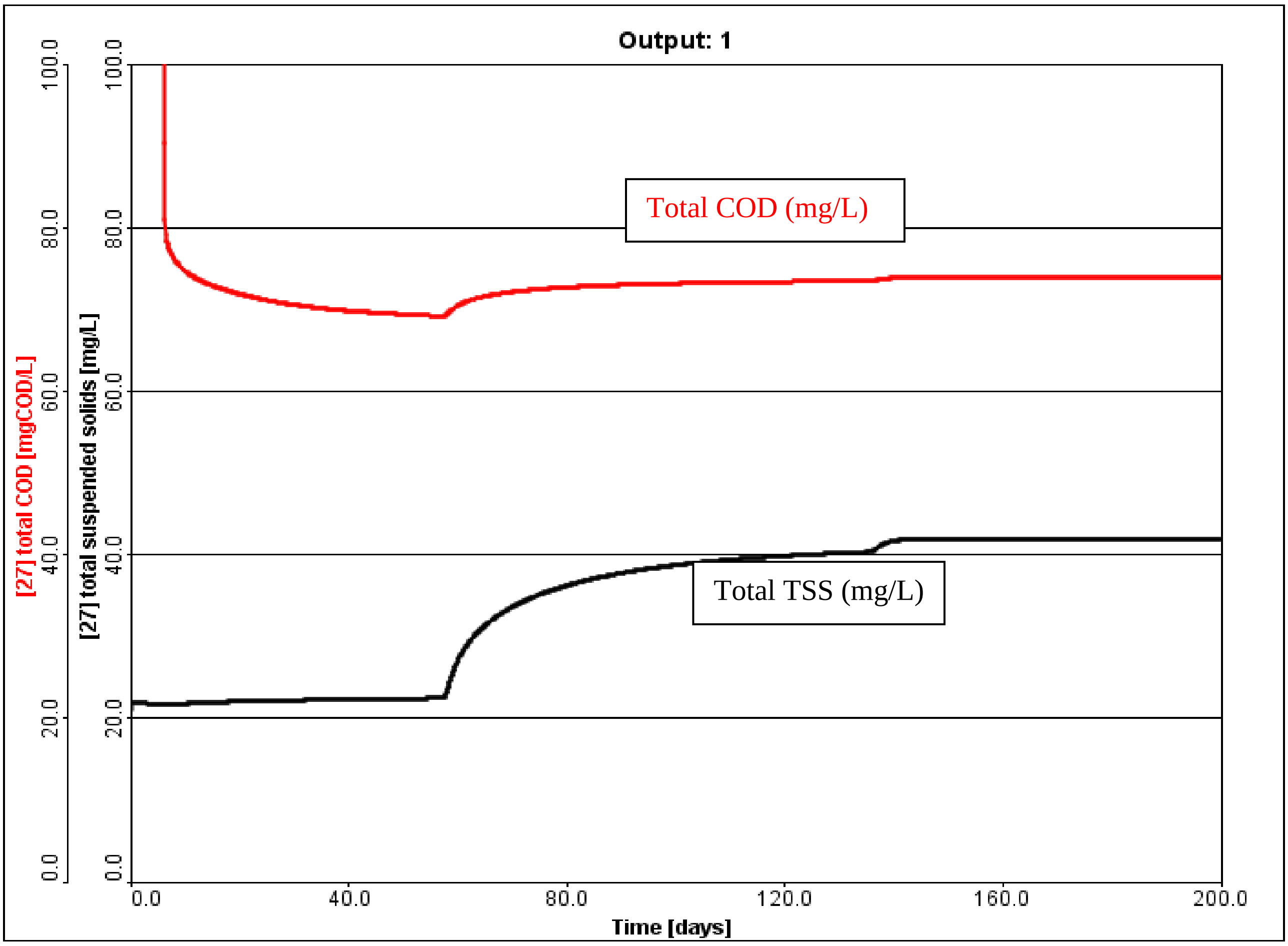

Figure 7 Response of the plant under the third scenario.

5. Conclusions

The Al-Muamirah WWTP is considered as one of the modern wastewater treatment plants in Iraq. In the present study, this plant was modelled by using the GPS-X program with four scenarios of operation. The most important conclusions can be summarized as follows:

- The model of Al-Muamirah WWTP by using GPS-X is with a good validity due to the little difference between the observed and the simulated output values.
- The operation of the plant in the half capacity of the sedimentation tanks instead of the maximum capacity leads to an increase in the concentration of the pollutants. Thus, the removal efficiency of pollutants decreases to a critical state due to the decrease in the value of HRT to 8 hours with the increase of the values of the surface overflow rate and the solid loading rate.

- The operation of the plant under the half capacity of the sedimentation tanks leads to an increase in the concentration of pollutants. Accordingly, the removal efficiency of pollutants decreases to a critical state due to the decrease in the value of HRT to 16 hours with the increase of the values of the surface overflow rate and the solid loading rate.
- Increasing the concentrations of the pollutants entering the plant in the future leads to an increase in the amount of RAS and WAS, but these concentrations remain within the permissible limits because the plant is operated with the total capacity of the sedimentation basins, thus it can treat the increasing of the concentrations in the wastewater.
- The arrival of the influent wastewater to the maximum capacity of the plant reduces the value of the HRT and increases the values of SOF and SLR, thus reducing the efficiency of the station, but it remains within the acceptable limits, and this is an indication of the efficiency of the treatment system used in the plant and its design capacity.

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Table of Abbreviations

No	Abbreviations	Description
1	BOD	Biochemical Oxygen Demand
2	COD	Chemical Oxygen Demand
3	TSS	Total Suspended Solids
4	WWTP	Wastewater Treatment Plant
5	ODs	Oxidation Ditches
6	ASM	Activated Sludge Model
7	EBPR	Enhanced Biological Phosphorus Removal
8	SBR	Sequencing Batch Reactor
9	MLSS	Suspended Solids in Mixed Liquor
10	TKN	Kotal Nitrogen
11	AS	Activated Sludge
12	NH3	Total Ammonia
13	WAS	Waste Activated Sludge
14	HRT	Hydraulic Retention Time

15	SOR	Surface Overflow Rate
16	SLR	Solid Loading Rate
17	RAS	return activated sludge

نمذجة و محاكاة محطة المعيميرة لمعالجة مياه الصرف الصحي بواسطة برنامج GPS-X

الخلاصة: *أصبحت النمذجة الرياضية أداة لا غنى عنها للإدارة المستدامة لمياه الصرف الصحي ، خاصة لمحاكاة العمليات البيولوجية المعقدة. تركز هذه الدراسة على نمذجة ومحاكاة محطة معالجة مياه الصرف الصحي بالمعمرة والتي يعد نظامها خندقًا للأكسدة باستخدام حزمة برنامج GPS-X simulator للتحقق من أداء المحطة من بين أربعة سيناريوهات في ظروف مختلفة. تم قياس العينات أسبوعيا لمدة ثمانية أسابيع. تم أخذ عينات من مياه الصرف الصحي المتدفقة من محطة المعالجة. كانت معايير التلوث التي تم اختبارها لهذه العينات هي الطلب الكيميائي الحيوي على الأكسجين (BOD) ، والطلب الكيميائي للأكسجين (COD) ، وإجمالي المواد الصلبة العالقة (TSS). أظهرت النتائج أن قيم COD و TSS في مياه الصرف الصحي كانت ؛ 47 مجم / لتر و 9 مجم / لتر للسيناريو الأول ، 57 مجم / لتر و 73 مجم / لتر للسيناريو الثاني ، 66 مجم / لتر و 14.97 مجم / لتر للسيناريو الثالث ، 74 مجم / لتر و 42 مجم / لتر L للسيناريو الرابع ، على التوالي. ظلت تركيزات الملوثات في مياه الصرف الصحي المتدفقة ضمن الحدود المقبولة (أقل من 100 بالنسبة للأكسجين) و (أقل من 40 بالنسبة للمواد الصلبة الذائبة الكلية). هذا مؤشر على كفاءة الأداء الجيد لنظام المعالجة المستخدم في المصنع وكفاية وملاءمة قدرته التصميمية.*