# تأثير التغيرات السنوية في درجات الحرارة على كفاءة إزالة مغذيات الاثراء العشوائي من محطة معالجة مياه الصرف الصحي في العراق

**أ.م.د. علي هادي غاوي**

**كلية الهندسة / جامعة القادسية**

**ali.ghawi@qu.edu.iq**

**تاريخ الاستلام : ٢٠٢٠/٦/٢٠**

**تاريخ القبول : ٢٠٢٠/٧/٢٥**

الخلاصة :

**في هذا البحث ، تم استخدام برنامج GPS-X ٦,١ المتخصص في تصميم وحدات معالجة مياه الصرف الصحي لغرض دراسة تأثير تغير درجات الحرارة على كفاءة وحدات المعالجة في إزالة النتروجين والفسفور من مياه الصرف الصحي وجعلها مطابقة للمعايير العراقية لغرض إعادة التدوير والاستخدام في الزراعة في مدينة الرميثة بمحافظة المثنى في جنوب العراق. تمت دراسة تأثير تغير درجة الحرارة خلال عام واحد على جودة المياه المنتجة وتأثيرها على كفاءة محطة المعالجة في إزالة الفوسفور والنيتروجين. تظهر النتائج أن سلسلة من شروط المفاعلات اللاهوائية والهوائية تساعد على إزالة العناصر الغذائية البيولوجية بكفاءة. كانت تركيزات مركبات الفوسفور ومركبات النيتروجين و COD و BOD و TSS أقل من المحددات البيئية المسموح بها. باستثناء إطلاق مركبات الفوسفور خلال الصيف (تموز واب) بسبب حساسية الكائنات المحتوية على الفوسفور لتأثير درجة الحرارة. تمت معالجة التركيزات المتزايدة من الفوسفور المنتج في الصيف بإضافة جرعات المواد الكيميائية (أملاح الألمنيوم أو الحديد) في مراحل مختلفة من محطة معالجة مياه الصرف الصحي والجرعة المطلوبة من Alum في حدود ٠,٤–٠,٨ kgAl / kg P تأثير ، اعتمادًا على استراتيجية الجرعة المضافة.**

الكلمات المفتاحية : برك الاكسدة؛ الري؛ مغذيات الاثراء العشوائي؛ مياه الصرف الصحي؛ درجة الحرارة.

# Effect of yearly temperature variations on removal efficiency of nutrients from wastewater treatment plant in Iraq

Assist. Prof. Dr. Ali Hadi Ghawi

College of Engineering / University of Al-Qadisiyah

**ali.ghawi@qu.edu.iq**

Date received: 20/6/2020
Acceptance date: 25/7/2020

**Abstract**

In this study, the use of the modeling software GPS-X 6.1 specialized in the design of sewage treatment units. To remove the phosphorus and nitrogen from the treated wastewater and make it identical to the Iraqi standards for the purpose of recycling and use in agriculture in the district of Al-Rumaitha in Al-Muthanna province in southern Iraq. The effect of changing the temperature during one year on the quality of the water produced, and its effect on the efficiency of the treatment plant in the removal of phosphorus and nitrogen was studied. Results show that a series of conditions of anaerobic, oxygen-oxygenated and aerobic reactors help to efficiently remove biological nutrients. Concentrations of phosphorus compounds, nitrogen compounds, COD, BOD, and TSS were less than permissible environmental determinants. Except for the release of phosphorus compounds during the summer (July and August) due to the sensitivity of phosphorus-containing organisms to the effect of temperature. The increased concentrations of phosphorus produced in summer were processed by adding chemicals dosing ($Al_2(SO_4)_3$ or iron) in various stages of the wastewater treatment plant and required dosage of alum in the range of 0.4-0.8 kgAl / kg P influent, depending on the dosage strategy.

**Keywords: Oxidation Ditched; Irrigation; Nutrients; Wastewater; Temperature**

## 1. Introduction

Water is the most natural source of water. Water is the most important natural resource. Because the Earth has limited resources, water can be transformed into sources of pollution and environmental degradation, so water quality should be controlled if possible to prevent environmental pollution (Samorì, et al., 2013 and Ghawi, 2017).

Sewage and sewage are closely related to water and soil pollution. It is therefore imperative that waste water and effluent residues should be treated in an integrated manner so that they do not reach water sources whether they are used for domestic, recreational or agricultural purposes (Pasereh, et al., 2017, and Ghawi, 2019).

The purpose of wastewater treatment is to accelerate the natural processes that occur to wastewater under tight conditions and with a small volume.

One of the important reasons for developing methods of treating that water is its effect on public health and the environment, as treatment was limited to removing suspended and floating materials and getting rid of decomposing organic materials and some pathogenic microorganisms. As a result of the advancement of science in the field of chemistry, biochemistry, microbiology and increased knowledge of the impact of pollutants on the environment, whether in the short or long term, in addition to industrial progress and the production of new materials, it was necessary to develop methods of treating those waters that would be able to remove most of the pollutants that were not easy. Remove them by the old methods used. Tertiary treatment is used to remove residual contaminants from secondary treatment. This includes the disposal of nitrogen, phosphorous and suspended matter, among others. Its facilities consist of physical, chemical and biological treatment units. (Ghawi, 2018a, and Ghawi, 2018b).

The goal of biological treatment of waste is to reduce the COD and BOD content in the treated water as well as reduce the concentration of nutrients such as nitrogen and phosphorous (Mata, et al., 2010).

The tertiary stage of wastewater treatment follows the biological treatment phase (secondary) and aims to increase processing efficiency up to 99% for the reduction of BOD5 and the reduction of nitrogen and phosphorus concentrations to the values allowed by the standards. The use of in-depth treatment of sewage can be used in the following cases (Mark, and Robert, 2017). Low capacity for self-purification of the water supply to which the water will be delivered. The need to reduce nitrogen and phosphorous concentrations in treated wastewater. When the water is bad in the area and treated wastewater is used in human activities again, this situation is similar to our case where it is necessary to use the treated water for irrigation and other activities.

Finally, if the concentration of phosphorus in urban wastewater is about 10-20 g / m 3, it does not have a toxic effect on humans, but it causes the growth of algae and algae in the water and therefore the water in oxygen, especially in the deep places, which leads to the fermentation Odor and non-granular taste. The conventional

treatment of sewage water reduces the concentration of phosphorus from about 15-20 in raw water to 10-15 in water out of mechanical treatment. Therefore, in tertiary treatment of this water to remove excess phosphorus (Lee, et al., 2015).
The methods used for in- tertiary treatment are numerous and several can be used to treat wastewater (Kim, et al 2014):

The objective of this research is to study the effect of changing temperature during the year on the process of removing phosphorus and nitrogen from the wastewater produced by the wastewater treatment plant in Al-Rumaitha (WWTP), and make the water produced by the treatment suitable for irrigation and matching the Iraqi determinants.

## 2. Material and Methods

### 2.1 Al- Rumeitha WWTP

Rumaitha is an Iraqi city and a district center in the province of Muthanna in southern Iraq, estimated to have a population of about 100 thousand people. Al-Rumaitha is located on a branch of the Euphrates River (**Figure 1**). The rural areas adjacent to Al-Rumaitha are characterized by the cultivation of date palms and grains. Al-Rumaytha is located north of Samawah and 25 km away. Al-Rumaitha is an agricultural area, so it is necessary to recycle and reuse the wastewater in agriculture. Al- Rumeitha wastewater treatment plant was a traditional oxidation ditch mechanical secondary treatment plant with an approximate design capacity of average dry weather flow 22000 m3/d. In this research, the design of the approved process to achieve the removal of phosphorous and nitrogen from treated wastewater and the effect of annual changes in the temperature affecting were described.


**Figure 1.** Al Rumeitha site map**.**

**2.2 Influent characteristics of Al Rumeitha Sewage Treatment Plant**

The population of the city of Al Rumeitha is about 100,000 people, and the standard daily typically load values for each equivalent inhabitant of the BOD5 ranges between 40 to 80 gramBOD5, and the flow rate for the city is (22000 $m^3$/day) and the average BOD5 is 350 $mg.l^{-1}$, it is possible A contribution estimate of 77 g BOD5/ Equivalent inhabitants per day. Given this $BOD_5$ contribution, it is possible to verify the mean of the properties affecting in proportion to this parameter.

SERECO S.R.L. technology was used in this study to improve performance of P and N removal units. Compares estimates obtained by adopting different sets of load values as shown in Table 1. The GPS-X 6.1 software modeling tool have been used in this study. As shown in **Table 1**, the affected COD should be much higher than official data in Iraq (460 mg / L), and therefore a precautionary value of 650 mg / L was assumed for the treatment unit.

**Table 1**. Inflow wastewater characteristic.

| **Code $mg.l^{-1}$** | **High typical value WWTP** | **High typical value WWTP estimated (USA)** | **typical value WWTP estimated Regional** | **GPS-X Value** | **WWTP Iraq** |
|---|---|---|---|---|---|
| $B.O.D_5$ | 340 | 350 | 178 | 451 | 355 |
| C.O.D. | 750 | 820 | 349 | 720 | 450 |
| T.S.S. | 410 | 410 | 251 | 410 | 410 |

| | | | | | |
|---|---|---|---|---|---|
| T.N. | 68 | 56 | 49 | | 35 |
| $NH_4$-N | 44 | 33 | 46 | | 20 |
| T.P. | 13 | 8.5 | 5.5 | | 8 |

**2.3 Process design for EBNR**

Type of BWWTP process in Al Rumeitha WWTP is the activated sludge process. It oxidizes organic nitrogen and ammonium to nitrates (the N process) by ensuring additional aeration capacity and favorable containment time for the sludge to choose slow-growing nitrogenous biomass. To reduce N concentration in the treated effluent, it is possible to enter a non-toxic section where nitrates will be used in place of oxygen to oxidize the easily degradable denitrification process. Thus nitrate will be converted into nitrogen gas and released into the air. In the oxidation ditches, the mixed liquor is exposed to aerated zones alternated to anoxic zones while circulating around the channel. For the purpose of achieving optimum nitrogen removal in the processing unit, the presence of easily biodegradable C.O.D is necessary and can be achieved through different sources. At the Al Rumeitha WWTP, sludge from the anaerobic tank (to remove phosphorus) will enter the harmless areas at the maximum distance from the ventilation (**Figure 2**), for the purpose of making use of the easily degradable materials coming in with the effect.

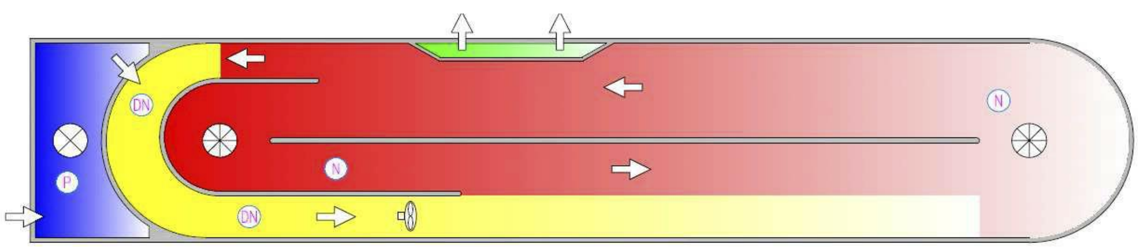


**Figure 2.** Al Rumeitha WWTP oxidation ditched

During normal biodegradation processes, small amounts of P are used for the growth of the biomass, but a large removal efficiency of the treatment unit can be achieved through improved P removal. The last operation is based on the introduction of an anaerobic tank similar to the marker, that is, one in which the accumulation of phospholipids is preferred. These bacteria are capable of storing P in the cell when a sequence of anaerobic and anaerobic conditions is achieved carbon storage and P release will occur in the anaerobic region, while this carbon will be used later in the anaerobic and aerobic tanks and phosphorous uptake will take place. Then P is discharged as the biomass is lost

.

## 3. Results and Discussion

### 3.1 The WWTP design

Standard design procedure is used to determine the initial tank size and estimate sludge production (Metcalf 2003). Once the influencing properties and the desired mixed liquid concentration have been fixed, a minimal SRT and sludge production estimate (depending on the kinetics of the activated sludge model) results in an estimate of the size of the aerated and anaerobic tanks. Al Rumaitha wastewater treatment plant performance has been designed and improved through the use of GPS-X 6.1 modeling and simulation software. GPS-X 6.1 was used to simulate and verify operation performance under minimum temperatures, extreme loading conditions, and typical fluctuations in these parameters.

### 3.2 Simulations and validations using GPS-X 6.1

Figure 3 shows the Al Rumeitha WWTP layout design by using GPS-X 6.1.

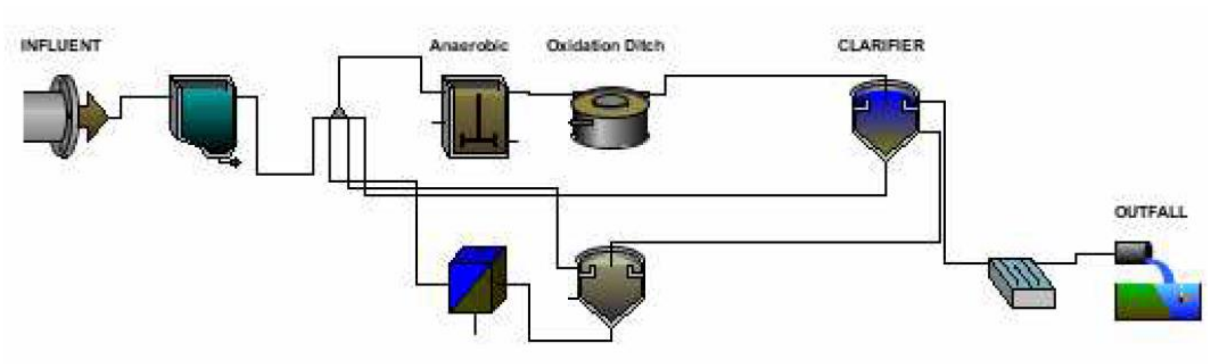


**Figure 3.** Al Rumeitha WWTP layout.

### 3.3 Simulate daily variations of effective load and flow

The change in daily flow is  the typical flow rate of household sewage (Metcalf 2003), **Figure 4** illustrates the differences in daily flow for 3 days of operation.

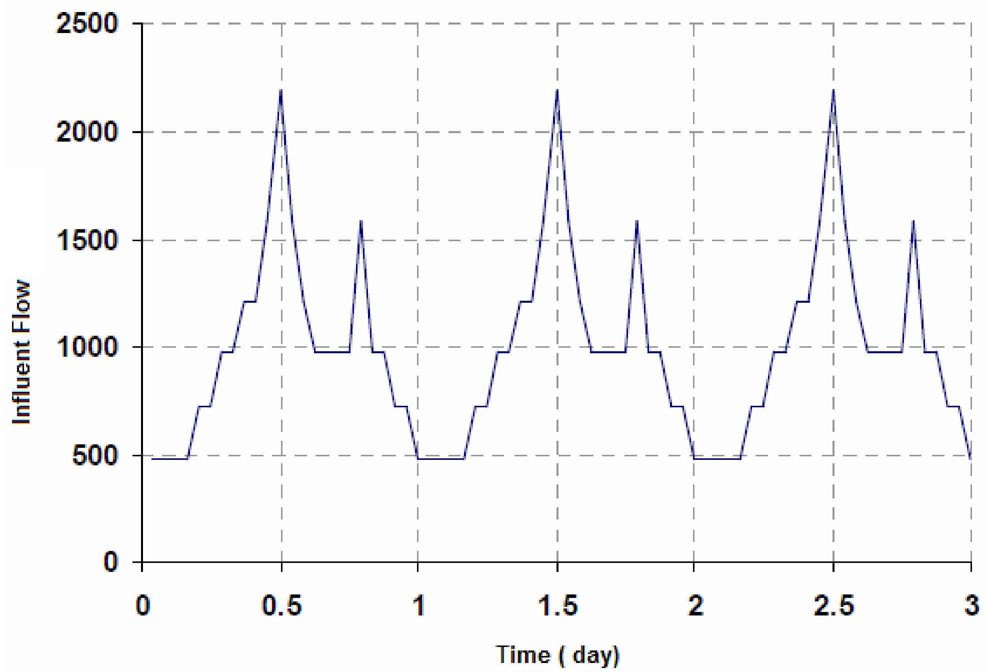


**Figure 4.** Daily flow changing for 3 days of working.

**Figure 5** and **Figure 6** show the results of treated wastewater using simulation led under the aforementioned daily changes at a liquid temperature of 16 ° C. It can be seen that all parameters are under the required standard.

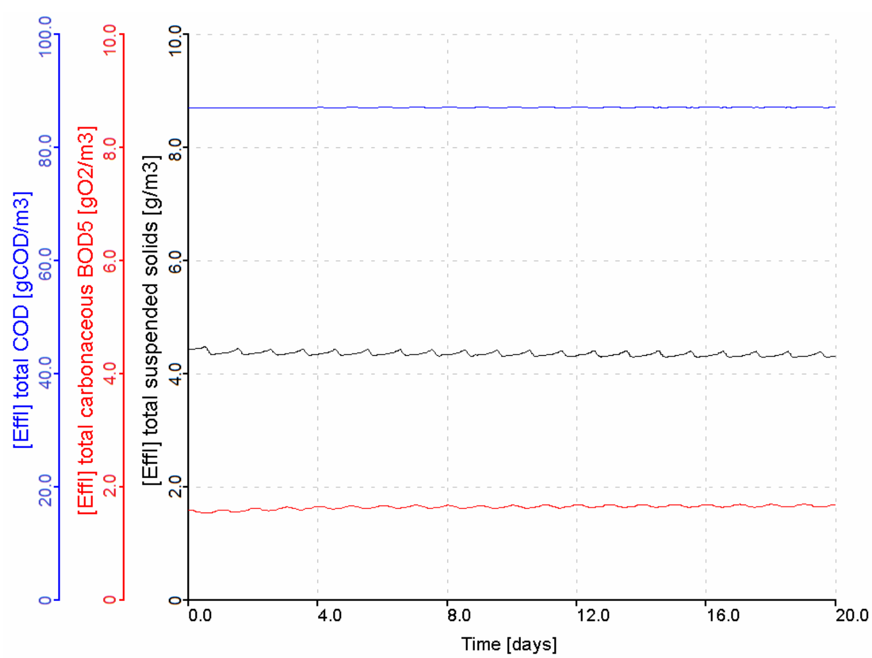


**Figure 5.** The C.O.D, B.O.D5 and T.S.S. in effluent with 16°C.

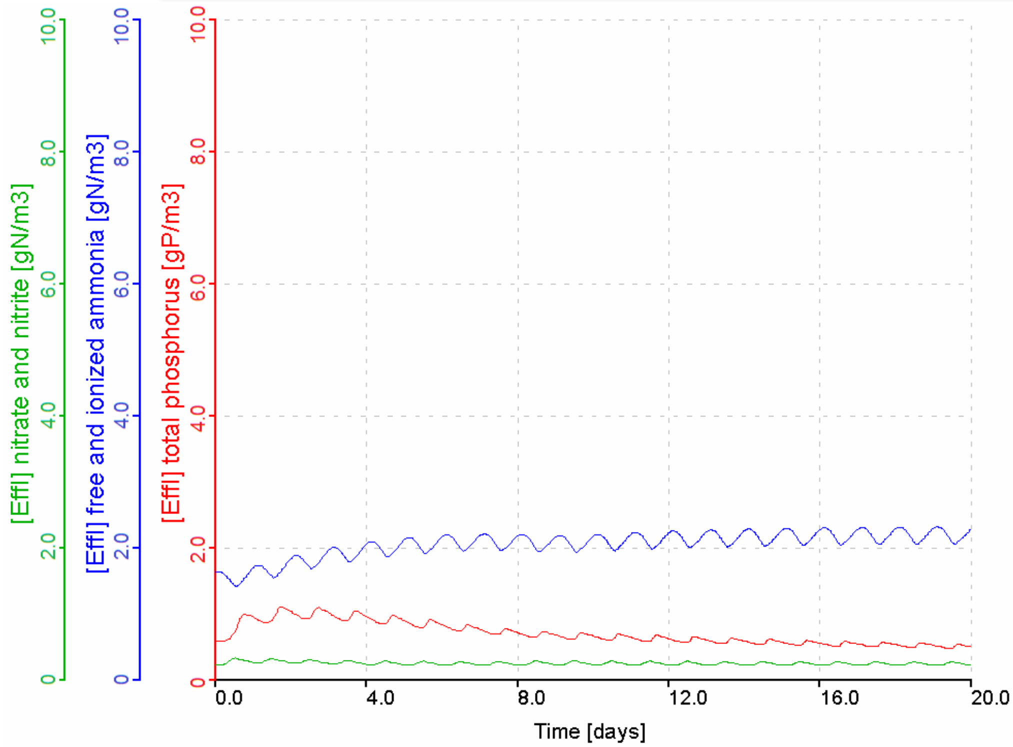


**Figure 6.** The p, n nitrate, in effluent at 16°C.

### 3.4 Simulate annual changes in the temperature of the effluent wastewater

In **Figure 7**, the change of WWT temperature during the year is required design temperature where the results appear.

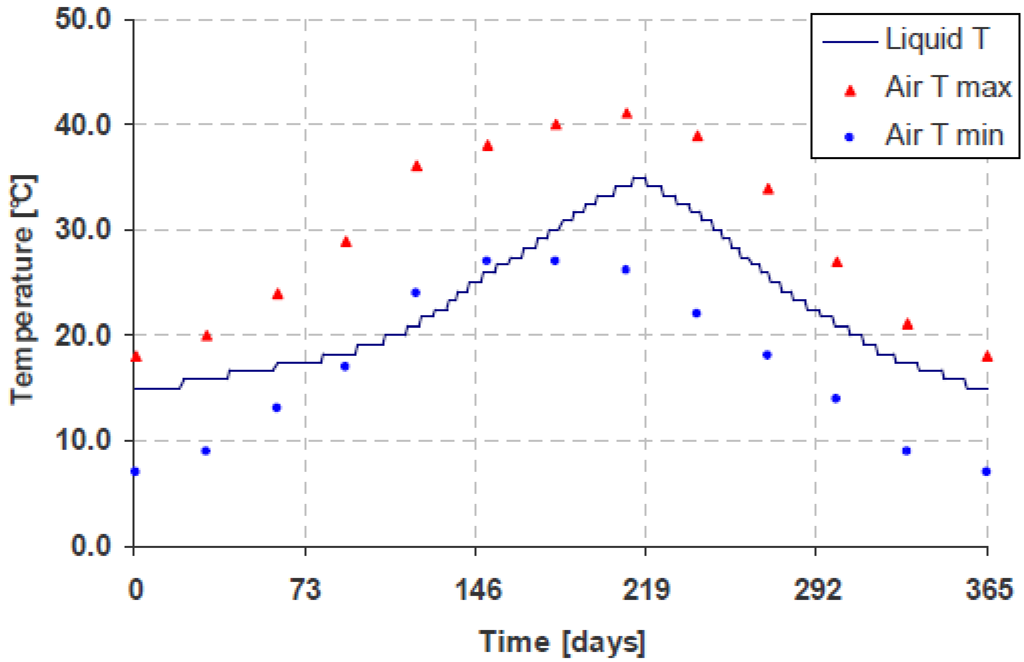


**Figure 7.** The yearly WWT temperature diffrence.

**Figure 8** shows temperature increasing in summer season lead to a considerable release of P in the WWT effluent. Possible action to reduce the phosphorus content in the effluent are discussed in the following section. All other parameters remain below the required limits all over the year.

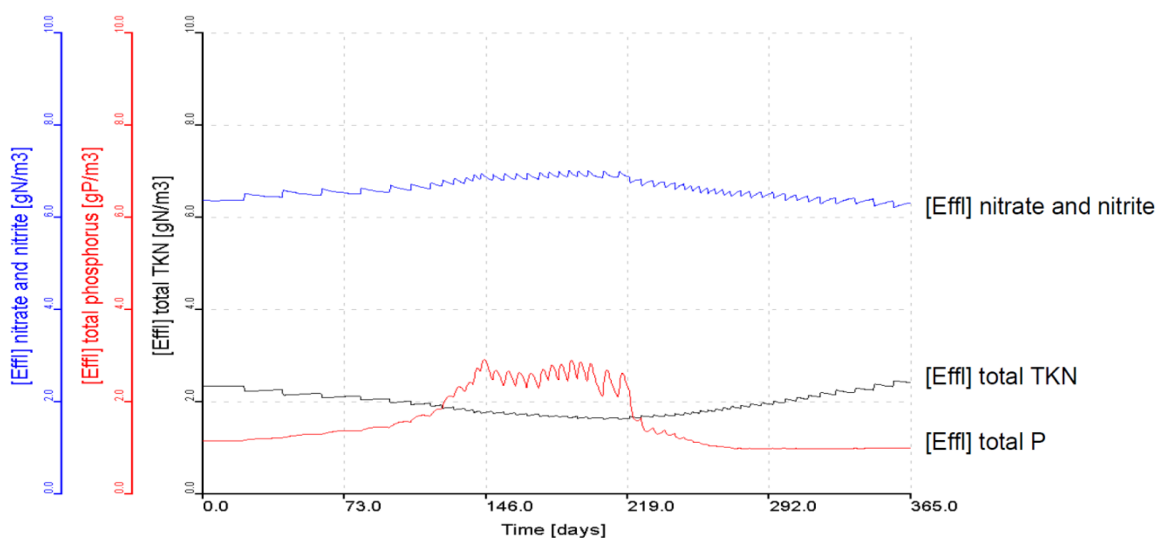


**Figure 8**. P, $NH_3$ and N, in effluent WWTP.

### 3.5 Suggested options for controlling phosphorous flow

The P concentration can be controlled by dosing of chemicals (AL or Fe salts) at different stages of the WWTP in Rumaitha. The occurrence of anaerobic conditions in the sludge treatment line is known to lead to the release of large amounts of soluble organic P into the river into the float and WWT. If these currents need to return to the water line without any additional treatment, they can contribute strongly to the P load on the water line. In this case, the dose of chemicals added to the wasted sludge or in all liquid streams returned to the water line can provide several advantages, as the precipitation of P can be better controlled in the concentrated streams, resulting in less quantity, better dosage and control chemicals. Flexibility. In the processes, the effluent capacity of sludge and dehydrated water sludge is improved.

On the other hand, where it is known that the summer temperature in Iraq leads to instability of the biological removal of P also in the case of adding a dose of chemicals in the sludge line. In this case, chemical dosing added prior to the secondary sedimentation tank would allow control of the P-concentration flow while keeping the costs of chemical additions as low as possible. To ensure maximum flexibility in the operation of the WWTP at Al Rumaitha, direct chemical dosing is required in both the water and sludge lines. According to previous results, the required dose of alum ranges in the range of 0.4-0.8 kgAl / kgPinfluent, depending on the dose strategy. This corresponds to about 5-10 kg alum / kg of liquid matter and a molar ratio of 0.7-1.1.

### 3.5 Expected effluent quality

The effluent water quality was estimated the optimum procedure by using GPS-X 6.1 simulation tool as shown in the **Table 2**.

**Table 2.** The effluent quality data.

| **Code mg.l$^{-1}$** | **WWTP Effluent** | **estimated at 20°C Temperature** | **GPS-X result at 15°C temperature and dosage** |
|---|---|---|---|
| TSS | 30 | 13 | 12 |
| COD | 100 | 55 | 34 |
| $BOD_5$ | 20 | 2 | 5.8 |
| TN | 12 | 8 | 3.7 |
| TKN | 7 | 4.5 | 2.2 |
| Ammonium | | 0.56 | 1.1 |
| Nitrate | | 5.6 | 1.56 |
| TP | 2 | 1.6 | 0.8 |

## 4. Conclusions

Use the modeling software GPS-X 6.1 to design a WWTP in Al-Rumaitha district with a capacity of 100,000 people. The treatment plant is oxidized ditched. The effect of change in discharge and temperature changes on the removal of N and P from treated WWTP for irrigation was studied. The results showed that all effluent COD, BOD5, TSS, phosphorus, and ammonium nitrate are among the Iraqi specifications throughout the year, except for the increased concentration of phosphorus in the summer so it was controlled by adding chemicals dosing ($Al_2(SO_4)_3$ or iron) in various sections of the WWT plant. Therefore, the resulting water can be recycled and used in irrigation as it is within Iraqi standards of water used in irrigation purposes.

## References

1. Ghawi A. H. 2017, Study of the reuse of greywater in the irrigation of the home garden in rural areas. Journal of Engineering and Applied Sciences, 12 (26 SI). 7944-7950.
2. Ghawi A. H., 2018a. Optimum design of phosphorus and nitrogen removal from domestic wastewater treatment plant. International Journal of Engineering and Technology (UAE), 7 (4.20) 310-315.
3. Ghawi A. H., 2018b, Study on the development of household wastewater treatment unit. Journal of Ecological Engineering. Vol. 19 (2), 63-71.
4. Ghawi, A. H. 2019. Development of the greywater domestic treatment unit for irrigation of the garden in rural areas. Journal of Ecological Engineering, 20(3), 46-56. https://doi.org/10.12911/22998993/99732
5. Kim B.H., Kang Z., Ramanan R., Choi J.E., Cho D.H., Oh H.M., and Kim H., 2014, Nutrient removal and biofuel production in high rate algal pond using real municipal wastewater. J. Microbiol. Biotechnol., 24, pp. 1123-1132.
6. Lee C.S., Lee S.A., Ko S.R., Oh H.M., and Ahn C.Y., 2015, Effects of photoperiod on nutrient removal, biomass production, and algal-bacterial population dynamics in lab-scale photo bioreactors treating municipal wastewater. Water Res., 68, pp. 680-691.
7. Mark E. G., and Robert S. C., 2017, The Zeolite-Anammox Treatment Process for Nitrogen Removal from Wastewater—a Review. Water 9, 901; doi:10.3390/w9110901 www.mdpi.com/journal/water.
8. Mata T.M., Martins A.A., and Caetano N.S., 2010, Microalgae for biodiesel production and other applications: A Review. Renew. Sustain. Energy Rev., 14, pp. 217-232.
9. Metcalf and Eddy 2003, Wastewater engineering: treatment and reuse. Fourth Edition, McGraw-Hill, New York.
10. Pasereh F., Borghei S. M., Hosseini S.N., and Javid A.H., 2017, Removal of Nitrogen and Phosphorus Simultaneously from Sanitary Wastewater of Yasouj in

Pilot-Scale in 5-Stage Bardenpho Process. Bulgarian Chemical Communications, Volume 49, Special Issue J, (pp. 329 – 320).

11. Samorì G., Samorì C., Guerrini F., and Pistocchi R., 2013, Growth and nitrogen removal capacity of desmodesmus communis and of a natural microalgae consortium in a batch culture system in view of urban wastewater treatment: Part I. Water Res., 47, pp. 791-801.