Upgrade of Al-Aziziah Wastewater Treatment (Wasit) to Meet Nutrient Removal Requirements

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Abstract

The aim of this paper is to verify of suggestions to upgrade the existing process of wastewater treatment to achieve nutrient removal (phosphorus and nitrogen) from the treated wastewater. The results show that the adding a cyclic anaerobic, anoxic and aerobic condition helped to biological nutrient removal efficiencies. The effluent phosphorus and nitrogen contaminants concentrations were below the maximum permissible concentration under various conditions of flow and temperature except considerable release of phosphorus during summer (July and August) because the sensitivity of phosphate accumulating organisms PAOs to the temperature effect.

Keywords: nutrient, removal, wastewater, GPX, model.

المستخلص

هدف البحث هو التحقق من المقترحات لتحسين أداء طريقة المعالجة التي تعمل بها محطة معالجة مياه المجاري لأحراز إزالة المغذيات (مركبات الفسفور والمركبات النتروجينية) من المياه المعالجة. اظهرت النتائج أن عمل سلسلة من ظروف المفاعلات اللاهوائية والمنزوعة الأوكسجين والهوائية يساعد على كفائة إزالة المغذيات بالطرق البيولوجية. وكانت تراكيز مركبات الفسفور والمركبات النتروجينية أقل من المحددات البيئية المسموح بها ولمختلف التصاريف ومختلف درجات الحرارة فيما عدا تحرير لمركبات الفسفور خلال فصل الصيف (تموز و آب) بسبب حساسية الكائنات الحية الخازنة للفسفور لتاثير درجة الحرارة.

الكلمات المفتاحية: إزالة، المغذيات، الفسفور، النتروجين، مياه ، المجاري

1. Introduction

When wastewater effluents contain nutrient (nitrogen and phosphorus compounds) which discharge to receiving water bodies, the discharged nutrient compounds can cause detrimental environment impacts on the receiving water body and accelerated eutrophication phenomena. Traditionally, biological nitrogen removal was achieved by the nitrification and denitrification processes. The nitrification process converts ammonium to nitrate, with nitrite as an intermediate product, by autotrophic ammonium and nitrite oxidizing organisms using oxygen as the electron acceptor. Denitrification is an integral process involving biological nitrogen removal, which reduces the nitrate to nitrite and nitrogen gas by heterotrophic organisms using organic carbon as the electron donor (Sedlak, 1991, Sotirakou *et. al*., 1999, Din□er and Kargi, 2000 and Zafarzadeh *et. al*., 2010).

Enhanced biological phosphorus removal EBPR used to upgrade activated sludge process to achieve phosphorus removal the end of 1950s (Wentzel *et. al*., 1992). Since then, many amendments to the EBPR systems have been given by researchers (Peng and Ge, 2011,Yuan and Oleszkiewicz, 2011).

In the EBPR treatment system involves enrichment of the phosphate accumulating organisms (PAOs)within the mixed community,which able to accumulate large quantities of polyphosphate (poly-P) in their cells and thus reduced residual phosphorus concentration wastewater (Zuthi *et. al*.,2013).The highest phosphorous concentration is found in the biomass with domestic sewage as a substrate is near 7% (Droste,1997).

This case study illustrates the adding process at a municipal wastewater treatment project that required to upgrade the existing oxidation ditch process for nutrient removal from treated wastewater.

2. Case study existing data

Al-Aziziah wastewater treatment plant was a traditional oxidation ditch mechanical secondary treatment plant with an approximate design capacity of average dry weather flow 23486 m3/d. More specific information on the basic design data are provided in Tables 1 and 2.

2.1 Upgrading the existing plant for enhance of biological nutrient removal:

The biological treatment of municipal wastewater is typically based on the so called activated

sludge process, i.e. on the use of suspended biomass capable to oxidize organic compound. Organic nitrogen and ammonium can be also oxidized to nitrate (nitrification process) by ensuring additional aeration capacity and the adequate sludge retention time for the selection of slow growing nitrifying biomass.

In order to reduce the concentration of nitrogen in the treated effluent, it is possible to introduce an anoxic tank in which the nitrate will be used instead of oxygen for the oxidation of readily biodegradable organic matter (denitrification process). The nitrate will be consequently converted to nitrogen gas and released to the atmosphere. In the oxidation ditches, the mixed liquor is exposed to aerated zones alternated to anoxic zones while circulating around the channel. At the Al-Aziziah plant, the presence of two aerated sections alternated to two anoxic sections will ensure a satisfactory level of denitrification, especially if the aeration intensity was properly controlled. For an optimal denitrification process, the presence of readily biodegradable COD is mandatory and can be satisfied by internal or external sources. At the Al-Aziziah WWTP, the influent inlet point has been moved from the aerated to the anoxic zones in between the two aerators as shown in Fig. 1 in order to favor the utilization of readily biodegradable matter coming with the influent. During normal biological degradation processes marginal amounts of phosphorus are used for the biomass growth, however significant removal efficiency can be achieved by enhanced biological phosphorus removal (EBPR).The latter process is based on the introduction of an anaerobic tank similar to a selector, i.e. a tank in which the growth of phosphorus accumulating organisms (PAO) is favored. These bacteria are able to store phosphates into the cell when a sequence of an anaerobic and aerobic conditions is achieved: carbon storage and phosphorus release will happen in the anaerobic zone, while this carbon will subsequently be utilized in the anoxic and aerobic tanks and phosphorus uptake will take place. Phosphorus will be then discharged with the wasted biomass.

3. Results and discussion

The upgrade EBPR process design shown in Fig.1 has been verified and optimized by implementing the proposed plant layout in the GPS-X 5.0 modeling and simulation software (Hydromantis) in conditions of minimum temperature, peak loading. Then, the operation of WWTP layout of Fig. 2 has been simulated in dynamic conditions: 1) daily variation of the influent flow rate at average temperature and 2) yearly variation of wastewater temperature at average influent flow rate. The results of these simulation are shown and discussed in the following:

3.1 Process verification and simulations with GPS-X

A summary of the results for process design performances in conditions of minimum temperature, peak loading and typical fluctuations of these parameters is presented in Table 3. The plant layout as simulated in GPS-X (Hydromantis) is shown Fig. 2.

3.2 Effect of daily variations of influent flow and load

Daily flow variations have been simulated according to typical flow rate profiles for municipal sewers given by Metcalf & Eddy 2003, Fig. 3 shows the assumed variations for 3 days of operation. The results of simulation under the daily variations showed in Fig. 3 and an average wastewater temperature of 16°C show that the effluent contaminants concentrations were below the maximum permissible concentration as given in Fig. 4 and Fig. 5.

3.3 Effect of yearly variations of influent temperature

The wastewater temperature variation during the year has been simulated according to the provided ambient temperature values, and the assumed trend is shown in Fig. 6.

As shown in the Fig.7, increasing temperature in summer (July and August) time more than 30 °C lead to a considerable release of phosphorus in the effluent, that can be attributed to a certain instability of the biological process for the removal of phosphorus in the water line, as well as to the increased phosphorus release from the thickening because storage of sludge at higher temperature can favor fermentation processes and creation of anaerobic conditions. The others effluent contaminants concentrations (NH_4^+-N, NO_3^--N, BOD_5, COD, TSS) were below the maximum permissible limits as demonstrated in Fig. 7 and Fig. 8.

4. Conclusions

The upgrading of Al-Azeziah wastewater treatment plant by adding a cyclic anaerobic, anoxic and aerobic condition helped to biological nutrient removal efficiencies. The effluent contaminants concentrations were below the maximum permissible concentration under various conditions of flow and temperature except considerable release of phosphorus during summer (July and August) because the sensitivity of PAOs to the temperature effect.

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Table 1: Basic design data.

Inflow (m^3/hr.)			Temperature		
Max.	Average	Min.	Max.	Average	Min.
2188	979	476	34	16	10

Table 2: Influent and effluent wastewater characteristics

Influent characteristics (mg/l)						Effluent characteristics (mg/l)					
BOD_5	COD	TSS	TN	NH_4^+-N	TP	BOD_5	COD	TSS	NO_3^--N	NH_4^+-N	TP
350	670	400	40	20	8	20	100	30	50	10	2

Table 3: A summary of the results for process design performances

Parameter	Unit	Quantity	Remarks
Anaerobic tank volume	m^3	2100	Suggested
Aerobic zone volume in oxidation ditch	m^3	10000	Exist
Anoxic zone volume in oxidation ditch	m^3	29000	Exist
Total HRT	day	42	Exist
Total SRT	day	27.1	GPS-X
MLSS	kg/m^3	4.5	GPS-X
F/M	kg BOD/kg VSS.d	0.07	GPS-X
Sludge recycle ratio		1	GPS-X
Sludge production	kg/d	7000	GPS-X
Observed yield	kg TSS/kg BOD	0.85	GPS-X
Effluent NO_3^-N	mg/l	0.2	GPS-X
Effluent TP	mg/l	0.2	GPS-X
Average oxygen requirements	kg/d	11000	GPS-X

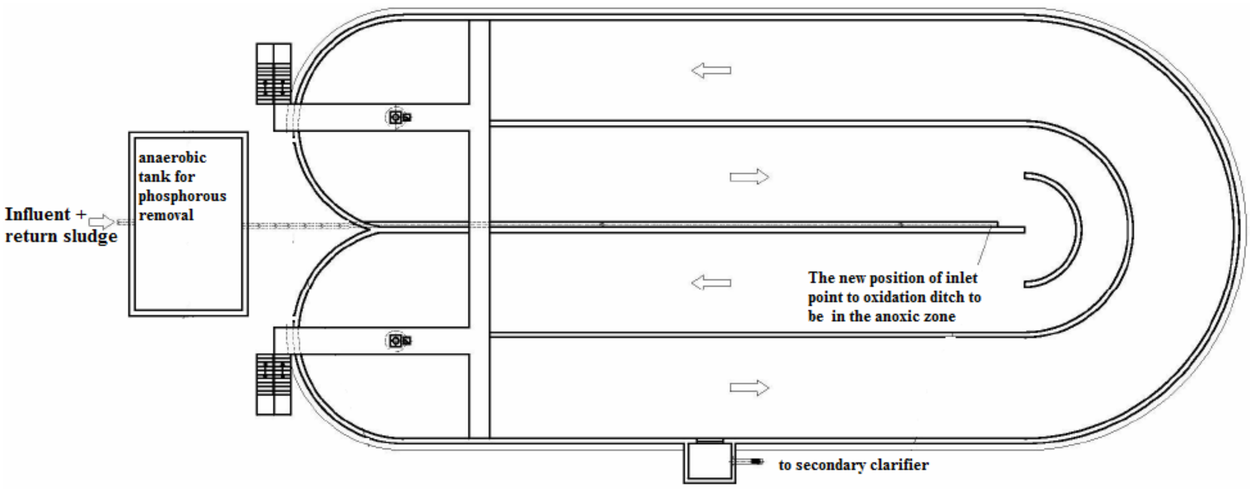

Figure 1: The upgrading suggestions of existing biological process.

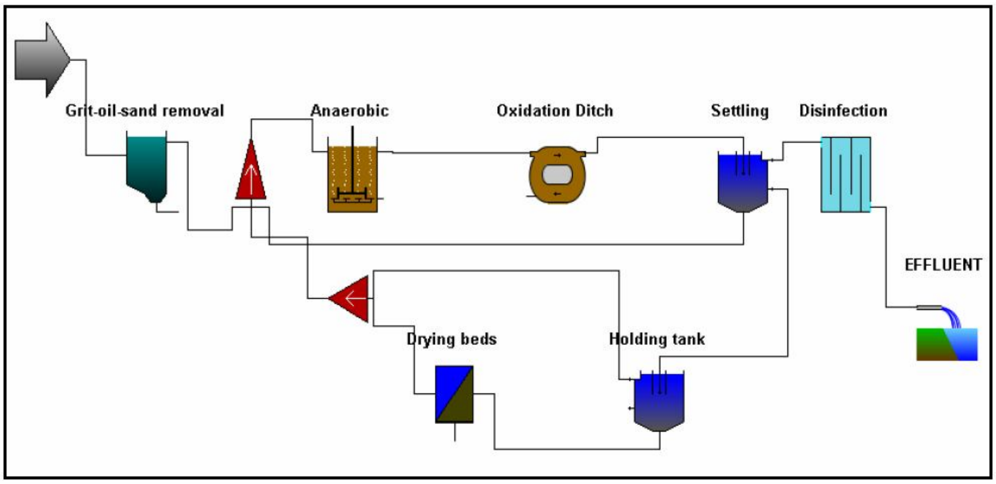

Fig. 2: GPS-X simulation of EBPR for Al-Azeziah WWTP

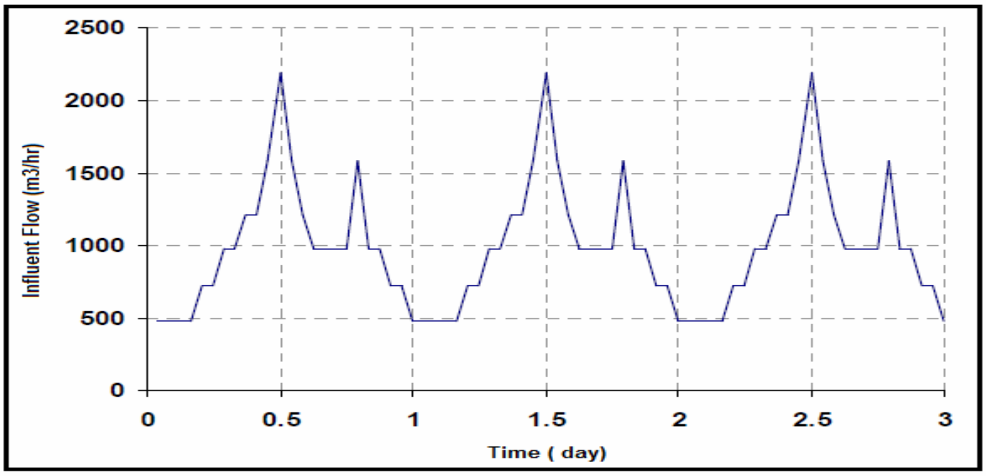

Fig. 3: Simulation of daily flow variation.

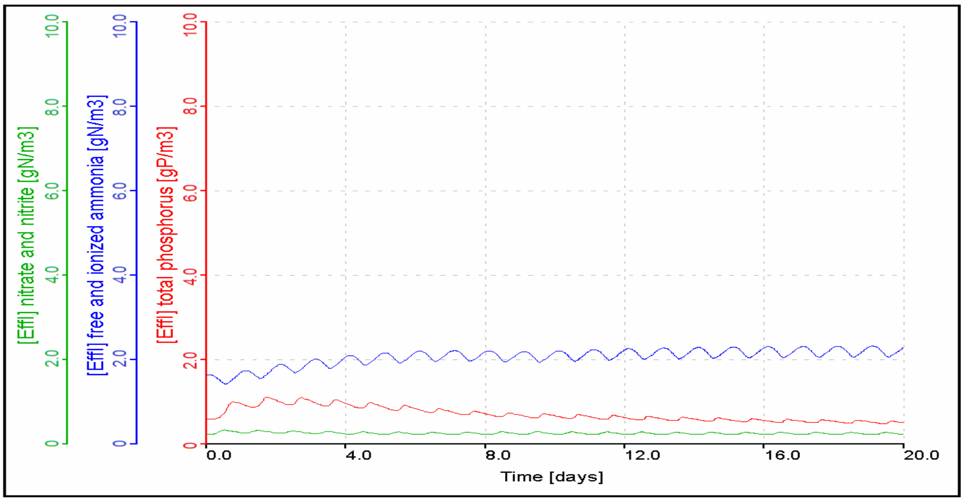

Fig. 4: Simulation results of phosphorus, ammonium nitrate, in effluent under the daily variations of flow and an average wastewater temperature of 16°C

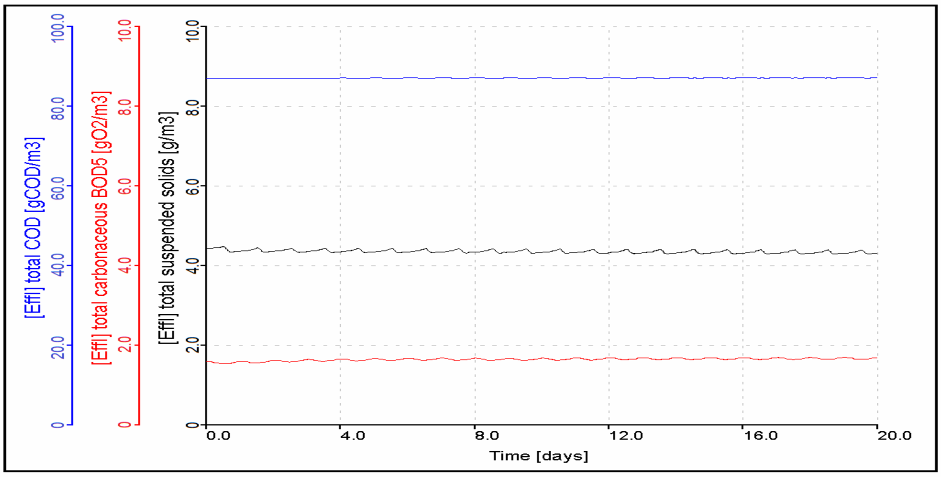

Fig. 5: Simulation results of COD, BOD5 and TSS in effluent under the daily variations of flow and an average wastewater temperature of 16°C.

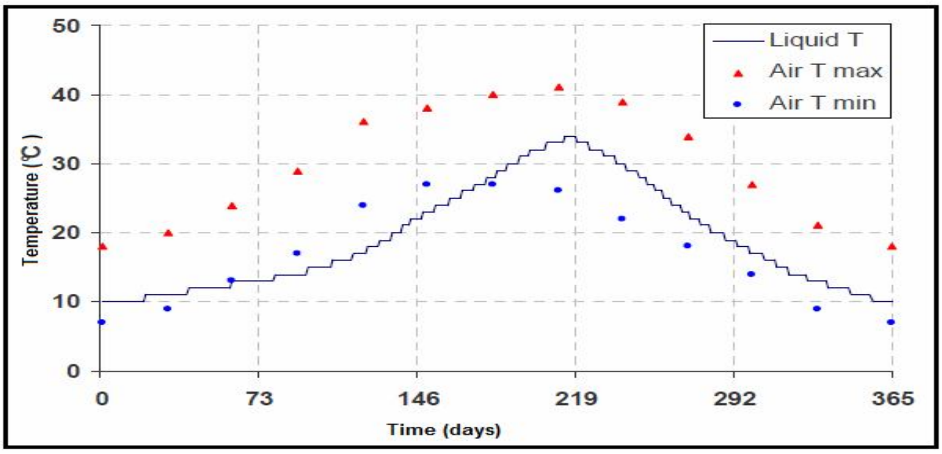

Fig. 6: Simulation of yearly wastewater temperature variation.

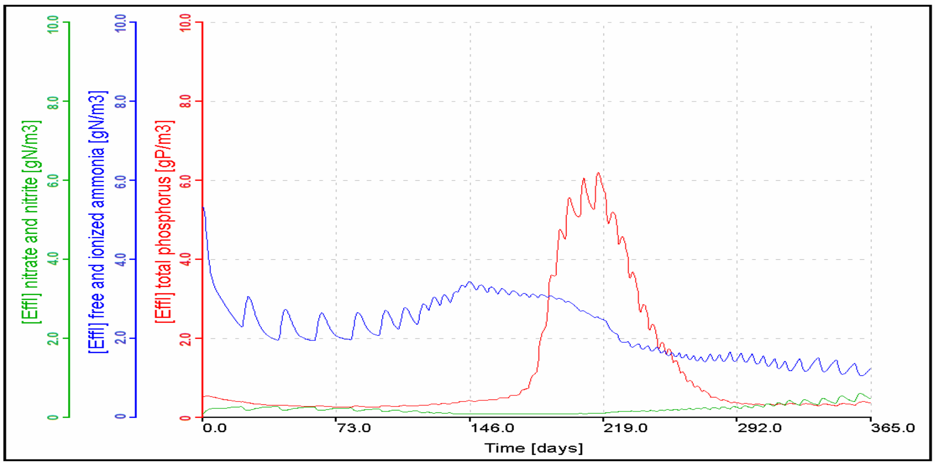

Fig. 7: Simulation results of phosphorus, ammonium and nitrate, in effluent under yearly variation of Wastewater temperature at average influent flowrate

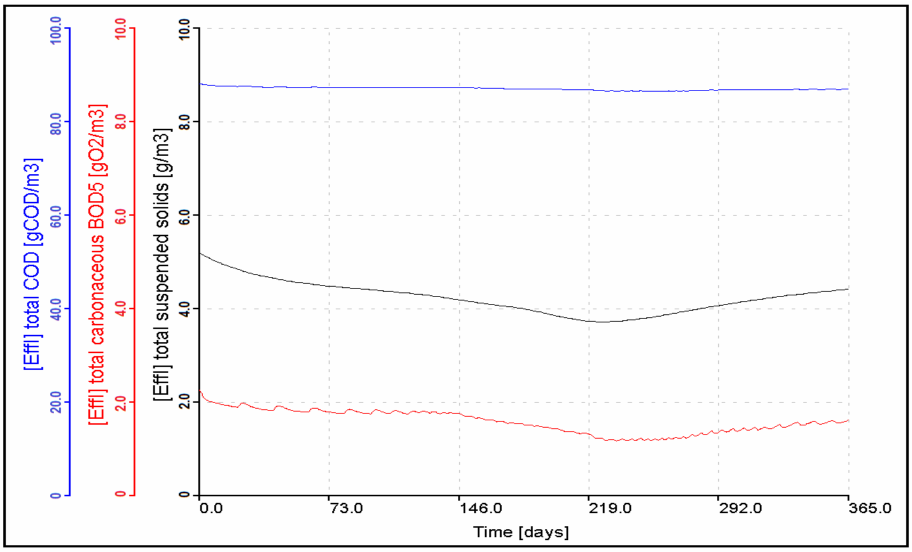

Fig. 8: Simulation results of COD, BOD_5 and TSS in effluent under yearly variation of Wastewater temperature at average influent flowrate