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Performance Assessment of Medium Size Industrial Wastewater Treatment Plant

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Abstract: *In this study, the performance of a medium sized industrial wastewater treatment plant (WWTP), in Kuwait, was investigated. The industrial wastewater treatment plant is of 7,500 m^3/d capacity, and its treatment scheme is composed of primary reception lagoons, primary chemical treatment with dissolved air flotation (DAF) units, and an activated sludge process. With the overall objective of identifying retrofitting scenarios for the plant, the study objectives were to assess the current bottlenecks, identify specific performance related operational parameters, and propose options for expansion or ex-site replication. The wastewater treatment plant was operated well below its capacity (3,500 to 5,000 m^3/d), it was found to produce excessive sludge after the primary chemical treatment due to use of chemicals and lower efficiency of the activated sludge process due to low biological community population caused by the inhibitive chemical contained in the industrial wastewater and introduced by the primary chemical treatment. Potential retrofitting scenarios were found to be the segregation of the received industrial wastewater by industry type, replacement of the chemical treatment by primary treatment stage with anaerobic biological reactor, and the use of an integrated film process instead of the conventional activated sludge process. It was found that through the use of the integrated film process (aerobic), the effluent could achieve 20 mg/l COD and dissolved oxygen > 2.0 mg/l.*

Keywords: *Industrial wastewater treatment plant, Integrated film biological treatment, Retrofitting wastewater treatment plants*

1. Introduction

Wastewater reuse is becoming an economic alternative to augment water supplies in water stressed countries since it is inexpensive, sustainable when resource recovery technologies are employed, and is a tool to adapt to climate change in arid and semi-arid countries. Industrial wastewater, since it may contain harmful and refractory pollutants, need to be treated with high standards and reliability to render it safe to dispose off in the environment. The occurrence and concentration of the chemicals and pathogenic microorganisms in industrial wastewater vary between industries depending on the type and location of industrial facility. It also varies with the type of treatment received, type of storage provided, and the collection system materials. Depending on the intended reuse application, industrial wastewater, usually, is channeled through various reuse system components and technologies to meet the reuse standard. To ensure that the quality of treated industrial wastewater meet standards, the treatment scheme may include many technologies to remove chemicals and pathogens which may cause harm to the environment and, ultimately, cause harm to humans through the food chain. The degree of reliability of industrial wastewater treatment schemes and options rely to a great extent on the sophistication of the treatment schemes and its diverse contaminant removal abilities (1).

At present, the typical four stages of wastewater treatment are preliminary, primary, secondary, and tertiary (or advanced) treatment. There is a huge number of treatment technologies available can be selectively deployed to meet different types of reuse standards. Most reused water, however, will have to undergo some form of disinfection such as chlorination, UV, ozonation, hydrogen peroxide, or combinations of these disinfection technologies.

According to Lee and Tan (2) the Public Utilities Board of Singapore, started producing high quality treated wastewater, referred to as NEWater in 2003. NEWater was made available for direct non-potable use (DNPU) and indirect potable use (IPU). This treated wastewater is of high quality which meets and exceeds the water quality guidance set out in the World Health Organization Drinking Water Quality Guidelines (3) as well as the United States Environmental Protection Agency National Primary Drinking Water Regulations (4).

The industrial wastewater treatment plant considered in this study consists of preliminary treatment, chemical treatment and biological treatment at the secondary level. Disinfection by chlorination is then applied to effluent before storage in storage tanks. The plant does not utilize anaerobic processes or advanced treatment processes to further polish its effluent.

Al-Wafra Industrial Wastewater Treatment Plant, in Kuwait, receives industrial wastewater from various industries via tankers to the maximum daily capacity of 7,500 m3. According to Al-Dhafeeri (5) around 300 tankers daily undergo testing before admitting their wastewater into the plant and in case tests indicate unsuitability some will be rejected. The accepted tankers are responsible for 5,000 m3/d load at which the plant is operating currently. This level of operation is maintained and imposed by the volume of generated sludge (5).

Due to the limited capacity of the plant and the challenges to reuse its effluent, there is a need to study the plant performance, identify its operational issues, and identify ways to optimize its performance in order for it to serve its intended purposes. Additionally, the lack of centralized industrial wastewater treatment plants in Kuwait presents an imperative to study this only plant and identify potential improvements in its performance to serve as a guide for future out-scaling or upgrading to support industrial expansion and environmental protection in Kuwait.

Outscaling Al-Wafra industrial wastewater treatment plant requires improvements made to its performance and its treated wastewater value and it can be achieved in two major ways:

- Build on the current experience to improve the efficacy of the current plant by adding the necessary technology and capacity, and
- Provide ways to replicate its performance in other sites by providing experience based guidance on technology and treatment schemes.

2. Methods

A visit was conducted to the wastewater treatment plant to collect data and information related to its performance. Furthermore, upon identification of the plant major issues, two processes were tested at pilot scale using actual wastewater from the mainstream of the plant to assess their potential of integration into the treatment scheme. The first process was anaerobic reactor for the treatment of primary wastewater and the other is an integrated film hybrid reactor (aerobic) for the biological treatment of secondary water. The two processes were experimented using high flow rate of 400 ml/min (high loading) and low flow rate of 240 ml/min (low loading) using guidelines set for plastic packing trickling filters set by Metcalf and eddy (2014). The pilot reactors were sized at 60*60*80 cm and packed with random packing of a bio-plastic material (150 m2/m3 surface area) as shown in Fig. 1. Then, the two pilot scale processes efficiency was evaluated and compared to the wastewater quality produced at the plant in terms of chemical oxygen demand (COD). COD analysis was conducted according to APHA standards (6).

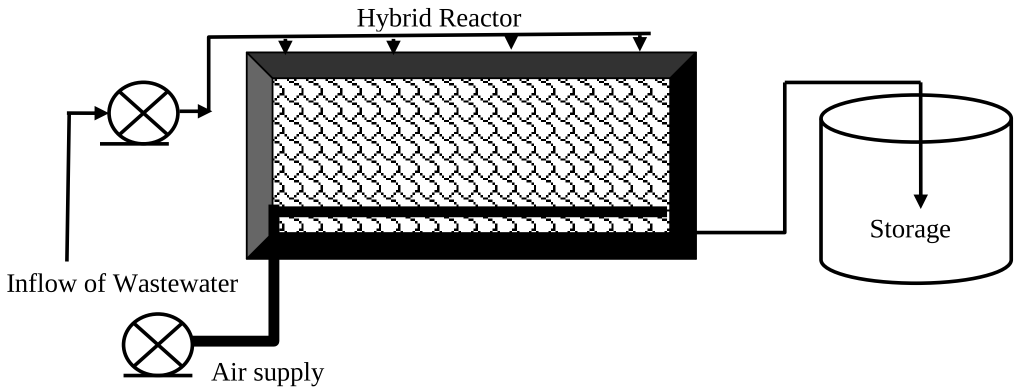

Fig. 1. Treatment process schematic and sampling locations.

3. Results and Discussion

During the field visits the main issues raised by the plant operator were the excessive use of chemicals in the chemical treatment stage resulting in sludge amounts more than the capacity of the incinerator and the low biological growth in the activated sludge process. To resolve these issues two scenarios of anaerobic and aerobic biological processes were proposed and tested as described in the methods section.

The first scenario was a hybrid biological reactor as a replacement of the activated sludge process operated under two loading scenarios and two aeration scenarios (2.0 and 4.0 mg/l DO). The most promising of these scenarios was found to be the high loading (400 ml/min) and low air (2.0 mg/l DO) scenario. The effluent of this scenario was found to render effluents which meet the tripartite agreement for the plant in terms of COD (Table 1).

During the experiments the temperature average was 24.45 oC, and the pH varied between 7 for the inflow up to 8 for the effluent. The COD and BOD concentrations varied on daily basis and ranged between 150-912 and 83-505 mg/l for COD and BOD respectively. Thus, the BOD/COD ratio varied between 0.49 and 0.55.

Hybrid biological reactors are usually used as a replacement of the conventional activated sludge process (aerobic), as an advanced biological treatment (aerobic), or as a primary decomposition step (anaerobic) before aerobic biological treatment (Metcalf and eddy, 2014). In our previous study (7) we have reported on the performance with respect to TOC removal and it was found that the process could serve under any of these scenarios. With respect to COD, the best anaerobic scenario was the high loading scenario which renders effluents congruent with the primary chemical treatment effluents (Table 1). In Table 1, the desired effluent concentrations for the final effluent are set by the Kuwait EPA. For the anaerobic scenario, since it was used a primary treatment, the desired effluent is set by the plant design for the activated sludge process.

TABLE I: Results of Pilot Hybrid Biological Rector Under Aerobic and anaerobic Scenarios.

Operating Parameters	Scenario	
	Anaerobic	Aerobic
Loading (COD) (mg/l/min)	1388	1388
Oxygen concentration (mg/l)	Anaerobic (<1)	2.0
Desired Effluent COD (mg/l)	400	20
Average Effluent COD (mg/l)	250 (10 day average)	<13(10 day average)

These results confirm the potential use of anaerobic and aerobic hybrid biological reactors for industrial wastewater treatment (8-11).

4. Conclusions

In conclusion the performance of this industrial wastewater treatment plant could be greatly enhanced by the use of anaerobic hybrid biological reactor for the primary treatment stage and a hybrid biological reactor operated at high loading and low air in the place of the conventional activated sludge process. These two modifications will greatly reduce the amounts of sludge produced by the chemical treatment and will enhance the population of microorganisms in the secondary treatment leading to reduced operational cost of the plant.

5. Acknowledgements

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