Rehabilitation of Wastewater Treatment Plant of Sakhnin City in Israel by Using Advanced Technologies

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Abstract

This study deals with the rehabilitation of waste water treatment plant (WWTP) of Sakhnin city in Israel. To increase low removal efficiency of the facultative pond (FP) and seasonal reservoir (SR) of the WWTP, different kinds of reactors having different operating conditions were established by the name of two tasks such as intermittent trickling bio filters (ITBFs) and concrete tunnels, respectively. According to the evaluation of the results, it was observed that ITBFs and tunnel units contribute to reasonable removal capacity on sCOD, TSS, NH_3-N and PO_4-P parameters. When it is considered establishing a full scale treatment plant to rehabilitate FP and SR units of available WWTP, this study will be able to a guide for decision makers.

Introduction

There is no doubt that the lack of water in the Middle East and other developing countries is one of the most serious problems we have to face. The problem has been exacerbated in recent years due to the sharp increase in the domestic water demand, caused by an increasing demand from larger populations as well as moves to raise the standard of living.

The Towns Association for Environmental Quality (TAEQ) is an organization based on an initiative of local professionals and key persons in the local municipality. Established in 1993 as a regional environmental quality unit, it is funded by the local municipalities and the Ministries of Environment and Interior in Sakhnin city of Israel.

The Sakhnin wastewater treatment plant (WWTP) includes sewage treatment facilities consisting of two settling anaerobic ponds, a facultative oxidation pond, and a storage pond with a volume of 180,000 m^3. After the treatment process, the water in this storage pond is acceptable for the irrigation of certain crops, most notably olive groves, which surround the facility and are prevalent throughout the region. As part of the LIFE Third Countries initiative of the European Commission, TAEQ will began to technologically upgrade the existing wastewater treatment facilities to produce improved quality effluent for local agricultural irrigation.

This study was performed mainly in the facilities of the Sakhnin Rural Development Center (SRDC) in Israel (1). The WWTP plant of Sakhnin given in Figure 1 treats about 2.000 m^3 each day of the town's wastewater with conventional technology that includes a series of ponds as follows:

- Two anaerobic ponds (sedimentation ponds which are based on biological activity without oxygen, each with a volume of 5.000 cubic meters).
- One facultative pond (FP) (a pond where biological activity is combined with anaerobic bacteria).
- One 150.000 cubic meter wastewater seasonal reservoir (SR).
- An effluent chlorination unit.

Figure 1. Available wastewater treatment plant of Sakhnin.

The "series of ponds" technology is a very common WWTP technology in rural areas and is operating widespread in Israel (2). Upgrading the technologies used in connection with this type of technology will help save water (by using the effluent for irrigation), protect other water resources, and prevent odor nuisances. The problem of water scarcity in Israel led to the development of WWT and effluent reuse technologies.

The goals are to achieve a purification stage which is acceptable in agriculture rising in the area, developing irrigation systems land on recycling water to enable saving good water for purposes other than irrigation.

TAEQ recently received funding from the European Commission to implement a LIFE Third Countries project. This project will technologically upgrade existing wastewater treatment facilities to produce improved quality effluent for local agricultural irrigation. One of the primary educational programs developed will encourage international cooperation between Israeli and Turkish professionals on environmental problems dealing with wastewater treatment and reuse. This research conducted at the Sakhnin center on wastewater treatment will serve as a model to all rural communities throughout the world.

Materials and Methods

For the rehabilitation of the WWTP, different advanced treatment tasks such as ITBFs and stripped concrete tunnels were constructed to rehabilitate the facultative pond FP and seasonal reservoir SR, respectively.

During the establishing of the ITBFs, 16 experimental units were manufactured, according to specially designed feeding system, sampling means, inlet and outlet lines. Two basic models were produced: 8 units of regular size model (1.5 meters high) and 8 units of the longer size units (2.5 meters high). The working volumes of the two models are 120 L and 200 L, respectively. Air distribution pipes were installed into some of the ITBF reactors and the proportions of air to liquid was 10/1. The dosing pumps are timer controlled and the system includes a complete pumping station and intermediate tank in order to provide the system with effluent from the available FP of the full scale Sakhnin WWTP. Several types of fixed medium materials were purchased (chopped olive wood and chopped pine wood of two sizes each).

When the installation of tunnels as a simulation of present SR, the experimental units for testing the project's hypothesis were designed in the shape of tunnels for simulating the flow regime in the SR. Tunnel dimensions are 8 meters long, 2 meters deep, and 1 meter wide. Three tunnels were constructed from concrete cast and are located about 30 meters from the bank of the Sakhnin WWTP. Arrangements were done to feed the experimental SR ponds with the same quality of wastewater that is feeding the full scale operating SR. There is an array consisting of a pump, intermediary tank, dosing pumps, and timer controllers. The tunnels were built with "plug flow" hydraulic regime. In part of the channels, air diffusers will be added to enhance biological activity. In some of the channels bundles of plastic strips will be dipped to supply large surface area for the development of active biomass attached to the plastic strips. The view of the units is shown in Figure 2a and 2b, respectively.

a) ITBFs as simulation of FP

b) Tunnels as simulation of SR

Figure 2. General view of the established pilot units.

Characteristics of the ITBFs and tunnel reactors are given in Table 1 and Table 2, respectively.

Table 1. ITBFs units and design criteria

Reactors #	Height of biofilter	Type of wood chips	Size of wood chips	Aeration	Retention time (day)
1	2.5	Olive wood	4``	-	6
2	2.5	Olive wood	2``	-	6
3	2.5	Pine wood	4``	-	6
4	1.5	Olive wood	4``	-	6
5	1.5	Olive wood	2``	-	6
6	1.5	Pine wood	4``	-	6
7	2.5	Pine wood	2``	-	6
8	2.5	Pine wood	2``	+	6
9	1.5	Pine wood	2``	-	6
10	1.5	Pine wood	2``	+	6
11	2.5	Pine wood	4``	+	10
12	2.5	Pine wood	2``	-	10
13	2.5	Pine wood	2``	+	3
14	1.5	Pine wood	4``	+	10
15	1.5	Pine wood	2``	+	10
16	1.5	Pine wood	2``	+	3

Table 2. Tunnel reactors and design criteria

Reactors #	Reactor type	Fixed medium	Aeration	Retention time (day)
1	Rectengular	-	+	60
2	Rectengular	+	-	60
3	Rectengular	+	+	60

In Table 3 average concentration and removal efficiencies of the two units in available WWTP were given, respectively. As seen from Table 3, these low efficiency results shoved that rehabilitation study of the WWTP was inevitable.

Table 3. Effluent concentration and removal rates of the units in the present WWTP.

Parameters	**Concentrations**		**Removal efficiency, %**	
	FP	**SR**	**FP**	**SR**
sCOD, mg/L	489	317.7	6.7	29.4
NH_3-N, mg/L	51.6	46.9	3.6	17.1
PO_4-P, mg/l	15.6	14.8	18.1	No reduction
TSS, mg/L	125.5	90.8	16.3	13.2

During the monitoring of the effluent characteristics of the new two units, all the parameters such as sCOD, TSS, NH_3-N and PO_4-P were analyzed according to the APHA-AWWA-WPCF (3). At the end of a-one year monitoring programme (April 2005-2006), removal efficiencies of two redesigned units were evaluated.

Results and Discussions

After a-6 week start-up periods, the effluent water quality parameters such as sCOD, NH_3-N, PO_4-P and TSS of two units were analyzed. The total experimental period was 12 months.

Each of the units includes different reactors which have special operating processes. Each of the reactors gives different removal efficiencies in their effluents. To determine the best reactor type in each of the units, the effluent pollution parameters in both ITBFs and tunnel system were monitored for one year.

The results of the ITBFs study were given in Figure 3, 4, 5 and 6, respectively for different initial concentrations. As seen in each of the figures, only two reactors which have maximum removal efficiencies were shown for different two heights. One of the two reactors expresses a-1.5 m height and the other one a-2.5 m height. This determination study is the most important issue to rehabilitate FP unit of the available WWTP during the establishing full scale system.

sCOD removal rates of the ITBF units decrease when the sCOD inlet concentrations increases. The maximum sCOD removal rates were determined at lowest sCOD inlet 300 mg/l. removal efficiencies of are as 81.4% and 87.7% in R-15 and R-8 for the 1.5 m and 2.5 m heights, respectively. As seen from Figure 3, there are some main effective factors on having high ratio sCOD removal efficiency. The most effective factor is having aeration system of the reactors. The others are material size and retention time. It is easily said that the reactor with aeration, fine materials size and longer retention time gives better results on sCOD removals.

In Figure 4, TSS removal rates were shown. It is clearly said that TSS removal rate depends exactly on the material size and long retention time. The thinner material size gives the best result. From Figure 4, R-15 and R-12 have the highest TSS removal rates with the value of 95.2% and 98.8% for a-1.5 m and a-2.5 m height, respectively.

The variation of NH_3-N concentration throughout the ITBF reactors is given in Figure 5. As seen from Figure 5, R-14 and 8 installed with aeration systems to capable of removing NH_3-N as expected as a result of nitrification process. The maximum NH_3-N removal rate was obtained at lowest NH_3-N initial concentration as 40.2 mg/l. R-14 and R-8 were determined having the highest removal rates as 79% as 87.9% for 1.5 m and 2.5 m heights, respectively. During the experimental period, inlet pH values changed between 7.7 and 8.3 which were in the optimum range of nitrification process (4). As nitrification process needs alkalinity, low pH values were determined in effluent at the end of the nitrification process as 5.7 and 6.2.

As for the phosphorus removal in the reactors, Figure 6 shows the performance of the reactors. As seen from Figure 6, filters having without aeration have higher phosphorus removal capacities than the aerobic ones. This indicates that in the anaerobic conditions denitrifying consortium presents in these reactors so phosphate accumulation by this consortium is used in excess of the metabolic requirements (5). As seen from Figure 6, the highest PO_4-P removal level with a percentage of 89% and 89.3%, respectively in R-6 and R-12. According to the results, it is clear that anaerobic conditions have higher PO_4-P removal rates.

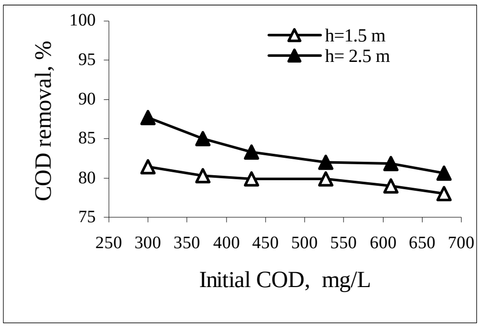

Figure 3. sCOD removal efficiency.

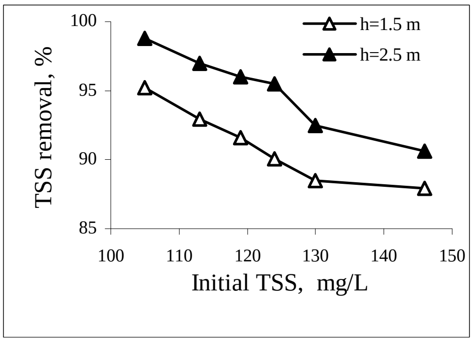

Figure 4. TSS removal efficiency.

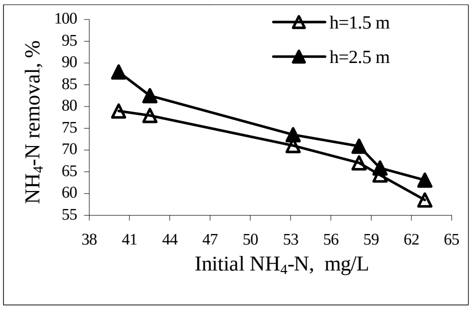

Figure 5. NH_3-N removal efficiency

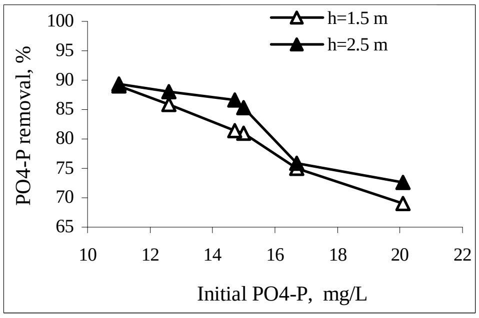

Figure 6. PO_4-P removal efficiency.

At the end of the studies, a-2.5 m height ITBF reactor gives higher removal results when it is compared with a-1.5 m height. Establishing an ITBFs system to rehabilitate the available FP system, the effluent water pollution qualities of FP will be improved at high ratios.

In tunnel systems, effluents quality parameters such as sCOD, TSS, PO_4-P and NH_3-N of the constructed tunnels were given in Figure 7. As seen from Figure 7, it is clearly seen that the R-3 including strips and aeration gives the best results. sCOD, TSS and phosphorus removal values are higher than the other two reactors with the values of it 86.5%, 97.2% and 90.7%, respectively as maximum. The nitrification capacity of the all reactors was also tested during the measurement studies. According to the analyses results, changing of the nitrification capacity of the all reactors are shown in Figure 8. As seen from Figure 8, the best nitrification process occurred in R-3 having aeration system and strips. According to the figure, the effluent NH_3-N concentration was determined 0.8 mg/L. This value is rather low concentration for NH_3-N when it is compared with the available SR unit effluent. With the construction of R-3 the NH_3-N removal rate will be increased up to 98.3% as maximum.

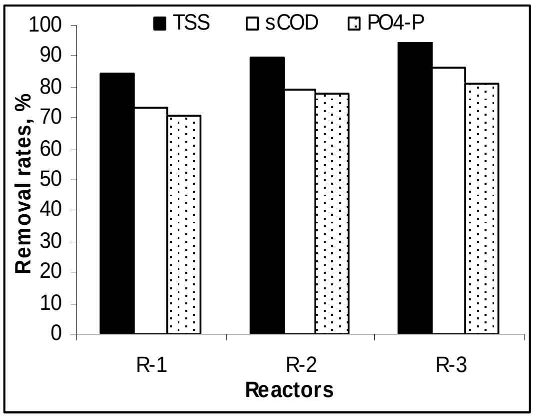

Figure 7. sCOD, TSS and PO_4-P removals

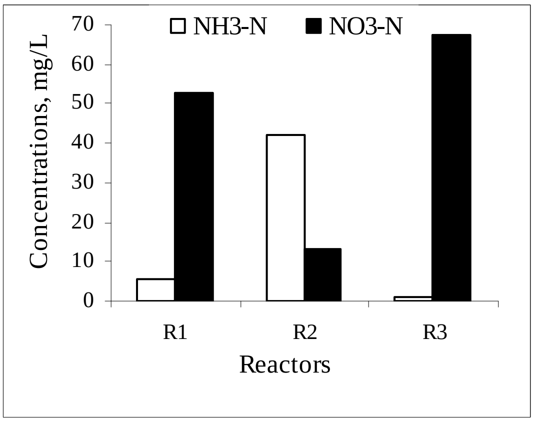

Figure 8. NH_3-N and NO_3-N changing in the reactors

At the end of the study it was seen that redesigned two units contribute at high removal ratios. The maximum removal rate results determined in the study were given in Table 4 for each unit. As seen from the Table 4, there are big differences between available and redesigned units.

Table 4. Comparison of the available and redesigned unit efficiency rates

Parameters	**Removal efficiency of available WWTP, %**		**Removal efficiency of redesigned units, %**	
	FP	**SR**	**FP**	**SR**
sCOD, mg/L	6.7	29.4	87.7	86.5
NH_3-N, mg/L	3.6	17.1	87.9	98.5
PO_4-P, mg/l	18.1	No reduction	89.3	90.7
TSS, mg/L	16.3	13.2	98.8	97.2

CONCLUSION

To increase the low removal efficiency of the FP and SR units, different ITBF and tunnel reactors were established as a pilot scale at the bank of the available WWTP. According to the evaluation of the results, it was observed that ITBFs and tunnel units contribute to reasonable removal capacity on sCOD, TSS, NH_3-N and PO_4-P parameters.

When it is considered establishing a full scale treatment plant to rehabilitate FP and SR units of available WWTP, this study will be able to a guide for decision makers.

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