Chapter 14
Industrial Wastewater Treatment Systems in Egypt: Difficulties and Proposed Solutions

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Abstract The industrial wastewater disposal into surface water and/or land has become a vital issue to consider especially when it becomes a threat to the aquatic life and surrounding environment. Consequently, thorough studies and analyses should be done for the quality of wastewater being discharged from the different industries to determine and implement the most suitable method of treatment at feasible costs. In Egypt, this has been done for 10th of Ramadan City, New Nubaria City, New Borg El Arab City, and Industrial Area of Mubarak – Quesnna. It was found that the optimum treatment facility to be used for the first was oxidation ponds for the availability of vast areas; for the second city best results for treating combined domestic and industrial WW was to construct an anaerobic pond at the inlet of the existing WWTP with a retention time of over 6 h, which can be considered as flow equalization basin; for the third city, studies showed that best results could be attained when domestic and industrial WW are mixed and treated using an activated sludge process but replacing the primary tanks with anaerobic ponds; as for the fourth and last city, it was recommended to install additional units to enhance the treatment of industrial WW before combining it with the received domestic WW to proceed with the treatment process.

Keywords Anaerobic ponds • Chemical treatment • Cost • Industrial WW • Organic load • UASB

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14.1 Introduction

The effluent constituent of wastewater released from industries varies depending on the type of production of the industry. Organic loads in terms of BOD and TSS could alter along the day causing high short-term loadings, in other words "shock loadings"; this becomes a prime problem in the operation of treatment plants with limited capacities [5]. Moreover, various hazardous materials such as heavy metals, organic micro-pollutants, solvents, paints and other chemical are produced from different industries with various activities [3]. Consequently, it is necessary that industries don't drain their effluent wastewater nor to collections systems, nor to treatment facilities before being analyzed and determining their constituents and mass loadings before disposal. About 50% of the industries in Egypt, on statistical analyses done for 37 industries in Egypt, violate the Egyptian environmental law and discharge their effluents into the public sewage network [2] leading to deterioration problems in the sewage pipe network, the biological activity during treatment in WWTPs and threatening the aquatic life in streams and rivers; specially that industrial WW could contain massive loads of toxic materials and increase the cost and environmental risks of sludge treatment and disposal [1].

Hence, the properties of industrial wastewater should be studied in terms of its physical characteristics (which include: solid material, odor, temperature degree, color, and turbidity), chemical characteristics (which include: organic material, industrial detergent, phenol, volatile organic material, organic components indicator, inorganic material), and biological characteristics before discharging the effluent to the sewage network.

This research includes studies done for the combined domestic and industrial WW produced from four Egyptian cities which include: 10th of Ramadan city, New Nubaria city, New Borg El Arab city, and Mubarak industrial zone in Quesnna and shows the different proposed treatment facilities to enhance the final effluent treated quality of the combined domestic and industrial wastewater before discharging it to surface waters.

14.2 Materials and Methods

In order to determine the most suitable type of treatment for each of the above mentioned city, industrial wastewater samples were taken to be analyzed at the Egyptian labs to identify its constituents and loads to be treated. Tests were done to measure pH, COD, BOD_5, TSS, TDS, precipitated solids in 10 min, precipitated solids in 30 min, oil and grease, and phenol using the American Standards Methods. Results are presented in Table 14.1 below. It is worth mentioning that some of the cities don't include separate networks to receive the industrial and domestic wastewater produced but they depend on common networks as those networks of 10th of

Table 14.1 Available characteristics of industrial wastewater for some Egyptian countries compared to the allowable limits determined by the Egyptian environmental law

Type of test	Unit	10th of Ramadan	New Nubaria	New Borg El Arab	Mubarak industrial zone	Allowable limits[a]
pH	–	5.2–6.6	4.9–6.3	5.5–8.1	4.8–8.9	6–9.5
COD	mgO_2L^{-1}	760–1,646	953–7,600	945–1,454	1,790–9,680	1,100
BOD5	mgO_2L^{-1}	420–900	389–2,390	319–417	1,050–3,900	600
TSS	$mg\ L^{-1}$	220–610	250–1,200	400–504	1,153–2,750	800
TDS	$mg\ L^{-1}$	1,122–1,200	1,700–7,800	–	–	2,000
Precipitated solids in 10 min	$mg\ L^{-1}$	15.0	7.0	25	2.0	8.0
Precipitated solids in 30 min	$mg\ L^{-1}$	17.0	11	27.0	12.0	15.0
Oil and grease	$mg\ L^{-1}$	81–112	20–50	25–385	32–304	100
Phenol	$mg\ L^{-1}$	0.7	–	0.74	0.2	0.05

[a]Allowable limits to be discharged to the sewerage system are set according to Law no. 44/2000 in Egypt

Ramadan city. Some cities include separate networks for industrial and sanitary wastewater, which combine in pump stations (PS) before treatment such as in New Nubaria city. Other countries contain separate networks and PSs to the treatment plant such as New Borg El Arab city and Mubarak industrial zone.

As a means to protect WWTPs and its treatment systems, the Egyptian authorities had set up standards and limits for the allowable concentrations of pollutants in the industrial wastewater discharged by the different industries to the sewage network system. This part of the study includes different systems used at current for treating these types of WW and suggested methods for enhancing the treatment efficiency of industrial wastewater whether the waste produced from industrial areas or those combined with sanitary wastewater for the different cities.

14.3 Case Study I: 10th of Ramadan City

Main Problem: As illustrated in Fig. 14.1, there are currently two sources for industrial wastewater at 10th of Ramadan: the first source includes industrial waste only (treated and untreated) with a flow rate of about 130,000 $m^3\ day^{-1}$ coming from heavy industrial zone at south of the city; the second source includes the industrial waste coming from the boundaries of the residential area combined with domestic sewage. Despite the presence of independent networks for wastewater for every area, the industrial and sanitary wastewaters are combined in the main common lines to be discharged to the treatment plant. The flow rate of the combined industrial and sanitary wastewater is estimated to be approximately 90,000 $m^3\ day^{-1}$, 55.5% of which represents industrial wastewater.

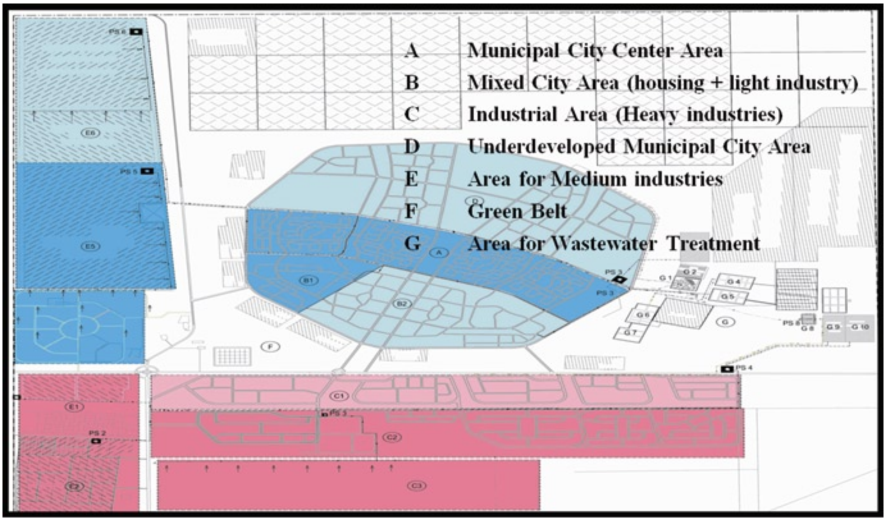


Fig. 14.1 Project area at 10th of Ramadan city

14.3.1 First Source: Raw Industrial Wastewater Treatment

Industrial wastewater received from the south of the city is discharged into oxidation ponds number 3 as shown in Fig. 14.2. These ponds were established in the eastern boundaries in the 10th of Ramadan with a design capacity of 60,000 m^3 day^{-1}, including (anaerobic, facultative and maturation ponds). Currently, the efficiency of these three ponds is deteriorating due to hydraulic over loads and the lack of purification and maintenance ever since they have been established. In addition, these ponds are not coated and they had turned into forests full of trees, grass and ditch reed with high densities affecting the efficiency of treatment in these ponds. Table 14.2 displays the characteristics of influent and effluent WW from these ponds by samples taken and analyzed by the city authorities at year 2007. Results clearly show that these ponds are unable to treat industrial wastewater to reach the allowed standards.

14.3.2 Second Source: Combined Domestic and Industrial Wastewaters

Combined domestic and industrial wastewaters are gathered from the networks to the main PS which directs all wastewater of about 90,000 m^3 day^{-1} to the mechanical WWTP (primary treatment), then to the aerated lagoons to continue secondary treatment; yet the effluent concentrations as displayed in Table 14.3 don't comply with the allowable standards.

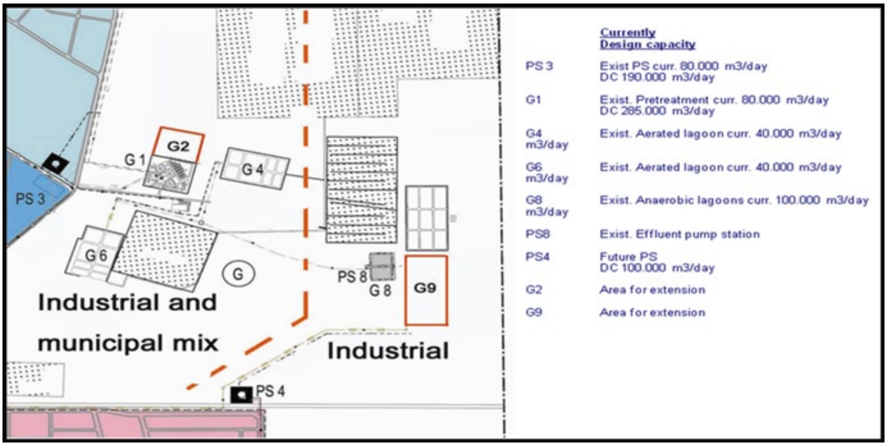


Fig. 14.2 Schematic diagram showing all the existing WWT facilities in 10th of Ramadan city and the suggested solution for enhancement of all facilities

Table 14.2 Result of analyzed samples taken from the influent and effluent of oxidation ponds no:3

		Concentration from ponds no:3 (mg L^{-1})	
Item	Unit	Influent	Effluent
TSS	mg L^{-1}	447–610	120–394
COD	mg L^{-1}	760–1,646	341–698
BOD_5	mg L^{-1}	635–900	240–380

Table 14.3 The characteristics of raw, primary, and secondary treated combined domestic and industrial wastewater

Item (ppm)	Characteristics of raw industrial WW	Results of primary treated WW (from mechanical WWTP)	Results of secondary treated WW (from aerated lagoons)	Required WW characteristics according to law 48/1982
COD	814–1,542	650–1,033	340–676	80
BOD	420–780	260–620	190–300	60
TSS	220–440	154–220	160–290	50

14.3.3 Suggested Solutions for Enhancing Industrial Wastewater Treatment in the 10th of Ramadan City

Aiming to reach the effluent allowable standards, it is suggested that industrial wastewater be separated from residential wastewater; this would allow better treatment of the domestic wastewater and the ability to use treated effluent in irrigating green areas inside the population mass as well as irrigating some crops. As for the industrial wastewater treatment, three different alternatives are proposed in the following lines:

- First alternative: Using chemical treatment
  Chemical treatment is the most suitable ways in treating industrial wastewater. A study was conducted to experiment a number of curdled chemical substances (lime, Alum, H_2O_2 and Ferric chloride) for raw and combined industrial WW. Ferric chloride was chosen for combined domestic and industrial wastewater resulting from the 10th of Ramadan city because of the small dose required (300 mg L^{-1}) in addition to the minimized amount of sludge produced compared to other chemical substances. However, the cost of using ferric chloride in treatment would reach 725,000 £ wk^{-1}, the number of required sludge concentrating tanks would increase from 4 to 20 tanks, and the number of required sludge drying tanks would increase from 29 to 285 tanks.

  This study concluded that it is difficult to use chemical treatment from the practical and economical aspect despite of its success from the practical aspect. According to what was previously mentioned, it is not recommended to use chemical treatment for industrial wastewater in the 10th of Ramadan city.
- Second alternative: Using UASB reactors
  UASB system is one of the modern treatment methods and is ideal for treating industrial wastewater which contains high proportions of COD that may exceed 10,000 mg L^{-1}. Its efficiency in removing COD could vary from 60% to 80%. However, this system is more expensive either in establishing, operating or maintenance from natural oxidation ponds. It also faces a lot of difficulties in implementation and requires well trained technicians and automatic controlling devices in all operation sections of the plant. Thus, it wouldn't be advised to use such a system in this case, especially at high industrial flow rates (about 180,000 m^3 day^{-1} currently and approximately 570,000 m^3 day^{-1} by the year 2050).
- Third alternative: Using anaerobic ponds followed by activated sludge system
  The most suitable and preferred method for treating industrial wastewater (180,000 m^3 day^{-1}) is to use anaerobic oxidation ponds to primary treat the industrial wastewater in order to reduce the concentration of COD and TSS followed by an activated sludge system. This can be achieved using the new established anaerobic ponds (180,000 m^3 day^{-1} total design capacity), not working yet, followed by the existing aerated lagoons (190,000 m^3 day^{-1} total design capacity) as illustrated in Figs. 14.2 and 14.3. For the domestic WWTP, it is proposed to construct secondary treatment (Biolak system) along with the existing primary tanks to treat all the domestic wastewater produced at 10th of Ramadan (which is about 286,000 m^3 day^{-1}) as illustrated in Figs. 14.2 and 14.4. It is proposed to implement a Biolak system (aeration and sedimentation occur in the tank) to follow the existing primary tanks, then allow the effluent wastewater to flow through sand filters for tertiary treatment.

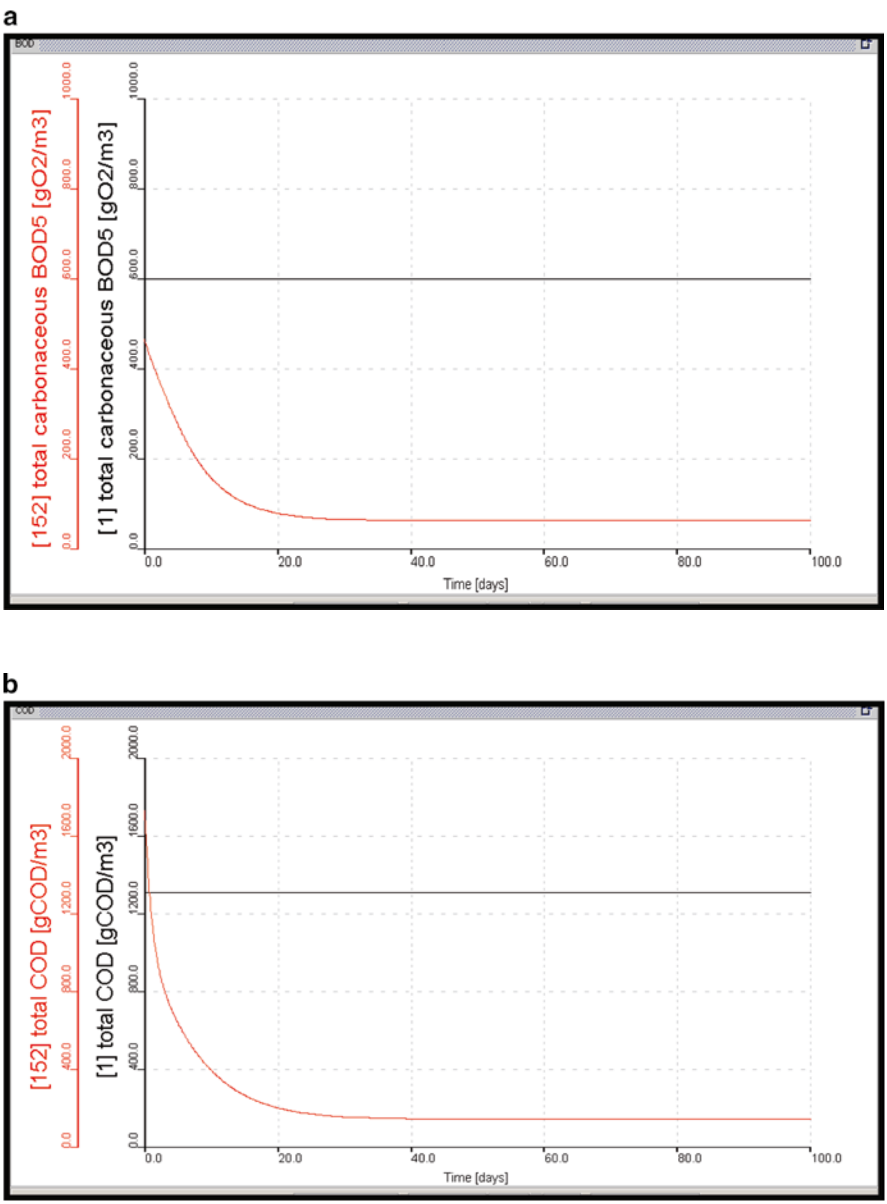
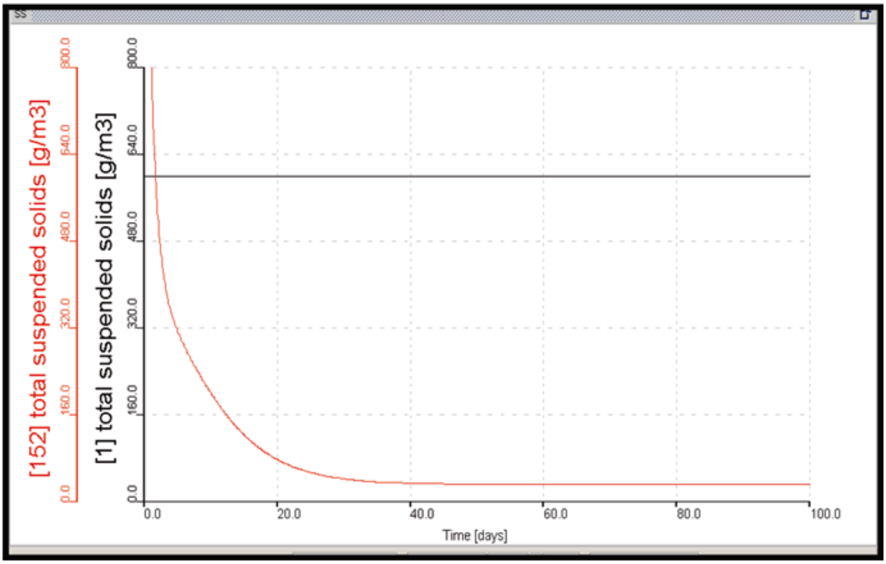


Fig. 14.3 Proposed connection between the new established anaerobic ponds and the existing aerated lagoons to treat all discharged industrial wastewater from 10th of Ramadan industries. (**a**) BOD5 inlet and outlet concentrations in the proposed system ($BOD_{in} = 600$ g O_2 m^{-3}, $BOD_{out} = 60$ g O_2 m^{-3}). (**b**) COD inlet and outlet concentrations in the proposed system ($COD_{in} = 1{,}400$ mg L^{-1}, $COD_{out} = 180$ mg L^{-1}).

c



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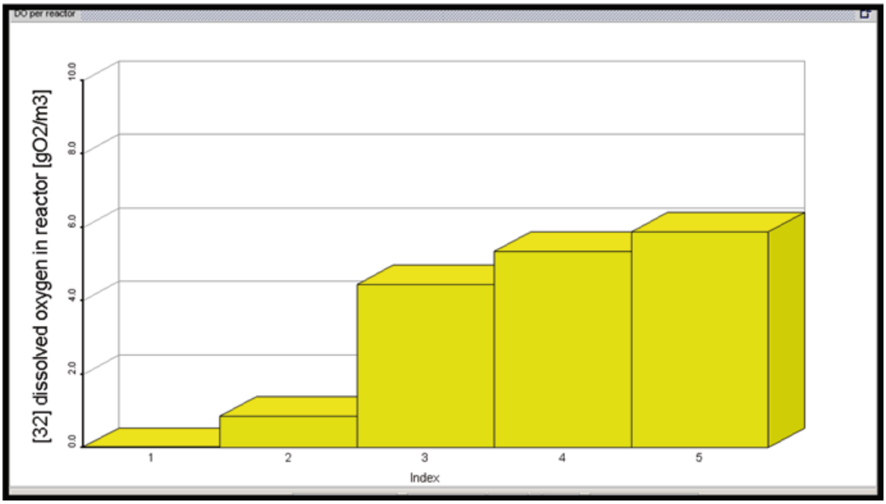
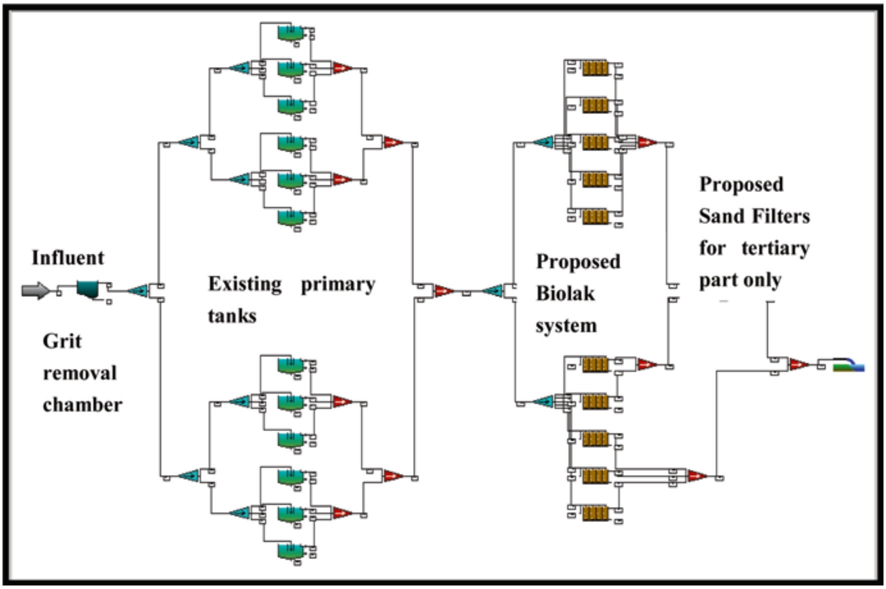


Fig. 14.3 (continued) (**c**) Suspended solids inlet and outlet concentrations in the proposed system (SS_{in} = 600 mg L^{-1}, SS_{out} = 33 mg L^{-1}). (**d**) Dissolved oxygen effluent concentration in the proposed system (Effluent DO = 5.8 mg L^{-1})



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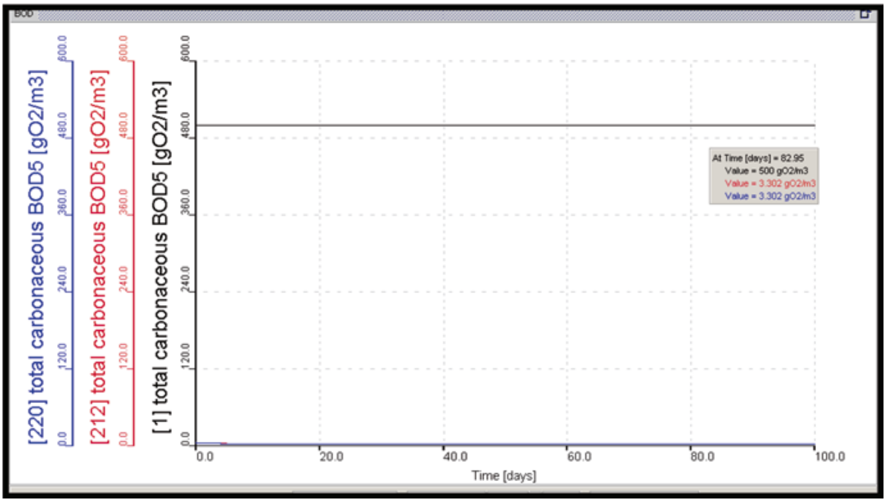

Fig. 14.4 Proposed extensions of mechanical WWTP using the existing PSTs followed by Biolak basins and slow sand filters to treat the domestic wastewater discharged by the city. (**a**) Total carbonaceous BOD5 concentrations in the proposed system.

b

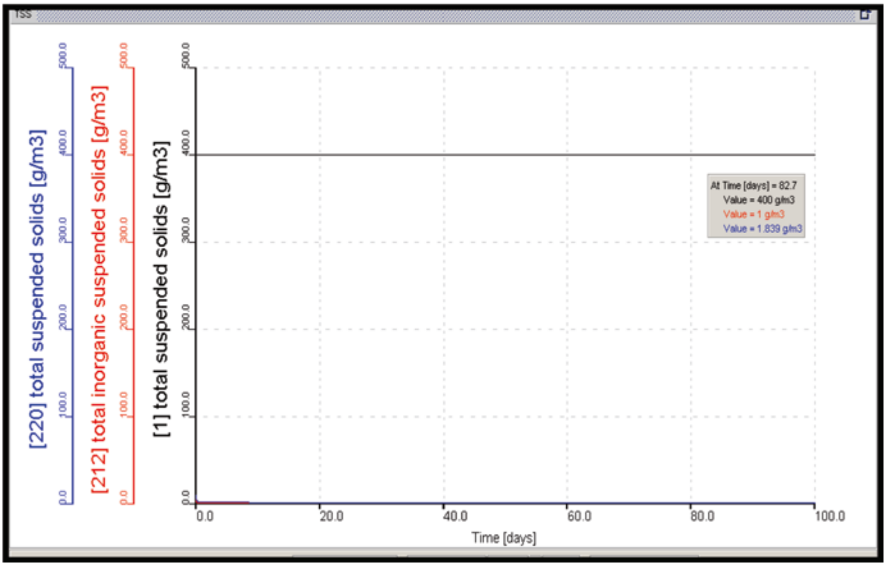

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Fig. 14.4 (continued) (**b**) Total suspended solids concentrations in the proposed system. (**c**) Dissolved oxygen concentration in reactor in the proposed system (DO = 9 mg L^{-1})

14.4 Case Study II: New Nubaria City

The New Nubaria city is a small city and was designed to include two residential districts and two industrial areas. There are two sources of industrial wastewater in the city: raw industrial wastewater and combined domestic and industrial wastewater.

Main Problem: There is an existing mechanical WWTP that is designed to receive a 6,800 m^3 day^{-1} total flow pumped at different timings from 3 pump stations that work alternatively. Thus the influent characteristics of wastewater change as it being pumped from each PS. The mechanical treatment plant consists of two aeration tanks followed by two final clarifiers followed by a chlorine tank. After that the treated WW is transported to the nearest drain outside the city. Table 14.4 presents the characteristics of combined domestic and industrial wastewater and the current removal efficiency of pollutants.

From these facts it is clear that the effluent quality of WW doesn't comply with the required standard. This is due to the continual variation of high influent levels of COD and BOD, especially that the current WWTP was designed to treat domestic wastewater only. Also the plant is hydraulically over loaded, since the incoming flow rates exceeding the design capacity.

Before suggesting the best treatment method for industrial wastewater in New Nubaria city, a study of level of efficiency for the current plant was performed. One of the computer programs has been used (GPS-X) to evaluate the performance level of the current condition of the plant. The influent flow rate, concentration of pollutants over the day, dimensions of the units and their operating conditions have been used. The program gave the various pollutants concentrations expected under different conditions. Figures 14.5–14.7 show some of the expected output results from the program representing the expected results to be discharged from the current WWTP under the current operation conditions.

Figures 14.6 and 14.7 illustrate the high effluent concentrations of COD and SS which may reach 6,000 mg $L^{-1}$and 1,200 mg L^{-1}, respectively, indicating the poor level of treatment efficiency of the plant due to the high influent organic load resulting from industrial wastewater and flow over loading.

Table 14.4 Characteristics of sanitary and industrial wastewater in the treatment plant of New Nubaria city

Item	Unit	Influent	Effluent	Acceptable range
pH	–	4.8	5.6	6–9
COD	mg O_2 L^{-1}	7,600	5,500	80
BOD	mg O_2 L^{-1}	2,400	1,400	60
TSS	mg L^{-1}	1,200	1,100	50
Oil and grease	mg L^{-1}	50	38	10

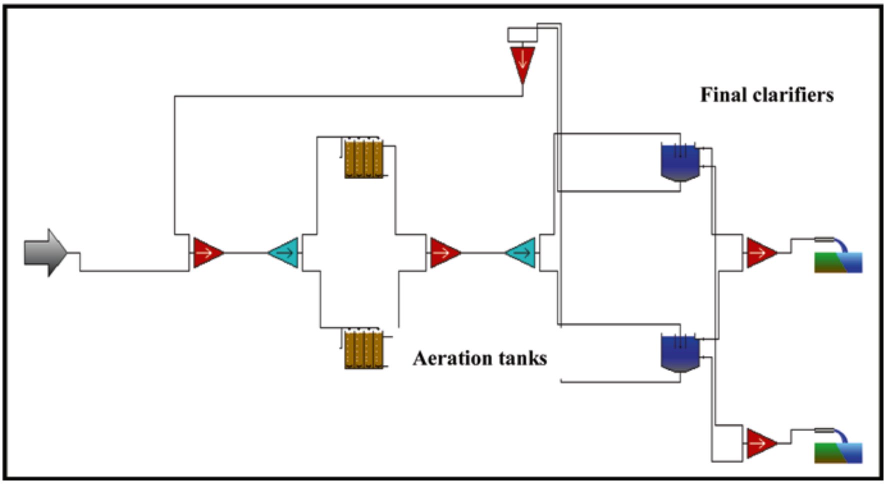

Fig. 14.5 Schematic diagram shows layout of Noubaria WWTP (existing facilities)

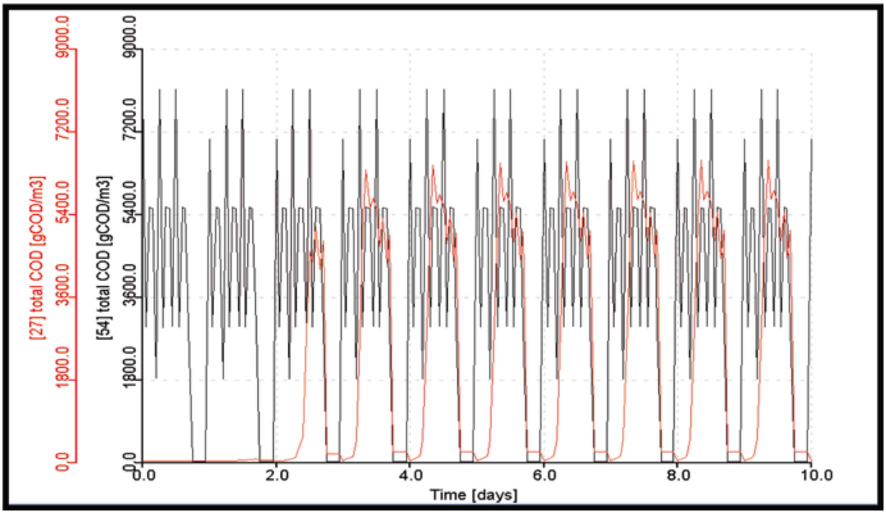

Fig. 14.6 Influent and effluent COD concentrations

14.4.1 Suggested Solution for the Industrial Wastewater Produced at New Nubaria City

Two suggestions could be proposed to enhance the performance level of the existing WWTP. The first solution suggests treating the organic load being released from the factories to acceptable standards according to law no. 44/2000 before being disposed to the plant and which would most likely be difficult to implement.

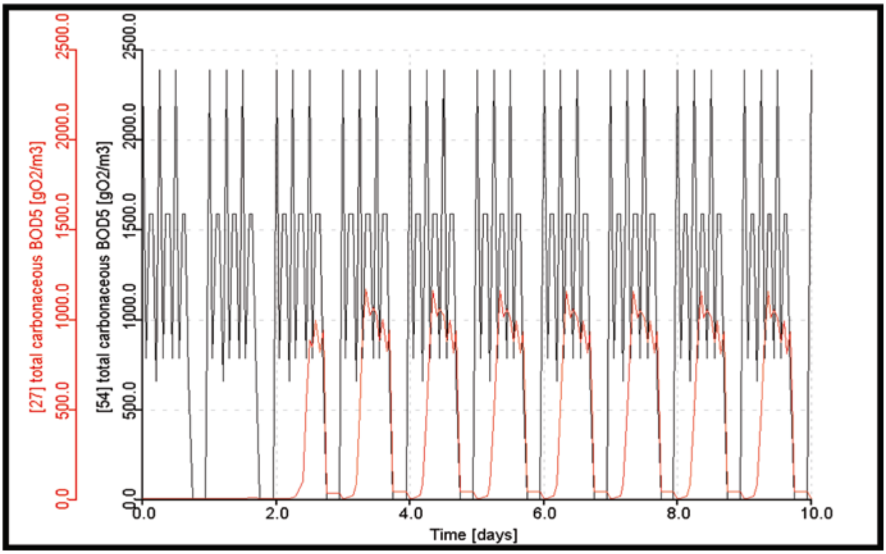

Fig. 14.7 Influent and effluent SS concentrations

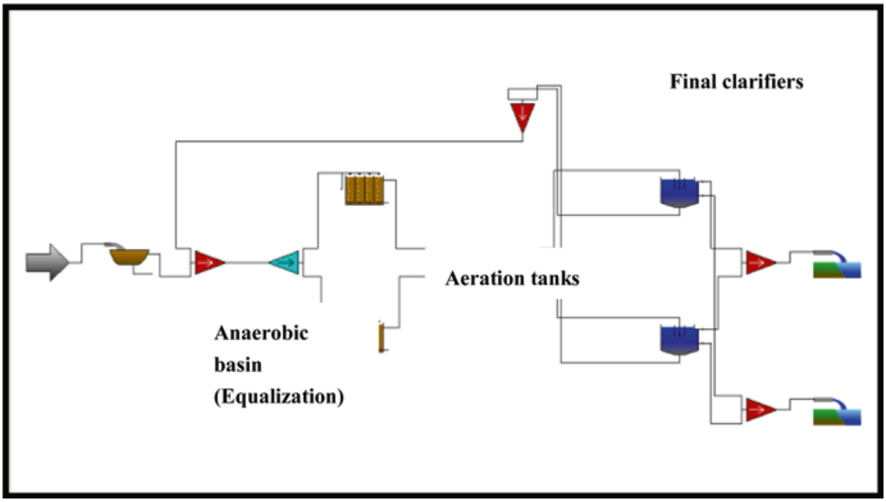

Fig. 14.8 Schematic diagram shows the modifications suggested for Noubaria WWTP

The second suggests constructing anaerobic basin at the inlet of the plant to decrease concentrations of BOD and COD, and more importantly, it would act as a flow equalization tank which would decrease the continual variation in the levels of COD and BOD in the aeration tanks; hence improve the efficiency of the treatment process inside the plant. The second proposal has been studied using GPS-X and the results are illustrated in Fig. 14.8.

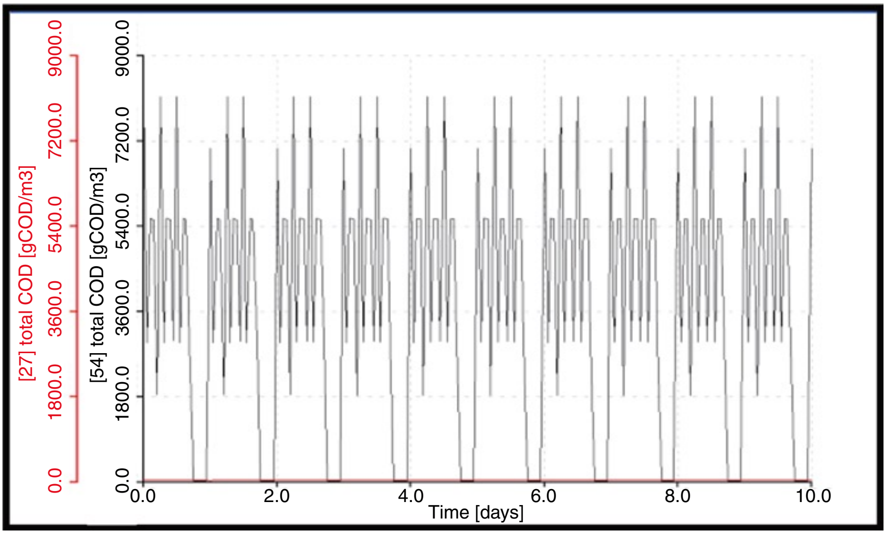

Fig. 14.9 Influent and effluent COD concentrations

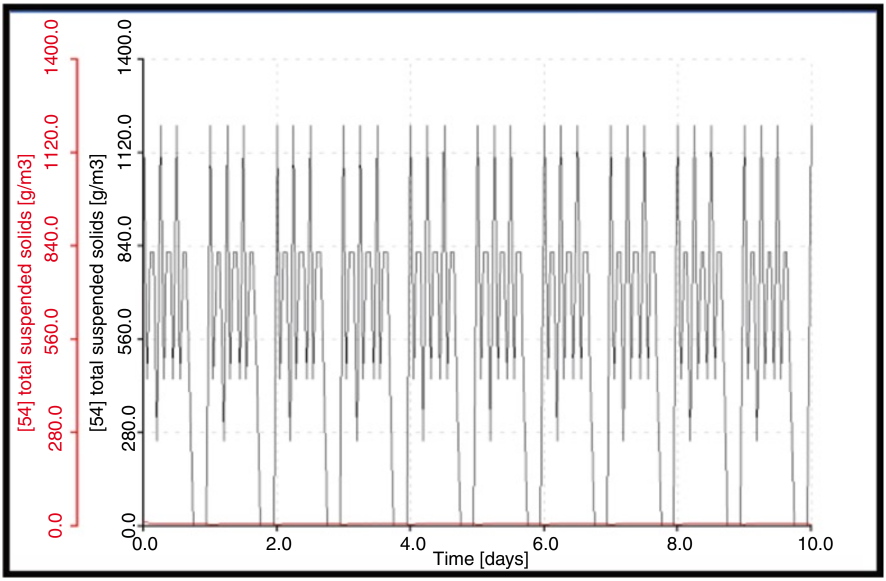

Fig. 14.10 Influent and effluent SS concentrations

Figures 14.9 and 14.10 illustrate the enhanced and steady effluent concentrations of COD and SS, 70 ppm and 30 ppm respectively, showing the vital importance of constructing anaerobic basin before proceeding with the treatment process.

14.5 Case Study III: New Borg El Arab City

New Borg El Arab, with an aimed population of 535,000 is characterized with its various industrial activities which play a major role in the development of the city. The amount of domestic wastewater is estimated to reach 136,000 m^3 day^{-1} at the saturation level, while the amount of industrial WW is estimates to reach 162,000 m^3 day^{-1} by 2017 according to the modified general layout of Borg el Arab city.

Main Problem: In the present, the domestic WW produced from the city (30,000 m^3 day^{-1}) in addition to about 45,000 m^3 day^{-1} industrial WW are treated through a WWTP located east of the city using 6 batteries of oxidation ponds (include aerobic, facultative and maturation ponds). The other portion of industrial WW received from another area is being disposed into a pond or lake located at El Mahager area west of the city with an area of 55 acres.

Table 14.5 illustrates the characteristics of domestic and industrial wastewater produced from the city. It is clear that the concentration of pollutants is moderate and close to the allowable standards, which in turn signifies the adherence of most of the factories to treat their waste before disposing it into stream water or sewage networks. Table 14.5 displays the characteristics of influent and effluent WW from the treatment plant with the oxidation pond system. It is clear that the treatment plant is inefficient in decreasing the amount of organic load for the industrial wastewater to the allowable standards. The other portion of the received industrial wastewater is disposed in the lake where part of the water is allowed to leak into the ground and the remaining water is vaporized. Recently the high level of ground water was noticed in the neighboring areas near to this pond in addition to the over flooding of the wastewater above the embankments leading to environmental problems in the surrounding area.

14.5.1 Suggested Solution for Industrial Wastewater in New Borg El Arab City

According to the improved general layout of Borg El Arab city, it is suggested to establish a WWTP west of the city at El Mahager area to treat all domestic WW conveyed from the city till the level of saturation. Because New Borg El Arab is distinguished, most factories primarily treat their wastes before discharging it into the sewerage system. Hence, it is suggested to combine domestic and industrial WW which is free of any poisonous material and treat them together to dilute the concentration of organic load present in the industrial wastewater.

For primary treatment, two alternatives were suggested: the first depends on the use of primary sedimentation tanks that remove about 40–60% of SS and about 30–40% of organic substances. The second alternative depends on the use of anaerobic ponds. GPS-X program was used to simulate both alternatives and has proven to use the second alternative as shown in Figs. 14.11–14.13. Simulation results showed the possibility of reaching the allowable effluent concentration limits using the above proposed system.

Table 14.5 Characteristics of domestic and industrial WW for New Borg El Arab WWTP (oxidation ponds)

Item	Unit	Domestic and industrial wastewater (3 batteries)		Industrial wastewater (3 batteries)		Acceptable ranges of effluent
		Influent	Effluent	Influent	Effluent	
pH	–	5.5	6.5	7.1	7.3	6–9
COD	$mgO_2\ L^{-1}$	748	422	1,454	621	80
BOD	$mgO_2\ L^{-1}$	289	104	417	189	60
TSS	$mg\ L^{-1}$	134	26	504	172	50
Oil and grease	$mg\ L^{-1}$	315	65	385	230	10

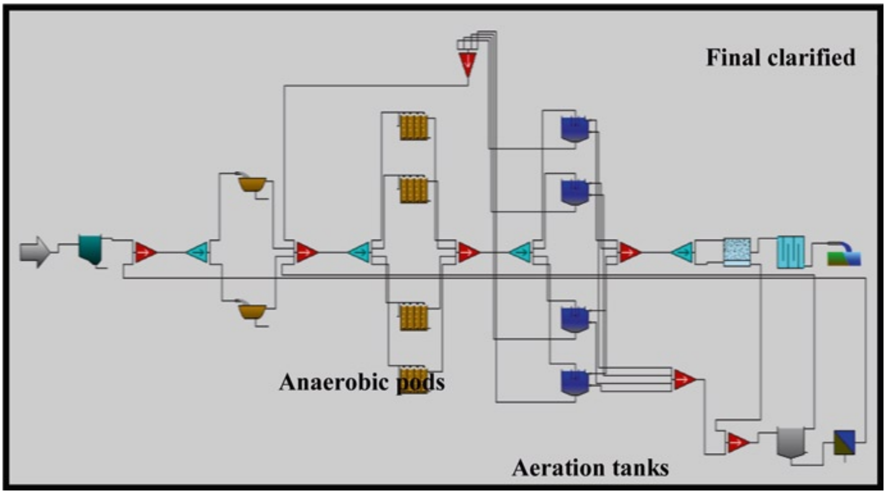

Fig. 14.11 Layout of Borg El Arab WWTP (using anaerobic ponds)

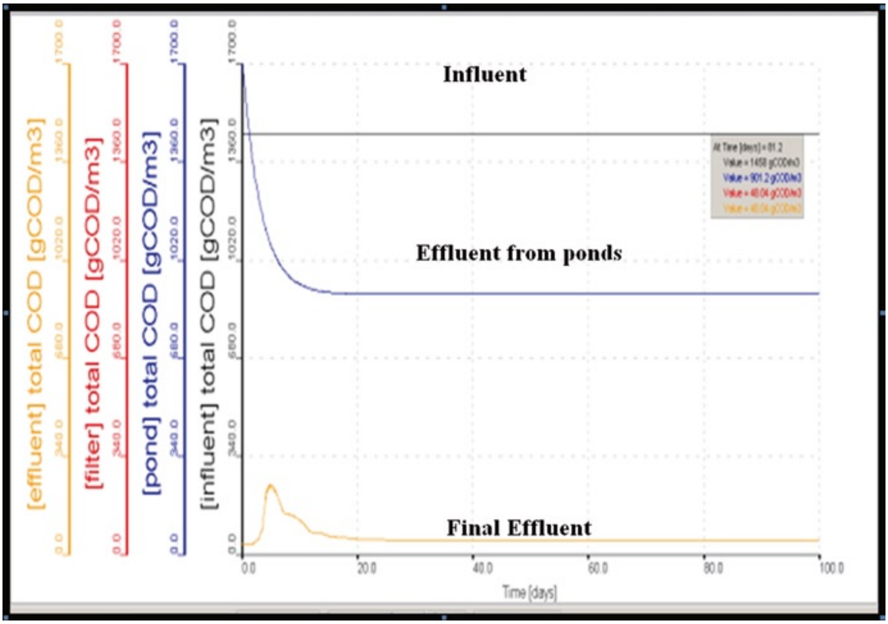

Fig. 14.12 Concentration of COD at different locations

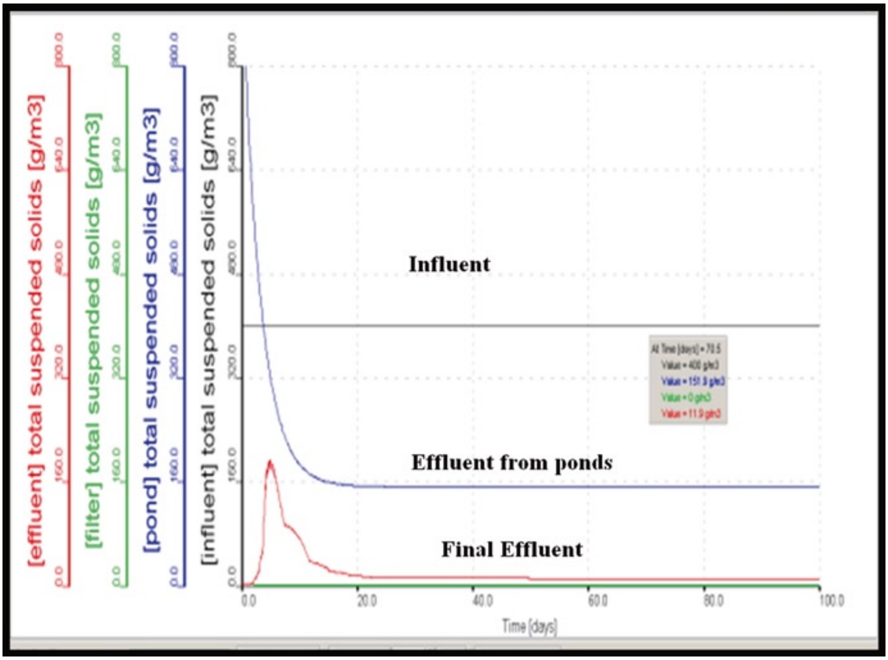

Fig. 14.13 Concentration of SS at different locations

14.6 Case Study IV: Mubarak Industrial Zone-Quesnna

The industrial zone of Mubarak belongs to Quesnna district in Monofia governorate. This area was planned and divided into four industrial zones; each includes a number of factories with different activities. There is a common wastewater network for these areas to gather industrial wastewater and domestic sewage from labors which end with three pump stations. Table 14.1 shows the characteristics of combined wastewater in Mubarak industrial zone. Results show the high levels of organic load indicating that most of the factories avoid primary treating their wastewater before discharging them into the network system.

Main Problem: The expected total discharge from Mubarak industrial zone is about 42,000 m^3 day^{-1} at the level of saturation, 32,000 m^3 day^{-1} of this shall represent the raw industrial wastewater. At present, a mechanical treatment plant is under construction with a design capacity of 62,000 m^3 day^{-1}. 42,000 m^3 day^{-1} of this capacity is from Mubarak zone and the rest 20,000 m^3 day^{-1} is from the neighboring villages. However, this plant is designed to receive and treat domestic wastewater only based on a 500 mg L^{-1} organic load and suspended solids concentration of 450 mg L^{-1}. Table 14.1 illustrated the great difference in the concentrations of organic loads in both domestic and industrial wastewater, signifying the necessity of an equalization tank to be implemented at the inlet of the existing WWTP. Results also show the decreased ratio of BOD/COD resulting from the increase of untreated industrial wastewater compared to domestic wastewater. Moreover, a high level of chrome was found to be present in the wastewater discharged from the first industrial region (55.3 mg L^{-1}), requiring treating chrome to the allowable standards. Chrome is produced from some industries such as leather, paper, coating and dyes industries. Chrome composition represents a real danger on public health as they infect the lungs, kidneys, liver, digestive system, and may cause skin cancer. They also have a direct effect on the biological process inside treatment plants. Consequently, it is preferred to mix domestic and industrial wastewater influents to the treatment plant to decrease the concentration of the organic loads.

Currently, raw wastewater is disposed temporarily in a drain near by the city till the treatment plant is implemented and operated.

14.6.1 Suggested Solution for Industrial WWT in Mubarak Industrial Zone

It is well known that the quality of industrial wastewater differs and varies according to the types of industries and the amount of production. Industrial wastewater may contain high levels of dissolved organic substances in addition to poisonous substances which may harm the biological treatment process; hence, a nontraditional treatment process including the following units is being suggested:

1. Chromium removal unit (for WW received from 1st PS only)
2. Flow equalization tank (for received industrial and domestic WW)
3. A removal and/or a decrease COD unit.

Due to the high levels of COD in influent WW to the plant, it is recommended to use anaerobic biological treatment (anaerobic oxidation ponds or UASB system) to decrease the concentration of COD, followed by aerated biological treatment (Biolak system) to make treated WW achieve the aimed characteristics.

Anaerobic oxidation ponds system is not preferred in this case for it requires vast areas of land which is not available here because removal units of COD must be put inside the currently implemented treatment plant so it could be connected to the remaining treatment units (aeration tanks – final sedimentation). However these ponds are known for their low costs of establishment, operation and maintenance but their efficiency may not exceed 45%.

As for the UASB system, it is considered as one of the modern treatment methods and it is perfect for industrial wastewater treatment with high levels of COD which may exceed 10,000 mg L^{-1}. They are preferred compared to anaerobic oxidation ponds system as they don't require vast areas of land and their efficiency in removing COD may vary between 60% and 80%. This system is expensive in operation, establishment and maintenance. It must be mentioned that the sponsoring and financing organization for the costs of implementing, operating and maintaining the industrial wastewater treatment station is the Investors Institution in Mubarak industrial zone. Consequently there will be no obstacles in implementing and operating these units.

Extended aeration shall be followed by the anaerobic process where a high proportion of the organic load (COD) is expected to be removed until reaching the allowable limits (80 mg L^{-1}). This system is known for its low costs of implementation and low energy needed for aeration. However it requires vast areas of land compared to traditional treatment.

Figure 14.14 illustrates currently implemented WWTP units while Fig. 14.15 displays the suggested modifications for primary treatment of industrial wastewater to reach the allowable standards that could make it treatable combined with domestic wastewater.

14.7 Conclusion

From the above research, it could be concluded that:

- Industrial wastewater could be a threat to the surrounding community and environment if not handled cautiously.
- Wastewater analyses should be regularly done, especially for industrial WW to be able to determine the required type of treatment in case a treatment plant is to be constructed and to maintain the level of efficiency of an operating plant, mainly the biological process.
- The process to be selected depends on several factors, such as characteristics of the incoming wastewater, land availability and costs
- In case of 10th of Ramadan city, vast areas were available which encouraged the use of anaerobic oxidation ponds followed by aerated lagoons.
- In case of New Nubaria city, a combination between anaerobic basin (working as equalization tank) and the existing secondary treatment was suggested due to the continual variation in the influent organic load.
- In case of New Borg EL Arab, a combined system was also suggested between anaerobic ponds and activated sludge system.
- Mubarak industrial zone also had a problem with the industrial WW produced from the factories due to the high percentage of Chrome found. Because limited area is available, the investors responsible for the development of the city could propose constructing UASB units followed by the establishment of a Biolak system.

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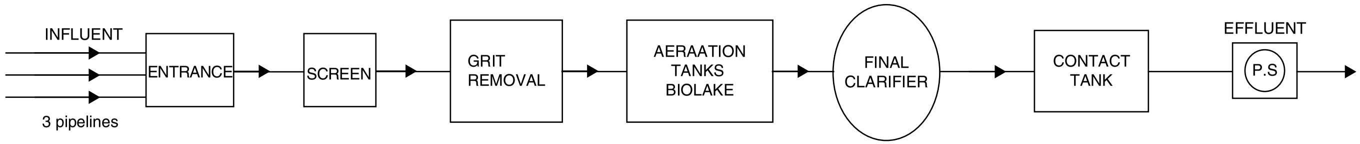

Fig. 14.14 Schematic diagram shows treatment units in the current WWTP

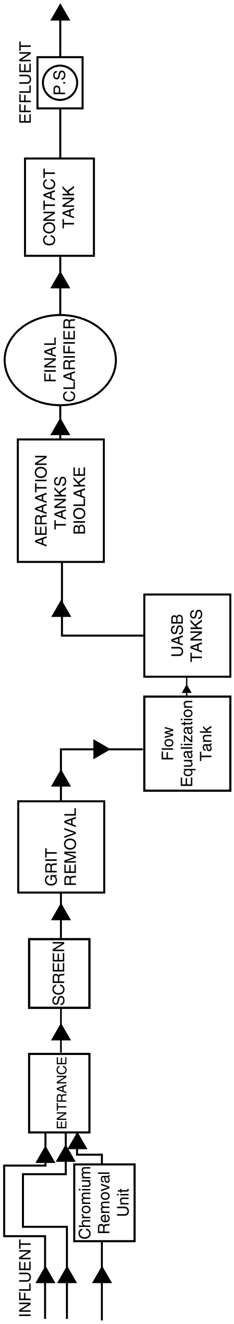

Fig. 14.15 Schematic diagram shows the additional treatment units for industrial wastewater

References

1. Abdel Wahaab R (2000) Upgrading of industrial wastewater treatment units at automobile industry. Biomed Environ Sci 13:219–224
2. Abou-Elela SI, Nasr FA, Doma HS, Ibrahim HS, Badr NM (2005) Sustainable wastewater management in an Egyptian industry city. J Manage Environ Qual 16:257–266
3. El-Gohary F, Abdel Wahaab R, Nasr F, Ali HI (1996) Development industrial wastewater management programme (case study). In: Proceedings of the 2nd specialized conference on pretreatment of industrial wastewater, Athens, 16–18 Oct 1996, pp 148–155
4. Hydromantis Inc (2001) GPS-X user's guide. Version 5.0, Canada
5. Tchobanoglous G, Burton FL, Stensel HD (2003) Wastewater engineering (treatment disposal reuse), 4th edn. Metcalf and Eddy/McGraw-Hill Book Company, New York