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INDUSTRIAL WASTEWATER MANAGEMENT IN EGYPTIAN INDUSTRIAL ZONES

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ABSTRACT

The industrial wastewater management in Egypt is one of the main goals for sustainable development. The water crisis in Egypt has lead the industrial sector to search for resource efficiency and cleaner production technologies through a proper management of water, energy, and raw materials. As a result, the aim of this study is to compare between different scenarios for industrial wastewater management in Egyptian industrial zones to choose the optimum environmental solution for industrial wastewater management. Quesna industrial zone in Monofeya governorate was chosen as a case study where different scenarios for industrial wastewater management are proposed in this study to choose the optimum environmental solution for industrial wastewater management. Industrial wastewater samples were taken from ten factories representing the ten main industrial sectors in the study area and sixteen parameters were measured in each sample. Results achieved from different applied scenarios showed variation in flow rates, industrial wastewater loads, treatment methods, removal efficiencies, capital and operation costs of the applied scenarios. Finally, these scenarios were compared technically and financially to determine the optimum environmental solution for industrial wastewater management. This study could be applied for all industrial zones in Egypt using the same methodologies.

KEYWORDS: Industrial Wastewater Management (IWWM), Quesna Industrial Zone, Industrial Sectors in Egypt, Industrial Wastewater Treatment (IWWT), Optimum Environmental Solution, Removal Efficiency, Industrial Wastewater Load.

INTRODUCTION

Industries make up about 80 % of the entire pollution load in wastewater, industrial and domestic activities result in the production of vast quantities of wastewater. The liquid industrial waste discharged into urban sanitation has increased both in volume and complexity during recent decades. In addition, municipal wastewater has changed in composition, not only through the increased amount of household chemicals in use but also through the discharge of varying amounts of industrial waste into public sewers.

Domestic water use in Egypt is about 8% of all water use and is expected to rise as the population grows and urbanization continues. Industrial water use is about 6% and is also expected to double rise if the industrial growth rate will be about 5 % (National Plan for Water Resources - Ministry of Irrigation), while the agricultural water use comprises the largest share about 86% of all water use. At the mean time the potential for developing other renewable sources for freshwater in Egypt is limited.

Different studies handled the treatment types of IWW of different industrial sectors. Some of which are: Mohamed (2012) who focused on treatment of painting IWW, Ashor (2013) who studied treatment of liquid wastes produced by ceramic industry, and El-Hefny (2018) who made an important study on upgrading of existing dairy IWWTP. These studies discussed the treatment of IWW in different factories but did not include management of IWW for a specific industrial sector or for an industrial zone in Egypt.

On the other hand, the current study is the first one to discuss the management system of IWW of Egyptian industrial zones where Mubarak Industrial Zone in Quesna City was taken as a case study representing the whole industrial areas in Egypt taking in consideration that management differs from one area to another according to the existing activities in each zone but the methodology will be the same.

Because of increasing demand and pressure on natural resources by growing human population, the main objective of this study is comparing different scenariosfor industrial wastewater management in the Egyptian industrial zones to determine the optimum environmental solution for industrial wastewater management in order to achieve sustainable development and water conservation. In addition,this study contributes in reviewing relevant international and national legislation, discussing recycling and re-use of industrial wastewater and disposal of industrial wastewater.

MATERIALS AND METHODS

This study selected Quesna industrial zone located in Monofeya governorate. This industrial zone is representative for Egyptian industrial zones including ten main industrial sectors representing 150 factories (Investment Map of Monofeya Governorate, 2012) where four different scenarios for industrial wastewater management are proposed in this study to choose the optimum environmental solution. Ten samples were taken from ten different factories representing the ten main industrial sectors in Quesna industrial zone. These sectors are: food, pharmaceutical, chemicals, electric & engineering, metals, plastic, pulp & paper, agriculture, and textile sectors.

Each sample was taken twice a week with a total of eight samples per month. Different parameters were measured during January, April, and May 2017 including BOD, COD, pH, heavy metals (Ni, Cr, and Zn), TSS, TDS, oil & grease, Chloride, Phenol, total Nitrogen, total Phosphorus, Sulphates, Ammonia, Temperature, and the number of coliform bacteria. Each parameter was measured with certain equipment according to the American Standard Methods (2009).

RESULTS AND DISCUSSION

Surveying Quesna industrial zone, resulted in finding one centralized industrial wastewater treatment plant. The maximum value of flow entering the existing centralized wastewater treatment plant in Quesna industrial zone equals 30,000 m^3/day. This flow includes the domestic wastewater for three villages (Al-Manashy, Kofour Al-Raml, and Al-Khawagah) with amount equals 6,000 m^3/ day.

This study proposed four scenarios to manage the industrial wastewater generated from Quesna industrial zone. These scenarios are:

1. Scenario (1)

Proposes that all companies will discharge their IWW without any treatment to one centralized IWWTP (figure 1).The centralized IWWTP will include two stages physico-chemical treatment unit and biological treatment unit to achieve the permissible limits for agriculture usage (figure 2). In this scenario, no sewage network is needed and transportation is not needed as well. Regarding companies that store the untreated wastewater in large tanks should have their own sewage network to discharge their IWW to the main network.

2. Scenario (2)

Presentes that all companies will discharge their IWW after applying pretreatment inside them to one centralized IWWTP (figure 3). The pretreatment process differs from one sector to another. The centralized IWWTP will include one stage physico-chemical treatment unit and biological treatment unit followed by tertiary treatment that contains filter sand unit to achieve the permissible limits for agriculture usage (figure 4). In this scenario, no sewage network is needed, and transportation is not needed as well. Regarding companies that store the untreated wastewater in large tanks and the companies that have no pretreatment for their IWW, they should have their own pretreatment units in their facilities to discharge their IWW to the main network.

3. Scenario (3)

Suggests that all companies having the same wastewater parameters in their IWW will discharge to individual treatment unit after mixing together before discharging to one Centralized IWWP to treat the final stream. As a result, three individual IWWT units will be found before being discharged to the centralized IWWTP. The first unit will gather the discharge IWW from food and agriculture sectors, whereas the second unit will gather the discharge IWW from textile, tannery, plastic, pharmaceutical, pulp and paper sectors. Metals, chemicals, electrical and engineering sectors will discharge their IWW to the third unit. The outlet of these three individual IWWT units will be discharged together to one centralized IWWP (figure 5). The first individual treatment unit will include one stage physico-chemical treatment unit and biological treatment unit. The second individual treatment unit will include one stage physico-chemical treatment unit and one biological treatment unit followed by tertiary treatment that contains filter sand unit, whereas the third individual treatment unit will include one stage physico-chemical treatment unit and biological treatment unit. In this scenario, transportation is needed to collect the companies of the same sector together. The output of the three individual treatment units will discharge to the centralized IWWTP which includes one biological treatment unit to achieve the permissible limits for agriculture usage. In addition, sewage network is needed to discharge to the three individual treatment units and then to be collected together before entering to the centralized IWWTP (figure 6).

4. Scenario (4)

Proposes that all companies in the same sector will discharge their IWW after collecting by transportation trucks to a specific IWWTP (figure 7). The IWWTP of food sector will include one stage of physico-chemical treatment unit and biological treatment unit followed by activated sludge biological nutrient removal process (NRP), whereas the IWWTP of pharmaceutical sector will include one stage of physico-chemical treatment unit and biological treatment unit followed by advanced oxidation processing (AOP). The IWWTP of chemicals sector will include one stage of physico-chemical treatment unit and biological treatment unit. While the IWWTP of plastic sector will include two stages of physico-chemical treatment unit and biological treatment unit. The IWWTP of electrical and engineering sector will include one stage of physico-chemical treatment unit and biological treatment unit, and the IWWTP of tannery sector will include one stage of physico-chemical treatment unit and biological treatment unit followed by tertiary treatment (Ion Exchange Process). The IWWTPs of metals, pulp and paper sectors will include two stages of physico-chemical treatment unit and biological treatment unit. The IWWTP of agriculture sector will include one stage of physico-chemical treatment unit and biological treatment unit followed by activated sludge biological nutrient removal process (NRP), whereas the IWWTP of Textile sector will include one stage of physico-chemical treatment unit and biological treatment unit followed by tertiary treatment (Sand Filter). In this scenario, transportation is needed to collect the companies of the same sector together as mentioned before. The output of each IWWTP complies with the permissible limits for agriculture usage. In addition, sewage network is needed to discharge to the ten IWWTPs.

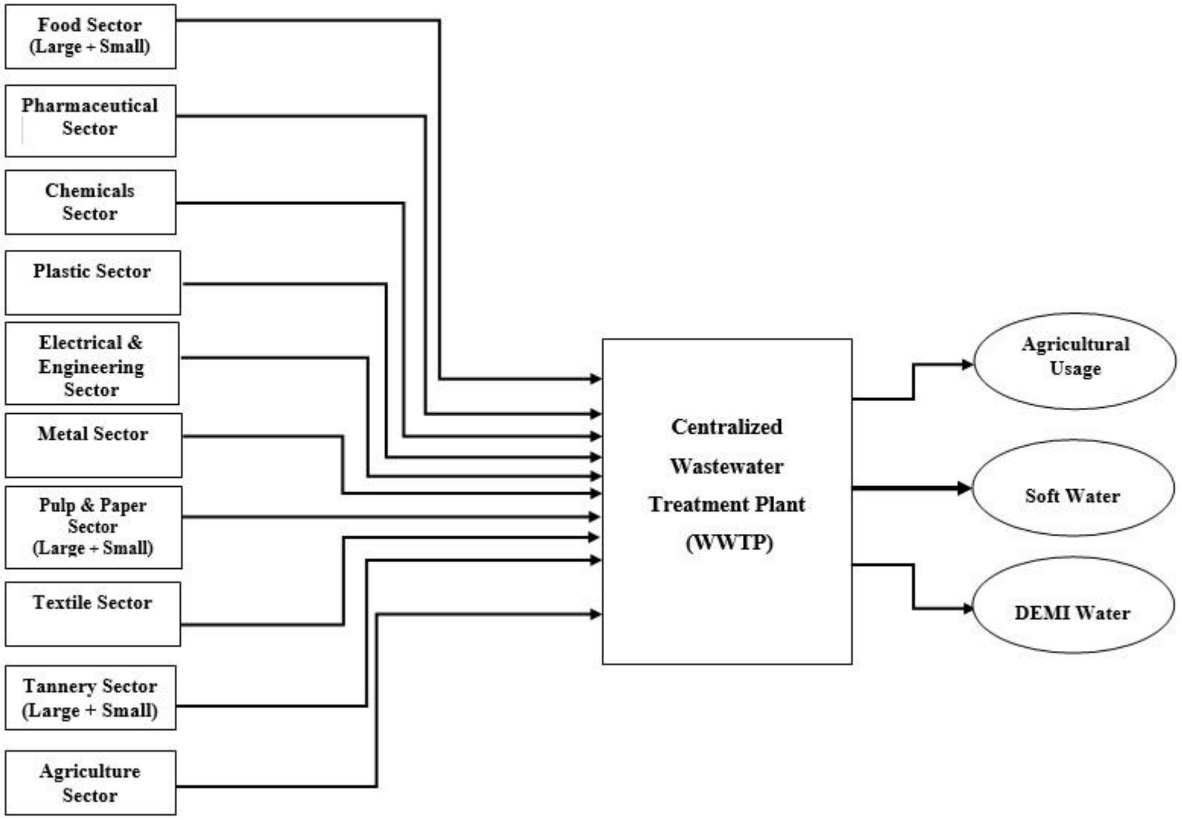

Figure 1: Scheme for Scenario (1).

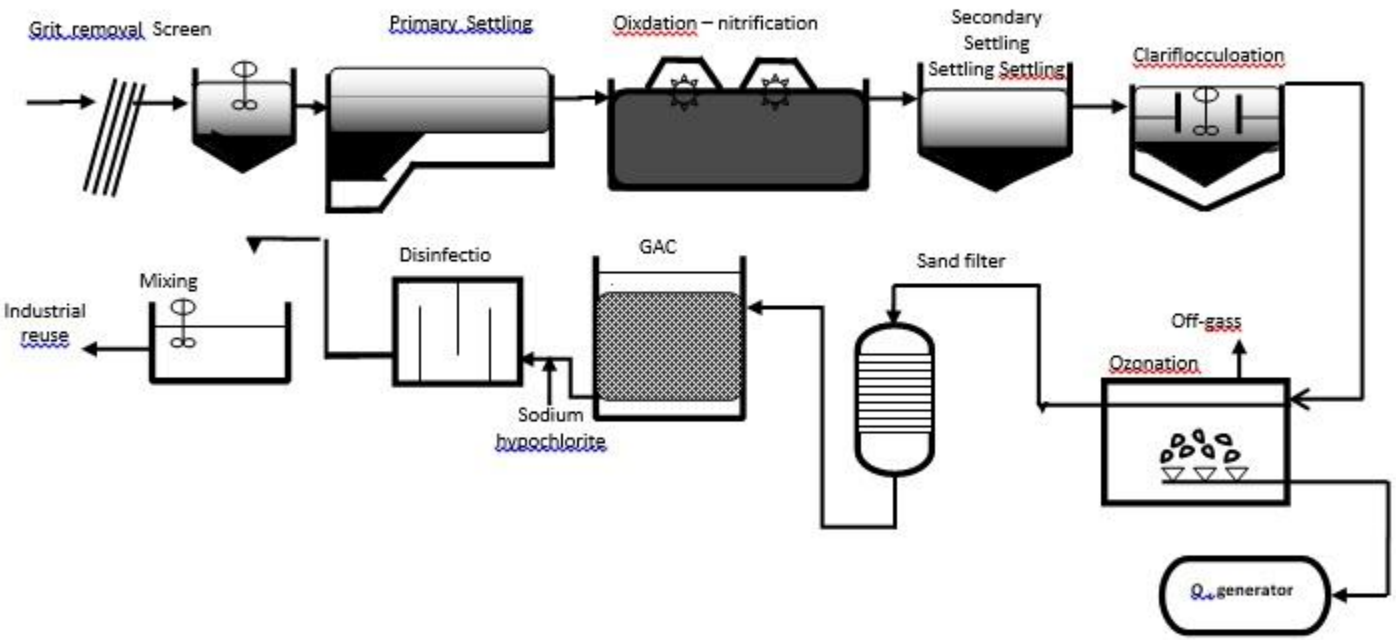

Figure 2: Sketch of IWWTP for Scenario (1).

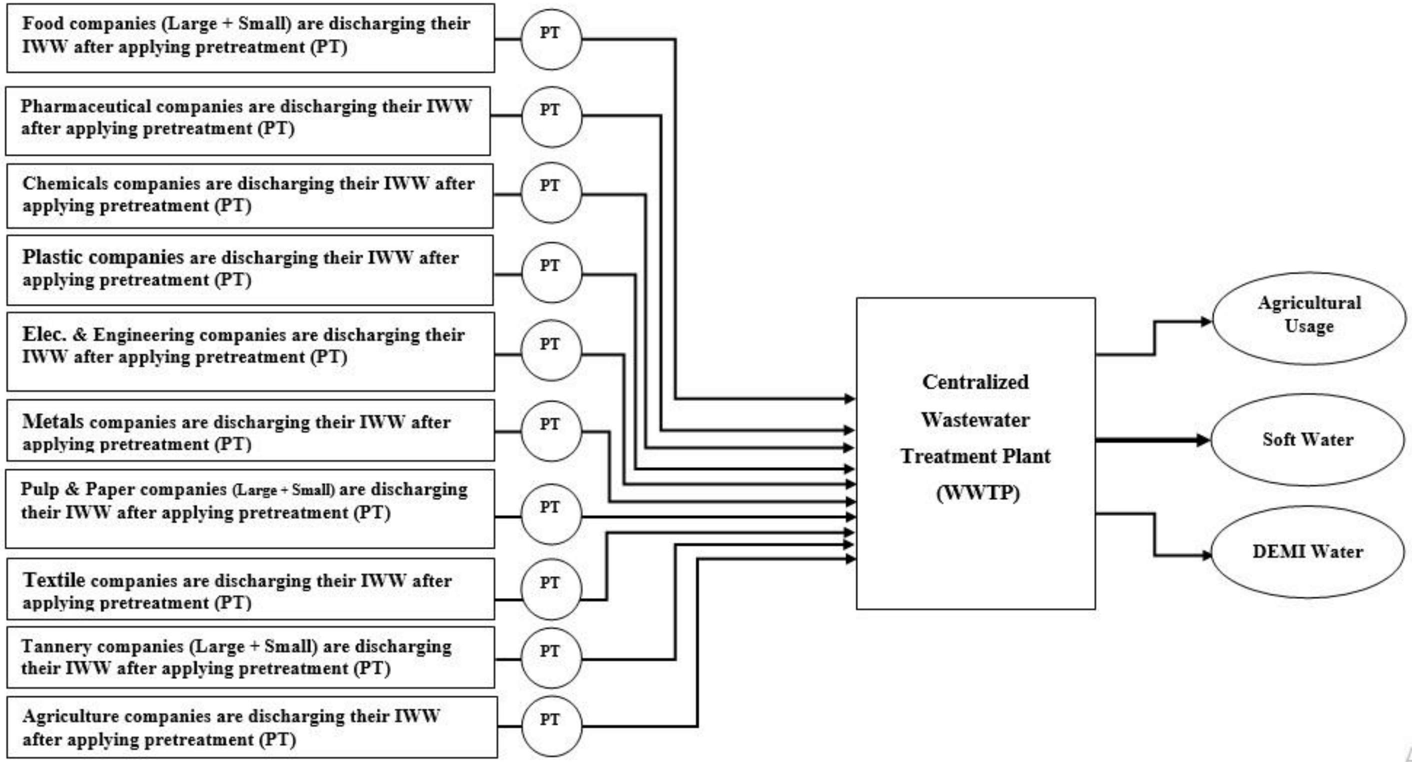

Figure 3: Scheme for Scenario (2).

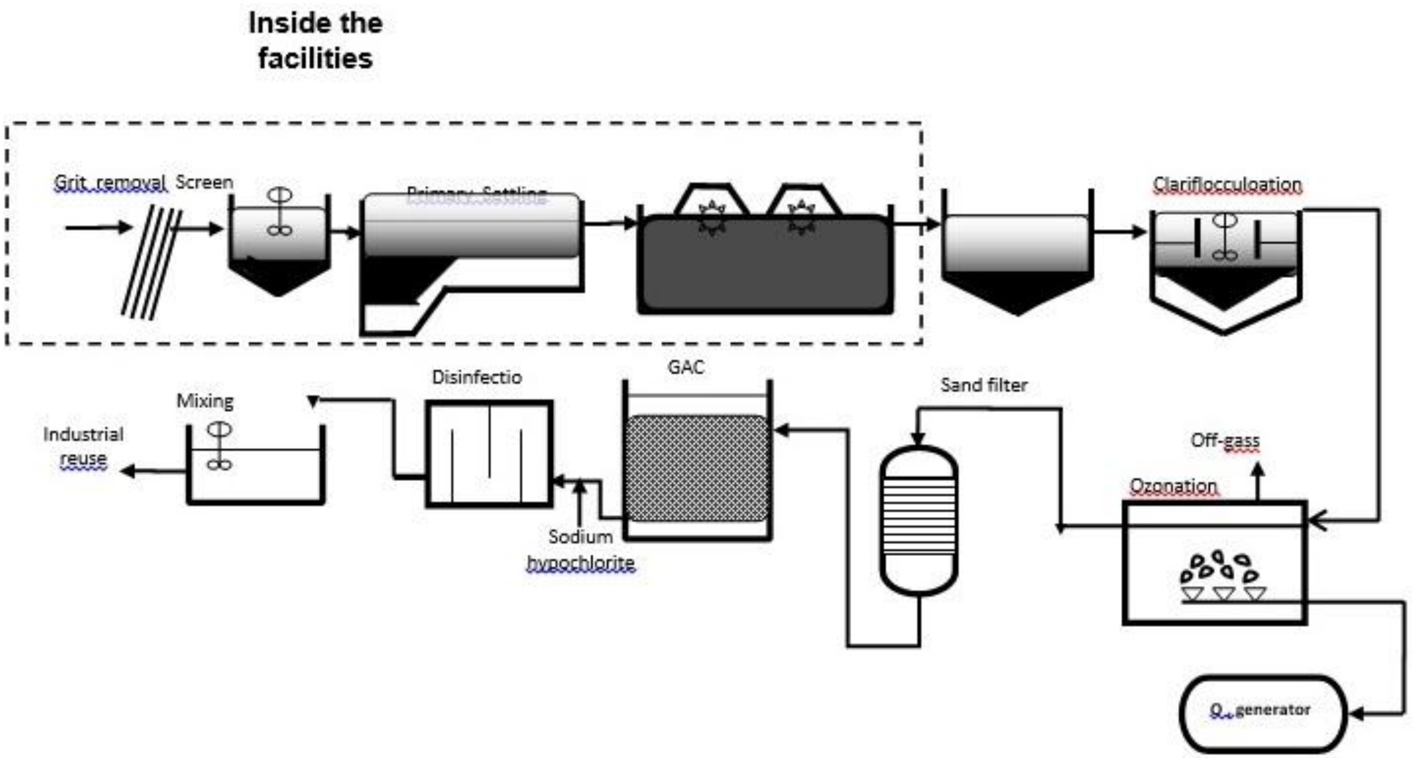

Figure 4: Sketch of IWWTP for Scenario (2).

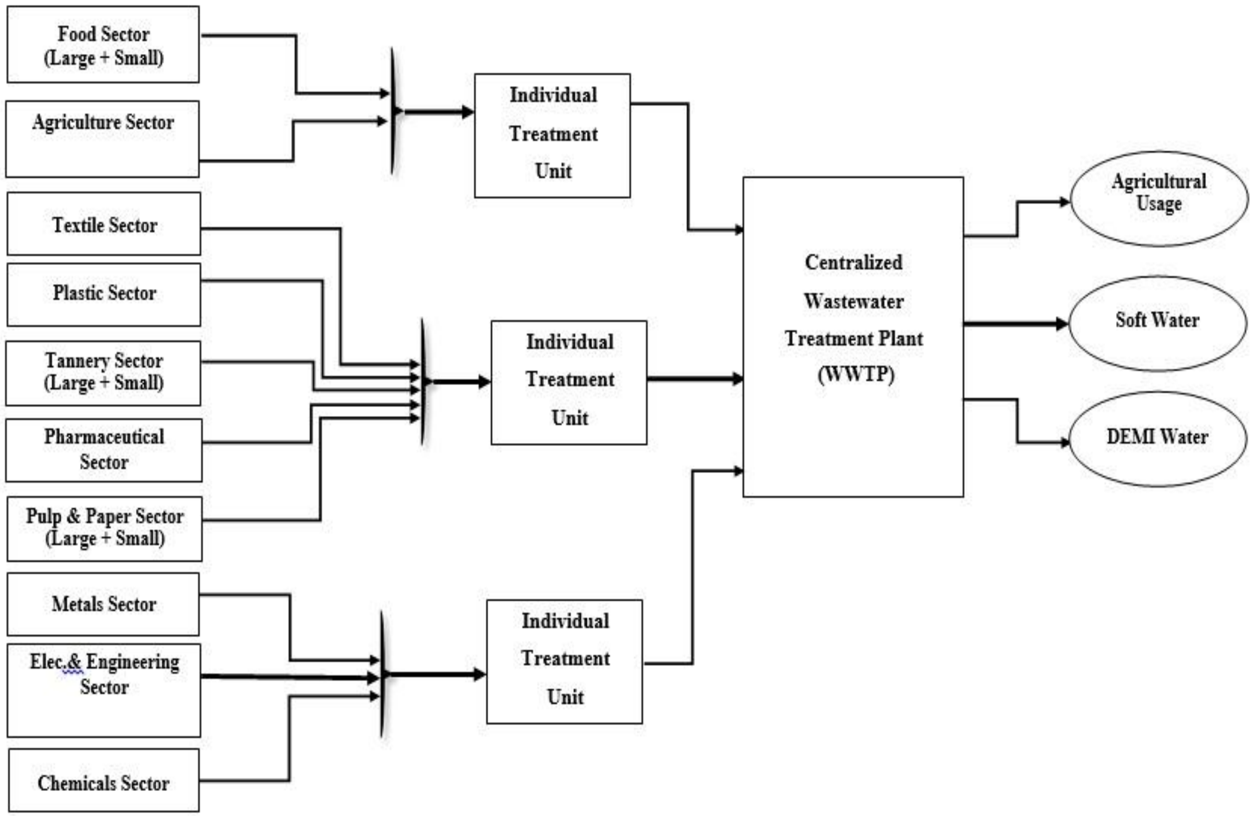

Figure 5: Scheme for Scenario (3).

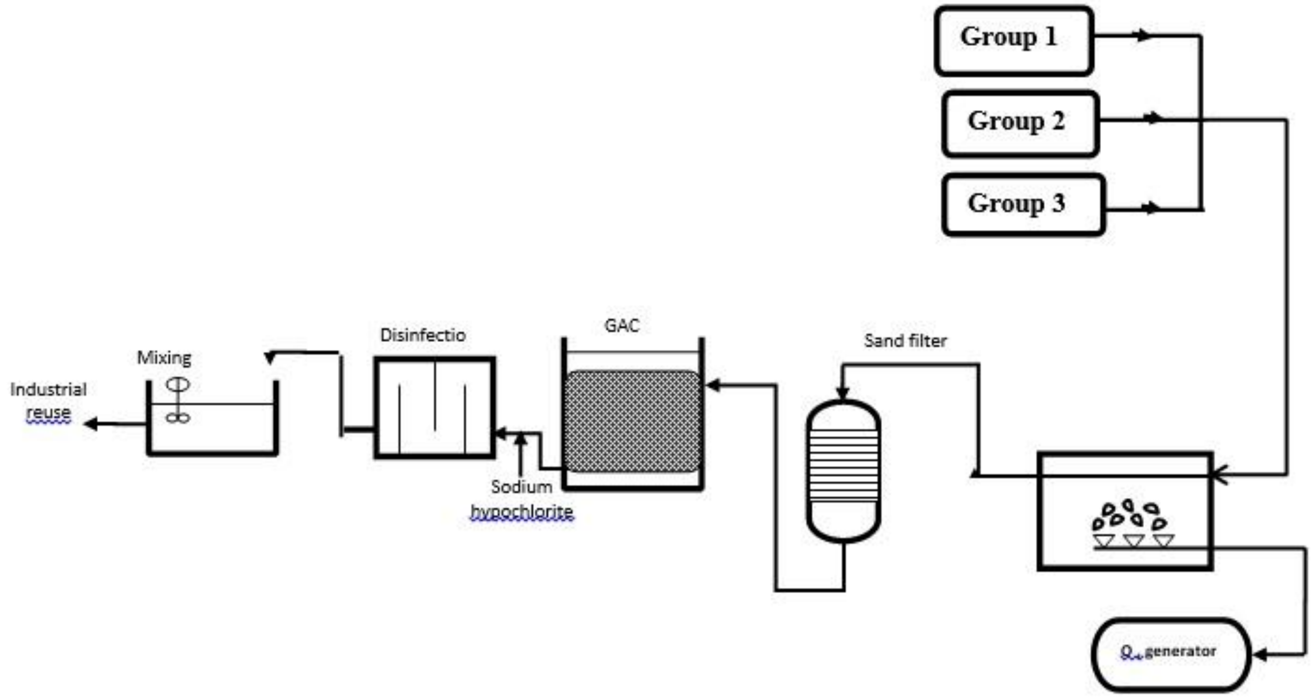

Figure 6: Sketch of IWWTP for Scenario (3).

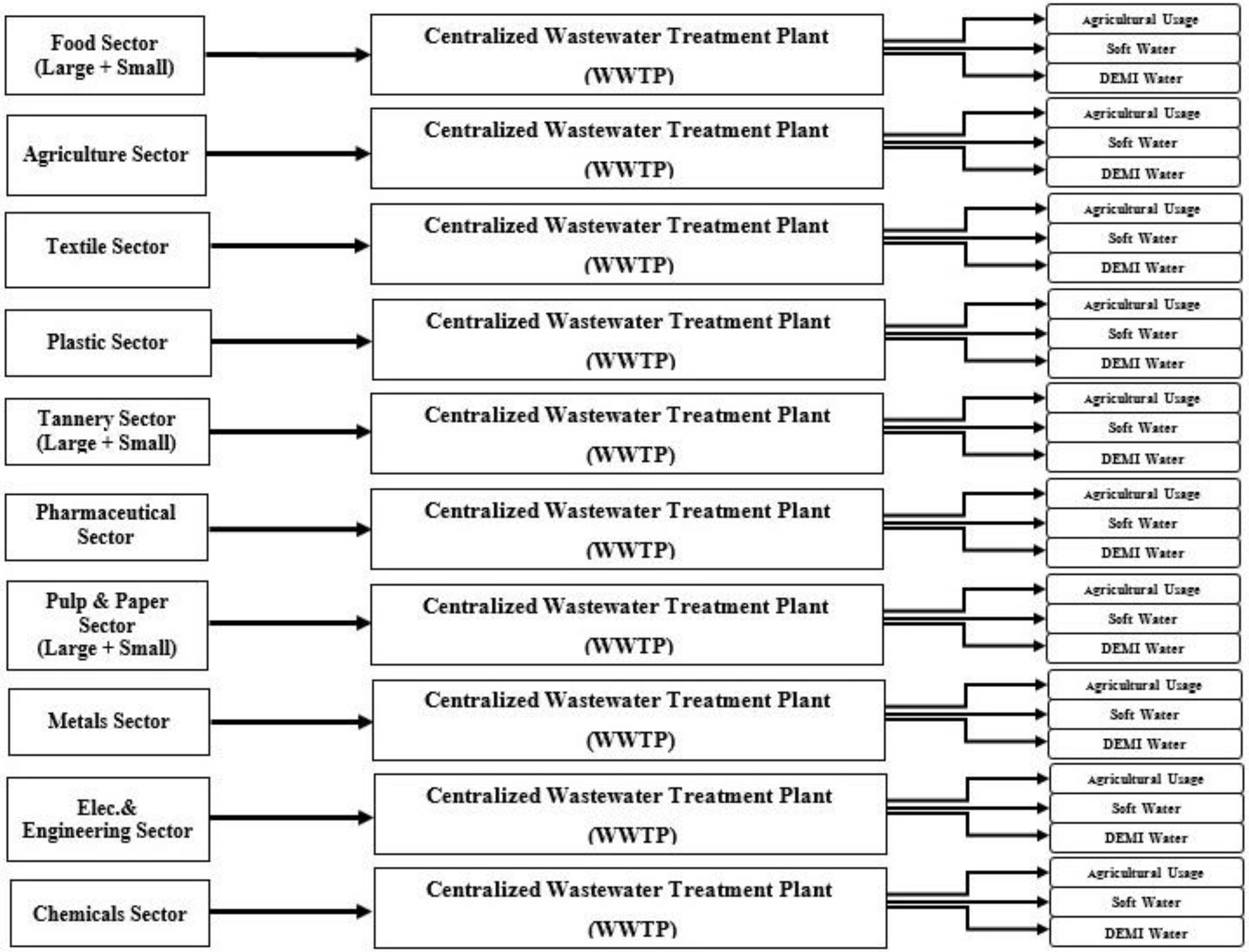

Figure 7: Scheme for Scenario (4).

A final evaluation covers both technical & financial evaluation. There are different methods to include both evaluations for the total evaluation. The most applied method especially in this branch of work is to calculate the effect of technical evaluation on the financial amount to get the final real cost by dividing the financial budget of each sector on its technical evaluation ratio as illustrated in the following tables. Table (1) illustrated the technical comparison for the applied scenarios, while table (2) illustrated the financial comparison between them to know the best solution economically taking into consideration different financial cost referred to market prices in August 2018 for construction cost, operation cost and maintenance cost. Finally, table (3) illustrated the total evaluation results where scenario 3 (the industrial sectors having similar industrial wastewater characteristics were grouped together to be treated before being discharged to the centralized IWWTP) has the smallest total cost value after applying the technical evaluation (**600,500,000EGP**), followed by scenario 1 (all factories of different industrial sectors discharge their industrial wastewater directly to the centralized IWWTP without any pretreatment) which has the second smallest total cost after applying the technical evaluation which is (609,787,234 EGP).

Table 1: Technical Comparison between Applied Scenarios.

No.	Comparison Face	Wt.	Scenario 1	Wt.	Scenario 2	Wt.	Scenario 3	Wt.	Scenario 4	Wt.
1	Skills needed	**10**	high	**7**	low	**3**	medium	**5**	medium	**5**
2	Energy needed	**15**	high	**4**	low	**12**	medium	**8**	high	**5**
3	Efficiency	**10**	high	**8**	Very high	**10**	Very high	**10**	Very high	**10**
4	Labors number	**10**	low	**8**	medium	**6**	medium	**6**	high	**4**
5	Required area (m^2)	**10**	medium	**7**	low	**9**	high	**5**	Very high	**3**
6	Operations and maintenance needed	**15**	Very high	**3**	medium	**8**	Low	**13**	Very low	**15**
7	Control	**5**	low	**1**	medium	**3**	high	**5**	high	**5**
8	Life time	**10**	low	**2**	medium	**6**	high	**9**	high	**9**
9	Stability	**5**	low	**1**	medium	**3**	high	**4**	very high	**5**
10	Mechanical equipment needed	**5**	medium	**3**	medium	**3**	high	**4**	high	**4**
11	Time for settlement of IWWTP	**5**	medium	**3**	high	**2**	medium	**3**	low	**5**
Total Technical Evaluation		**100**		**47**		**65**		**72**		**70**
Total Technical Evaluation			**4**		**3**		**1**		**2**	

Table 2: Financial Comparison between Applied Scenarios.

Comparison Item	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Initial Cost	70,000,000	140,000,000	105,000,000	150,000,000
A- Land	10,000,000	40,000,000	25,000,000	30,000,000
B- Construction cost	30,000,000	50,000,000	40,000,000	60,000,000
C- Electrical and mechanical cost	30,000,000	50,000,000	40,000,000	60,000,000
Operational Cost	152,100,000	317,600,000	241,360,000	448,840,000
A- Labors	46,800,000	60,200,000	56,160,000	84,240,000
B- Energy	46,800,000	140,400,000	93,600,000	187,200,000
C- Spare parts	39,000,000	78,000,000	60,400,000	117,000,000
D- Repairing maintenance cost	19,500,000	39,000,000	31,200,000	60,400,000
Rehabilitation Cost	58,500,000	97,500,000	78,000,000	117,000,000
Loan Cost	6,000,000	10,000,000	8,000,000	12,000,000
Total Financial Evaluation/ 20 Years	286,600,000	565,100,000	432,360,000	727,840,000
Total Financial Evaluation	1	3	2	4

Table 3: Total Evaluation between Different Solutions.

Comparison Face	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Technical evaluation ratio %	47%	65%	72%	70%
Total Financial Evaluation/ 20 years	286,600,000	565,100,000	432,360,000	727,840,000
Total Cost after applying Technical Evaluation	609,787,234	869,384,615	600,500,000	1,039,771,429
Final Evaluation	2	3	1	4

Scenario 2 (all factories of different industrial sectors discharge their industrial wastewater to the centralized IWWTP after being pretreated inside the facilities) has the third smallest total cost value after applying the technical evaluation (869,384,615 EGP), whereas scenario 4 (all factories of the same sector collect their IWW to be treated together inside a specific IWWTP before being reused in the agriculture usage) has the highest total cost value after applying the technical evaluation (1,039,771,429 EGP)which is a very high value as a result of presence of ten IWWTPs in this scenario.

CONCLUSION

It has been concluded from technical, financial, and total discussion that:

- The study put a system for choosing the optimum solution for industrial wastewater management in any industrial zones by several steps and applying several scenarios with comparing between them technically, financially and environmentally.
- In our case (Quesna Industrial Zone) the optimum solution after several comparisons is Scenario 3 (the industrial sectors having similar industrial wastewater characteristics were grouped together to be treated before being discharged to the centralized IWWTP) for management of IWW, where the total cost after applying the technical evaluation is (**600,500,000EGP**) per 20 years.
- The second optimum environmental solution for IWW management is Scenario 1 (all factories of different industrial sectors discharge their industrial wastewater directly to the centralized IWWTP without any pretreatment) where the total cost after applying the technical evaluation is (609,787,234 EGP) per 20 years. Also, this scenario is the best solution regarding the financial comparison.
- Even Scenario 3 was higher financially than Scenario 1 but after taking the technical comparison into consideration, it became the lowest one in the cost. That shows the high effect of the technical and environmental consideration.
- Prefer in the industrial zones to be from 1 or 2 groups of industry whom connected together with raw materials and the possibility of reuse the by-products and share some products that minimize the varieties of industrial wastewater and dependency in the cost of its treatment.
- In another industrial zone, another solution could be the optimum one depending on the industries types, activities, the raw industrial wastewater quality and quantity varieties and the applied treatment solution.

RECOMMENDATIONS

From the current study & the results obtained, scenario 3 (the industrial sectors having similar industrial wastewater characteristics were grouped together to be treated before being discharged to the centralized IWWTP) is the optimum environmental solution for industrial wastewater management in Quesna industrial zone, which differs from the existing situation because the later needs additional treatments to achieve the required environmental limits.

The main recommendations for our study are:
Modifications for the existing wastewater treatment plant should be carried out to achieve the required environmental limits.

Mixing of domestic water of the three villages in Quesna industrial zone with the industrial wastewater should be stopped.

This study puts light on the optimum environmental solution for IWW management of Quesna industrial zone. This solution could be applied for any industrial zone in Egypt as long as the same methodologies are carried out.

Apply scenario 3 in the Quesna industrial zone if possible, to achieve the optimum solution. This could be happened by give the public sector or special company to manage the industrial zone and sell the water again to the facilities with cheap price.

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