COMPARING TWO DIFFERENT ENVIRONMENTAL SOLUTIONS FOR INDUSTRIAL WASTEWATER MANAGEMENT IN QUESNA INDUSTRIAL ZONE

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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 2 different environmental solutions for industrial wastewater management in Quesna industrial zone in Monofeya governorate. Industrial wastewater samples were taken from ten factories representing the ten main industrial sectors in the study area and five parameters were measured in each sample.

Results achieved from the two 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 best environmental solution for industrial wastewater management in Quesna industrial zone. This study could be applied for all industrial zone in Egypt using the same methodologies.

Key words: Industrial Wastewater Management (IWWM), Quesna Industrial Zone, Industrial Sectors in Quesna, Industrial Wastewater Treatment (IWWT), Environmental Solutions, Removal Efficiency, and Industrial Wastewater Load.

INTRODUCTION

After the First World War, industrial activities based on natural resources began to increase. 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.

Internationally, different studies were carried out such as the thesis presented by Toll (2009) on the current situation in Chile with regard to the treatment of industrial wastewater. This study aimed to identify the potential for the implementation of separation technologies. Another important study was carried out by Saikku (2006) who mentioned that the concept of an eco-industrial park is a sector of industrial ecology, which draws analogies from natural ecosystems to human industrial systems as Kalundborg in Denmark. Her study serves as a background for the first planned eco-industrial park in Finland, at Rantasalmi municipality which involves mainly small mechanical wood processing companies.

In Italy, Tessitore *et al.* (2015) studied the evolution of eco- industrial parks and stated that it is a development opportunity for many territories and companies where the key element of Italian eco-industrial parks is the management body, an entity provided by national legislation to manage and coordinate companies and to develop more environmentally sustainable production practices. The study introduced an important environmental management experience implemented in Italy.

In China, Liu and Côté (2017) carried out another study on the case of eco-industrial parks, where they considered them critical for sustainable development, ecosystem services are increasingly being put on the policy agendas of governments and corporations in China.

Rio de Janeiro showed an important study carried out by Veiga *et al.* (2008) who stated that the eco-industrial park is an environmental management tool that is being spread in many nations as an industrial model that can reconcile the three "Es" of sustainability - environment, social equity and economic efficiency - as it reorganizes industrial practices and activities in order to meet sustainable development goals. In addition, it is a tool towards the reduction, reuse and recycling (3R's) of by-products and wastes.

In Egypt, many previous studies discussed the treatment types of Industrial Wastewater (IWW) of different sectors. Some of which are: Mohamed (2012), who studied treatment of painting IWW, Ashor (2013), who focused in her study on 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.

On the other hand, the current study is the first one to discuss the management system of IWW in one of the Egyptian industrial zones, where Mubarak Industrial Zone in Quesna City has ten main industrial sectors, they are: Plastic sector including 19 companies, Pulp and Paper sector including 3 large companies and 10 small companies, Chemicals sector including 11 companies, Electric and Engineering sector including 13 companies, Agricultural sector including 14 companies, Textile sector including 28 companies, Metals sector including 10 companies, Food sector including 3 large companies and 27 small companies, Tanneries sector including 3 large companies and 4 small companies, and Pharmaceutical sector including 5 companies (Investment Map of Monofeya Governorate, 2012).

Because of increasing demand and pressure on natural resources by growing human population, the main objective of this study is comparing between the effective solution of industrial wastewater management and the existing industrial wastewater management in Quesna industrial zone to achieve the sustainable development and water conservation.

MATERIALS AND METHODS

This study focused on 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 two different scenarios for industrial wastewater management are proposed in this study to choose the best 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.

A sample was taken twice a week with a total of eight samples per month. Different parameters were measured during one year 2016 including BOD, COD, heavy metals (Ni, Cr, and Zn), TSS and TDS. Each parameter was measured with certain equipment according to the American Standard Methods for the analysis of water and wastewater (2009). The industrial wastewater flow rate for each industrial sector was measured per day then the average value was calculated per each month in m3/ day. The industrial wastewater load for existing situation in each sector is calculated by multiplying the maximum value for each parameter by the flow rate average value in each month per day. The study proposed two scenarios to manage the industrial wastewater generated from Quesna industrial zone. These scenarios are:

Scenario (1): proposes that all companies will discharge their IWW without any treatment to one centralized IWWTP.

Scenario (2): proposes that the industrial sectors having similar industrial wastewater characteristics were grouped together to be treated before being discharged to the centralized IWWTP.

The outlet of the IWWTP for the two scenarios will be used for agricultural usage. The parameters for the outlet of the IWWTP will be presented in the table (1).

Table (1): Specifications for Agricultural usage (Law 48/ 1982)

Parameters	Values
TDS	1,000
TSS	30
BOD	30
COD	50
Ni	0.1
Cr	0.05
Zn	2

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 m3/ day. This flow includes the domestic wastewater for three villages (Al-Manashy, Kofour Al-Raml, and Al-Khawagah) with amount equals 6,000 m3/ day. The expected results for applying the two proposed scenarios to manage the industrial wastewater generated from Quesna industrial zones as follow:

SCENARIO 1: In this scenario, we propose that all companies will discharge their IWW without any treatment to one centralized IWWTP as showing in the figure (1) below. The load of discharging into the centralized IWWTP and the maximum flow rate in m3/ day is presented in table (2), while the table (3) is showing the back calculation to the concentration in mg/l which will enter the centralized IWWTP and the expected outputs after applying the required treatment.

The centralized IWWTP will include two stages phyisco-chemical treatment unit and biological treatment unit to achieve the permissible limits for agriculture usage. 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 in order to discharge their IWW to the main network. The removal efficiency of the centralized IWWP is presented in table (3).

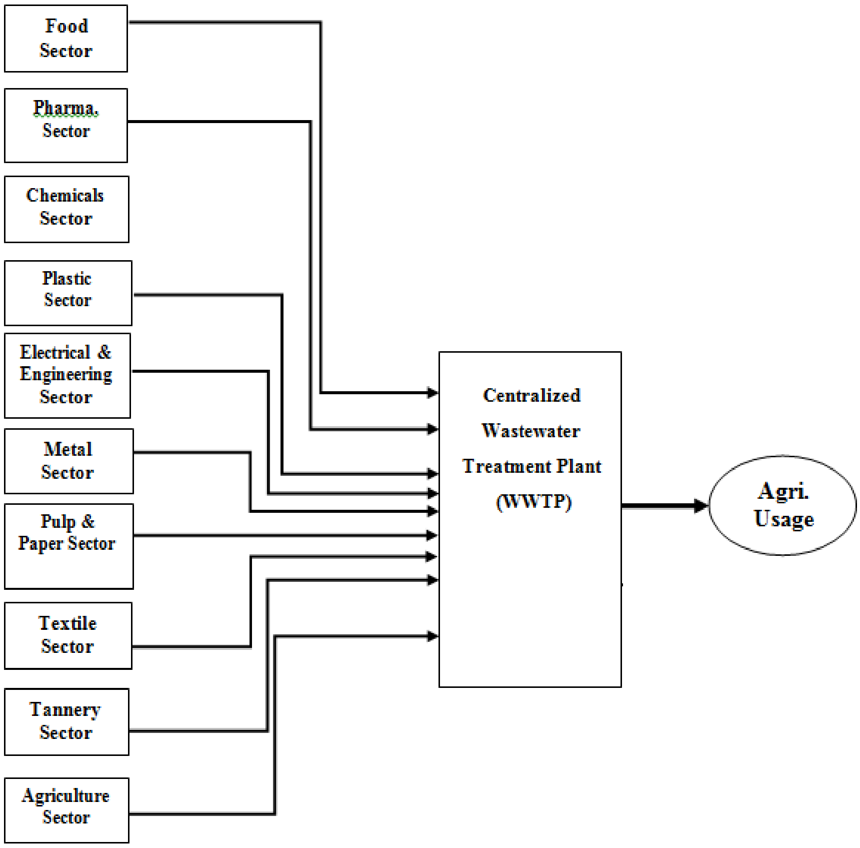

Figure (1): Scheme for Scenario (1)

Table (2): The estimated industrial wastewater load and max. flow rate in Scenario 1

		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Large Food Sector	Min	3	900	504	720	360	675	0	0	0
	Max			1944	1845	1467	3103.20	0	0	0
	Ave			1181.93	1287.38	909.48	1875.52	0	0	0
Small Food Sector	Min	27	945	573.48	107.33	582.39	1358.78	0	0	0
	Max			1334.34	344.25	1168.83	3178.04	0	0	0
	Ave			880.57	815.54	847.17	2094.61	0	0	0
Pharma. Sector	Min	5	1800	834.40	1168	1452	4192	0	0	0
	Max			1222.77	12274.50	7992	16143.75	0	0	0
	Ave			1088.53	7684.23	4992.24	10231.81	0	0	0
Chemicals Sector	Min	11	3850	4090.24	4147.61	1669.36	2688.84	0	0	0
	Max			5120.50	5882.80	2079	3349.50	0	0	0
	Ave			4473.52	5043.53	1814.83	2924.30	0	0	0

Followed Table (2): The estimated industrial wastewater load and max. flow rate in Scenario 1

		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Plastic Sector	Min	19	760	3170.91	5856.18	4950.45	8196.60	0	0	0
	Max			3531.72	7815.08	6606.68	10940.20	0	0	0
	Ave			3366.10	6677.69	5636.94	9343.81	0	0	0
Electric & Engineering Sector	Min	13	650	318.73	188.37	166.73	258.51	3.73	0.01	3.33
	Max			624	331.50	211.25	344.50	5.07	0.04	4.27
	Ave			378.80	274.27	187.59	313.63	4.52	0.02	3.95
Large Tannery Sector	Min	3	5,100	5625	8739	4437	10638	0	2245.50	0
	Max			6415.80	9934.80	5049	12066.60	0	2524.50	0
	Ave			6209.07	9604.01	4880.47	11698.05	0	2439.44	0
Small Tannery Sector	Min	4	1,200	1250	1814.80	982	2360	0	499	0
	Max			1509.60	2220	1182	2839.20	0	595.20	0
	Ave			1392	2026.05	1091.01	2622.52	0	0	0
Metals Sector	Min	10	600	3947.40	2135.16	969.30	1453.14	0	0	0.27
	Max			4398	2371.20	1081.20	1620	0.06	302.40	0.42
	Ave			4165.23	2251.88	1023.23	1533.46	0.01	280.56	0.35

Followed Table (2): The estimated industrial wastewater load and max. flow rate in Scenario 1

		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Large Pulp & paper Sector	Min	3	4,500	31863.75	47989.20	21845.70	32416.20	0	0	0
	Max			38594.25	63702	22648.50	33592.50	0	0	0
	Ave			36685.20	44794.71	22402.77	33247.83	0	0	0
Small Pulp & paper Sector	Min	10	350	2086.26	3514.70	1608.96	2382.40	0	0	0
	Max			3265.15	3977.82	1761.55	2612.75	0	0	0
	Ave			2625.50	3734.14	1712.48	2541.54	0	0	0
Agriculture Sector	Min	14	2,520	1734.60	1734.60	5744.76	8506.40	0	0	0
	Max			2472.12	2227.68	7396.20	10962	0	0	0
	Ave			2096.62	1988.37	6611.82	9805.19	0	0	0
Textile Sector	Min	28	840	2205	6720	1170.40	2394	0	0	0.21
	Max			2657.76	17220	1404.48	2874.48	0.01	0.01	0.26
	Ave			2473.70	11442.64	1304.45	2634.24	0	0.01	0.23
Total	Min	150	24,015	58203.77	84834.94	45939.05	77519.86	3.74	3007	3.81
	Max			73090.01	130146.63	60047.69	103626.72	5.14	3422	4.95
	Ave			65646.89	107490.79	52993.37	90573.29	4.44	3215	4.38

Table (3): The estimated IWW parameters concentration which will enter the centralized IWWTP and its outputs

	TDS	TSS	BOD5	COD	Ni	Cr	Zn
Concentration (inlet) (mg/ l)	3043.51	5419.39	2500.42	4315.08	0.21	142.50	0.21
Pre-Treatment Unit (mg/ l)	3043.51	3793.57	1875.32	3236.31	0.21	142.50	0.21
Phyisco-Chemical Treatment Unit (1) (mg/ l)	1826.11	948.39	1031.43	1779.97	0.21	7.13	0.21
Biological Treatment Unit (1) (mg/ l)	1004.36	47.42	51.57	89	0.01	0.36	0.01
Phyisco-Chemical Treatment Unit (2) (mg/ l)	602.62	11.85	28.36	48.95	0.01	0.02	0.01
Biological Treatment Unit (2) (mg/ l)	331.44	0.59	1.42	2.45	0	0	0
Concentration Outlet)((mg/ l) of Drain Law 48/82 for agriculture usage	1000	30	30	50	0.10	0.05	2
Removal Eff. (%η) Final	89.11	99.99	99.94	99.94	99.75	100	99.75

SCENARIO 2: In this scenario, it was proposed 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 showing in the figure (2) below. 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.

The loads and max flow rate discharged to the three individual IWWT units is presented in table (4). While table (5) represents the back calculation to the concentration in mg/ l entering the individual IWWT units and the expected outputs after applying the required treatment for each unit. Table (6) will present the back calculation to the concentration in mg/ l entering the centralized IWWTP and the expected outputs after applying the required treatment.

The first individual treatment unit will include one stage phyisco-chemical treatment unit and biological treatment unit. The second individual treatment unit will include one stage phyisco-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 phyisco-chemical treatment unit and biological treatment unit. In this scenario, transportation is needed to collect the companies of the same sector together as mentioned before. 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. The removal efficiencies of the three individual treatment units and the centralized IWWP are presented in tables (5) & (6) respectively.

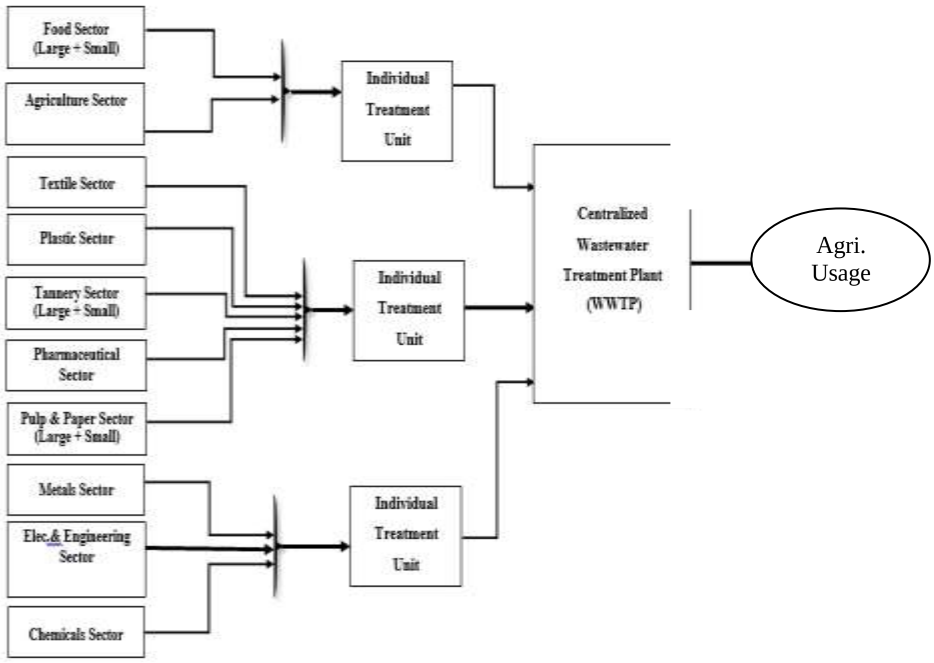

Figure (2): Scheme for Scenario (2)

Table (4): The estimated IWW load and max. flow rate entered the 3 individual treatment units for Scenario 2

Group (1)		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Large Food Sector	Min	3	900	504	720	360	675	0	0	0
	Max			1944	1845	1467	3103.20	0	0	0
	Ave			1181.93	1287.38	909.48	1875.52	0	0	0
Small Food Sector	Min	27	945	573.48	107.33	582.39	1358.78	0	0	0
	Max			1334.34	344.25	1168.83	3178.04	0	0	0
	Ave			880.57	815.54	847.17	2094.61	0	0	0
Agriculture Sector	Min	14	2520	1734.60	1734.60	5744.76	8506.40	0	0	0
	Max			2472.12	2227.68	7396.20	10962	0	0	0
	Ave			2096.62	1988.37	6611.82	9805.19	0	0	0
Total (1)	Min	44	4365	2812.08	2561.93	6687.15	10540.18	0	0	0
	Max			5750.46	4416.93	10032.03	17243.24	0	0	0
	Ave			4281.27	3489.43	8359.59	13891.71	0	0	0

Followed Table (4): The estimated IWW load and max. flow rate entered the 3 individual treatment units for Scenario 2

Group (2)		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Pharm Sector	Min	5	1800	834.40	1168	1452	4192	0	0	0
	Max			1222.77	12274.50	7992	16143.75	0	0	0
	Ave			1088.53	7684.23	4992.24	10231.81	0	0	0
Plastic Sector	Min	19	760	3170.91	5856.18	4950.45	8196.60	0	0	0
	Max			3531.72	7815.08	6606.68	10940.20	0	0	0
	Ave			3366.10	6677.69	5636.94	9343.81	0	0	0
Large Tannery Sector	Min	3	5100	5625	8739	4437	10638	0	2245.50	0
	Max			6415.80	9934.80	5049	12066.60	0	2524.50	0
	Ave			6209.07	9604.01	4880.47	11698.05	0	2439.44	0
Small Tannery Sector	Min	4	1200	1250	1814.80	982	2360	0	499	0
	Max			1509.60	2220	1182	2839.20	0	595.20	0
	Ave			1392	2026.05	1091.01	2622.52	0	546.66	0
Large Pulp & paper Sector	Min	3	4500	31863.75	47989.20	21845.70	32416.20	0	0	0
	Max			38594.25	63702	22648.50	33592.50	0	0	0
	Ave			36685.20	44794.71	22402.77	33247.83	0	0	0

Followed Table (4): The estimated IWW load and max. flow rate entered the 3 individual treatment units for Scenario 2

Group (2)		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Small Pulp & paper Sector	Min	10	350	2086.26	3514.70	1608.96	2382.40	0	0	0
	Max			3265.15	3977.82	1761.55	2612.75	0	0	0
	Ave			2625.50	3734.14	1712.48	2541.54	0	0	0
Textile Sector	Min	28	840	2205	6720	1170.40	2394	0	0	0.21
	Max			2657.76	17220	1404.48	2874.48	0.01	0.01	0.26
	Ave			2473.70	11442.64	1304.45	2634.24	0	0.01	0.23
Total (2)	Min	72	14550	47035.32	75801.88	36446.51	62579.20	0	2744.50	0.21
	Max			57197.05	117144.20	46644.21	81069.48	0.01	3119.71	0.26
	Ave			52116.19	96473.04	41545.36	71824.34	0	2932.10	0.23

Followed Table(4): The estimated IWW load and max. flow rate entered the 3 individual treatment units for Scenario 2

Group (3)		No. of Factories	Max Flow (m3/ day)	TDS (Kg/ day)	TSS (Kg/ day)	BOD5 (Kg/day)	COD (Kg/ day)	Ni (Kg/ day)	Cr (Kg/ day)	Zn (Kg/ day)
Chemicals Sector	Min	11	3,850	4090.24	4147.61	1669.36	2688.84	0	0	0
	Max			5120.50	5882.80	2079	3349.50	0	0	0
	Ave			4473.52	5043.53	1814.83	2924.30	0	0	0
Electric & Engineering Sector	Min	13	650	318.73	188.37	166.73	258.51	3.73	0.01	3.33
	Max			624	331.50	211.25	344.50	5.07	0.04	4.27
	Ave			378.80	274.27	187.59	313.63	4.52	0.02	3.95
Metals Sector	Min	10	600	3947.40	2135.16	969.30	1453.14	0.01	262.98	0.27
	Max			4398	2371.20	1081.20	1620	0.06	302.40	0.42
	Ave			4165.23	2251.88	1023.23	1533.46	0.01	280.56	0.35
Total (3)	Min	34	5,100	8356.37	6471.14	2805.39	4400.49	3.74	262.99	3.60
	Max			10142.50	8585.50	3371.45	5314	5.13	302.44	4.69
	Ave			9249.44	7528.32	3088.42	4857.24	4.44	282.71	4.14

Table (5): The estimated IWW parameters concentration entering the 3 treatment units and their outputs

The First Treatment Unit for Group (1)	TDS	TSS	BOD5	COD	Ni	Cr	Zn
Concentration (inlet) (mg/ l)	1317.40	1011.90	2298.29	3950.34	0	0	0
Pre-Treatment Unit (mg/ l)	1317.40	708.33	1723.72	2962.76	0	0	0
Phyisco-Chemical Treatment Unit (1) (mg/ l)	790.44	177.08	948.04	1629.52	0	0	0
Biological Treatment Unit (1) (mg/ l)	434.74	8.85	47.40	81.48	0	0	0
Concentration (Outlet) (mg/ l) of Drain Law 48/82 for agriculture	1000	30	30	50	0.1	0.05	2
Removal Eff. (%η)	67	99.13	97.94	97.94	-	-	-

Followed Table (5): The estimated IWW parameters concentration entering the 3 treatment units and their outputs

The First Treatment Unit for Group (2)	TDS	TSS	BOD5	COD	Ni	Cr	Zn
Concentration (inlet) (mg/ l)	3931.07	8051.15	3205.79	5571.79	0	214.41	0.02
Pre-Treatment Unit (mg/ l)	3931.07	5635.80	2404.34	4178.84	0	214.41	0.02
Phyisco-Chemical Treatment Unit (1) (mg/ l)	2358.64	1408.95	1322.39	2298.36	0	10.72	0
Biological Treatment Unit (1) (mg/ l)	1297.25	70.45	66.12	114.92	0	0.54	0
Tertiary Treatment Unit (mg/ l)	778.35	17.61	36.37	63.20	0	0.03	0
Concentration (Outlet) (mg/ l) of Drain Law 48/82 for agriculture	1000	30	30	50	0.10	0.05	2
Removal Eff. (%η) Final	80.20	99.78	98.87	98.87	-	99.99	99.99

Followed Table (5): The estimated IWW parameters concentration entering the 3 treatment units and their outputs

The First Treatment Unit for Group (3)	TDS	TSS	BOD5	COD	Ni	Cr	Zn
Concentration (inlet) (mg/ l)	1988.73	1683.43	661.07	1041.96	1.01	59.30	0.92
Pre-Treatment Unit (mg/ l)	1988.73	1178.40	495.80	781.47	1.01	59.30	0.92
Phyisco-Chemical Treatment Unit (1) (mg/ l)	1193.24	294.60	272.69	429.81	1.01	59.30	0.92
Biological Treatment Unit (1) (mg/ l)	656.28	14.73	13.63	21.49	0.35	2.97	0.32
Concentration (Outlet) (mg/ l) of Drain Law 48/82 for agriculture	1000	30	30	50	0.10	0.05	2
Removal Eff. (%η) Final	67	99.13	97.94	97.94	65	95	65

Table (6): The estimated IWW parameters concentration entering the centralized IWWTP and its outputs

Centralized IWWTP	Zn	Cr	Ni	COD	BOD5	TSS	TDS
Concentration inlet (mg/ l)	0.07	0.65	0.08	57.67	33.54	15.41	689.97
Biological Treatment Unit (1) (mg/ l)	0.02	0.03	0.03	2.88	1.68	0.77	379.48
Concentration Outlet (mg/ l) of Drain Law 48/82 for agriculture	2	0.05	0.10	50	30	30	1000
Removal Eff. (%η)	65	95	65	95	95	95	45

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 (7) illustrated the technical comparison for the applied two scenarios, while table (8) 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 (9) illustrated the total evaluation results where scenario 2 (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 (7): Technical Comparison between Applied Two Scenarios

No.	Comparison Face	Wt.	Scenario 1	Wt.	Scenario 2	Wt.
1	Skills needed	10	High	7	medium	5
2	Energy needed	15	High	4	medium	8
3	Efficiency	10	High	8	Very high	10
4	Labors number	10	Low	8	medium	6
5	Required area (m2)	10	medium	7	High	5
6	Operations and maintenance needed	15	Very high	3	Low	13
7	Control	5	Low	1	High	5
8	Life time	10	Low	2	High	9
9	Stability	5	Low	1	High	4
10	Mechanical equipment needed	5	medium	3	High	4
11	Time for settlement of IWWTP	5	medium	3	medium	3
Total Technical Evaluation		100		47		72
Total Technical Evaluation			2		1	

Table (8): Financial Comparison between Applied Two Scenarios

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

Table (9): Total Evaluation between Different Solutions

Comparison Face	Scenario 1	Scenario 2
Technical evaluation ratio %	47%	72%
Total Financial Evaluation/ 20 years	286,600,000	432,360,000
Total Cost after applying Technical Evaluation	609,787,234	600,500,000
Final Evaluation	2	1

CONCLUSION

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

- In this study (Quesna Industrial Zone) the best solution after several comparisons is Scenario 2 (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.

- Even Scenario 2 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 best one depending on the industries types, activities, the raw industrial wastewater quality and quantity varieties and the applied treatment solution.

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مقارنة بين الحلول البيئية لإدارة مياه الصرف الصناعي في منطقة قويسنا الصناعية

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المستخلص

تعد إدارة مياه الصرف الصناعي في مصر أحد الأهداف الرئيسية للتنمية المستدامة. وقد أدت أزمة المياه في مصر إلى قيام القطاع الصناعي بالبحث عن كفاءة استخدام الموارد وتقنيات الإنتاج الأنظف من خلال الإدارة السليمة للمياه والطاقة والمواد الخام. ونتيجة لذلك، تهدف هذه الدراسة إلى مقارنة الحلول البيئية المختلفة لإدارة مياه الصرف الصناعي في المناطق الصناعية المصرية. وقد تم اختيار منطقة قويسنا الصناعية بمحافظة المنوفية كدراسة حالة حيث تم اقتراح حلين بيئيين مختلفين

في هذه الدراسة لإدارة مياه الصرف الصناعي لاختيار الحل البيئي الأفضل لها. وتم أخذ عينات لمياه الصرف الصناعي من عشرة مصانع تمثل القطاعات الصناعية الرئيسية العشرة بمنطقة الدراسة، ثم قياس خمسة مكونات يمكن تواجدها في مياه الصرف الصناعي.

وأظهرت نتائج السيناريوهان المطبقين تباين في معدلات التدفق، وأحمال مياه الصرف الصناعي، وطرق معالجتها، وكفاءة تلك المحطات، بالإضافة إلى رأس المال وتكاليف التشغيل للسيناريوهان المطبقين. وأخيرًا، تم مقارنة السيناريوهان مع بعضها البعض تقنياً ومالياً وبيئياً لتحديد الحل البيئي الأمثل لإدارة مياه الصرف الصناعي لمنطقة قويسنا الصناعية. كما يمكن تطبيق هذه الدراسة على جميع المناطق الصناعية في مصر باستخدام نفس المنهجية المتبعة في هذه الدراسة.

الكلمات ذات الصلة: إدارة مياه الصرف الصناعي، منطقة قويسنا الصناعية، القطاعات الصناعية في مدينة قويسنا، معالجة مياه الصرف الصناعي، الحلول البيئية ، كفاءة الإزالة لمحطات المعالجة، حمل التلوث في مياه الصرف الصناعي.