Integrated Industrial Wastewater Management of Egyptian Ferro Alloys Company

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Abstract:

The Egyptian Ferro Alloys Company is the main producer of Ferro Alloys in Egypt. The factory is located North of Idfu City. The factory production capacity is 56000 ton per year of Ferro Alloys. Secondary factory products are Silica dust and Slag with an average production of 18255 and 4730 ton per year respectively.

The factory has water treatment plant to produce water for domestic purpose. It consumes raw water from the Nile for industrial purposes (Cooling and quartz washing), where 50 % of cooling water is recycled to the system. The water consumption rates of cooling water, quartz washing as well as domestic use are 1712 m3/hr (862 m3/hr recycled + 850 m3/hr), 200 m3/hr (Recycled) and 40 m3/hr respectively. Accordingly, the net water consumption is 890 m3/hr.

The factory discharges 50% of the cooling water to the Nile violating law No. 48/1982 in temperature level specially in summer months. In the past, The factory discharged the quartz washing water to the Nile violating law No. 48/1982. Accordingly, the factory put the quartz washing water into the closed cycle, which creates problems in the networks and operation processes. The domestic wastewater is routinely evacuated and disposed to the desert violating The regulatory limits.

Accordingly, scheme of combined in-process, in-plant and end of pipe treatment module should be used in order to reduce the level of pollutants to comply with requirements of law 48/1982, article No. 61 and Decree No. 44, year 2000.

In process modifications are suggested: First, to apply spray nozzles in quartz washing to reduce water consumption in quartz washing. Second, to rehabilitate the intake pump station (will be totally financed by the factory). The annual cost benefit of in-process modifications are LE 12000 and LE 107,047 respectively. The payback period of in-process modifications are 2.15 years and 1.7 years respectively.

In plant modifications are suggested for cooling towers for both furnace (No.1 & No.2) and transformers. The purpose of in plant modifications to reduce water consumption and water discharge into the Nile and fulfill discharge limits to the Nile as indicated in Law 48/1982.

End of pipe treatments are suggested for quartz washing as well as for domestic wastewater. The Quartz washing water will be treated to fulfill water quality suitable for reuse for quartz washing. The domestic wastewater will be treated to fulfill water quality

as indicated in Decree No. 44/ year 2000 for reuse for irrigation. The treated water will be reused for tress and garden irrigation.

The capital cost of in-process modification and in-plant modifications are LE 25,800 and LE 893,000 respectively. The capital cost of Quartz washing water treatment and domestic wastewater treatment are LE 2,400,000 and LE 2,110,000 respectively.

Introduction:

The Egyptian Ferro Alloys Company is located in Idfu City, Aswan Governorate. The factory is surrounded by the Nile , El Attawany village, Cairo Aswan Rail way line, and building belong to the Electric Egyptian Company. The factory produces Ferro Alloys capacity with production capacity of 56000 ton per year of. The Secondary products are Silica dust and Slag with an average production of 18255 and 4730 ton per year respectively.The factory discharges cooling water to the Nile violating law 48/1982. It also evacuates the domestic wastewater by the use of tank car to the desert violating the regulatory limits.

Study's Scope of The Work:

In order for the factory to comply with the environmental legislation, different remedial actions have to be taken. Such measures including combinations of in process/in plant and end – of-pipe treatment modules are proposed in order to reduce the level of pollution parameters to comply with the requirements of law 48/1982 and Decree No. 44, year 2000. To achieve the above-mentioned objectives, the following tasks are planned: (1) Reducing thermal load through installation closed circuit cooling system system. (2) Reducing pollution load through point source treatment and process modifications. (3) Reducing washing water quantities through point process modifications. (4) Reducing wastewater volume by segregation of clean water streams and recycling. (5) To design an end-of-pipe treatment system to complete the in process / in-plant modifications in order to comply with regulations.

Activities During Reporting Period:

During the reporting period, the relevant data for water consumption, wastewater volume and characterization and production rates were collected and reviewed. Furthermore, the following activities were conducted during the study: Meeting with company officials. A committee from the company headed by the factory manager was assigned to follow up and accomplish the study requirments. The committee included a member responsible of the environmental affairs in the factory and members from all concerned departments. During meetings with the committee, the details of processes, water consumption , wastewater quantities and cooling system were presented and discussed , most data were gathered through these meetings. Number of site visits during which investigating the plant sections. The factory administration is asked to set monitoring of water consumption. Recent wastewater monitoring and analysis is carried out.

Water Consumption:

Source of Water is the River Nile. Water is used for different purposes, production as well as human consumption. The factory has water purification plant to produce water for human consumption. The plant capacity is 40 m3/hr. The purified water is used for human consumption as well as laboratory consumption. The estimated average domestic water consumption is 125 m3/day. Furthermore, the factory has water intake and pump station to lift the raw water from the River Nile into the production processes for cooling purposes as well as washing purpose. The estimated average of water consumption is

850 m3/hr and 40 m3/hr for cooling of furnaces and transformers etc. as well as domestic use rspectively.

Production Processes:

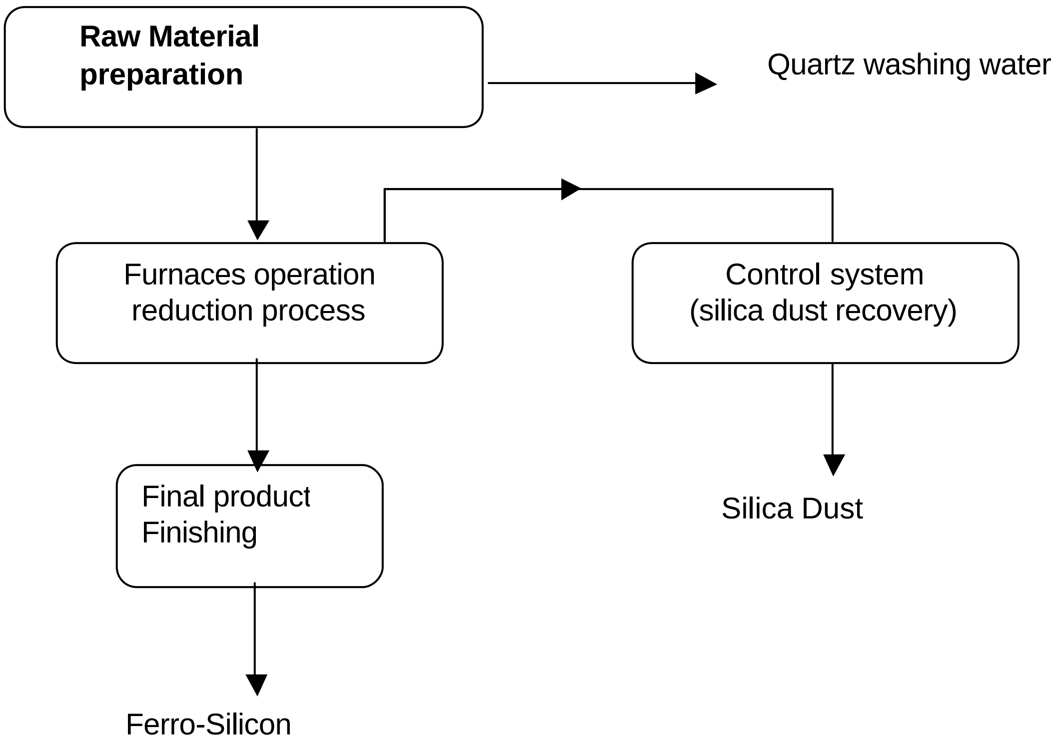

Fig. (1): Main Schematic Flow Diagram of Production Processes

Water Purification Plant:

The factory has water purification plant to produce water for human consumption. The plant capacity is 40 m3/hr. The plant has two clarifiers (Diameter = 4 ms /each) and four rapid gravity sand filters (2x2 ms / each). The clarifier capacity is 20 m3/hr each (Surface over flow rate = 40 m3/m2.d) and the filter capacity is 18 m3/hr each (Filtration rate = 4.5 m3/m2.hr) The filters are back washed once every day. The back wash water is discharged into lagoon system within the factory.

The Pump Station:

The pump station was constructed in 1984. It has receiving tank and pumps building. The receiving tank dimensions are 6x6x18 ms with 650 m3 capacity. The pump station has six pumps with theoretical capacity of 460 – 480 m3/hr per each pump. In the normal operation, the factory operates 4 –5 pumps per day and the other pumps are standby.

The Network:

The factory has water network to serve the production process. Water is used for cooling of the four furnaces as well as the transformers. Other water is used for washing of quartz. Cooling water used for cooling of furnaces and transformers are collected through a network to be returned into the pump station receiving tank.

Cooling Water System:

The factory carried out a trial to put all cooling water in the closed cycle, but this trial caused problems for the operation of the furnaces. Accordingly, the factory carried out a second trial to put 50 % of the cooling water in the closed cycle, while other cooling water is discharged to the River Nile. This final trial has been in operation until now because it has not any adverse effect on the operation of the furnaces.

Wastewater Discharged:

Cooling water:

As a result of the factory second successful trial to put 50 % of cooling water in closed cycle, 50 % of cooling water is discharged into the River Nile. The recycled cooling water includes both cooling water of furnaces (3&4), Air production station and transformers. The discharged cooling water includes both cooling water of furnaces (1&2), Research building and furnace and production workshop. The quality of the discharged cooling water into the River Nile sometime exceeds the discharge limits in suspended solids (due to quartz washing water recycling) and oil and grease (due to transformers maintenance). The estimated flow of discharged cooling water is 850 m3/hr. The estimated flow of recycled cooling water is 862 m3/hr, see Figure (2-a) Schematic flow diagram of water flow in the factory.

Quartz Wash Water:

In the past, the factory discharged the quartz washing water into the River Nile violating law 48/1982 in suspended solids. Now, as a result of the poor quality of quartz wash water, the factory put the wash water into closed cycle. This cause occasional operational problems in the pipe networks as well as production processes. The estimated average flow of quartz wash water is 200 m3/hr.

Domestic Wastewater:

Wastewater is discharged from the laboratories and the administration building. The laboratories and the administration building are connected to sewer line ended with collection Sump. Wastewater is collected in wastewater collection Sump, which is evacuated routinely and transported into the desert violating the regulatory standards. The estimated average flow of domestic wastewater is around 100 m3/d.

Wastewater Analysis Results:

In order to carry out integrated wastewater management in the Egyptian Ferro Alloys Company, field flow measurements as well as wastewater sampling plan were implemented in February 2003. The data of the water consumption rates, the wastewater streams and wastewater characteristics are reviewed and updated. The water consumption rates and wastewater rates are presented in tables (2) & (3). The sampling analyzing results of wastewater characteristics are described in table (4). Other sampling and analysing were carried out for both quartz washing water and domestic wastewater in April 2003 and the analysis results are presented in table (5).

Table (2) Estimated Water Consumption Rates According

Departments	**Water Consumption (M3/hr)**
Furnaces	750 + (750 Recycled)
Transformers Cooling	(62 Recycled)
Air Production Station	(50 Recycled)
Research Building & Furnace	70

Production Workshop	30
Total Consumption for Cooling	**850 + (862 Recycled)**
Quartz Washing	(200 Recycled)
Water Treatment Plant	40
Total	**890 + (1062** Recycled)

Table (3) Estimated Wastewater Discharge Rates

Departments	Water Discharge (M3/hr)	Disposal Site
Cooling Water OF Furnaces 1&2	750	To Nile
Cooling Water Research Building & Furnace	70	To Nile
Production Workshop	30	To Nile
Domestic Wastewater	30 (3.5 hr/d)	To Desert
Total	**880**	

Table (4) Wastewater Analysis Results in February 2003
(Analysis were conducted by Kom Ombo Water Treatment Plant Laboratory Staff)

Parameter	Quartz Washing Water	Furnace Cooling Water	Transformer Cooling Water	Domestic & LaboratoryWastewater	Permissible Limits Law 48/1982, Article 61
Temp., C	25	26	30	24	35
P H	8.5	8.2	8.2	7.75	6 - 9
Suspended Solids, mg/l	<u>385</u>	30	20	<u>70</u>	30
Total Dissolved Solids, mg/l	270	230	155	175	1200
BOD, mg/l	10	10	15	<u>50</u>	30
COD, mg/l	<u>50</u>	<u>50</u>	30	<u>80</u>	40
Oil & Grease	0.0	0.0	0.0	5	5

Table (5) Wastewater Analysis Results in April 2003
(Analysis were conducted by Kom Ombo Water Treatment Plant Laboratory Staff)

Parameter	Quartz Washing Water	Domestic & Laboratory Wastewater	Permissible Limits
P H	8.0	7.3	6 - 9

Setleability ml/l (10 min.)			
Setleability ml/l (30 min.)	2	11	
Suspended Solids, mg/l	456	90	30
Total Dissolved Solids, mg/l	270	175	1200
BOD, mg/l	60	110	15
COD, mg/l	75	130	40

Wastewater Streams Characterization:

Quartz Washing Water:

The analysis results presented in tables (4) & (5) indicate that quartz-washing water exceeds discharge limits to the river Nile in S. S., BOD, and COD. It contains high-suspended solids level in the range of 400-500 mg/l. The setleability value of quartz washing water indicates that the major nature of suspended solids is colloidal matter, which needs long time to settle. It also indicates that plain sedimentation is not effective method for treatment. Chemical treatment is most effective method for treatment quartz washing water with high level of colloidal matter. Accordingly, Bench scale jar test was conducted to test the applicability of chemical treatment of quartz washing water.

Domestic Wastewater:

The analysis results indicates that domestic wastewater parameter levels exceeds the land disposal regulatory limits. It is also noticed that domestic wastewater considered low strength wastewater. It includes low levels of S.S., BOD, and COD. It could be subjected to dillution by sub-surface water. Further field visit was carried out to investigate the sewerage system in the factory. It indicates that sub-surface water is near the ground surface. It is only 0.9 ms deep. It also noticed that the sewerage system is submerged by water specialy the manholes, which is full of water. This could explain the reason that the domestic wastewater is low strength wastewater. Further discussion with factory staff indicate that the sewerage system is old and could carry subsurface water in addition to domestic wastewater. Accordingly, rehabilitation of the sewerage system of the factory is recommended.

Cooling Water:

The analysis results of cooling water of furnaces and transformers indicates that its value of COD level exceed the discharge limits to the Nile as indicted in law 48/1982, article 61. With regard to the temperature values of cooling water, the measured values in February are within the discharge limits. It is expected that temperature values of cooling water measured in summer months would exceed discharge limits. Accordingly, Cooling system is recommended to recycle the cooling water, reducing discharge flow as well as reducing the temperature level to be within the discharge limit.

With respect to oil and grease level in cooling water, the past and recent analysis cooling water done by Booz- Allen, Chioda, and current study in 1994, 1999 and 2003, respectively. The results indicate that the oil and grease level were 22 mg/l, 0.0 mg/l and 0.0 mg/l respectively. This indicates that oil and grease level in cooling water is 0.0 in normal operation. With regard to transformer cooling, since the transformers oil is cooled by a cooling water circuit, the design considerations of such heat exchanger are carefully handled. Oil pressure is almost higher than the water pressure. Cooling water is usually clean where is not exposed to the oil leak due to pipe metal corrosion. Accordingly, preventive maintenance is very important for such heat exchanger. For carefully and regular periodic of such preventive maintenance, oil separator is not urgent for the present situation.

Bench Scale Jar Test:
Experiment Conducted:

Several experiments were conducted to explore various aspects of chemical treatment. The objective to treat quartz washing water to get treated water quality that can be reused for quartz washing as well as to comply with the discharge limit as indicated in Law No. 48 year 1982 Article No. 61. First, Alum is tested with different doses by several trials to determine the relative effectiveness of Alum doses as coagulant for chemical treatment of quartz washing water. Second, Alum with Polymer are tested with different doses to determine the relative effectiveness of polymers doses as coagulant aid for chemical treatment of quartz washing water. Finally, the best cost effective Alum and polymer doses are recommended for chemical treatment of quartz washing water. The experiments trials results are presented in tables (6) & (7). Further tests were carried out in May 29, 2003 and conducted in the laboratory of High Institute of Public Health, Alexandria University. The results are presented in tables (8) & (9).

Table (6) Jar Test Experiments Results using Alum as Coagulant in February 2003
(Analysis were conducted by Kom Ombo Water Treatment Plant Laboratory Staff)

Test No. 1	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5
Alum doses (mg/l)	20	30	40	60	80
Turbidity (NTU)	38	32	24	34	47

Table (7) Jar Test Experiments Results using Polymer with Alum as Coagulant
(Analysis were conducted by Kom Ombo Water Treatment Plant Laboratory Staff)

Test No. 3	Jar 1	Jar 2	Jar 3	Jar 4
Alum Doses (mg/l) and	20	30	40	50
Polymer dose (0.2 MG/L)				
Turbidity (NTU)	16	14	12	14
Supernatant S.S. (mg/l)	10	8	7	6

Table (8) Raw Quartz Washing Water Setleability Results
(Analysis were conducted by High Institute of Public Health Laboratory Staff, Alexandria University)

Parameter	Unit	Results of **Raw** Sample	Results of **Setteled** Sample
P H		7.6	7.67
Suspended Solids	Mg/l	722	262
Turbidity	NTU	440	210
Setleable Solids			
After 10 min	ML/L	1.5	
After 30 min	ML/L	2.9	
After 60 min	ML/L	3.4	

Table (9) Jar Test Experiments Results using Alum as Coagulant
(Analysis were conducted by High Institute of Public Health Laboratory Staff, Alexandria University)

Parameter	Unit	Alum Doses (10 mg/l)	Alum Doses (20 mg/l)	Alum Doses (30 mg/l)
P H		8.15	8.1	8.02
Supernatant Suspended Solids	Mg/l	83	66	58

Supernatant Turbidity	NTU	45	37	27

Experiment Results:

Anlysing results conducted by Kom Ombo Water Treatment Plant Laboratory Staff are presented as follow: First, test no. 1 is tried with large range of Alum doses. Second, test no.2 is tried with combination of polymer and alum doses. The results presented in tables (6) indicate that the cost effective range of Alum in chemical treatment of quartz washing water is in the range of 30 – 60 mg/l. The results presented in table (7) indicate that the combination 0.2 mg/l polymer with 20 –30 mg/l. Alum could reduce the suspended solids of quartz to the acceptable dischage limits to the Nile as indicated in Law 48/1982, article 61.

Further analysing results conducted by High Institute of Public Health Laboratory Staff, Alexandria University are presented as follow: First, table (8) indicates that the suspended solids of raw and setteled quartz washing water are 722 and 262 mg/l respectively. Furthermore, the Turbidity of raw and setteled quartz washing water are 440 and 210 mg/l respectively. Second, table (9) indicates that the suspended solids of chemically coagulated water by alum doses 10 mg/l , 20 mg/l and 30 mg/l are 83 mg/l, 66 mg/l and 58 mg/l respectively. Accordinglly, the results concluded that treatment of quartz washing water by physical sedimentation could not comply with law 48/82. It also indicates that chemical sedimentation by small doses of alum alone could not comply with law 48/82. Finally, the results of combined chemical sedimentation by alum and polymer could comply with law 48/82. In order to reuse of quartz washing water for quartz washing, further filtration unit should be added to the chemical treatment.

Schemes For Remedial Measures:

The scheme based on possible modules of in-process modifications, and end of pipe treatment system is suggested in order to achieve the project Activities, see figure (2-b).

In-process Modification:

Upgrading The Quartz Washing System:

Two mechanical washers (rotary drum type) are used for washing the crude quartz. The water consumption for quartz washing was reported before as 200 cubic m / hr. No instrument for measuring the water flow rates have been existed . In-process modification is recommended to reduce flow of quartz washing water, which would need treatment. This proposed to decrease the flow of used water for quartz washing (second stage) from 140 up to 90 cubic m / hr. by using a special full cone spray nozzles. A full cone spray (round pattern) nozzles are recommended for the quartz washers.

Due to the quartz gravity force in the washers , the working sector in the bottom of the rotary drums is 120 degree coverage area. A uniform distributed array of nozzles is suggested for each washer to cover the working sectors. A centrifugal rotodynamic pump equiped with its electrical motor must be inserted in the upstream of the piping system to keep the nozzles working pressure at 2.5 bar.

Rehabilitation of the main pump station

The main pump station was constructed in 1984. The present condition is critical either for the insufficient field requirement of water flow rates or in the disability of pump station maintenance itself . A secondary circulation of flow rates are expected between the individual pumps because of the different performance of each line and their valves . Such problems appear clearly in the summer season when the furnaces cooling water quantity is sensitive .

The pump station is in need of rehabilitation program to withstand its heavy duty load . In-process modification is recommended to improve the working condition of the main pump station as well as save energy consumption of the station. Basic renovation will include the replacement of two pumps line components such as shut off valves , non-return valves (after checking all reflux functionning), two centrifugal pumps repair , to install dismantling pieces on delivery sides , to replace the flow measurements in the twin delivery main pipes and also the required pressure gauges. The total estimation cost of the present pump station rehabilitation (for 2 pump sets only) will be 184 000 L.E.

In-Plant Modification:
Cooling Towers:

The water requirement to operate an electric arc furnace (EAF), is mainly for cooling purpose. The interruption of the flow or inadequate water quantities can lead to severe thermal over loading and in some cases catastrophic failure. Furnaces and transformers require extremely clean and high quality cooling water.

Cooling water for furnace 1 and furnace 2 is discharged to the Nile river. While cooling water for furnace 3, furnace 4, electrical transformers, air station and washing water of quartz are recycled through pump station collection tank.

It is expected that temperature values of cooling water measured in summer months would exceed discharge limits. Accordingly, Cooling system is recommended to recycle the cooling water of both Furnaces No.1 & No. 2, reducing discharge flow as well as reducing the temperature level to the discharge limits as indicated in Law 48/1982, article 61.

Conceptual Design:
Total Cooling Water Recycling (TCWR)

850 m^3/hr of water is the present fresh water consumption from the Nile river used to cool the furnaces and 1 &2, research building and woprkshop. Due to estimated 50% recycle of furnace cooling water, the total pumped water flow through pump station is 1912 m3/hr, see figure (2-a). 1500 m^3/hr and 62 m^3/hr of water are the present values used for cooling furnaces and electrical transformers respectivel. The recommended values of cooling of the furnaces is 1560 m3/hr. Cooling water is discharged with high temperature to the Nile which violating with law No. 48/1982, article 61. There is no water cooling towers in the factory. Installation of cooling towers is an essential solution.

In order to minimize intake and discharge water quantities, and so thermal load to the Nile river all of cooling water quantities for furnaces No. 1 & No.2 and electrical transformers must be recycled through cooling towers (see Fig. 5). The water in the closed loop circuit passes through a heat exchanger to remove heat from furnaces and transformers, then flows to a cooling tower for energy dissipation.

In such conceptual design (TCWR) the required water from the Nile to cool the furnaces 1 & 2 can be reduced from 750 m^3/hr to 24 m^3/hr (make –up water for cooling tower) in which 97 % water conservation will be confirmed, see Fig. (2-b).

Domestic Wastewater Treatment and Disposal:

With respect to domestic wastewater of the factory, Three alternatives were examined and evaluated and compared. **Alternative No. 1:** Use of Tank Cars to evacuate the domestic wastewater and transport it to Idfu domestic wastewater treatment plant**.** **Alternative No. 2:** Construct and operate domestic wastewater treatment plant within the factory and reuse of treated water for trees and garden irrigation. **Alternative No. 3:** Construct and operate pump station and 3 km pressure line into El Attawany Domestic Wastewater Treatment Plant, where a new track of stabilization ponds system is constructed and operated by El Attawany Community Development Association. Furthermore, the rehabilitation of the factory sewerage system is evaluated and estimated. The following is the conclusion of the cost estimate of each alternative. Comparison between Alternative is carried out and presented in table (10). The technical evaluation of alternatives is socred according to the permanence and sustainability. The reason of low technical score of alternative 3 is due to that the plant would be operated by community development assosciation (CDA). The risk of responsibilty between CDA and the facorty regarding regulation authority is high.

Alternative 1:

Estimated average domestic wastewater flow = 100 m3/d
The Volume of Tank car = 4 m3
The Number of Trips = 25 Trips
The cost of one trip = 20 LE
The total transportation cost = 500 LE per day
The authority disposal fees = 25 LE per day
The total cost = 191625 LE per year
= 192000 LE per year
The total cost per 15 years = 2,880,000 LE

Alternative 2:

Construction Cost Of DWWTP = 1,500,000 LE
Construction cost of Irrigation net work = 130,000 LE
Total Construction Cost of Alternative 2 = 1,630,000 LE
O & M Cost of Alternative 2 = 81,500 LE / Year
The total cost per 15 years = 2,852,500 LE

Alternative 3

The cost of pump station = 75,000 LE
The cost of 3 km pressure line = 900,000 LE
The cost of New Track of Ponds system = 400,000 LE
The cost of preparation of trees planting area = 50,000 LE
Total Construction Cost of Alternative 3 = 1,425,000 LE
O & M Cost of Alternative 3 = 71,250 LE / Year
The total cost per 15 years = 2,493,750 LE

Table (10) Comparison Between Wastewater Controlled Disposal Alternatives

	Total Cost in LE	**Technical Score**	**Cost Value**
Alternative (1)	2,880,000	8/10	360,000
Alternative (2)	2,852,500	9/10	**316,944**
Alternative (3)	2,493,750	7/10	356,250

***** Long life of equipments is assumed 15 years

The Cost of Rehabilitation of The Sewerage System:

8 inch Gravity Line 300 ms **=** 45000 LE
10 inch Gravity line 620 ms = 125000 LE
12 inch Gravity line 450 ms = 120000 LE
45 Manholes = 60000 LE
Total Cons. Cost of The Sewerage System = 350,000 LE

Break-down of the wastewater quality and treatment efficiency is conducted according to the following criteria:

The expected range of pollution parameters for wastewater streams and end of pipe effluent for both domestic wastewater and quartz washing water are presented in table (11).

Table (11) Expected Wastewater Streams Characteristics and Recomened Rgulatory Limits

Stream and Regulatory Limits	Temp in C	COD in mg/l	BOD in mg/l	Suspended Solids in mg/l	Oil & Grease in mg/l	Coliform MPN/100 ml
Domestic Wastewater	25 - 35	150 - 300	110 - 220	110 - 220	50	$7x10^6$/ 100 ml
Decree No. 44/2000 (group 3)	35	40	20	20	5	100 Fecal Coliform /100 ml
Cooling water blow down	30 - 40	15 - 50	10 - 30	20 - 60	25 - 50	2500 Coliform/ 100 ml
Law 48/1982, article 61	35	40	30	30	5	2500 Coliform/ 100 ml
Quartz Washing Water	25 - 35	35 - 150	10 - 120	250 - 750	5 -15	2500 Coliform/ 100 ml
Required Treated Quartz Washing Water Effluent Limits	35	40	20	20	1	2500 Coliform/ 100 ml

Preliminary Cost Estimate of Integrated Wastewater Management Project in Egyptian Ferro Alloys Company

Item	Preliminary Estimated Cost in LE
In-Process-Modifications 1	
1 - Modify the existing washing system for quartz by applying spray nozzles system.	
In-Process- Mod.1 Cost	**25,800**
O & M Cost	2,580
In-Process-Modifications 2	
Rehabilitation of one third capacity of pump station	
In- Process -Mod. 2 Cost	184,000*
O & M Cost	18,400*
Cooling System	
Cooling towers for Two furnaces	700,000
Cooling tower for Electric Transformer	193,000
Cooling System	**893,000**
O & M Cost	44,650
Quartz Washing Water Treatment	
Modify the existing sewer system to direct the washing water to QWWTP site - collection pit supported by screening system - two submerged pumps. Connection from plant site to Treated water reservoir.	150,000
Quartz Washing Water Treatment Plant (150 m3/hr – 1050 m3/d): flash mixer – coagulant & coagulant aid preparation and injection units – flocculator- clarifier – Gravity Sand Filter – Treated water reservoir - sludge collection pit – two sludge pumps – sludge dewatering unit.	3,000,000
Quartz Washing Water Treatment	**3,150,000**
O & M Cost	157,500
Domestic Wastewater Treatment	
Rehabilitate the existing sewer system and direct the wastewater to WWTP site	350,000
Collection pit supported by screening system - two submerged pumps.	50,000
- Biological treatment plant (30 M3/hr - 100 M3/d) (aeration basin – clarifier –rapid sand filter, UV unit –. Effluent collection tank – pumps - pressurized line to the irrigation system - Sludge holding tank -sludge pumps - sludge conditioning and thickener - sludge dewatering - Lab. Instruments	1,500,000
Irrigation system	130,000
Domestic WW End-of-Pipe Total Capital Cost	**2,030,000**
Operation & Maintenance Cost	101,500

Cost Benefit Analysis:

Item	Annual Benefit (AB)
In-Process Modification 1	
Application of spray nozzles system in the process of quartz washing	Saving 40 m3/d of water, Price of 1 m3 is 1 LE, 300 working days. AB= 12000 LE
	12000 LE/ year
In-Process Modification II	
Rehabilitation one third of the pump station	Save two pumps X 130 KW as an average power consumption per hour X 24 hours X 365 days/year Based on factory traiff 0.047 LE The annual saving = 107047 LE
	107047 LE/ year

Cost Analysis :

Item	Initial Cost (IC) in LE	Operation Cost (Op. C) in LE	Annual Benefit (AB) in LE	Payback Period In years
In-Process Modification				
Application of spray nozzles system in the process of quartz washing	25800	1500	12000	2.15
Rehabilitation One third of the pump station	184000	2380	107047	1.7