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Evaluation The Performance Of Wastewater Treatment Plant In Hilla Textile Company

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Abstract

The main purposes of this research are to evaluate the performance of the industrial wastewater treatment plant of the Hilla Textile Factories, finding an appropriate method of treating the industrial wastewater so as to render it fit for reuse and safe to be disposed stipulated by the Iraqi laws on effluent disposal. The removal efficiency of the different parameters of the water quality was low. It was found that the removal efficiency of COD is (20-21%), that of BOD is (17-30%) and that of TSS is (27-31%). The quality of the effluent was not in agreement with those of the Iraqi or the American standards.

الخلاصة

الغرض من البحث هو تقييم اداء محطة معالجة المياه الصناعية القذرة في معامل نسيج الحلة بالاضافة الى ايجاد الطريقة الملائمة لمعالجة تلك المياه لجعلها ضمن المواصفات المسموح بها في القوانين العراقية للبيئة.ان نسبة أزالة المواد (27−31)%.TSS و (17−30)%BOD(20−21)%,COD لغير مرغوب فيها بالمياه الى قيمها بالمواصفات القياسية ان المياه الناتجة بعد عملية المعالجة غير متوافقة مع المواصفات القياسية العراقية و الامريكية.

Introduction

Water quality

Source of water:

With the future need to safeguard the quality of fresh water supplies and reduce fresh water usage by the introduction of reclamation schemes, the control of industrial discharges will become of great importance. In many instances the wastes that industry discharges to the sewers are detrimental to the production of a high quality reclaimed water (Hart *et al*.,1983).

There are many sources of water. Most individuals and industry in U.S.A obtain their water from surface waters (streams, rivers, lakes, reservoirs) and groundwater. However, in other parts of the world, (e.g., the Middle East), construction of desalination plants has allowed the use of seawater as a source of drinking water. Reclaimed water is obtained from the treated effluent from a wastewater treatment plant. While it is technically feasible to pipe treated wastewater effluent into a drinking water treatment plant, most municipalities who utilize this option first discharge the treated wastewater effluent into a reservoir for a set period of time, after which the reservoir can then be used as a source of drinking water (Mihelcic and Hand, 1999).

Water pollution

Table (1) shows the types of wastewater contaminants produced from industry. Many of these pollutants resist degradation by the self-purification processes of the water environment as well as the controlled environment of the conventional biological treatment works and eventually find their way into potable water supplies.

Table (1): Effects of specific types of pollution in industrial waste Discharges.(Hart et al. 1983)

Water pollutants	Industries and industrial activities responsible	Adverse effects
Color	Pulp and paper, textiles, abattoirs, steel, dairy.	Visually objectionable.
Solids	Pulp and paper mills, textile factories, tanning, canning, breweries, steel mills, boiler-house operations, mining (drainage from mine dumps), abattoirs.	Blockage of sewer lines and equipment, damage to rivers by deposit of solids and depletion of oxygen.
Oil and grease	Abattoirs, wool-washers, tanneries, metal finishing, dairy plants, steel mills, oil refineries, railway workshops, locomotive, truck and aircraft washing, engineering works.	Blockage of sewer lines and equipment, floating scum on water which prevents transfer of oxygen, anaerobic conditions, unpleasant smell and attraction of flies.
Organic wastes	Pulp and paper, textiles, abattoirs, tanneries, canning, brewery, starch and yeast factories.	Overloading of conventional sewage treatment plants, depletion of oxygen in rivers.
Insecticides, Pesticides	Chemical, food and textile factories.	Toxic to bacterial and aquatic life; puts sewage treatment works out of action.
Heavy metals Cyanide	Pickling, plating. Metal finishing, plating, coking, refineries.	
Chemical wastes	Coking, synthetic dyes, chemicals, plastics, solvents, textile finishing, Kraft and Sulphite pulp.	Unpleasant taste and odor; toxic to aquatic life.
Acids (mineral and organic)	Steel pickling, chemicals, food processing, acid mine drainage.	Corrosion of concrete structures.
Alkalis, sodium	Metal finishing, plating, textile and pulp mills, tanneries, water softening, ion-exchange installations.	Toxic to fish, rendering water unsuitable for irrigation by causing brackish conditions due to imbalance of ions.
Nitrogen, phosphorus	Fertilizer plants, synthetic detergents.	Rapid growth of aquatic organisms, algae, Sphaerotilns natans.
Carbohydrates	Fruit and vegetable canning, sugar milling.	
Heat	Cooling, all physical and chemical processes.	Stimulates organic growth and reduces oxygen in water.
Detergents	Textiles , metal finishing,	Foaming.
Pathogens, viruses, worm	Hospitals, abattoirs.	Spreading of disease.

Industrial wastewater

Industries consume large quantities of water in different types. This water could be raw taken from natural sources like rivers or could be taken from drinking water nets. Whatever the sources are, its destination will be to the sewage nets or to the sources of water. In both cases, these waters must be treated before disposing it. Such treatments are of different types due to the different pollutants. Such different pollutants are always accompanied with high cost for the treatment process.

Recycle and reuse of water will minimize the consumption of water, saving some water that could be used for drinking.

Wastewater is treated to remove and decompose substances that are harmful to the natural environment. The substances are either directly decomposed or first separated and then decomposed, by using or promoting natural purification action. In other words, a treatment plant is built on separation and decomposition technologies as shown in Fig. (1).The processes of treating wastewater are usually divisible into many principal sections. The divisions according to (Peirce *et al*., 1998) (Inoue, 2006), are:

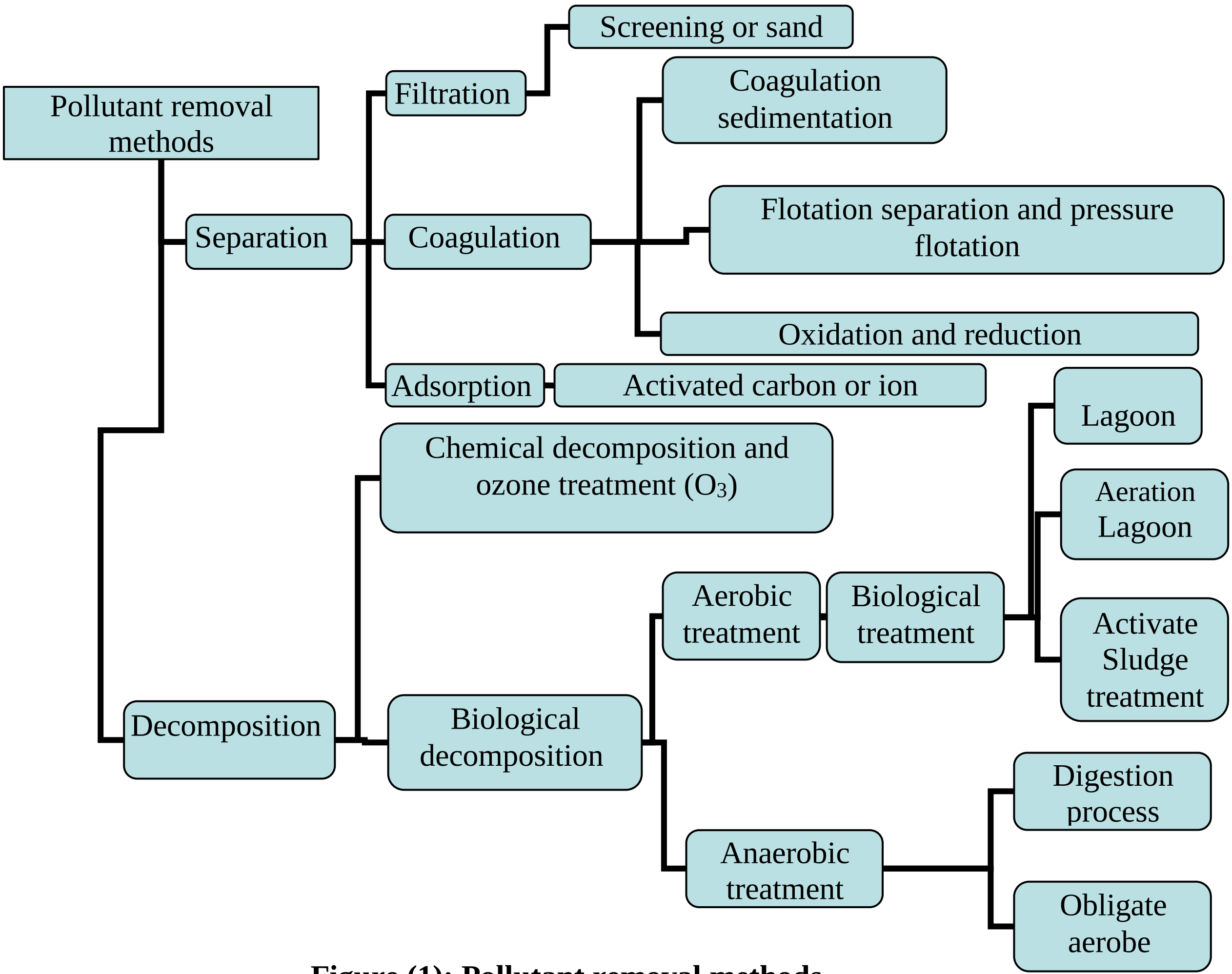


Figure (1): Pollutant removal methods

1-Activated Carbon adsorption:

Activated carbon comes in two forms: powdered activated carbon (PAC), and granular activated carbon (GAC). Both forms effect removal by physically adsorbing ' compounds. In the past, (PAC) was employed more frequently, primarily for color, taste and odor control. (PAC) reportedly was first used in the United States in 1929. However, both (PAC) and (GAC) are generally viewed as a reliable last recourse for removal of color, taste and odors particularly from industrial sources.

The adsorption process by activated carbon is able to remove color, odor, and taste. It is also capable to remove dissolved organic materials, detergent, grease, oil, phenols and hydro carbonate. The value of BOD is changed from (200mg/l) to I (1mg/l) whereas the value of COD is changed from (200mg/l) to (20mg/l) by using activated carbon (Al - Mallah, 2002).

The removal efficiency by activated carbon compared with other treatments are tabulated in Table (2) (AICE and EPA, 1976).

Table (2): Efficiency of activated carbon compared with other treatments (AICE and EPA, 1976)

Pollutant	Removal efficiency %		
	Chemical treatment	Biological treatment	Activated carbon
l.BOD_5 mg/l	50-70	70-95	60-95
2.COD mg/l	50-70	30-70	60-95
3.TSS mg/l	80-98	30-90	60-90
4.Color	80-90	10-80	80-98
5.Alkalinity mg/l	0-20	10-20	5

The table shows that the removal efficiency by activated carbon is very high, but the industrial waste must be treated by chemical and Biological treatments first and the remainder of the pollutants is then removed by activated carbon (AICE and EPA, 1976).

2-Granular activated carbon (GAC)

The contact system for granular activated carbon (GAC) consists of a cylindrical tank which contains a bed of the material. The water is passed through the bed with sufficient residence time allowed for completion of the adsorption process. The system may be operated in either a fixed-bed or moving-bed mode. Fixed-bed systems are batch operations that are taken off the line when the adsorptive capacity of the carbon is used up (Peavy *et al*., 1986).

The design of granular-activated- carbon systems is based on the flow rates and contact times. Flow rates of (0.08 to 0.4 n^3/m^2 .min) and contact times of (10 to 50 min) are based on empty-tank cross section and volume, form a common practice.

The effectiveness of (GAC) in removing color, taste and odor can be expressed by the following equation (Peavy *et al*., 1986).

$$Ln ((C_0/C_e) -1) = Ln (e^{KNoD/v} - l) – KC_0t \quad (2)$$

3-Powdered Activated Carbon (PAC)

Powdered activated carbon (PAC) cannot be used in a fixed-bed arrangement because of the tiny size of its particles and subsequent high head loss that would result from passing water through it. Powdered activated carbon is contacted with the water in open vessels where it is maintained in suspension for the necessary contact time and then removed by conventional solids-removal processes.

Powdered activated carbon is much more difficult to regenerate than granular. In wastewater treatment, powdered activated carbon is added to the aeration basin and removed with the biological solids in the secondary clarifiers. In this case, both refractory and biodegradable organics are adsorbed (Peavy *et al*., 1986). Carbon dosages may vary from (20 to 200 mg/l) depending on the results desired (Eckenfelder, 1989).

The Freundlich equation is expressed by Eq. (2) (Qasim *et al*., 2000).

$$X / M = kk\ C^{(1/n)} \quad (3)$$

Plant Description

The Hilla textile factories of the State Company for Textile Industries have been taken as the case study in this research.

The factories produce the following fabrics:

1- Cotton fabric and blending.
2- Velvet and jacquard fabric.
3. Synthetic fabric for special uses as blanket base.

The complex constitutes several productive, technical, and administrative sections. As follow

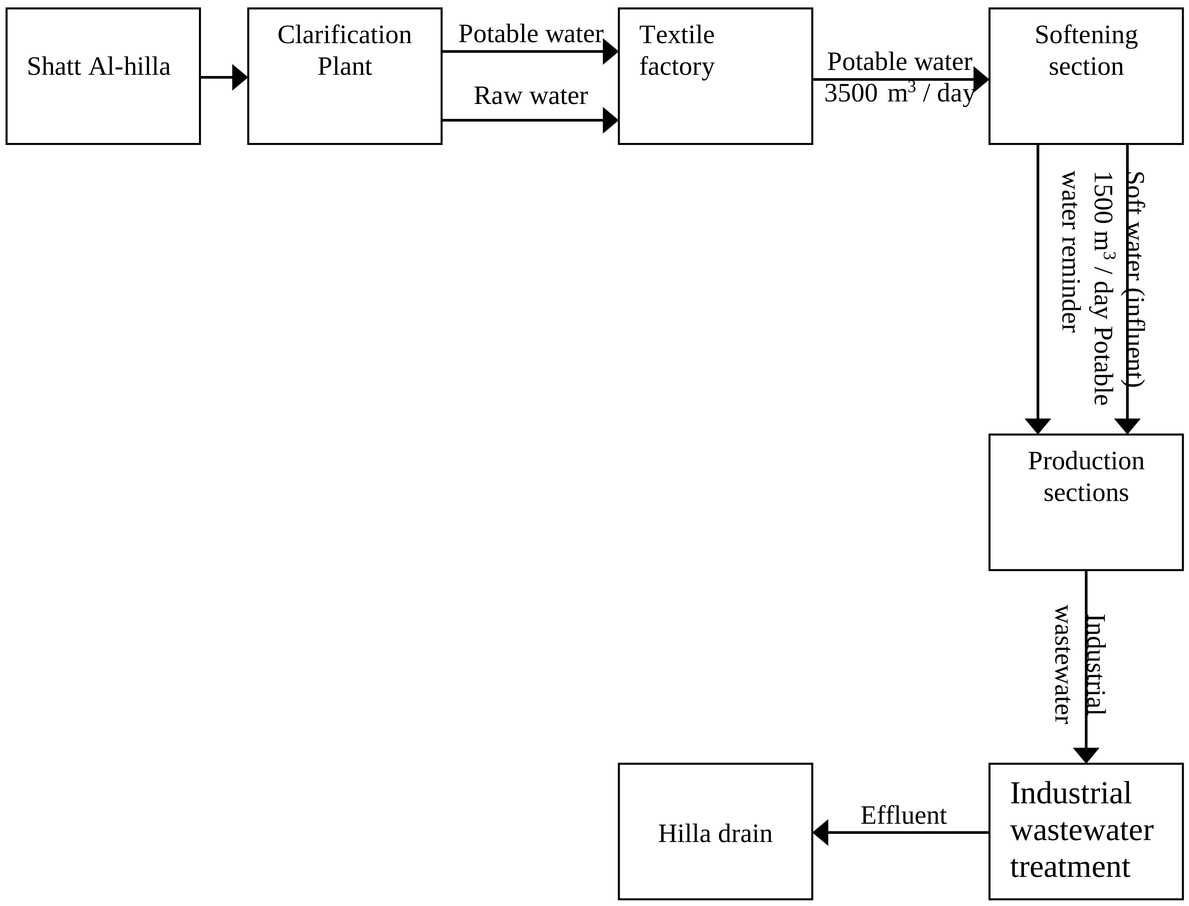
1. The spinning
2. The preparation

3. The textile or weaving.
4. The finishing
5. The velvet and jacquard section.

Those that have relations to the quality, use, and consumption of water, and consequently to the subject of this research, are briefly discussed hereafter.

1-Water supply and distribution Description

The total daily water consumption in Hilla Complex is nearly (3500 m^3/day). Of this, about (1500 m^3/day) is used for industrial purposes, and the remainder is for drinking and sanitary services, as shown in Fig. (2). The soft water (influent) and industrial wastewater (effluent) limits are summarized in Tables (3) and (4), respectively. However, the capacity of the existing treatment plant is (438 m^3) per working shift (7 hours)



Figure(2) : Schematic illustration of water supply and distribution of Hilla factories of the State Company for Textile Industries. (SCTI, 2006).

Table (3): The standard influent limit of soft water in textile industry (SCTI, 2006)

Parameter	**Limit**
pH	7.5-8.5
Cl^{-1}	600 mg/l
SO_4^{-2}	400 mg/l
Hardness	(0-1mg/l)
Conductivity	(1000-1500 ms/cm)
TDS	(500-1000 mg/l)

Table (4) : The standard effluent limits of industrial water in textile industry (SCTI, 2006)

Parameter	Limit
pH	6-9.5
Cl^{-1}	600 mg/l
SO_4^{-2}	400 mg/l
TSS	60 mg/l
BOD	40 mg/l
COD	100 mg/l
Fe	0.5 mg/l
Mn	0.1 mg/l
Zn	1.0 mg/l

2-The productive sections

A- Finishing section (Factory No. 1)

This section is the one that uses the largest quantity of water among other sections, which represent about (55%), of the water used in production. Moreover, it is the one that produces the most polluted effluent. The finishing process constitutes the following sub-processes:

1. Scouring and bleaching:

Scouring with hot alkali removes the natural waxes and pectins from the cotton together with spinning oils. Bleaching with hydrogen peroxide is used to whiten the fabric. Many chemicals are used in this stage, such as NaOH, caustic soda and sodium silicate. Steam is used to raise the temperature and increase moisture.

2. Dyeing and printing:

Cloth is colored to customers requirements by either dyeing .or printing. Final finishing in the form of easy care or handle finish is often carried out prior to the sale of the cloth. Chemical materials in different doses are used in this respect. The pollutants produced in this section are as follows.

a) Colors:

Colors are caused by different kinds of dyes such as direct, disperse and reactive dyes.

b) Suspended solids (TSS):

Such a contaminant results from cleaning machines, the remainder of fabric and sludge.

c) Oil and grease:

They are produced because of the use of oil in industrial operations. Grease is used in maintenance of machines. It is used continually.

d) High alkalinity and pH:

It is the result of using chemical materials like sodium hydroxide, which is used in large amount in the industrial processes.

e) High rate of organic materials:

It is the result of removing the starch and the use of organic colors. These materials cause an increase in the biochemical oxygen demand (BOD_5).

f) Small amounts of chlorides and sulfates:

It is the result of using some materials that contain chloride ion and sulfates like sodium chloride and colors that contain sulfates.

g) Large amounts of soaps, bleach, and detergents:

They are used too much in this section before and after the processes of dyeing and in the processes of coloring.

B- Velvet and jacquard section (Factory No. 2)

This section contains three units

1-Preparations: No industrial water is contributed.

2-Textile: No industrial water is contributed.

3-Finishing: It forms the principal user of the industrial water in the velvet and jacquard section. As for pollution, this section uses about (60 m^3) of water per day. Its pollution is less than the processing section (factory No l). However, pollution in this section is the result of using alkaline colors and chemical materials as used in the bleaching processes; (H_2O_2) and (NaOH) are used with (pH) equals (9).

The industrial wastewater treatment plant Description

The industrial wastewater that is produced from the productive sections is collected through a pipe network that ends to a special treatment plant. The treatment plant comprises the following basic units: The primary mixing tank, the sedimentation tank, the biological treatment tank, filters, the final sedimentation tank, and the final mixing tank, as shown in Fig. (3). A brief discussion of each unit is given

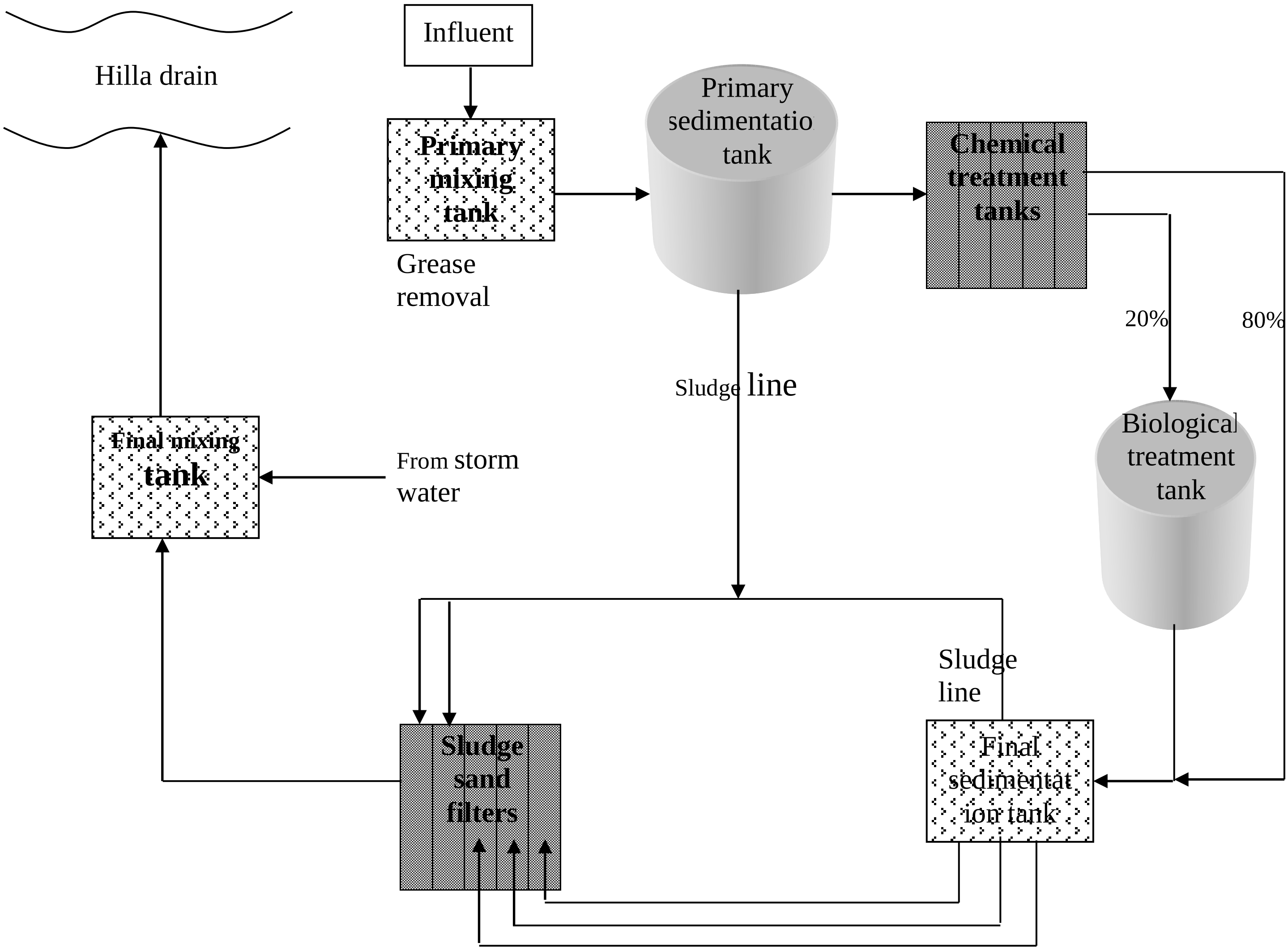


Figure (3): Industrial water treatment plant unit of the Hilla textile factory

1- The primary mixing tank

This tank is the first stage of the treatment. The process of receiving industrial water here may be considered as an equalization process. The tank has a square cross-section with (4m) length, (2m) width and (2m) depth. Water entering tills tank contains salts, dyes, grease and other suspended and dissolved organic materials. The tank is preceded by screens manhole. Grease, fats and oil are partially removed in this tank. The wastewater in this tank is then pumped by a set of submersible pumps to the primary sedimentation tank.

2- The primary sedimentation tank

The circular tank, which diameter is (25m), its depth is (1.6m), and its capacity is about (700 m^3). The tank is used as a sedimentation tank. It is equipped with a revolving bridge with a scraper mechanism at the bottom that removes sludge from the lower part of the tank. Sludge is pumped from there to sludge drying beds. Water then flows by gravity to the chemical treatment tanks.

3- The chemical treatment tanks

These are five tanks. Alum and lime are added in the tanks. Each tank has a square cross-section (2x2m) and a length of (2.5m). Residual grease is removed here. (20%) of the flow is then sent to the biological treatment units, while the rest is sent directly to the final sedimentation tank.

4- The biological treatment tank

The tank has an oval- circular shape. Its capacity is (200-250 m^3) Mechanical brushes are used in aerating the wastewater in this tank.

5- The final sedimentation tank

The tank is (20m) long, (9.5m) wide and has a depth between (1 to 3.5m). The tank is equipped with a revolving bridge with a scraper mechanism. Sludge is pumped from this tank to the sludge drying beds.

6- Filters

The plant involves five Filters. Two of these arc used to dry the primary sludge, while the other three are used to 1'ilter the combined effluent from the final sedimentation lank. The dimensions of each filter are (20 x 10 x 1.5m). A cross-section through a filter shows a layer of (35 cm) of sand resting on a layer of gravel of (35cm) in which the gravel is (5-18mm) in size .At the bottom, a final; layer of gravel of (20cm) in height is placed on a drainage system of perforated pipes. The gravel of this layer has a size of (18-50min). The drainage water from these filters is pumped by (3) pumps to the Hilla drain.

7- The final mixing tank

The tank is (4m) long, (8m) wide and (6.5m) deep. Final disposal of industrial wastewater effluent is pumped from this tank to the Mil la drain.

Results and Discussion

To evaluate the performance of the treatment plant, ten samples were taken from the primary and the final mixing tanks as indicated in Table (5). The samples were tested for pH, TSS, SO_4^{-2}, BOD_5, COD, hardness, and alkalinity according to **(**AWWA, 1985). The results of the tests are summarized in Table (6).The results indicate that the different units were not operating efficiently compared with (AICE and EPA) specification {as given in Table (2)} as seen by the individual removal efficiency of each parameter, e.g., TSS, BOD_5, and COD. This is believed to be due to lack of maintenance and overloading of the treatment plant.

Table (5): Sampling for the evaluation of performance of the existing treatment plant

Location	Sample No.	Date of sampling
The primary mixing tank (before treatment)	1-B 2-B	12/2/2006 16/4/2006
The final mixing tank (after treatment)	1-A 2-A	12/2/2006 16/4/2006

Table (6): Quality of the industrial water of Hilla Textile Factories before and after treatment

Sample No. (1)										
The tests	pH	TSS	SO_4^{-2}	BOD_5	COD	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Fe	Mn	Zn
		mg/l								
1-B	8	450	333	130	320	220	607	2.8	0.28	0.7
1-A	9	310	532*	91	252	165	310	0.9	0.12	0.4
The efficiency		31%		30%	21%					
Sample No. (2)										
The tests	pH	TSS	SO_4^{-2}	BOD_5	COD	Hardness as $CaCO_3$	Alkalinity as $CaCO_3$	Fe	Mn	Zn
		mg/l								
2-B	9.5	110	280	90	225	225	320	3.0	0.3	0.8
2-A	10	80	310*	75	180	180	292	1.2	0.14	0.3
The efficiency		27%		17%	20%					

The comparison between the measuring parameters I tables 5 and 6 (which are measured in chemical department in college of science / Babylon University) with standard parameters in tables 3 and 4 explains:

1. The existing wastewater treatment plant is not working efficiently. The removal efficiencies of the respective quality parameters were:

TSS = 27-31%, BOD_5 = 17-30% and COD = 20-21%

The values of TSS, BOD_5 and COD are very high because the small added amount of the activated carbon through treatment processes.

2. The applied physio-chemical treatment which involved neutralization, addition of alum and polyelectrolyte achieved a (COD) removal efficiency of around (50%).
3. According to the tests that were done, it was found that the quality of the water is not good at all to be reused in the industry or to be thrown in the river, because the removal efficiencies are less than the required, and some values are in contrast with the standard values.
4. The small increment in the efficiencies was happened because of the added soft water to the wastewater in the final mixing tank (after treatment) for the Sample No. (1).
5. Increase of (SO_4^{-2}) after treatment is due to residual Alum (which constitutes SO_4^{-2}).
6. It may be seen, high amount of Fe and Mn are due to the natural of the manufacturing processes in Textile Company.
7. The values of pH and Zn are approximately in the standard range.

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List of Symbols

Symbol	**Definition**
AICE	American Institute of Chemical Engineers
AWWA	American Water Work Association
BOD5	Biochemical Oxygen Demand at 5days
C	final or equilibrium concentration of the adsorbate, mg/l;
COD	Chemical Oxygen Demand
C_e	allowable effluent concentration, mg/1
C_0	influent concentration, mg/l
C_i	initial concentration of adsorbate, mg/l;
D	depth of bed, m
EPA	Environmental Protection Agency
GAC	Granular Activated Carbon
k	constant rate, m^3/kg.hr
kk	empirical constant
n	inverse constant
N_0	adsorptive capacity, kg solute/m^3 carbon
M	carbon dose, mg/l
PAC	Powdered Activated Carbon
pH	Hydrogen number
SCTI	State Company of Textile Industries
SS	Suspended Solids
v	linear flow rate, m/hr
t	service time, hr.
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
X	adsorbate actually adsorbed by carbon, mg/l ($X = C_i - C$)