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Identification and Selection of the Best Industrial Wastewater Treatment Techniques for Detergents Industry: A Case Study of Detergent Manufacturing Plant

M.Nazih A.Allah[1], Walid Abdel-Halim[1], and Hisham S. A.Halim[2]
[1] *Housing and Building National Research Center, HBNRC*
[2] *Cairo University- Faculty of Engineering – Civil Engineering Department.*

ABSTRACT

A bench scale model and treatability study was developed for chemical product "detergents, shampoos, toilet soaps and sanitary paper" industry to study the analysis of waste discharge. The main process lines used in the industry are fabric and home care production unit, soap production unit, and sanitary paper production unit. The main environmental problem of the industry is that the industrial wastewater resulting from the facility is not meeting the limits of the environmental regulations for the discharge of wastewater to the sewer network. Accordingly, the industry has to treat the wastewater prior to its discharge to the wastewater sanitary network.

The main objectives of this study are management and control of liquid and solid wastes in the industry as well as selecting the different possible treatment trains for the waste water prior to its discharge to the sewer system in order to protect the environment and to gain benefits as much as possible from the wasted materials and identify opportunities for introducing pollution prevention measures and best method for waste minimization as cleaner production system. The study is taking into account all types of waste production including wastewater and solid waste during the production processes activities.

Treatment Procedure is conducted through treatability study using two proposed streams of techniques; biological treatment technique (Anaerobic Treatment) and chemical treatment followed by biological treatment technique (Coagulation followed by Sedimentation). According to the different treatment alternatives conducted through the study, it is proved the biological method is not suitable for this type of waste, as the antifoaming chemicals and enzymes present in the wastewater leads to death of the microorganisms and accordingly the failure of the treatment system. As for the chemical treatment, it provided good results in both industrial wastewater mixed with domestic wastewater, and industrial wastewater alone. It also provided good results when using both ferric chloride and aluminum sulphate.

It is concluded that the coagulation and Flocculation process followed by plain sedimentation is the most reliable alternative treatment method for this kind of industry using ferric chloride for the wastewater without domestic wastewater. The removal efficiency reached 72 to 79%, 86 to 96%, 83 to 88% and 86% for COD, TSS, Phosphorous, and Oil and Grease respectively.

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I. INTRODUCTION AND BACKGROUND

In the early 1960's occasional instances of foaming were observed both in waste- water treatment plants and in surface waters receiving effluents. This phenomenon was shown to be due to the use in detergent products of a poorly biodegradable surfactant; which, consequently, was insufficiently removed during the treatment process. Industry reacted rapidly by replacing the problematic surfactant with a biodegradable equivalent. Since this time the removal of detergent surfactants in waste-water treatment plants has been the subject of much research; by industry, academia and regulatory authorities [9].

When phosphate detergents are used, disposal of the wastewater is an issue. The breakdown of phosphorus complexes in detergent wastewater (and other household products, as well as human and industrial wastes that contain phosphates) creates freely available phosphates; these can contribute to an oversupply of phosphate in waterways and cause an imbalance of the aquatic ecosystem. Disposal of phosphate-free detergent wastewater is also an environmental issue. As an alternative to phosphates, manufacturers can use a builder, or combination of builders, including zeolites (aluminosilicates), sodium citrate and nitrilotriacetate (NTA). Detergent wastewaters containing alternative builders also have environmental impacts and must be treated by sewage treatment works. Some of them (alkyl phenols) are estrogen mimics that can have serious detrimental effects on populations of aquatic animals, such as decreasing their ability to reproduce. Even after treatment, the environmental impacts of some alternative builders remain [11].

Soap is a basic material indiscriminately used by the rich and the poor. Since soaps are used both for bathing and washing, it has become an integral and indispensable part of human life.In the Middle Ages, Marseilles became the first soap-making center in Europe, followed by Genoa, and eventually Venice. In Germany, soap was manufactured but not widely used as a cleansing agent. For several centuries, the industry was limited to small-scale production using mainly plant ashes containing carbonate; the ashes were dispersed in water, then mixed with fat andboiled until the water evaporated. The reaction of fattyacid with alkali carbonate of the plant ashes formed thefinal product. Home laundry is one of the major household tasks in which lots of water and detergents areused. Today, many of the wonder cleaning detergents are available in the market. The washing detergents consist of different chemical components; surfactants, builders, fillers, bleaches, enzymes, optical brighteners, anti-redepositionagents, perfume and color.

The soap industry includes companies primarily engaged in making soap, synthetic organic detergents, inorganic alkaline detergents, and crude and refined glycerin from vegetable and animal fats. Small and medium sized soap producers should require no special physical infrastructure. They do need some of the basic services required by all businesses, such as good road access for bringing in production inputs and sending out finished products. It is possible that larger producers may need large amounts of utility services which, depending on the chosen location of the production facility, may have to be constructed. And depending on the types of inputs used (e.g., “hard” chemicals versus all natural ingredients), certain kinds of environmental investments may be required. Generally speaking, however, there appears to be no such requirements that would pose an insurmountable constraint to even smaller communities trying to attract or retain soap makers. Such firms must be aware of environmental regulations. The soap manufacturing industry is subject to regulations regarding a number of environmental issues such as Pretreatment of wastewater may be required when it is discharged to municipal sewers. Pretreatment of wastewater may also be required before its discharge into lagoons specifically constructed for such disposal [1].

The concentrations and removals of 16 fragrance materials (FMs) were measured in 17 U.S. and European wastewater treatment plants between 1997 and 2000 and were compared to predicted values. The average FM profile and concentrations in U.S. and European influent were similar. The average FM profile in primary effluent was similar to the average influent profile; however, the concentration of FMs was reduced by 14.6-50.6% in primary effluent. The average FM profile in final effluent was significantly different from the primary effluent profile and was a function of the design of the wastewater treatment plant. The overall plant removal (primary + secondary treatment) of FMs ranged from 87.8 to 99.9% for activated sludge plants, 58.6-99.8% for carousel plants, 88.9-99.9% for oxidation ditch plants, 71.3-98.6% for trickling filter plants, 80.8-99.9% for a rotating biological contactor plant, and 96.7-99.9% for lagoons [2].

Today, many of the wonder cleaning detergents are available in the market. These washing detergents consist of different chemical components; surfactants, builders, fillers, bleaches, enzymes, optical brighteners, antire-deposition agents, perfume and color. These, detergents make our clothes seem whiter or brighter by absorbingultraviolet light and remitting blue light. Foam boosters add suds but do not improve the cleaning action, enzymes attack grim, soil and stains but cause allergies [3]. Besides, lots of fillers used in powder detergents arepoured in drains causing wastage of useful products like common salt/washing soda and choking of rains/sewerage system. Powders contain more chemicals compared with liquids due to fillers. Sodium sulphate in these can wreak havoc on septic system [4]. Synthetic detergents and our laundry practices arecontributing to our ground level water pollution [5]. Another study conducted by Kannan et al. (2005) on the physio-chemical characteristics of water samples mixed with effluent discharged from textile industries at different sites revealed the elevated levels of calcium, magnesium, sodium, chromium, potassium, nickel, copper, zinc, carbonate, sulphate, nitrateand chloride in water. The concentration of these ions exceeded the limit prescribed by Bureau of Indian Standards (BIS). Water at these sites was found to be hard, blackish and not suitable for drinking purpose [6]. So, main environmental impact of detergents is related to their post use effectwhen the wash water is discharged into sewage system.

Majority of homemakers are using powder detergents for washing of clothes, which adds more to the chemical contamination of water as compared to liquid detergents. Besides, powder detergents are harsh on skin and fillers used in powder detergents add lots of salts in drainage system causing its choking and changing chemical nature of effluents. So we should stop use of powder detergents and start using liquid detergents to save resources, minimize water pollution, to protect our health and already sick drainage system from overloading [7].Ghai (2010) in his article, “Soap nut detergent-the best HE detergent” also mentioned that one of the major pollutant responsible for water pollution is the detergent that we use for our daily laundry. It is a well-known f act that detergents are non-degradable products that remain in the environment as such for years altogether. With amount of washing done every day in several hundreds of households, even in a single city, it is imaginable how much detergents go down the pipelines and into the large water bodies. The suffering aquatic life often shows signs of damage we are inflicting on it, in the form of several fishes and other aquatic creatures dying. These not only cause damage to the soil, water and aquatic life but also many times spoil our clothes and effect our skin. It should be our concern to notice the harm that chemicals are causing to our natural resources, therefore we should work towards putting our effort to conserve the environment [7].

Chemical analysis of wash water and detergent solution was done to analyses pH, total dissolved solids (TDS), chloride, sulphate, and carbonate and bicarbonate alkalinity. The resultsindicated that with the use of powder detergents, there was a significant increase in the level of pH, TDS, chlorides,sulphate, carbonate and bicarbonate in wash water, whereas very negligible change was found in all the above chemical parameters with the use of liquid detergents. So, we should give up powder detergents and start using the eco-friendly liquid detergents to save resources, to minimize water pollution and choking of drains [8].

Two wastewater sources that have been sufficiently important contributors to detergent pollution far removal studies to have been undertaken are municipal waste treatment plants and launderettes. On a nationwide basis, the volume of launderette waste is insignificant in comparison to the volume of municipal waste, but there are locations such as Suffolk County, N.Y., where launderette waste causes intensive local pollution problems by mixing with the groundwater used as the source of drinking water. Since thethe alkyl-benzene sulfonate (ABS) in completely treated municipal wastewater is often less than 1% of the total contaminants and less than 10% of the organic contaminants, any removal method for ABS alone must be very inexpensive in contrast to launderette waste treatment. Costs of a few cents or less/thousand gal are all that might be tolerated. Only a few methods at present can be considered. These include addition of cationic detergents, biodegradation of the ABS on soils and foaming [10].

Some results obtained indicate that a decrease of membrane cut-off value improves the efficiency of effluent treatment. The membrane with a cut-off of 0.5 kDa yields the best separation efficiency: the decrease of COD-Cr value is over 85%, which corresponds to COD-Cr of permeate equal to 8800 gO_2/m^3. It has been found that UF capillary modules made by Koch/Romicon are suitable for concentration of highly polluted effluents containing detergents. The modules applied are characterized by stable transport and separation properties. In the course of a long-term concentration of effluents, an essential drop in a permeability was not observed and the permeate quality remained almost constant, although a systematic increase in pollution load of the concentrate occurred [12].

One of the main consequences of the high level of surfactant production is the increase in the pollution caused by wastewaters coming from manufacturing plants of toiletries and detergents during the washing processes. The high and varied pollution loads of these effluents are mainly due to the residual products in the reactor, which have to be washed away in order to use the same production lines for the manufacture of other products. Most of detergent products reach the environment with domestic and industrial wastewaters. Detergent effluents can cause significant environmental problems because detergent product and its ingredients can be relatively toxic to aquatic life. A direct result of this production is the necessity of the manufacturers to assess the effluent characteristics of their wastewaters and consequently to define pollution control methods. In order to meet more stringent legislative requirements in discharging the wastewaters into the environment or into the sewage system, an effective treatment process must be applied. Because of environmental as well as economic reasons (e.g. increasing water prices) we are forced to look for new methods of wastewater treatment [13].

The water produced from car-wash processes was utilized as a model because it has various pollutants - oil, lubricants, detergents, solid particles, etc. The results showed that the turbidity and chemical oxygen demand (COD) values dramatically decrease by using the proposed treatment process, which consists of coagulation, flocculation, sand filtration, and oxidation followed by sand as well as activated carbon filtration. Moreover, the operating conditions were optimized. Without adjustment of the pH value of car-wash wastewater, it was found that 200 ppm of ferric chloride, as a coagulants, and 1 ppm of potassium permanganate, as an oxidant, are the optimum doses. The COD and turbidity values of the final treated wastewater were reduced by almost 88 and 100%, respectively. A prototype with 15 L capacity was designed and fabricated to investigate the scaling up and continuity of the proposed treatment strategy. The results were very promising and indicated that the introduced methodology can be industrially applied [14].

Surfactants are among the most widely disseminated xenobiotics that contribute significantly to the pollution profile of sewage and wastewaters of all kinds. Among the currently employed chemical unit processes in the treatment of wastewaters, coagulation-flocculation has received considerable attention for yielding high pollutant removal efficiency. Jar-test experiments are employed in order to determine the optimum conditions for the removal of surfactants, COD and turbidity in terms of effective dosage, and pH control. Treatment with FeCl3 proved to be effective in a pH range between 7 and 9. The process is very effective in the reduction of surfactants and COD, the removals are 99 and 88 % respectively, and increased BOD5 /COD index from 0.17 to 0.41. In addition to precipitation coagulation process, adsorptive micellar flocculation mechanism seems contribute to the removal of surfactants and organic matters from this rejection [15].

Among the currently employed chemical unit processes in wastewater treatment, coagulation-flocculation has received considerable attention for yielding high pollutant removal efficiency. This process can be directly applied to wastewaters without being affected by the toxicity in the wastewater and could constitute a simple, selective and economically acceptable alternative. The objectives of this study are the examination of coagulation precipitation process efficiency for the treatment of industrial wastewaterswith high surfactants content, especially in terms of organic matter and surfactants removals. More specifically, the aim is the determination of the most appropriate iron chloride dose, the examination of pH effects on removal capacity and the identification ofoptimum experimental conditions for the efficient application of this process [16].

The mean inputs of BOD5, COD, and LAS to the SBR system were 292.40 ± 45.28, 597.15 ± 97.30, and 3.29 ± 0.92 mg/L, and the mean outputs were 20.59 ± 3.54, 59.34 ± 9.47, and 0.606 ± 0.09 mg/L, respectively. The removal efficiency of BOD5, COD and LAS were respectively 92.95%, 90.06% and 81.6%. The results of ANOVA indicated that there was a significant relationship between the mean inputs and outputs of BOD5, COD, and the detergents ($P \leq 0.001$). With the proper operation of wastewater the treatment plant and increasing the retention time, the removal efficiency of the detergents increased. In addition, according to the environmental standards for BOD5, COD and the detergents, the results of the present study indicated that the outputs of these parameters from the SBR system were appropriate for agricultural irrigation [17].

The results of the study by Fernandes et al. on domestic wastewater treatment using SBR process with limited air indicated that the removal efficiency of COD was 83% which is lower than the corresponding value of the present study. This difference can be attributed to different air strategies employed in the two studies [18].Ghahfarrokhi et al. conducted a study on removal of detergents from hospital wastewaters using SBR method and indicated removal efficiencies of 94.54%, 92.97% and 84.99% for BOD5, COD and detergents, respectively. These results are in agreement with those of the present study and indicate that in appropriate conditions, SBR system can remove more than 90% of BOD5 and COD and more than 80% of detergents from wastewaters [19]. Nowadays, there are a wide variety of wastewater treatment systems; however, sequencing batch reactor (SBR) seems to be the most promising and appropriate modified activated sludge process which can be utilized to remove carbon and nitrogen organic matters [20]. In aquatic environment, detergents float on the surface of water as a surface layer and disfigure the aquatic environment, reduce gas exchange and endanger the aquatic animals' health by decreasing the dissolved oxygen. These compounds change the taste and smell of the water, produce fume on the surface of water, cause disruption in the process of water and wastewater treatment, increase the treatment costs, and lead to aquatic animals' death [21-24]. In a study by Pirsaheb et althe average of LAS removal in extended aeration process in winter and summer were 94.06% and 99.23%, respectively. In a study by Duarte et al. degradation of LAS in anaerobic SBR (ASBR) was evaluated [22].Detergent (LAS) removal from wastewater by aerobic processes in well-designed municipal wastewater treatment plants was above 90% [23].

The result of the wastewater characterization showed that the concentration of the organic matter were high, expressed as COD, in the range of4920 mg L-1, while the biodegradable portion was low. These values indicate that organic compounds are not easily subjected to biological treatment. In addition, methylene blue active substance appeared high concentration as well as total solids and turbidity. The experiments for the treatment of the wastewater were performed using various chemicals such as time, alum and ferric chloride. The use of lime gave 21 and 17%, COD and MBAS removal, while by using alum slightly higher was achieved, 37 and 28%, respectively. The use of ferric chloride led to a 89% COD removal and a 80% surfactant removal [25].

II. STATEMENT OF THE ENVIRONMENTAL PROBLEM

The chemicals used during the manufacturing processes are very toxic, hazardous and has severe impact on the environment and health of the workers. As a result of the manufacturing processes, different types of wastes are produced mainly liquid and solid wastes. The liquid waste was found to be extremely soluble in water and very hardly biodegraded; accordingly it is very difficult to treat. As conclusion, the average values of pH, COD, oil and grease, and total phosphorous are above the limits of the Egyptian Environmental Regulation (Decree 44/2000), while values of BOD, TSS, settle-able solids, and total nitrogen are within the limits. Accordingly, the industry has to treat the wastewater prior to its discharge to the wastewater sanitary network.

III. STUDY OBJECTIVES

The main objectives of this study are management and control of liquid and solid wastes in the industry as well as selecting the different possible treatment trains for the wastewater prior to its discharge to the sewer system in order to protect the environment and to gain benefits as much as possible from the wasted materials and identify opportunities for introducing pollution prevention measures and best method for waste minimization as cleaner production system. The study is taking into account all types of waste production including wastewater and solid waste during the production processes activities.

The main objective is achieved via verifying some of sub-objectives such as reduce pollution load in terms of volume and concentration of wastewater through point source treatment, investigating the activities carried out in the industry and identifying the different wastewater discharge streams, identifying the characteristics and flow rates for each wastewater stream, selecting the wastewater streams that need to be treated prior to its discharge to the sewer system, identifying the different possible treatment trains for the wastewater, conducting treatability analysis for investigating the feasibility of each of the identified trains, selecting the most suitable treatment train, and developing the basic design for the selected treatment train.

IV. MATERIALS AND METHODS

There are two wastewater drainage networks and two end-of-pipe discharge points in the industry, one for industrial wastewater and the other for the domestic wastewater. The industrial wastewater end-of pipe discharge points include wastewater discharges from detergents production line, detergents packing line, shampoo production line, and spillages or leakages during of cleaning of tank farm. The domestic wastewater discharge points include wastewater discharges from the wastewater generated from the washing of equipment at the end of the shifts in the soap production line, and wastewater discharges from all domestic sources within the industry, including toilets, restaurant, irrigation, cleaning, etc.

Due to the great variation in the quality and quantity of wastewater produced, a continuous monitoring program was carried out to identify the quality and quantity of wastewater discharged. Samples have taken from the process and end-of-pipe industrial wastewater and other point of industrial wastewaters discharge during the process activities to perform a preliminary assessment of the environmental status of the facility.

To achieve the required objectives, the study is conducted following some steps and approaches as evaluate the current environmental conditions in the production and service units to determine the industry required to upgrade these units in order to reduce pollution load in the final effluent, data collection including the collection of information relevant to the different activities in the industry including qualitative and quantitative estimation of solid and liquid wastes, collecting composite wastewater samples from the end-of-pipe industrial effluent (the samples were analyzed by specialized laboratory and the results are used for selection of the most appropriate alternative schemes), check on the compliance with national environmental regulation and legislation and description of the existing environmental situation in the industry, and studying the different approaches for pollution prevention and suggesting possible end-of-pipe treatment modules.

4.1 Water balance and Wastewater Discharge of the industry process

The manufacturing process consume huge amount of water it reaches 467 m^3/day while the overall total wastewater discharge equals 343 m^3/day. There are two wastewater drainage networks and two end-of-pipe discharge points in the industry, one for industrial wastewater and the other for the domestic wastewater. The industrial wastewater end-of pipe discharge points include wastewater discharges from detergents production line, detergents packing line, shampoo production line, and spillages or leakages during of cleaning of tank farm. The domestic wastewater discharge points include wastewater discharges generated from the washing of equipment at the end of the shifts in the soap production line, and wastewater discharges from all domestic sources within the industry, including toilets, restaurant, irrigation, cleaning, etc.

In addition flow rates were either measured or estimated from the different discharge points. Flow rates were measured from the detergents making unit and from the industrial end of pipe after the shampoo production unit has stopped. Flow measurements were carried out using the ISCO 4250 area velocity. As for wastewater from detergents packaging unit, soap production unit and the domestic wastewater they were estimated based on the data provided by industry. The following table and diagram llustrate the water and wastewater balance of the industry.

Table-1: Water Computation and Wastewater Discharge

Wastewater Discharge Sources	**Consumptionm3/day**	**Wastewater discharge m^3/day**
Detergents Making	319	250
Detergents Packaging	4	4
Cleaning of the Tank Farm	6	6
Soap Production	15	13
Sub-Total: Industrial End of pipe	329	260
Domestic Wastewater	123	70
Total	**467**	**343**

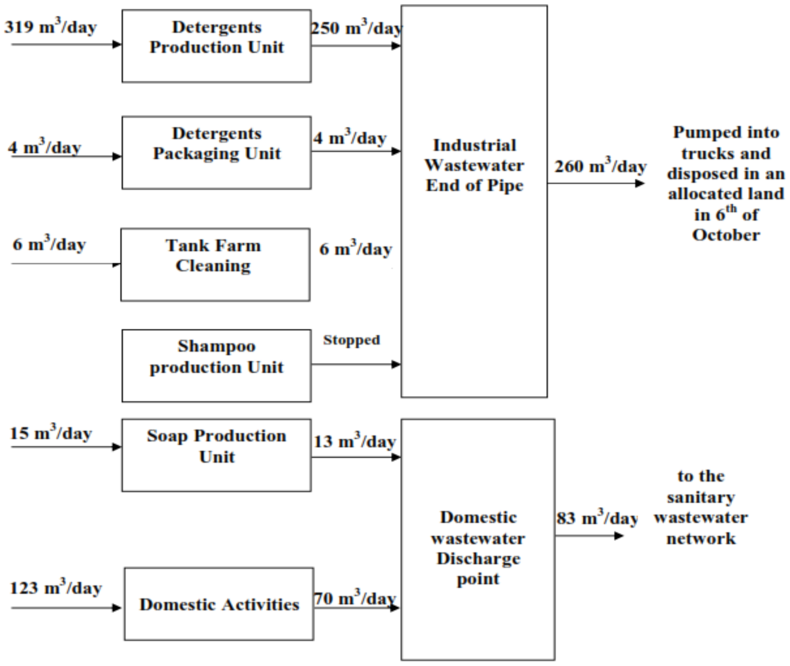

Fig.1: Water Balancing During the Manufacturing Process

4-2: Sampling and characterization of wastewater

Separate composite samples were collected from grinding and polishing departments as well as end-of-pipe effluent during the working days to avoid the variations in the pollution loads during day and night. This was done to get representative samples for analyses to get a clear picture of wastewater specification. The analyses were carried out according to the Standard Methods for Examination of Water and Wastewater [15] and covered pH, Chemical and Biological Oxygen Demand (COD& BOD), Total suspended solids (TSS), conductivity and Lead.

Separate composite samples were collected and taken over a period of 24-hours from the different discharge point of each production line as well as from the end of pipe effluent during the working days to avoid the variations in the pollution loads during day and night.This was done to get representative samples for analyses to get a clear picture of wastewater specification. The analyses were carried out according to the Standard Methods for Examination of Water and Wastewater [26] and covered pH, Chemical and Biological Oxygen Demand (COD& BOD), Total suspended solids (TSS), settle-able solids, and total nitrogen.

V. RESULTS AND DISCUSSION

5-1: Characterization of liquid wastewater

Characterizations of wastewater from the industry process as well as end off pipe are depicted in following tables and figures.Analysis of nine composite samples taken from the soap production unit is illustrated in Table (2) and figure (2) below. The results obtained from the soap production unit indicated that the average values for the COD, BOD and oil and grease are above the limits of Decree 44/2000, while the values for the pH, TSS settleable solids, and total phosphorous and total organic nitrogen are within the limits.

Table-2: Characteristics of the wastewater from Soap Production Unit

Parameters	Unit	min.	max.	avg.
PH		5.7	8.7	6.8
Chemical Oxygen Demand	mgO_2/l	1422	9900	4195
Biological Oxygen Demand	mgO_2/l	140	5100	1675
Total Suspended Solids	mgSS/l	214	1710	543
Settleable Solids 10 min	ml/l	2	14	5.8
Settleable Solids 30 min	ml/l	5	13	7
Total Phosphorous	mgP/l	0.8	23.3	7.7
Total Organic Nitrogen	mgN_2/l	10.1	36	19.54
Oil & Grease	mg/l	292	4859	1175

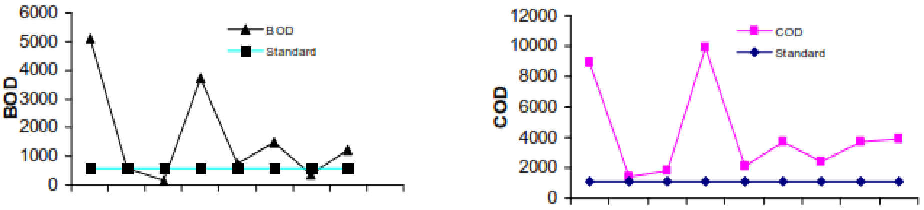

Fig.2: Characteristics of the wastewater from Soap Production Unit

Analysis of six composite samples taken from the domestic wastewater mixed with the wastewater discharged from soap production is illustrated in Table (3) and figure (3) below. The results obtained indicated that the average values indicate that dilution has occurred for the wastewater from the soap production unit after mixing with the domestic wastewater. Average values for all parameters are within the limits except for the oil and grease, which are still above the limit.

Table-3: Characteristics of the wastewater discharged from soap production unit and domestic wastewater

Parameters	Unit	min.	max.	avg.
pH		5.9	9.0	7.5
Chemical Oxygen Demand	mgO_2/l	372	2877	1081
Biological Oxygen Demand	mgO_2/l	100	632	288
Total Suspended Solids	mgSS/l	45	742	221
10 min Settable Solids 30 min	ml/l	0.3 0.5	10 11	2.9 3.6
Total Phosphorous	mgP/l	2.4	11.2	6.08
Total Organic Nitrogen	mgN_2/l	8.9	54	19.84
Oil & Grease	mg/l	144	506	318.2

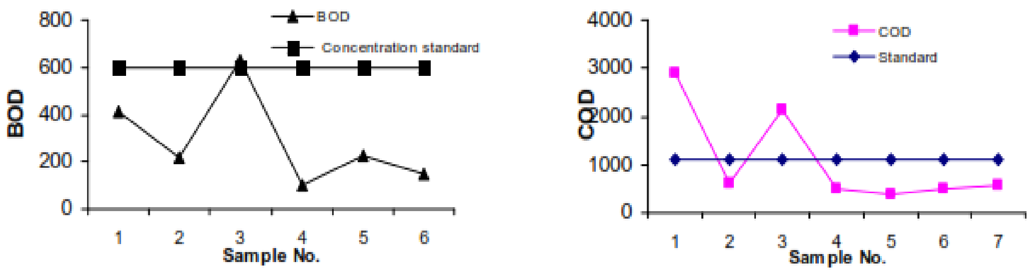

Fig.3: Characteristics of the wastewater discharged from soap department and domestic wastewater

Analysis of the six composite samples taken from the detergents packaging unitis illustrated in Table (4) and figure (4) below. The results obtained indicated that the average values are within the limits for pH, COD, BOD. TSS, settleable solids, and total organic nitrogen, while values for total phosphorous and oil and grease are above the limits.

Table-4: Characteristics of the Wastewater from Packaging Unit

Parameters	Unit	min.	max.	avg.
pH		7	9.9	8.75
Chemical Oxygen Demand	mgO_2/l	195	1698	928.3
Biological Oxygen Demand	mgO_2/l	54	255	134.5
COD /BOD		4:1	7:1	7:1
Total Suspended Solids	mgSS/l	25	690	252.2
Total Phosphorous	mgP/l	14.4	50	28.5
Total Organic Nitrogen	mgN_2/l	6.7	33.6	13.2
Oil & Grease	mg/l	44	283	189

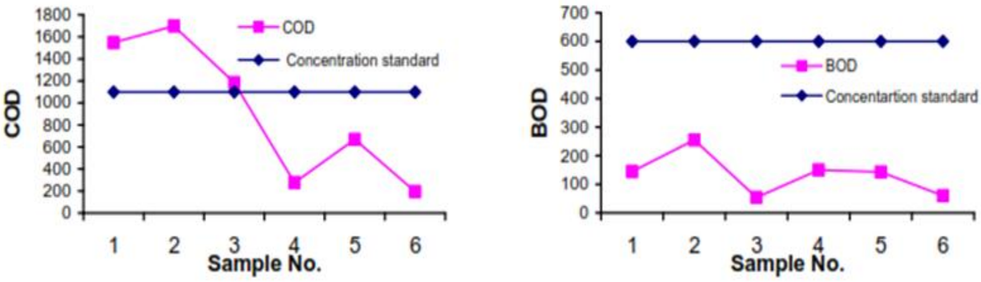

Fig.4: Characteristics of the Wastewater from Packaging Unit

Analysis of six composite samples taken from the detergents production unit is illustrated in Table (5) and figure (5) below. The results obtained indicated that the average values of pH, COD, BOD, total phosphorous, and oil and grease are above the limits, while values of settle able solids and total organic nitrogen are within the limits.

Table-5: Characteristics of the Wastewater from Detergents Production Unit

Parameters	Unit	min.	max.	avg.
pH		8.4	10.5	9.65
Chemical Oxygen Demand	mgO_2/l	653	11976	4986
Biological Oxygen Demand	mgO_2/l	95	3420	1499.8
COD/BOD		7:1	3.5:1	3:1
Total Suspended Solids	mgSS/l	50	277	145.3
Total Phosphorous	mgP/l	18.4	144	75.8
Total Organic Nitrogen	mgN_2/l	7.8	38	15.2
Oil & Grease	mg/l	75	5331	1435.5

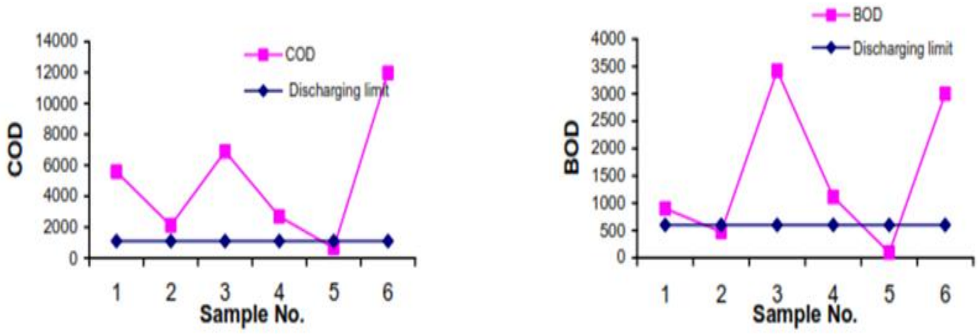

Fig.5: Characteristics of the Wastewater from Detergents Production Unit

Analysis of four composite samples taken from the discharge of the shampoo production unit is illustrated in Table (6) and figure (6) below. The results obtained indicated that the average values of pH, TSS, settleable solids, total phosphorous, total organic nitrogen are within limits, while average values of COD, BOD, and oil and grease exceed the limits.

Table-6: Characteristics of the Wastewater from Shampoo Production Unit

Parameters	Unit	min.	max.	avg.
pH		6.6	9.5	7.7
Chemical Oxygen Demand	mgO_2/l	2013	20295	7794
Biological Oxygen Demand	mgO_2/l	375	9065	3222.5
COD / BOD		5:1	2:1	2.4:1
Total Suspended Solids	mgSS/l	140	1182	529.5
Settable Solids	ml/l	--	--	--
Total Phosphorous	mgP/l	0.8	57.6	17.8
Total Organic Nitrogen	mgN_2/l	8.9	54.6	26.8
Oil & Grease	mg/l	77	1902	1020.3

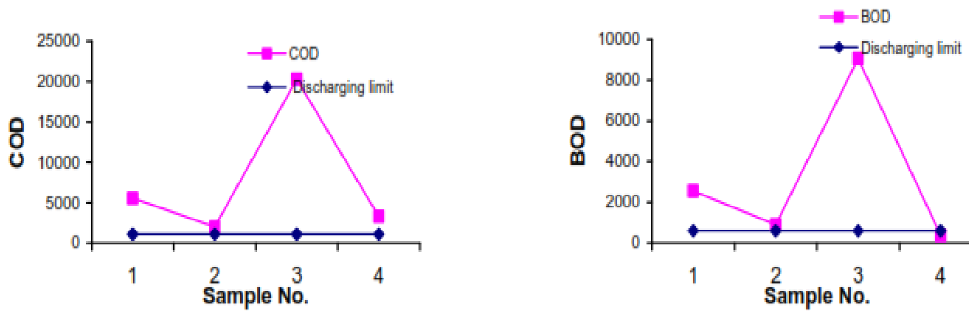

Fig.6: Characteristics of the Wastewater from Shampoo Production Unit

Analysis of six composite samples taken from the discharge of cleaning of the tank farm area is presented in Table (7) and figure (7) below. The results obtained indicated that the average values for pH, COD, BOD, TSS, settleable solids, total phosphorous, and oil and grease exceed the limits, while average values of total organic nitrogen are within the limits. It is clear from the analysis of the six samples that the concentration of pollutants is high in three of the samples, while in the last three samples, the concentration has decreased tremendously. This could be attributed to good housekeeping measures carried out during the loading process that minimized the spills and ensured that all valves of all tanks are tightly closed and accordingly no leakages occur.

Table-7: Characteristics of the Wastewater from the Tank Farm Cleaning

Parameters	Unit	min.	max.	avg.
pH		8.5	12.5	11
Chemical Oxygen Demand	mgO_2/l	2730	14610	6852
Biological Oxygen Demand	mgO_2/l	50	1950	910
Total Suspended Solids	mgSS/l	61	14030	2650
Settable Solids 10 min	ml/l	8	400	204
Settable Solids 30 min		25	620	323
Total Phosphorous	mgP/l	7	99	43.9
Total Organic Nitrogen	mgN_2/l	8.9	84	34.2
Oil & Grease	mg/l	116	8715	1933

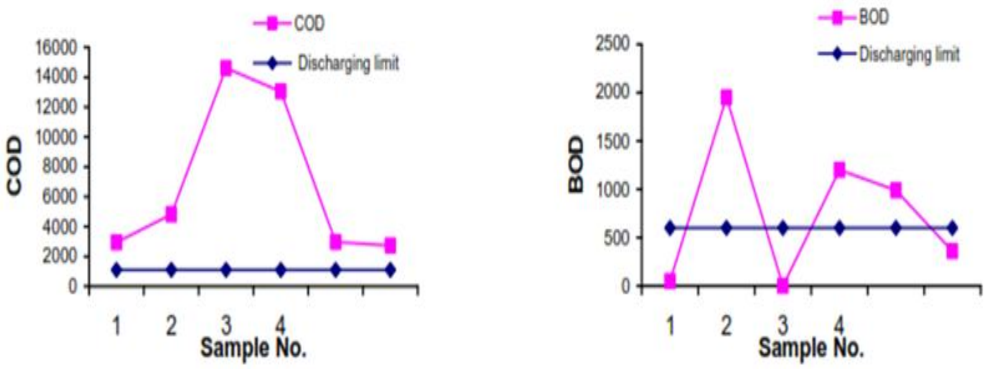

Fig.7: Characteristics of the Wastewater from the Tank Farm Cleaning

Industrial end-of pipe wastewater includes wastewater from the detergents making unit, detergents packing unit, tank farm area cleaning and the shampoo production unit. Four composite samples were taken from the end-of-pipe, while the shampoo production line was still operating, while five composite samples were taken after the shampoo stopped operation. Analyses of the nine samples are presented in Table (8). It is clear that COD, BOD values has decreased after the wastewater from the shampoo production line has stopped, this could also be attributed to the good housekeeping in the cleaning of the tank farm area. The results obtained indicated that the average values of pH, COD, oil and grease, and total phosphorous are above the limits, while values of BOD, TSS, settleable solids, and total nitrogen are within the limits.

Table-8: Characteristics of Industrial End of Pipe Wastewater without Wastewater from Shampoo Production

Parameters	Unit	min.	max.	avg.
pH		8.6	9.7	9.3
Chemical Oxygen Demand	mgO_2/l	900	2680	2052
Biological Oxygen Demand	mgO_2/l	350	1102	592
Total Suspended Solids	mgSS/l	32	331	150
Settleable solids	mg/l	0	0	0
Total Phosphorous	mgP/l	23	75	36
Total Organic Nitrogen	mgN_2/l	5.6	35.84	18
Oil & Grease	mg/l	198	1296	565

As mentioned before, one of the objectives of conducting wastewater analysis for each source separately is to identify wastewater streams that are complying with Egyptian Environmental Regulations that are not complying, and accordingly identify wastewater streams that need to be treated and others that can be discharged directly to the sewage network. Accordingly based on the analysis carried out for each wastewater stream, it could be concluded that all wastewater streams cannot be discharged directly to the sewage system without treatment.

Table (9) and figures (8-16) belowillustrate the minimum, maximum and average values for each parameter in the different wastewater streams. Values that are not complying with the limits of Egyptian Environmental Regulations are highlighted in the table. It could be concluded that:

- Wastewater generated from the Detergents Making Unit and from the Cleaning of the Tank Farm Area are the two streams that contain the highest concentration of pollutants.
- Wastewater from the Detergents Packaging Unit contains the lowest concentration of pollutants. All of the average values for the parameters are within the permissible limits except for the total phosphorous and oil and grease.
- Average Oil and Grease values in all wastewater streams are above the limits.
- Wastewater from the Soap Production Unit discharged with the domestic wastewater increases the pollutants in the domestic wastewater stream. Although the average values for the domestic wastewater stream mixed with the soap wastewater are all within the permissible limits, except for the oil and grease, however the COD and BOD values in two of the measured samples are above the permissible limits. Since this stream is discharged directly to the sewage network thus the wastewater from the soap production has to be separated from the domestic wastewater and treated with the industrial wastewater.

Based on the results it is clear that all generated wastewater streams need to be treated, except for the domestic wastewater stream that can be discharged directly to the sewage network. However, domestic wastewater was added to the wastewater to be treated, as it would assist in both the biological and chemical treatment. In the biological treatment, adding domestic wastewater to the industrial wastewater would accelerate the biological treatment process, as it would provide the necessary nutritional requirements for microbial growth. As for the chemical treatment, the addition of domestic wastewater will assist in the flocculation process

Accordingly, for the purpose of the treatability analysis all wastewater streams were mixed according to their discharge ratio.

Table (10): Wastewater Mixing Ratio

Discharge Sources	Mixing Ratio
Discharge from Detergents Making Unit	0.73
Discharge from the Detergents Packaging Unit	0.01
Discharge from Soap production unit	0.04
Discharge from tank farm cleaning	0.02
Domestic Wastewater	0.2

The result for the values of the different parameters after mixing wastewater streams is presented in Table (11). From the presented results it could be seen that none of the nine mixed samples is complying with the Egyptian Environmental Regulations.

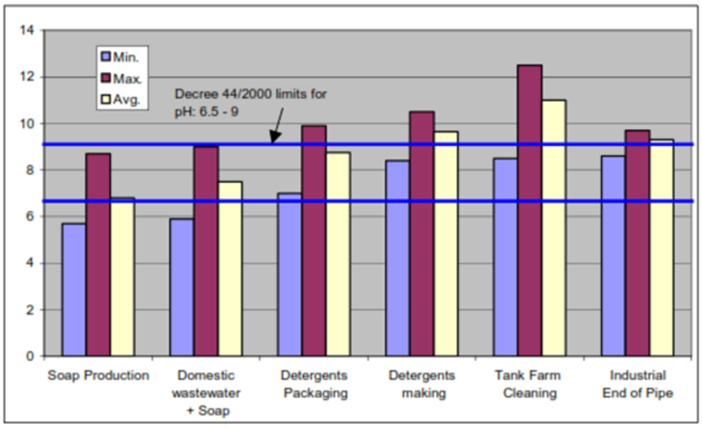

Figure (8): pH values in different wastewater streams

Table-9: Compiled Wastewater Analysis

Parameters	Discharge From Soap Production Unit			Domestic wastewater mixed with wastewater from Soap Production			Discharge from Detergents Packaging Unit			Discharge from Detergents Making Unit			Discharge from Tank Farm Cleaning			Industrial End of Pipe			Decree 44/2000 Limit
	Min.	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	*Min.*	*Max.*	*Avg.*	
pH	5.7	8.7	6.8	5.9	9.0	7.5	7	9.9	8.75	8.4	10.5	9.65	8.5	12.5	11	8.6	9.7	9.3	6-9.5
Chemical Oxygen Demand (mg O_2/l)	1422	9900	4195	372	2877	1081	195	1698	928.3	653	11976	4986	2730	14610	6852	900	2680	2052	1100
Biological Oxygen Demand (mg O_2/l)	140	5100	1675	100	632	288	54	255	134.5	95	3420	1499.8	50	1950	910	350	1102	592	600
Total Suspended Solids (mg SS/l)	214	1710	543	45	742	221	25	690	252.2	50	277	145.3	61	14030	2650	32	331	150	800
10 min Settleable Solids (ml/l) 30 min	2 5	14 13	5.8 7	0.3 0.5	10 11	2.9 3.6	-- --	-- --	-- --	-- --	-- --	-- --	8 25	400 620	204 323	-- --	-- --	-- --	8 15
Total Phosphorous (mg P/l)	0.8	23.3	7.7	2.4	11.2	6.08	14.4	50	28.5	18.4	144	75.8	7	99	43.9	23	75	36	25
Total Organic Nitrogen (mg N_2/l)	10.1	36	19.54	8.9	54	19.84	6.7	33.6	13.2	7.8	38	15.2	8.9	84	34.2	5.6	35.84	18	100
Oil and Grease (mg/l)	292	4859	1175	144	506	318.2	44	283	189	75	5331	1435.5	116	8715	1933	198	1296	565	100

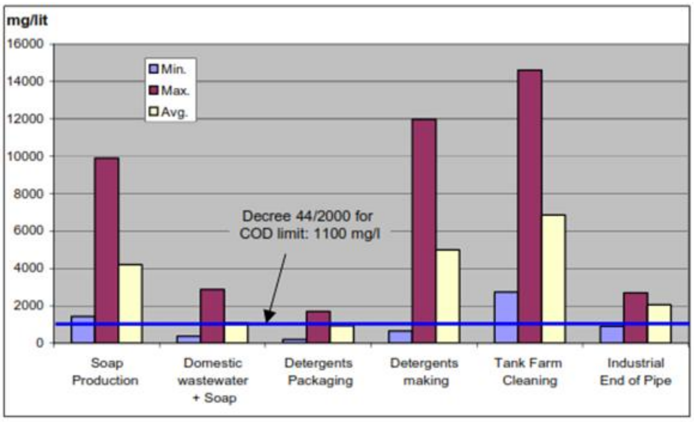

Figure (9): COD values in different wastewater streams

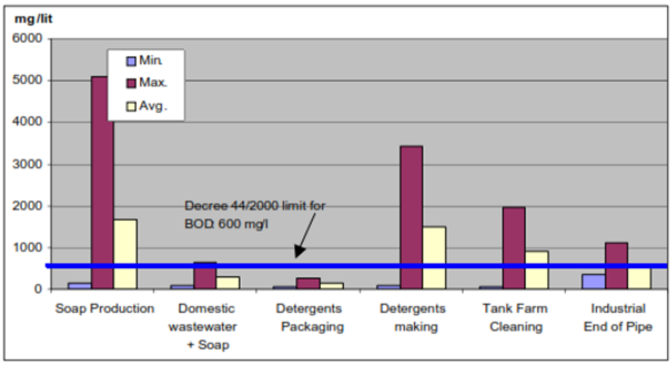

Figure (10): BOD values in different wastewater streams

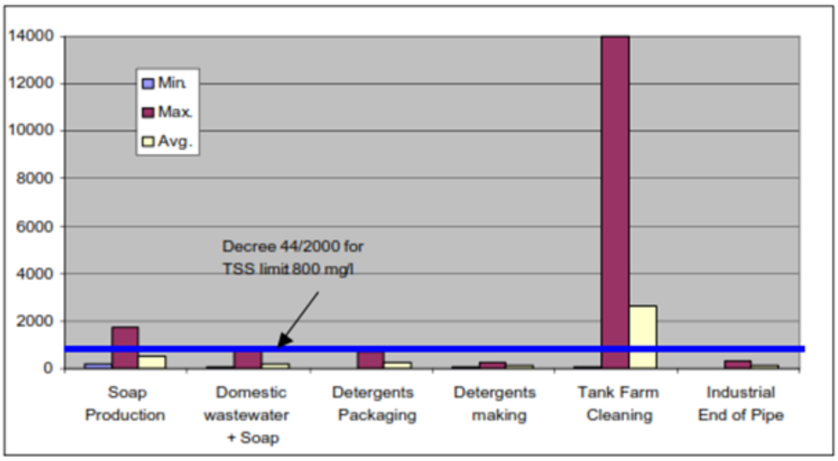

Figure (11): TSS values in different wastewater streams

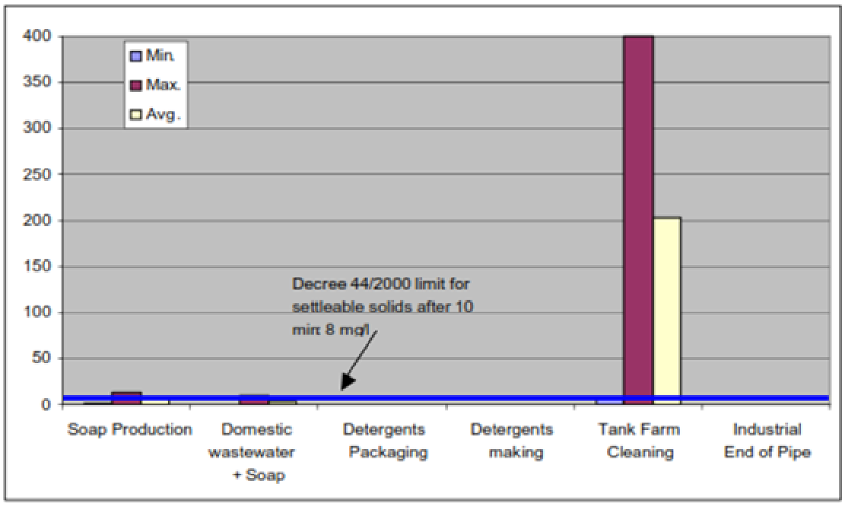

Figure (12): Settleable Solid Values after 10 min. in different wastewater streams

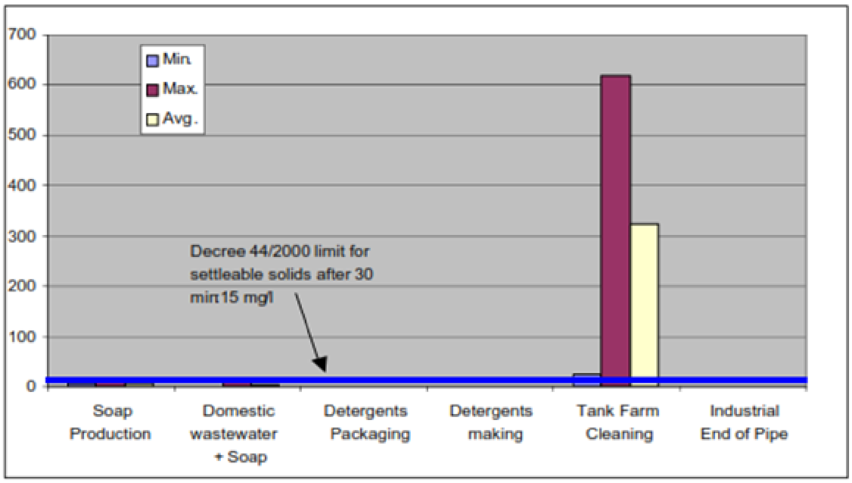

Figure (13): Settleable solid values after 30 min. in different wastewater streams

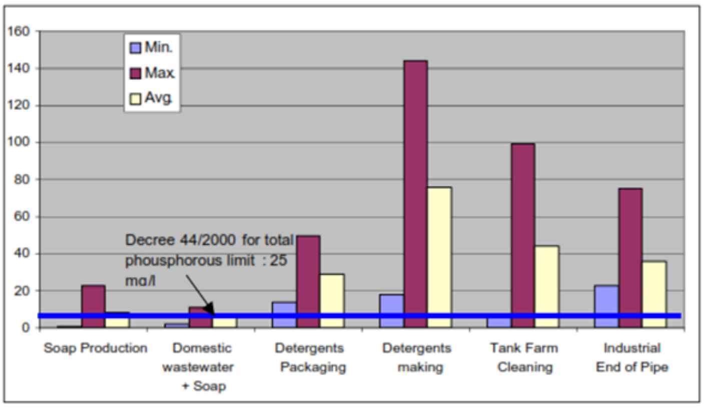

Figure (14): Total Phosphorous values in different wastewater streams

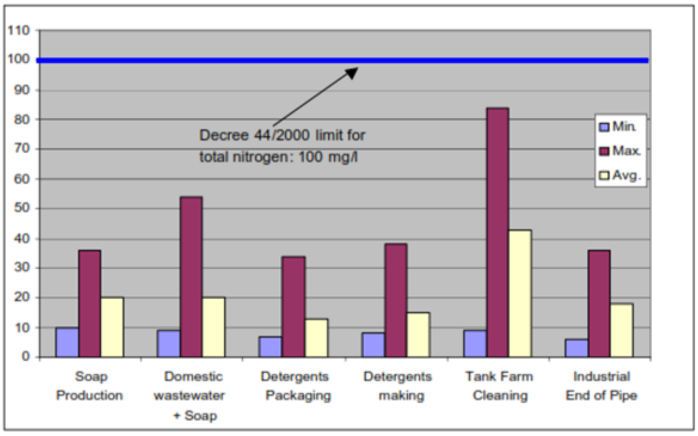

Figure (15): Total Nitrogen Values in different Wastewater Streams

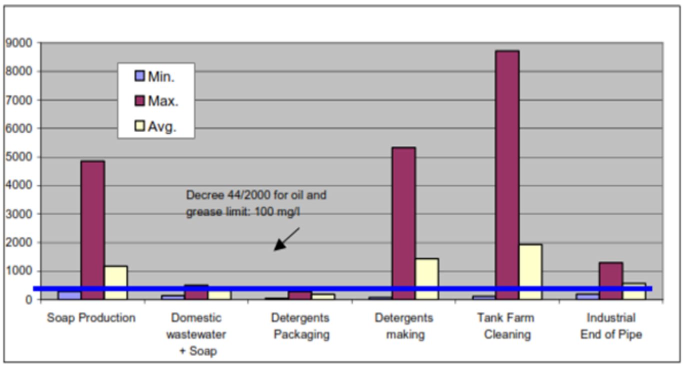

Figure (16): Oil and Grease values in different wastewater streams

Table-11: Characteristics of the Mixed Wastewater for Treatment

Parameters	Unit	Min.	Max.	Avg.	Limits
PH		6.4	12.6	10.15	6-9.5
Chemical Oxygen Demand	mgO_2/l	1023	10260	4089	1100
Biological Oxygen Demand	mgO_2/l	200	1680	936	600
Total Suspended Solids	mgSS/l	84	832	352	800
Total Phosphorous	mgP/l	16	280	55.6	25
Total Organic Nitrogen	mgN_2/l	12.2	57	27	100
Oil & Grease	mg/l	43.4	3485	989	100

5-2 Treatability Study and Identification of Possible Treatment Schemes

There are two treatment schemes identified based on the characteristics of the wastewater. The first scheme is biological treatment, while the second is chemical treatment followed by biological treatment. The biological treatment scheme is divided into aerobic and anaerobic treatment. The anaerobic treatment would be carried out as batch as well as continuous processes. The aerobic biological treatment would be carried out using activated sludge process. The chemical scheme would be carried out using different concentrations of ferric chloride and lime, and different concentrations of aluminum sulphate and lime. The resulting wastewater would then be biologically treated. Figure (17) below illustrates the proposed treatment schemes.

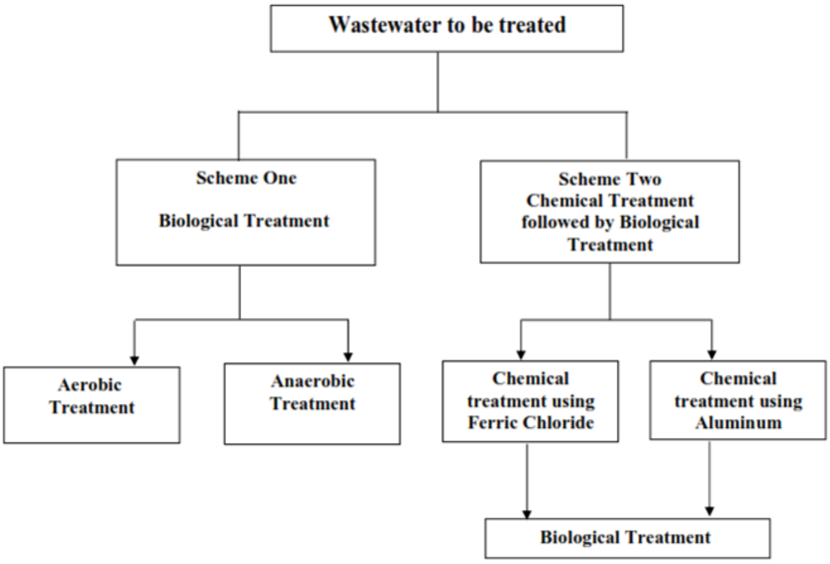

Fig.17: The Proposed Treatment Schemes

Biological Treatment

Three biological processes were carried out: batch anaerobic treatment, continuous anaerobic treatment, and aerobic treatment via activated sludge. In the batch anaerobic treatment, to develop the design parameters for the continuous anaerobic treatment, a one-liter batch reactor has been operated. The hydraulic retention time was 24 hrs. The sludge concentration was 25g VSS/l. The results obtained are presented in Table (13). From the available data, it can be seen that COD removal did not exceed 17%. This failure could be attributed to the high concentration of sodium in the wastewater (5400 mg/l). From previous studies [27], it was found that high concentrations of sodium ions inhibit the activity of methanogenic organisms. To overcome this effect, the required dose of potassium was added to the continuous system.

Table-12: Efficiency of the Batch Anaerobic Treatment, (Detention Time 24 Hours)

Parameters	Unit	Raw Wastewater	Treated wastewater	% Removal
PH		9.7	7.3	
Total Chemical Oxygen Demand	mgO_2/l	5962	4958	17
Total Suspended Solids	mgSS/l	432	480	--
Total Phosphorous	mgP/l	33	25	24
Total Organic Nitrogen	mgN_2/l	19	10	47
Oil & Grease	mg/l	2229	2119	4

In the continuous anaerobic treatment, the Upward-Flow Anaerobic Sludge Bed (UASB) was used in this experiment. The hydraulic retention time is 24 hours. Daily measurements of the pH, COD and suspended solids were carried out. Complete analysis of the influent and the effluent was carried out once a week (Table 14). During the first operating week the COD concentration of the raw wastewater was 10260 mgO2/l. The COD was reduced by only 30%. The suspended solids increased by 20%. This followed by gradual deterioration of the treatment process. This deterioration can be attributed to the death of the microorganisms that was not able to grow and survive in the environment provided by the wastewater; accordingly the sludge was converted into a suspension that was discharged with the effluent.

Table-13: Evaluation of the Continuous Anaerobic treatment using UASB Reactor (Detention time 24 hours)

Parameters	Unit	1		2		3		4	
		In	Eff.	In	Eff.	In	Eff.	In	Eff.
PH		10.4	7.8	10.0	7.2	8.7	7.2	9.2	7.0
Chemical Oxygen Demand	mgO_2/l	10260	6810	4770	7020	2070	3945	1926	4290
Soluble		9234	5952	4150	5010	1834	3100	1637	3749
Biological Oxygen Demand	mgO_2/l	1680		Toxic		497	1890	200	1920
Total Suspended Solids	mgSS/l	492	592	832	670	84	87	105	188
Total Phosphorous	mgP/l	28		18		35	44	24	33.6
Total Organic Nitrogen	mgN_2/l	40		57		12.2	26	13.4	27
Oil & Grease and extractable matter	mg/l	43		3485		264	337	574	663

In the aerobic treatment via activated sludge, batch laboratory experiment was carried out using activated sludge process. To study the effect of aeration period on the quality of the final effluent different aeration times ranging from one to 24 hours have been investigated. Fixed amount of adapted sludge (3-4 g/l) was used. Air supply was adjusted to provide at least 2 mg O2/l in the aeration reactor. Ammonium dihydrogen phosphate was added to overcome the deficiency in the nitrogen concentration which is necessary to satisfy the ratio COD: N: P 300:5:1 required for aerobic biological treatment. To overcome the foaming problem produced as a result of the aeration process, 5mg/l antifoam was added to the wastewater. This amount could be changed according to the wastewater quality. Characteristics of the final effluent were determined after settling for one hour. The results obtained are presented in Table (14).

Table-14: Characterization of Aerobic Treated Effluent Using Activated Sludge

Parameters	Unit	Raw	Hours					
			0	1	2	3	4	24
pH		9.2	7.3					
Chemical Oxygen Demand	mgO_2/l	5962	4054	4200	4605	4970	4110	4000
TSS	mg/l	976	614	1420	1485	1630	1598	1550
Sludge analysis Sludge volume Total Sludge Weight	ml/l g/l		250 3.5	230 3.0				200 1.5
pH		9.8	7.5					
Chemical Oxygen Demand	mgO_2/l	1986	630	702	663	831	690	471
TSS		202	118	178	204	220	242	232
Sludge analysis Sludge volume Total Sludge Weight	ml/l g/l		400 3.4	300 2.6	400 3.7	300 2.1	280 1.3	300 1.8

From the presented results it can be seen that about 50% of COD removal took place at the zero time (mixing and immediate sedimentation). This reduction can be attributed to physical reaction rather to the biological treatment. After the zero times the change of COD and TSS values with time does not follow a uniform trend, there is a slight decrease and increase in the values of COD, and a considerable increase in the TSS values followed by a minor decrease.

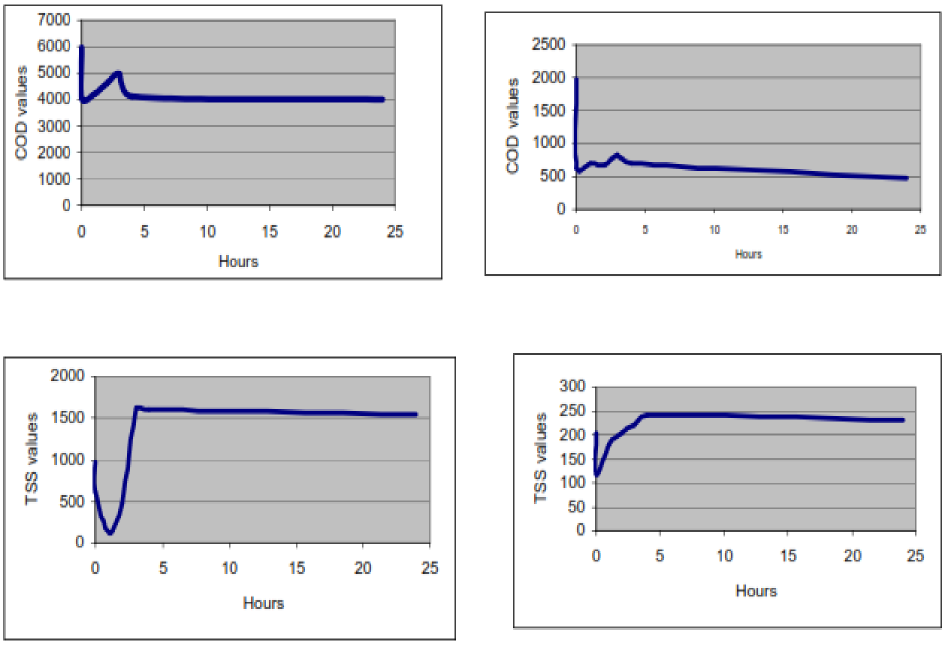

Fig.18: COD and TSS Values change over time in the Activated Sludge Process

Chemical Treatment:

Chemical treatment via coagulation followed by sedimentation was investigated. The coagulants used for this study were: ferric chloride aided with lime, and aluminum sulphate aided with lime. The optimum pH-value and coagulant dose were determined for each coagulant. The Jar-Test was used for this purpose. Chemical treatment was carried out for the mixed wastewater containing all industrial wastewater streams as well as the domestic wastewater, and for the industrial wastewater without domestic wastewater. The reason for adding the domestic wastewater is to investigate its effect in accelerating the coagulation process.

Treatment of Wastewater without Domestic Wastewater, Three samples were mixed without the domestic wastewater. Experiments were carried out on the samples using ferric chloride aided with lime, as well as Aluminum Sulphate aided with lime. Using Ferric Chloride as a Coagulant, available data indicated that the optimum pH-value in which ferric chloride achieves the best coagulation results ranged from 8.2 to 8.5. Accordingly, the dose of commercial ferric chloride(6%) was added depending on the wastewater characteristics. For each sample several doses of ferric chloride were added until the pH was adjusted. Doses of ferric chloride used ranged from 350 mg/lit to 625mg/lit. The results indicated that the removal rates for COD, TSS, phousphourous and oil and grease are presented. Based on the analysis, COD removal rate ranged from 72% to79%, TSS removal rate ranged from 86% to 96%, phousphorous removal rate ranged from 83% to 88%. Oil and grease removal rate is measured in one sample and the rate is 86%.

Using aluminum sulphateas a Coagulant, available data indicated that the optimum pH-value in which alluminumsulphateachieves the best coagulation results is around 6.5. Accordingly, the dose of anhydrous aluminium sulphate was added depending on the wastewater characteristics. For each sample several doses of ferric chloride were added until the pH was adjusted. Doses of ferric chloride used ranged from 625 mg/lit to 1000 mg/lit. The results indicated that the removal rates for COD, TSS, phousphourous and oil and grease are presented. Based on the analysis, COD removal rate ranged from 74% to 85%, TSS removal rate ranged from 52% to 98%, phousphorous removal rate ranged from 79% to 87%. Oil and grease removal rate is measured in one sample and the rate is 85%.

Treatment of Wastewater including Domestic Wastewater, Five samples were mixed including the domestic wastewater. Similar to the treatment carried out for the wastewater with domestic wastewater, experiments were carried out on the samples using ferric chloride aided with lime, as well as Alum aided with lime. Using Ferric Chloride as a Coagulant, as mentioned above the optimum pH-value in which ferric chloride achieve the best coagualtion results ranged from 8.2 to 8.5. Accordingly, the dose of commercial ferric chloride (6% H2O) was added depending on the wastewater characteristics. For each sample several doses of ferric chloride were added until the pH was adjusted. Doses of ferric chloride used ranged from 200 mg/lit to 600 mg/lit. The results indicated that the COD removal rate ranged from 66% to 80%, TSS removal rate ranged from 79% to 96%, phousphorous removal rate ranged from 71% to 86%, and oil and grease removal rate ranged from 82%to 88%.

Using aluminum sulphateas a Coagulant, as mentioned above the the optimum pH-value in which alluminum sulphate achieve the best cogulation results is around 6.5. Accordingly, the dose of anhydrous aluminium sulphate was added depending on the wastewater characteristics. For each sample several doses of ferric chloride were added until the pH was adjusted. Doses of ferric chloride used ranged from 1000 mg/lit to 1600 mg/lit. The results indicated that the COD removal rate ranged from 71% to 79%, TSS removal rate ranged from 63% to 95%, phousphorous removal rate ranged from 68% to 94%, and oil and grease removal rate ranged from 78% to 80%.

Biological treatment was not carried out after the chemical treatment in both the wastewater including domestic waster and without domestic wastewater, as the chemical treatment alone has acieved the required results, and the wasterwater parameters reached the required limits that are complying with Egyptian Environmental Regulations for the discharge to the sanitary sewage networks.

The engineering design and cost analysis for proposed alternatives

The previous results indicated that the best process alternative is the coagulation/flocculation followed by plain sedimentation give high treatment efficiency of the wastewater. Accordingly, basic engineering design is conducted for this alternative. The suggested treatment sequence of the end of pipe effluent wastewater from the factory, as shown if figure 19, shall comprise the following:

- Equalization tank for wastewater retention to ensure constant quality.
- Feeding of coagulant.
- Flash mixing of coagulant with wastewater in a mixing tank.
- Flocculation of the effluent from the flash mixing tank in baffled flocculation tank.
- Sedimentation
- Filter press or any type of filtering processes

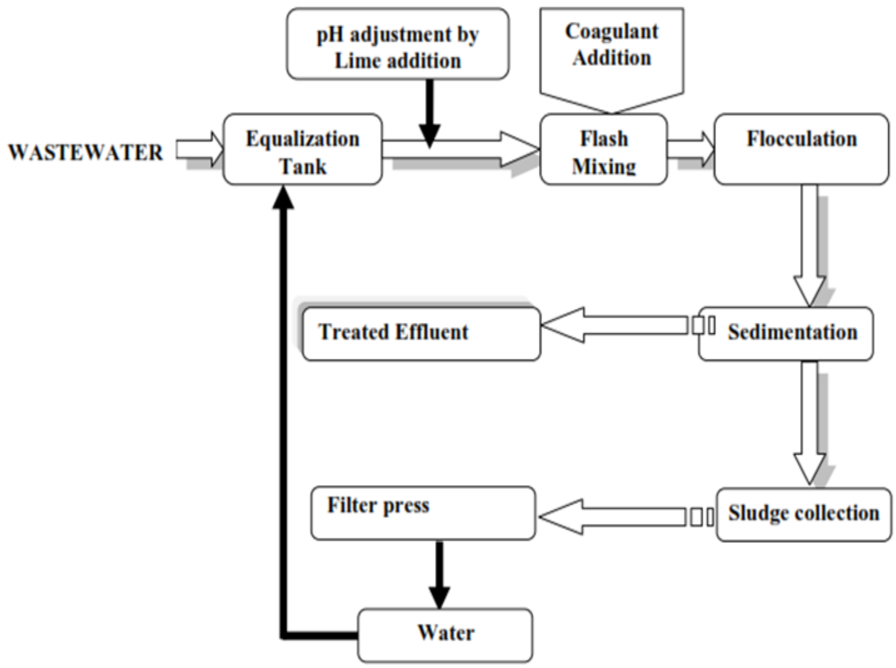

Fig.19: The Suggested Treatment Sequence of the End Of Pipe Effluent

a) **Coagulation/flocculation** this depend on one cylinderical tankswith volume 7 m3 and retention time 30 minutes supported with provided with mechanical mixers. The tanks supplied with aluminum sulphate injection system.

b) **Plain sedimentation** this depend on one tanks with volume 25 m3 and retention time 2-3 hours supported with mechanical scraper for sludge collection. Weir loading for clarified water shall be more than 240 m3/m /day. Outlet collecting concrete channel to collect the clarifed water through adjustable over flow weir made of anti corresive materila.

c) **Sludge Treatment Unit Sludge and scum** from the settling tank shall be passed to the sludge collection sump. The sump shall be circular concret with volume not less than 3 m3. The sump shall be equipped with two submersible pumps each with flow 3.0 m3/hr one working and the second is standby. The sludge pumps shall be pumped the raw sludge to the dewatering system. The dewatered outlet sludge should contain a minimum of 20 – 25 %.

Cost assessment for Industrial wastewater treatment plant

Equalization Tank	**EGP**
Two pumps submersible pumps flow 14.5 m3/hr @ 8 mt complete with pipes	**40, 000**
Two submersible mixers	**50, 000**
Fine static screen 15 m3/hr complete with screening container	**70, 000**
Flash mixing Tank	
Flash mixer complete with steel support	**15, 000**
Sedimentation tanks	
Half steel bridge complete with flocculator drum, Paddle agitator, Scum box, outlet weirs and scum baffle	**110, 000**
Sludge Pit	
Two pumps submersible pumps flow 3.0 m3/hr @ 15 mt complete with pipes, valves and fittings	**25, 000**
Dewatering Unit	
Including predewatering unit, filter press and dewatering units and sludge container	**350 000**
Chemical System	
Alum sulphate unit	
Two dosing pumps, two mixers, two tanks complete with all accessories	**140, 000**

The following figures illustrate the basic engineering drawings for the best process alternative.

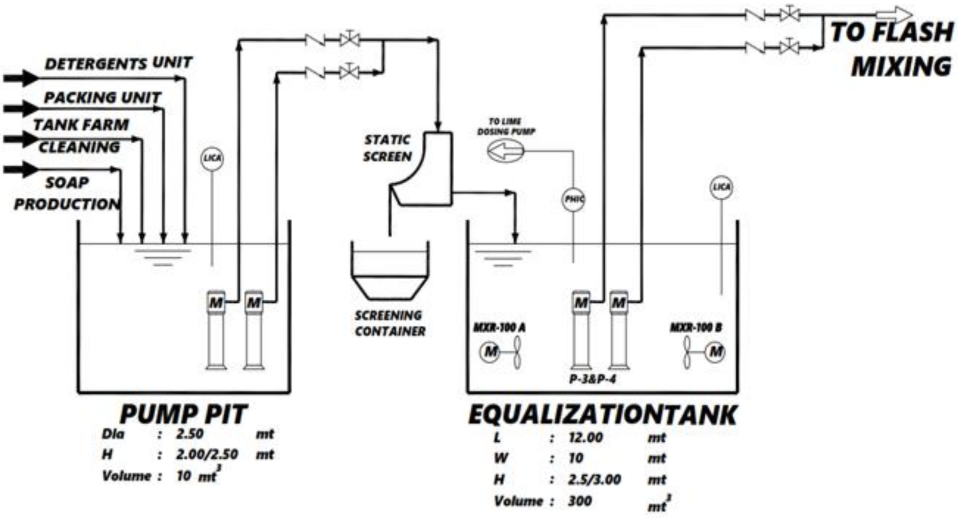

Fig.20: The Suggested Treatment Process Part-1

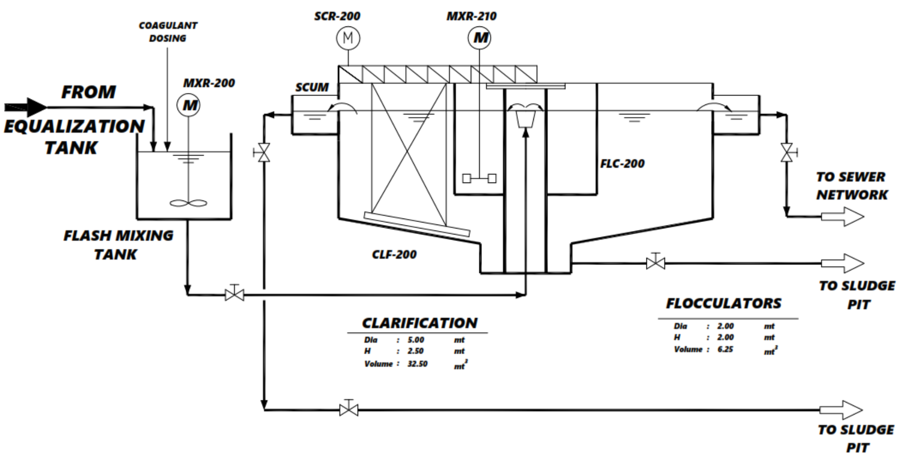

Fig.20: The suggested treatment Process Part-2

VI. CONCLUSION AND ASSESSMENT OF THE TREATMENT ALTERNATIVES

According to the different treatment alternatives presented above, that the biological method is not suitable for this type of waste, as the antifoaming chemicals and enzymes present in the wastewater leads to death of the microorganisms and accordingly the failure of the treatment system. As for the chemical treatment, it provided good results in both industrial wastewater mixed with domestic wastewater, and industrial wastewater alone. It also provided good results when using both ferric chloride and aluminum sulphate. Therefore there are two decisions that need to be taken. The first is whether to treat the industrial wastewater separately or to add the domestic wastewater to it, the other is whether to use ferric chloride or aluminum sulphate.

Regarding the usage of domestic wastewater, there are four aspects based upon which a comparison can be carried out between chemical treatment of wastewater including domestic wastewater and without domestic wastewater. These aspects are:

- Dose of the chemical used
- Removal rates of the different pollutants
- Volume and quantity of resulting sludge
- Wastewater load

A comparison of the first three aspects in the two wastewater streams is carried out in Table (15).

Table-15: Comparison between Chemical Treatment of Wastewater including Domestic Wastewater and Without Domestic Wastewater

	Wastewater with domestic wastewater	Wastewater without domestic wastewater
Using Ferric Chloride		
Dose of ferric chloride	200 mg/lit - 600 mg/lit.	350 mg/lit to 625mg/lit.
Removal Rates		
COD	66% to 80%	72%-79%
TSS	79% to 96%	86%-96%
Phosphorous	71% to 86%	83%-88%
Oil and Grease	78% to 80%.	86%
Resulting Sludge	100 mg/l –400 ml/l 0.9-3.6 g/l	120-185 ml/l 1.2-2 g/l
Using Aluminum Sulphate		
Dose of ferric chloride	1000 mg/lit - 1600 mg/lit.	625 mg/lit -1000 mg/lit
Removal Rates		
COD	71% - 79%	74%-85%
TSS	63% - 95%	52%-98%
Phosphorous	68% - 94%	79%-87%
Oil and Grease	78% - 80%.	85%
Resulting Sludge	130-200ml/l 0.6-1.8 g/l	145-185 ml/l 1.2-2.1 g/l

It is clear from Table (15), that chemical doses, rates of removal of pollutants, and amount and volume of sludge are nearly the same in both wastewater streams, whether ferric chloride is used or aluminum sulphate. As for the wastewater loads, in the wastewater stream including domestic wastewater, the flow rate is 343 m3/day, and without the domestic the wastewater to be treated is 273 m3/day. Accordingly, 20% from the load on the wastewater treatment plant could be reduced if the domestic wastewater was not added.

Accordingly, from the previous study it is concluded that the coagulation and Flocculation process followed by plain sedimentation is the most reliable alternative treatment method for this kind of industry using ferric chloridefor the wastewater without domestic wastewater. The removal efficiency reached 72 to 79%, 86 to 96%, 83 to 88% and 86% for COD, TSS, Phosphorous, and Oil and Grease respectively.

REFERENCES

[1]. U.S. Department of Labor’s Small Business Handbook: Laws, Regulations, and Technical Assistance Services, November 1997.

[2]. Simonich SL, Federle TW, Eckhoff WS, Rottiers A, Webb S, Sabaliunas D, de Wolf W (2002): Removal of fragrance materials during U.S. and European wastewater treatment. Environ SciTechnol 36(13):2839-2847.

[3]. HathiDaksha 2007. Meet the House Cleaning Brigade, Spectrum. The Tribune, February 11, 2007 , P. 1.

[4]. Frydendall Emily 2009. How Laundry Detergent Works. From <http://home.howstuffworks.com/laundrydetergent3.htm> (Retrieved on January 15 2011).

[5]. Weir Keith 2007 Laundry Detergents - The Curse Upon Our Environment and Water Systems From <http://ezinearticles.com/?Laundry-Detergents—The-Cu r se -Up on -Ou r-En vi r onme n t -An d-Wa t er -Systems&id=509599> (Retrieved on October 24 2011).

[6]. Kannan V, Ramesh R, Kumar S 2005. Study on ground water characteristics and the effects of discharged effluents from textile units at Karur District. J Environ Bio, 26(2): 269-72.

[7]. GeetuGoel and SurinderjitKaur (2012): A Study on Chemical Contamination of Water Due to Household Laundry Detergents. J Hum Ecol, 38(1): 65-69.

[8]. Ghai VU 2010. Soap Nut Detergent – The Best HE Detergent. From http://www.ezine articles.com/ (Retrieved on November 29 2010).

[9]. T.C.J. Feijtel& E.J. van de Plassche, RIVM Report no. 679101 025, September 1995.

[10]. C. A. Brunner, U.S. Department Of Health, Education and Walfare; Public Health Service: Methods for Removing Detergents From Wastewaters. The Journal Of The American Chemists Society. P814 Vol. 41 (1967).

[11]. The Disposal of Soaps and Detergents (www.epa.sa.gov.au/files/8431_soaps_detergents.pdf. EPA 547/04-April 2004.

[12]. IzabelaKowalskaet al.: Removal Of Detergents From Industrial Wastewater In Ultrafiltration Process. Environment Protection Engineering, Vol. 31 (2005).

[13]. Papadopoulos A., Savvides C., L Oizidis M.: An assessment of the quality and treatment of detergent wastewater, Water Science Technology, 1997, 36, pp. 377–381.

[14]. Abdelmoez W, Barakat NA, Moaz A.: Treatment of wastewater contaminated with detergents and mineral oils using effective and scalable technology. Water Sci Technol. 2013;68(5):974-81. doi: 10.2166/wst.2013.275.

[15]. M. A. Aboulhassan, S. Souabi, A. Yaacoubi and M.Baudu: Removal of surfactant from industrial wastewaters by coagulation flocculation process. Int. J. Environ. Sci. Tech., 3 (4): 327-332, 2006. ISSN: 1735-1472.

[16]. Adak, A.,Bandyopadhyay, M. and Pal, A., (2005). Removal of anionic surfactant from wastewater by alumina: a case study. Colloid.Surface., 254 , 165-171.

[17]. HadiEslami; ParvanehTalebiHematabadi; SeyedVahidGhelmani; Akbar SalehiVaziri; Zahra Derakhshan: The Performance of Advanced Sequencing Batch Reactor in Wastewater Treatment Plant to Remove Organic Materials and Linear Alkyl Benzene Sulfonates. Jundishapur J Health Sci. 2015 July; 7(3). DOI: 10.17795/jjhs-29620.

[18]. Fernandes H, Jungles MK, Hoffmann H, Antonio RV, Costa RH. Full-scale sequencing batch reactor (SBR) for domestic wastewater: performance and diversity of microbial communities. Bioresour Technol. 2013;132:262–8.

[19]. Ghahfarrokhi BB, Ehramposh MH, Nasiri P, Ghasemee A, Rezaee- Javanmardi R. Survey of amount of removed detergents and organic Materials of hospital wastewater with SBR developed method (case study of Yazd city). JEST. 2010;12(2):61–70.

[20]. Zeng W, Yang Y, Li L, Wang X, Peng Y. Effect of nitrite from nitritation on biological phosphorus removal in a sequencing batch reactor treating domestic wastewater. Bioresour Technol. 2011;102(12):6657–64.

[21]. Ebrahimi A, Ehrampoosh M, Samaie M, Ghelmani S, Talebi P, Dehghan M, et al. Removal Efficiency of Linear Alkyl Benzene Sulfonate (LAS) in Yazd Stabilization Pond. Sci Info Database, Iran. 2010;21(76):38–43.

[22]. Pirsaheb M, Khamutian R, Dargahi A. Efficiency of Activated Sludge Process (Extended Aeration) in Removal of Linear Alkyl Benzene Sulfonate (LAS) from Municipal Wastewater - Case Study: Wastewater Treatment of Paveh City. j of health. 2013;4(3):249–59.

[23]. Kwok T. . Assessing the effect of surfactants on activated sludge processes using sequencing batch reactors.. Australia: RMIT University; 2011.

[24]. Justin MZ, Vrhovsek D, Stuhlbacher A, Bulc TG. Treatment of wastewater in hybrid constructed wetland from the production of vinegar and packaging of detergents. Desalination. 2009;246(1-3):100–9.

[25]. Mahvi, A.H.: Removal of anionic surfactants in detergent wastewater by chemicalcoagulation [2004]. National Agricultural Research Centre.Tehran Univ. of Medical Sciences (Iran). Dept. of EnvironmentalHealth Engineering (http://www.parc.gov.pk/NARC/narc.html)

[26]. APHA, AWWA, WEF,; Standard Methods for the Examination of Water and Wastewater (22nd edition) Washington: APHA, AWWA, WPCF,2012.

[27]. O.P.Sahu; P.K.Chaudhari: Review on Chemical treatment of Industrial Waste Water. J. Appl. Sci. Environ. Manage. June 2013, Vol. 17 (2) 241-257.