ISSN XXXX XXXX © 2019 IJESC

Research Article Volume 9 Issue No.4

Evaluation of the appropriate Industrial Wastewater Treatment Techniques from Food and Dairy Processing Industry (Case Study of Dairy Processing Industry)

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Abstract:
The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. The wastewater is characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contains fats, nutrients, lactose, as well as detergents and sanitizing agents. Due to the high pollution load of dairy wastewater, the milk processing industries discharging untreated/partially treated wastewater cause serious environmental problems. The physico-chemical analysis of COD, BOD, TSS, oil and grease during the process reached 9000, 5600, 1388, 560 mg/l respectively. As well as, analysis of COD, BOD, TSS, oil and grease final wastewater effluent reached 3600, 1925, 1288, 190 mg/l respectively. It was cleared from wastewater analyses that the discharged from the wastewater effluent from the both production lines and final wastewater effluent were relatively high and violating the standards for discharge to the public sewer system (Decree 44/2000). The main objectives of this study to find a sustainable solution for the industrial wastewater in order to comply with the National Regulatory Standards governed by the ministerial decree (44/2000) for wastewater discharge into public sewage network to protect the environment. A treatability study, analysis, as well as bench scale model were conducted for investigating the feasibility of each of identifying the different possible treatment trains, selecting the most suitable treatment train that need to be treated prior to its discharge to the sewer system. The study investigated the appropriate treatment techniques using three proposed streams of techniques; DAF Unit Followed by biological treatment, Settling Unit Followed by biological treatment, standalone biological treatment via activated sludge. As results from the treatability study and bench scale model, it was noticed that reduction of the COD by 50% was achieved by applying DAF Unit Followed by biological treatment or Settling Unit Followed by biological treatment. By applying the standalone biological treatment via activated sludge, reduction of the COD from 88 to 95 after 5 to 6 hours detention time was archived. Accordingly, from the study it was concluded that the standalone biological treatment via activated sludge process is the most reliable alternative treatment technique of this kind of industry.

Keywords: Biological Treatment, Food Industry, Chemical and Physical Treatment, Industrial Wastewater Treatment, Cleaner Production, Dissolved Air Floatation

1. INTRODUCTION:

The industries are of importance in terms of its impact on the environment. The wastewaters from these industries are generally strong and may contain toxic parameters. Industrial wastes usually contain organic and inorganic matter in varying degrees of concentration. It contains acids, bases, toxic materials, and matter high in biological oxygen demand, color, and low in suspended solids. Many materials in the industries are toxic, mutagenic, carcinogenic or simply hardly biodegradable. Surfactants, emulsifiers and petroleum hydrocarbons that are being mixed with pesticide active ingredients form emulsion with water, which reduce performance efficiency of many treatment unit operations **[1].**Extended industrialization trends are generally associated with the increase in wastewater discharge of effluents loaded with organic and inorganic pollutants. The industrial growth is very difficult to separate from environmental pollution but it can be minimized through cost-effective approaches of pollution abatement **[2]**. Technologies to treat chemical industry effluents: in terms of wastewater treatment there are four classifications of treatment. Preliminary treatment involves the removal of large particles as well as solids found in the wastewater. The second classification is primary treatment, which involves the removal of organic and inorganic solids by means of a physical process, and the effluent produced is termed primary effluent. The third treatment is called secondary treatment; this is where suspended and residual organics and compounds are broken down. Secondary treatment involves biological (bacterial) degradation of undesired products. The fourth is tertiary treatment, normally a chemical process and very often including a residual disinfection **[3]**. It may be necessary to pretreat the wastes prior to release to the municipal system or it is necessary to a fully treatment when the wastes will be discharged directly to surface or ground waters **[4]**. Food and beverage industry is one of the major contributors to growth of all economies. In EU it constitutes the largest manufacturing sector in terms of turnover, value added and employment. However, the sector has been associated with various environmental issues including water usage and wastewater treatment. Food processing industry wastewater poses pollution problems due to its high COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand). Compared to other industrial sectors, food industry requires great amounts of water, since it is used throughout most of plant operations, such as production, cleaning, sanitizing, cooling and materials transport, among others. The wastewater streams with different levels of pollution load (low, medium and high contamination) are collected and treated in an on-site

installation or in a municipal sewage treatment plant. Increasing food production will increase the volume of sewage and the cost of disposal for food processing plants and present difficult challenges for municipal wastewater treatment plant operators **[5, 6]**. The wastewater characteristics play a key role in the selection of biological treatments. Chemical industrial wastewater can be treated by some biological oxidation method such as trickling filters, rotating biological contactor (RBC), activated sludge, or lagoons; also, coagulation is necessary for some waste **[7].** A proposed concept to select the appropriate treatment process for industrial wastewater based on molecular size and biodegradability of the pollutants **[5].** Biological treatment is still regarded as the most common and economical approach for the treatment of contaminants in wastewater. High-technology and low-cost bio-units have been successfully established for the treatment of variety of organics found in wastewater of municipal and industrial origin**.** However, activated sludge treatment was shown to degrade industrial wastewater in extents that ranged from complete to very poor degradation **[8]**. High amount of organic and inorganic compound in dairy wastewater can produce excess growth of algae, eutrophication and also effect on biodiversity that cause decreased water quality level that may affect human and animal health **[9]**. The raw milk is processed into various milk products in the dairy industry like consumer milk, butter, cheese, ghee and other bi-products handled each day. The increased production of milk based food products by these industries leads to generation of large quantity of wastewater consisting of high levels of organic contaminants, which leads great damage to aquatic ecosystem **[10]**. Dairy industries are involved in the manufacturing of various types of milk products such as fluid milk, butter, cheese, yogurt, condensed milk, flavored milk, milk powder, ice cream, etc. The dairy industry is one of the most polluting of industries, not only in terms of the volume of effluent generated, but also in terms of its characteristics as well. It generates about 0.2–10 liters of effluent per liter of processed milk with an average generation of about 2.5 liters of wastewater per liter of the milk processed **[11]**. The dairy industry wastewaters are primarily generated from the cleaning and washing operations in the milk processing plants. Dairy wastewater is characterized by high biological-oxygen demand (BOD) and chemical oxygen demand (COD) concentrations, and generally contains fats, nutrients, lactose, as well as detergents and sanitizing agents. Nutrients lead to eutrophication of receiving waters, and detergents affect the aquatic life. Due to the high pollution load of dairy wastewater, the milk processing industries discharging untreated/partially treated wastewater cause serious environmental problems **[12]**. The dairy industry is generally considered to be the largest source of food processing wastewater in many countries. Water is used throughout all steps of the dairy industry, including cleaning, sanitization, heating, cooling, and floor washing; naturally the industry's need for water is huge [1]. In general, wastes from the dairy processing industry contain a high concentration of organic material such as proteins, carbohydrates and lipids, high BOD and COD, and high concentrations of suspended solids and suspended oil-grease. All of these require specialized treatments to prevent or minimize environmental problems **[13]**. The activated sludge process is operated best at retention time of 5 days with BOD percentage removal fficiency of95%fordairywastewater. The treatment efficiency of the reactor in terms of BOD5 and COD removals was studied at different retention times and is used for the large scale treatment plants **[14]**. The COD of the effluent varied from 1589 to 1960 mg/l before treatment whereas after physical and biological treatment the values obtained from 185 to 239 mg/l respectively. The SVI content in the effluent varied from 320 to 600 mg/l before treatment whereas after physical and biological treatment the values obtained were from 38 to 95 mg/l **[15]**. Physico-chemical characterization of dairy wastewater was carried out. The parameters includes, pH, temperature, color, dissolve oxygen(DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), chloride, sulphate, nitrate and phosphorus were measured according to standard method. These methods were check present amount of nutrient content before and after inoculation of cyano-bacterial culture into dairy wastewater. The study shows the capability of cyano-bacterial species for the removal of nutrients presents in dairy wastewater to produce high value compounds and can remove 94% COD as well as 87% overall nutrient of dairy wastewater very efficiently **[9]**. Dairy industries produce unstable waste streams with increased temperatures, variable pH values, and high COD, BOD, nitrates and phosphates concentrations. The effluents coming out of dairy industry needs to be treated properly prior to disposal in the prescribed limits to control any possible environmental hazards. Apart from the traditional methods of treatment of wastewater, dairy industry needs special treatment techniques as it has contents having high proteins. The present study shows that rice husk ash can be used as adsorbent for treatment of dairy wastewater as it could bring about 48.6 mg/l of nitrates into 10 mg/l .This was achieved using an adsorbent dosage of 4g/l with coagulation period of one hour. Moreover it is cost-effective process since it is cheaply available. Modification to the present treat plant is suggested as per this study for more effective treatment by integrating coagulation and flocculation unit. Rice husk ash with a little amount of sugar is suggested as coagulant **[16]**. Pilot lab scale was erected in the Labanita dairy factory laboratory. The pilot consisted from feeding tank followed by DAF unit followed by SBR unit. Different operation scenarios had been applied to determine the optimal operation procedure and the best removal efficiency. The study illustrated the need of aeration system to be continuous that improved the dissolved oxygen stability in the SBR and improves the tank COD removal efficiency. TSS removal ratios increased gradually 90.5 %, 92.4% and 94.6% as a reason of decreasing aeration time to 5 hrs. After decreasing aeration time in SBR unit to 5 hrs the removal efficiency increased to 96.6%. But the decrease of aeration time to 4 hours decreased the COD removal efficiency to 95.8%. With respect to DAF unit the removal efficiency increased gradually with the increasing of the inflow rate from 32.9 % to 36.9% instead of 22.7% **[17]**. Using Physicochemical Treatment by Coagulation and Sedimentation it is resulted in reduction of COD and BOD by 81% and 85% respectively in the 24 hr composite sample. In the 48 hr sample, the reduction is 45% in the COD and 52% in BOD. Accordingly, the wastewater resulting after coagulation and sedimentation is complying with the discharge limits to the sewer system **[18]**. The conventional biological treatment methods are suitable for dairy wastewaters due to its high biodegradability. However, long chain fatty acids formed during the hydrolysis of lipids show the inhibitory action during anaerobic treatment. Sequencing batch reactor (SBR) and up flow anaerobic sludge blanket (UASB) systems seem to be the most promising technology for the biological treatment of dairy wastewaters **[19]**. Study on wastewater management in food processing enterprises was conducted using the Ciechanów Dairy Cooperative as an example. The efficiency of preliminary treatment of wastewater entering the municipal sewerage system was evaluated using basic pollution indices

for wastewater pre-treated in the process of chemical neutralisation as well as results of physical and chemical analyses of raw wastewater from age fraise and cottage cheese production lines. Chemical neutralisation reduced COD, total solids and total nitrogen by 75.8, 85 and 58.5%, respectively **[20]**. High strength of cake industry wastewater was sequentially treated by electro-Fenton (EF) and electrocoagulation (EC) processes. Results of tandem sequential treatment processes indicated 58.7 % TOC, 93.9 % total phosphate, 82.8 % TSS. Additionally, BOD5 /COD ratio was improved from 0.3 to 0.5 showing good biodegradability of cake wastewater **[21]**. Research dealt with the dairy wastewater treatment by graphene oxide nanosheets. The removal efficiencies of 90%, 80%, 84%, and 94% were observed for TN, TP, COD, and turbidity **[22].** The treatment mechanisms of contaminants in wastewater are highly dependent on the design and operational characteristics of the wastewater treatment plants (WWTPS). The membrane biological reactors (MBR) have proven to be efficient for the treatment of industrial wastewaters over conventional wastewater treatment plants when treatment efficiency is an important consideration. The pollution indicators (BOD, COD, total suspensions, temperature, appearance, and pH) of wastewater of food industry had high values but they remained within the range after treatment in the MBR. When analyzed at monthly intervals, 98% BOD5 and above 99%, COD removals were achieved. Overall efficiency of removed pollutants as COD, BOD and TSS from the wastewater was more than 90%. MBR technology is thus a better and advanced method to treat wastewater of food industries **[23].** Since the introduction of membrane technology into the food processing industry about four decades back, the number of applications as well as the membrane surface area is increasing very fast. Membrane separations are a very good technology for wastewater treatment, especially permeated water from certain membrane filtrations can be reused in production activities **[24]**. Only MBR treated effluent showed 95.33% COD, 62.3% TDS and 90.6% Turbidity, whereas MBR integrated with RO exhibited 97.5% COD, 90.2% TDS and 97% Turbidity reductions respectively **[10]**. Flotation and MBBR in combination with activated sludge are suitable technologies to treat concentrated food industry wastewater. In this plant, flotation had removed 64% of COD, 70% of BOD and 65% of oils and greases **[25]**. Fixed film processes are more superior when compared to suspended processes in several aspects. Small reactor size, simple operation and high reliability make this process a cost-effective system for biological treatment. Anaerobic fixed bed reactors (AFBRs) has been successfully and widely applied for the treatment of dairy industry wastewater due to its capacity for microorganism retention on the support and, therefore, the hydraulic retention time can be considerably reduced **[26]**. Membrane filtration can provide a significant role in the management of waste streams from food manufacturing operations. The DAF treatment provided 75.15 _ 3.95% reductions in COD, and the reduction in COD improved from 85% to 99% as the membrane pore size decreased. When all membranes were used after a DAF pre-treatment, a reduction in COD to less than 1200 ppm in the permeate stream was achieved **[27]**. Study was a review on the several methods and their performance evaluation comparison of dairy wastewater on the basis of evaluated parameters. The conventional methods were used to treat dairy wastewater such as Physico-chemical and biological treatment but widely biological treatment are used which are aerobic and anaerobic treatment. Conventional methods are proven to be less effective than the advanced methods because of high area requirement, problem of high maintenance cost, labor cost and also disposal problem of sludge. Treated wastewater using UASBR has more COD than treated with any other methods whereas biogas production is an advantage of UASBR. Reduction in BOD and COD are observed more in constructed (artificial) wetland method than other methods of treatment. Simultaneously constructed (artificial) wetlands have benefits of low cost and less manpower as well **[28]**. Coagulation–flocculation and flotation processes were evaluated for the pre-treatment of industrial wastewater. Up-flow anaerobic stage reactors (UASRs) used as a pre-treatment to activated sludge for industrial effluent have been shown to be efficient for the removal of industrial wastewater even at high concentrations **[29, 30]**. The proposed pre-treatment strategy for industrial wastewater is useful for assimilating its conventional physico-chemical characteristics to that of municipal wastewater **[31].** There are many ways to reduce the BOD and COD, but biological treatment is the primary mean. Both aerobic and anaerobic technologies have been used, while anaerobic treatment of wastewater has emerged as viable and economical alternative over the conventional aerobic treatment particularly for high BOD. In aerobic technologies number of different treatment methods are there like, activated sludge, sequencing batch reactor, rotating biological contactors trickling filter. Anaerobic treatment is most widely used for treating dairy wastewaters, predominantly UASB and hybrid anaerobic digester. The up flow anaerobic slug blanket reactors are most widely used and appropriate for treating dairy industry wastewaters. UASB reactors have been most widely used for the treatment of dairy and food wastewater. It was observed removal efficiency of COD, BOD, and TSS was 87.06%, 94.50%, and 56.54%, respectively. Anaerobic Sequencing Batch Reactors (ASBR) also used for obtaining high quality of dairy effluents. Removal rates ranged between 75 and 90% for BOD5, and 62 and 90 percent for COD were achieved **[32].** Dairy effluents are generally treated with physico-chemical and biological processes. The physico-chemical processes suffer the disadvantage that reagent costs are high and soluble COD removal is low. Further, chemical treatment could induce a secondary pollution due to the addition of chemical coagulants which may contaminate the treated water. The biological treatment process require more spaces and long time for treatment along with generation of high amount of sludge as well as high energy costs **[33].** The electro coagulation (EC) process could be other alternative process for treating the dairy effluent. Recently, electro coagulation process is emerging as a cost effective treatment method for the treatment of varieties of wastewater **[34]**

2. STATEMENT of the ENVIRONMENTAL PROBLEM:

The dairy industry is committed to reducing environmental impacts of their activities, and to continuously improve their environmental performance and to meeting or exceeding the requirements of all applicable environmental laws and regulation. There are no hazardous materials used or produced at the industry. The main source of industrial wastewater in EDAFCO is tanks wash water as well as process units and transportation lines wastewater. In addition, some expired products are drained in the industrial drain line. Thus, the wastewater has a high BOD and COD.As there is no wastewater treatment applied at the industry, the industrial wastewater discharged from the factories to the public sewer system without treatment. The industry is connected to public sewer and discharges its wastewater into it including chemicals and raw material waste. With regard to the wastewater discharged from the production lines, a great variation has

been recorded. The COD_{total} values ranged from 2760 to 9000 mgO2/l depending upon the on-going operation. The BOD values varied from 3600 to 5600 mgO2/l. Average values of Ammonia, organic nitrogen and phosphorous were 6 mg/l, 18 mg/l respectively. Suspended solids ranged from 612mg/l to 1388 mg/l. The high pollution load is mainly caused by the use of the same line for producing different products, milk and juice. This results in the need for additional washing and disinfecting of equipment and line as well as discharging unused material in the sewer. As conclusion of the lab analysis of the industrial wastewater effluent, Total COD value of the final wastewater ranged from 3600 to 5980 mgO2/l. The soluble COD fraction represents 43% to 55% of the CODtotal. Corresponding BOD values were 1925 and 3000 mgO2/l, respectively. Suspended solids were relatively high, ranging from 1090 to 1288 mg/l and it constituted 36% of the total solids content. Average total concentration was 6.8 mg/l. The concentration of oil and grease was relatively high. It ranged from190 to 267 mg/l with an average value of 229 mg/l. So, Analysis of COD, BOD, TSS, phosphorous, and oil and grease of the industry wastewater effluent are above the limits of the Egyptian Environmental Regulation (Decree 44/2000). The high pollution load is mainly caused by the use of the same line for producing different products, milk and juice. This results in the need for additional washing and disinfecting of equipment and line as well as discharging unused material in the sewer.Accordingly, the industry has to treat the wastewater prior to its discharge to the wastewater sanitary network.

3. OBJECTIVES OF THE STUDY:

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 as well as best method for waste minimization as cleaner production system.

4. MATERIALS AND METHODS

The audit program was carried out to monitor the environmentally damaged activities, compliance with legislation, opportunities for reductions, utilization and waste minimization strategies, effectiveness of existing management controls, potential remediation program and pollution prevention opportunities with relatively short payback periods. 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, 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. The study is conducted through very precise characterization of the wastewater produced from the final effluent during the working shifts and application of appropriate treatment options for the end-of-pipe using different treatment techniques to comply with environmental regulations.

4.1. Summary Description of the industry process and production lines: The industry includes several production lines which are Milk production process line, Juice production process line, and Tomato Paste production process line. The industry has several production units such as Cooling, Dilution, Pasteurization, Sterilization, Dearation, and Packing. The following block diagrams show these several production process line. The main raw materials used in the factory are raw milk, flavors, emulsifier, stabilizer, juice concentrate, salt, tomato paste and butter.

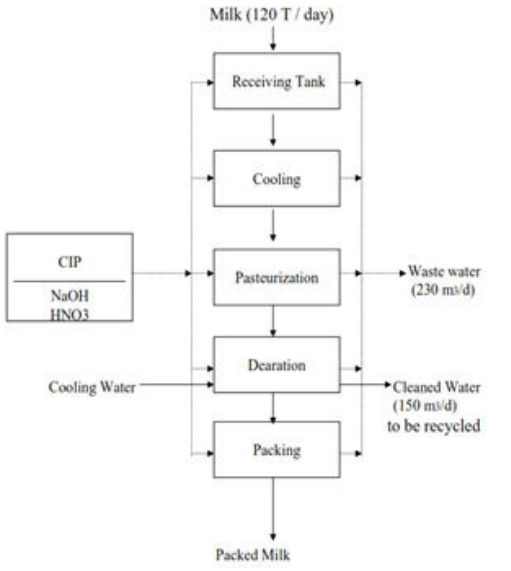

Figure 1-a: Block diagram of Milk Production Process Line

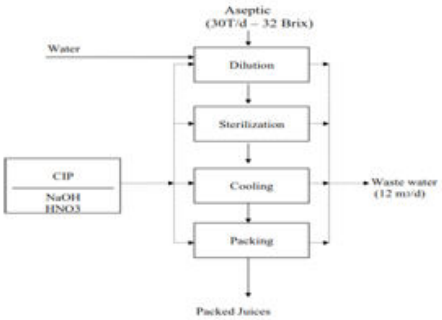

Figure 1-b: Block diagram of Juice Production Process Line

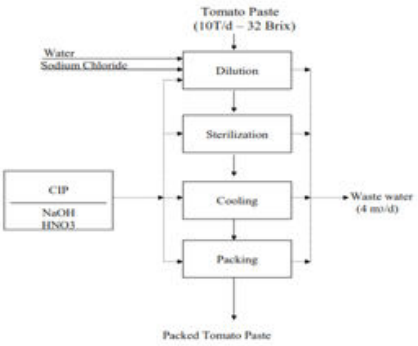

Figure 1-c: Block diagram of Tomato Paste Production Process Line

4.2 Water balance and Wastewater Discharge of the industry process: As for the domestic wastewater, it is mixed with the industrial wastewater prior to its discharge to the public sewer system. The industry consumes about 240 m^3/day for both domestic and industrial activities. About 12 m3/dare used for domestic purposes and 180 m3/d, which is mainly generated from washing operations, are discharged to the public sewer. The wastewater produced from the company is directly discharged without any treatment into sewer public network. The following table illustrates the industrial and domestic wastewater discharges of the process. A large amount of cleaned water (150 m3/d) from the dearator discharged with the wastewater, this water is quiet clean and it should be recycled and this will lead to decrease the hydraulic load to the WWTP by 30 %.

4.3 Sampling and characterization of wastewater

The main objective of the analysis is to investigate the compliance of the wastewater with the limits for discharge to the public sewer system, and in case of noncompliance identify and evaluate alternatives for management of the wastewater to reach compliance. For investigating the compliance of the discharged wastewater and identifying possible alternatives for its management, the sampling and analysis carried out for the wastewater in the industry was conducted as composite samples and analysis of the compiled industrial wastewater of the industry shifts as well as grab samples and analysis of the mixed industrial and domestic wastewater in each of the operating shifts. The analyses were carried out according to the Standard Methods for Examination of Water and Wastewater [35]. To evaluate the wastewater characteristics, various analysis of the effluent were performed. Due to the considerable variability in wastewater quality over time, grabs as composite well as were collected from different departments and end of pipe. All samples investigated to cover the following parameters: PH value, Total solids (at 105^{o}C &550^{o}C) , total suspended solids, settleable solids, total phosphate, COD_{total}, $COD_{filteral}$, BOD, ammonia, nitrite, nitrate, total kjeldahl nitrogen, and oil & grease.

5. RESULTS AND DISCUSSION

5.1: Characterization of Liquid Wastewater and Assessment of Compliance of Industrial Wastewater

For investigating the compliance of the discharged wastewater, the sampling and analysis carried out for the wastewater in the industry was conducted as composite samples and analysis of the industrial wastewater with and without the domestic wastewater. Analysis of the composite wastewater samples from industrial wastewater alone and end-of-pipe are shown in following tables and figures.

Table.1. Characteristics of the Industrial Wastewater

Parameters	Unit	Sample-1	Sample-2	Standards Limits
pH	--	4.12	12	6 – 9.5
Settleable matter 10 min	mg/l	120	5	8
Settleable matter 10 min	mg/l	100	10	15
Chemical oxygen demand, COD COD_{total}	mgO_2/l	4900	9000	1100
Chemical oxygen demand, COD $COD_{filteral}$	mgO_2/l	2445	5940	1100
Biological oxygen demand, BOD	mgO_2/l	3600	5600	600
Total suspended solids, TSS	mg/l	1388	1292	800
Volatile suspended solids, VSS	mg/l	1299	1032	
Total Kjeldahl nitrogen	mg N/l	17.9	198.8	100
Ammonia	mg N/l	5.88	6.9	
Nitrite	mg N/l	0.08	0.04	
Nitrate	mg N/l	9.6	600	
Total phosphorous	mg P/l	12.4	18.8	25
Oil & grease	mg/l	466	-----	100

Sample-1: Industrial wastewater, Sample-2: Washing water from the milk production process line

Table.2. Characteristics of the End-of-pipe (municipal and industrial wastewater)

Parameters	Unit	End-of-pipe	Standards Limits
pH	--	5.45	6 – 9.5
Settleable matter 10 min	mg/l	----	8
Settleable matter 10 min	mg/l	----	15
Chemical oxygen demand, COD COD_{total}	mgO_2/l	3600	1100
Chemical oxygen demand, COD $COD_{filteral}$	mgO_2/l	1560	1100
Biological oxygen demand, BOD	mgO_2/l	1925	600
Total suspended solids, TSS	mg/l	1288	800
Volatile suspended solids, VSS	mg/l	1212	

Parameters	Unit	End-of-pipe	Standards Limits
Total Kjeldahl nitrogen	mg N/l	67	100
Ammonia	mg N/l	2.2	
Nitrite	mg N/l	6	
Nitrate	mg N/l	3.6	
Total phosphorous	mg P/l	8.4	25
Oil & grease	mg/l	190	100

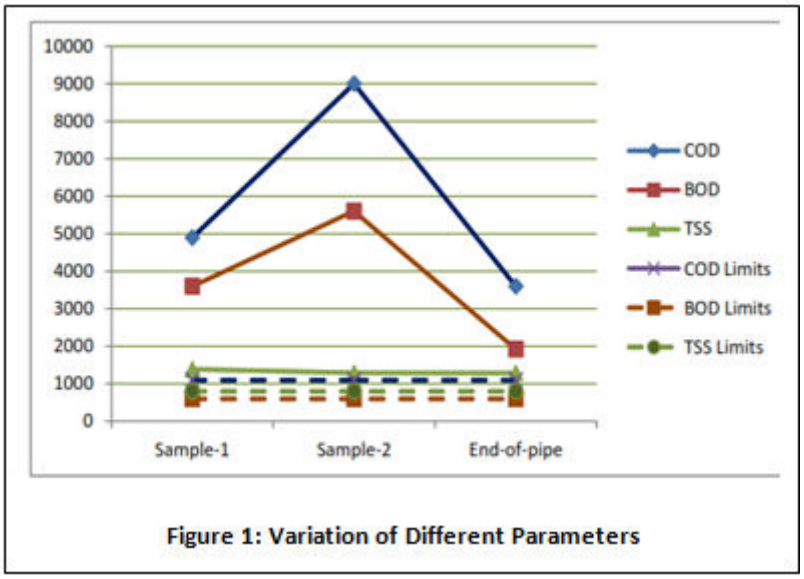

Figure 1: Variation of Different Parameters

With regard to the wastewater discharged from the production lines, a great variation has been recorded. The COD_{total} values ranged from 4900 to 9000 mgO_2/l depending upon the on-going operation. The BOD values varied from 3600 to 5600 mgO_2/l. Average values of Ammonia and phosphorous were 6.5 mg/l, 15.5 mg/l respectively. Total suspended solids ranged from 1299 mg/l to 1388 mg/l.The concentration of oil and grease was relatively high of 560 mg/l. Total COD_{total} value of the final wastewater effluent(municipal and industrial wastewater)was from 3600 mgO_2/l. The soluble COD fraction represents 43% of the COD_{total}. Corresponding BOD value was 1925 mgO_2/l, respectively. Suspended solids value was relatively high, 1288 mg/l. Average total phosphorous concentration was 8.4 mg/l. The concentration of oil and grease was relatively high of 190 mg/l. It was cleared from wastewater analyses that the effluent is violating the standards for discharge to the public sewer system (Decree 44/2000). The high pollution load is mainly caused by the use of the same line for producing different products, milk and juice. This results in the need for additional washing and disinfecting of equipment and line as well as discharging unused material in the sewer.

4.4 Treatability Study and Identification of Possible Treatment Schemes

A treatability study and analysis was conducted for investigating the feasibility of each of identifying the different possible treatment trains, selecting the most suitable treatment train, and developing the basic design for the selected treatment train for the wastewater streams that need to be treated prior to its discharge to the sewer system. Alternatives for management and treatment of the discharged industrial wastewater to the limits of the Egyptian Environmental Regulation (Decree 44/2000) will be identified and assessed to investigate their feasibility from environmental and technical perspectives. Pollutants in the domestic wastewater are expected to be lower than that of the industrial wastewater, accordingly mixing of the industrial and domestic wastewater is expected to dilute the pollutants discharged from the industrial wastewater. According to the laboratory analysis carried out for the mixed wastewater stream, it is clear that the pollutants concentration has decreased but it is still not complying with the regulatory discharge limits. As well as treatment procedure through a bench scale model and treatability study was developed for the industrial wastewater streams of the industry to study the analysis of waste discharges and investigate the most appropriate treatment techniques using three proposed streams of techniques; *DAF Unit Followed by biological treatment, Settling Unit Followed by biological treatment, standalone biological treatment via activated sludge.*

a) Alternative-1 "DAF Unit Followed by biological treatment": This alternative gets the benefits of the potential pollution load reduction following the DAF unit which reaches 50% as COD, in addition to the compacted size of the DAF unit compared to the settling tanks. Using the biological treatment following to the DAF unit is a must to reach the limits for discharging to the public sewer to be mixed with the other domestic streams. The pollution load to the biological unit will be reduced by 50% which leads to the reduction in size of the units. The main components for this alternative are:

- DAF unit (10 m3/hr capacity) complete with chemical dosing systems
- Equalizing tank (40 m3 capacity)
- Biological aeration tank 4 hrs detention time and 2000 – 3000 ppm as MLSS.
- Final settling tank 0.8 m/hr hydraulic load and 1.5 kg/hr solids loading
- Sludge handling system: sludge holding tank, pumps, and filter press.

b) Alternative-2: "Settling Unit Followed by biological treatment": This alternative gets the benefits of the potential

pollution load reduction following the settling unit which reaches 50% as COD, in addition to the ease of operation which is not the case inDAF unit due to its need for highly qualified operators to control its operation in a proper way. Using the biological treatment following to the DAF unit is a must to reach the limits for discharging to the public sewer to be mixed with the other domestic streams. The pollution load to the biological unit will be reduced by 50% which leads to the reduction in size of the units. The main components for this alternative are:

- Settling unit (2hrs detention time) complete with chemical dosing systems
- Equalizing tank (40 m3 capacity)
- Biological aeration tank of 4 hrs detention time and 2000 – 3000 ppm as MLSS.
- Final settling tank 0.8 m/hr hydraulic load and 1.5 kg/hr solids loading
- Sludge handling system: sludge holding tank, pumps, and filter press.

c) Alternative-3: "Only biological treatment": The biological treatment of settled wastewater via activated sludge is technically eligible as proved by the treatability study, since the percentage reduction in COD achieved ranges from 88 to95 after 5 to 6 hours detention time. Also, the biological treatment is considered appropriate because of its low consumption of power and labor, and can handle high flow rates of wastewater. The main components for this alternative are:

- Equalizing tank and pumps (6 hrs capacity)
- Biological aeration tank 8 hrs detention time and 2000 – 3000 ppm as MLSS.
- Final settling tank 0.8 m/hr hydraulic load and 1.5 kg/hr solids loading
- Sludge handling system: Sludge holding tank, pumps, filter press.

4.5 In-plant / In-Process modifications

The configuration of the network inside the industry is divided into two different parts. The first one is purely industrial ww from the production units, mainly washing for equipment and floors in addition to intermittent flow (very limited) from an open channel receiving the spilled expired product. The second part is domestic wastewater from other services buildings in addition to the cooling water. This means that the industrial part could be handled separately without any additional works to the existing collection system. For cooling system, the only open cooling circuit is the cooling required of the ammonia compressors/ condensers. The amount of water consumed for this system is estimated of range between 40 to 60 m3/day. Therefore, a closed circuit was proposed leading to water saving of 50 m3/day in average. The proposed system constitutes of; cold water tank and pump, hot water tank and pump, cooling tower of 10 m3/hrin capacity, recycling line to the cold water tank.

6- CONCLUSION AND ASSESSMENT OF THE TREATMENT ALTERNATIVES

The physico-chemical analysis of COD, BOD, TSS, oil and grease during the process reached 9000, 5600, 1388, 560 mg/l respectively. As well as, analysis of COD, BOD, TSS, oil and grease final wastewater effluent reached 3600, 1925, 1288, 190 mg/l respectively. It was cleared from wastewater analyses that the discharged from the wastewater effluent from the both production lines and final wastewater effluentwere relatively high and violating the standards for discharge to the public sewer system (Decree 44/2000). Moreover, the high pollution load is mainly caused by the use of the same line for producing different products, milk and juice. This results in the need for additional washing and disinfecting of equipment and line as well as discharging unused material in the sewer. The best strategy to clean highly contaminated industrial wastewater is in general to treat them at the source and sometimes by applying onsite treatment within the production lines with recycling of treated effluent**.** A treatability study, analysis, as well as bench scale model were conducted for investigating the feasibility of each of identifying the different possible treatment trains, selecting the most suitable treatment train that need to be treated prior to its discharge to the sewer system. The study investigated the appropriate treatment techniques using three proposed streams of techniques; *DAF Unit Followed by biological treatment, Settling Unit Followed by biological treatment, standalone biological treatment via activated sludge.* As results from the treatability study and bench scale model, it was noticed that reduction of the COD by 50% was achieved by applying DAF Unit Followed by biological treatment or Settling Unit Followed by biological treatment. By applying the standalone biological treatment via activated sludge, reduction of the COD from 88 to 95 after 5 to 6 hours detention time was archived. Accordingly, from the study it was concluded that the standalone biological treatment via activated sludge process is the most reliable alternative treatment technique of this kind of industry.

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