Performance Evaluation of Wastewater Treatment of Different Industries

A Dissertation

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in

Environment Science and Technology

Submitted

By

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CERTIFICATE

This is to certify that thesis entitled, "**Performance Evaluation of Wastewater Treatment of Different Industries**" submitted by **Ms. Megha Rana** in partial fulfilment of the requirements for the award of **Masters of Technology** Degree in **Environment Science & Technology** at **Thapar University**, **Patiala** is an authentic work carried out by her under our supervision and guidance.

To the best of our knowledge, the matter embodied in this thesis has not been submitted to any other university/ institute for award of any Degree or Diploma.

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DECLARATION

I, the undersigned, hereby declare that the research work presented in the M.Tech project entitled "**Performance Evaluation of Wastewater Treatment of Different Industries**" has been carried out by me under the supervision and guidance of ***Mr. K.S.Babu, department, Thapar University, Patiala***.

Further, I declare that no part of this Dissertation has been submitted for a degree or any other qualification of any other university or examining body in India/elsewhere.

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ABSTRACT

Industries generate moderately concentrated wastewater in huge volumes in terms of COD, BOD, TSS, TDS, Phosphate, Sulphate etc. It is not feasible to treat this wastewater in a single stage to meet the stipulated standards instead a combination of suitable treatments is required. The main objective of this paper was to perform a comparative study between secondary and tertiary treated sample characteristics from different industrial wastewater. Samples were collected from five industries in which two were STP, Two were textile industries and one was dairy industry. Characterisation of samples was done and efficiency of all the parameter is calculated. Parameters like pH COD, BOD, TSS, TDS, Phosphate concentration and Sulphate concentration are estimated.

Efficiency of all the parameters of industries was calculated. For trident group (textile industry) efficiency of TSS, TDS, COD, BOD, Sulphate and Phosphate concentration are, 52.84, 2.59, 59.09, 36.75, 7.74,16.66 %. For Raipur Kalan (STP) efficiency of pH, TSS, TDS, COD, BOD, Sulphate and Phosphate concentration are 10.97, 76.86, 8.11, 56.16, 79.91, 35.71,31.08 % respectively. For Radiant textiles (textile industry) efficiency of pH, TSS, TDS, COD, BOD, Sulphate and Phosphate concentration are 11.68, 60.23, 27.58, 10.98, 28.74, 5.85,12.5 % respectively. For Crown Milk (Dairy industry) efficiency of TSS, TDS, COD, BOD, Sulphate concentration are 2.97, 23.59, 43.29, 6.15, 20.6, 9.41 % respectively. For Ludhiana (STP) efficiency of pH, TSS, TDS, COD, BOD, Sulphate and Phosphate concentration are 28, 4.37, 67.65, 74.86, 46.42, 36.95 % respectively.

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LIST OF ABREVIATIONS

BOD - Biochemical Oxidation Demand

COD – Chemical Oxidation Demand

TSS - Total Suspended Solids

TDS – Total Dissolved Solids

Mg/L – Milligrams per Litres

STP – Sewage Treatment Plant

CHAPTER 1

INTRODUCTION

1.1. General

Industrial (process) wastewater is water discharged after being used in, or produced by, industrial production processes and which is of no further immediate value to these processes. Where process water recycling systems have been installed, process wastewater is the final discharge from these circuits. To meet quality standards for eventual discharge into public collecting systems, this process wastewater is understood to be subjected to ex-process in-plant treatment. For the purpose of this indicator cooling water is not considered to be industrial wastewater.

Tertiary treatment of public wastewater: Treatment (additional to secondary treatment) of nitrogen and/or phosphorous and/or any other pollutant affecting the quality or a specific use of water: microbiological pollution, colour etc. For organic pollution the treatment efficiencies that define a tertiary treatment are the following: organic pollution removal of at least 95% for BOD and 85% for COD, and at least one of the following:

- Nitrogen removal of at least 70%
- Phosphorus removal of at least 80%
- Microbiological removal achieving a faecal coli form density less than 1000 in 100 ml

Tertiary treatment is part of the treatment process which wastewater must go through before it can be discharged into the environment. The process includes four or five stages. These are preliminary, primary, secondary, and tertiary wastewater treatment; sometimes, this is followed by an additional step. There are several different types of tertiary treatment, all of which involve improving the quality of the waste to reduce its impact on the environment into which it is released.

The purpose of this work is to:

- ensure that waste water treatment plants are operated to the highest possible standards,

- improve maintenance practices,
- ensure that assets provided are maintained,
- educate operators and equip them with the essential skills,
- develop management skills,
- provide operators with essential process theory,
- provide operators with a knowledge of treatment standards, and
- Create an awareness of the extent and uses of the equipment provided.

1.2. Introduction to Wastewater Treatment Processes

Wastewater treatment is closely related to the standards or expectations set for the effluent quality. Wastewater treatment processes are designed to achieve improvements in the quality of the wastewater. The various treatment processes may reduce:

- Suspended solids (physical particles that can clog rivers or channels as they settle under gravity).
- Biodegradable organics (e.g. BOD) which can serve as "food" for microorganisms in the receiving body. Microorganisms combine this matter with oxygen from the water to yield the energy they need to thrive and multiply; unfortunately, this oxygen is also needed by fish and other organisms in the river. Heavy organic pollution can lead to "dead zones" where no fish can be found; sudden releases of heavy organic loads can lead to dramatic "Fishkill's".
- Pathogenic bacteria and other disease causing organisms These are most relevant where the receiving water is used for drinking, or where people would otherwise be in close contact with it; and
- Nutrients, including nitrates and phosphates. These nutrients can lead to high concentrations of unwanted algae, which can themselves become heavy loads of biodegradable organic load Treatment processes may also neutralize or removing industrial wastes and toxic chemicals. This type of treatment should ideally take place at the industrial plant itself, before discharge of their effluent in municipal sewers or water courses.

Widely used terminology refers to three levels of wastewater treatment: primary, secondary, and tertiary (or advanced).

1. **Primary** (mechanical) treatment is designed to remove gross, suspended and floating solids from raw sewage. It includes screening to trap solid objects and sedimentation by gravity to remove suspended solids. This level is sometimes referred to as “mechanical treatment”, although chemicals are often used to accelerate the sedimentation process. Primary treatment can reduce the BOD of the incoming wastewater by 20-30% and the total suspended solids by some 50-60%. Primary treatment is usually the first stage of wastewater treatment. Many advanced wastewater treatment plants in industrialized countries have started with primary treatment, and have then added other treatment stages as wastewater load has grown, as the need for treatment has increased, and as resources have become available.

2. **Secondary** (biological) treatment removes the dissolved organic matter that escapes primary treatment. This is achieved by microbes consuming the organic matter as food, and converting it to carbon dioxide, water, and energy for their own growth and reproduction. The biological process is then followed by additional settling tanks (“secondary sedimentation") to remove more of the suspended solids. About 85% of the suspended solids and BOD can be removed by a well running plant with secondary treatment. Secondary treatment technologies include the basic activated sludge process, the variants of pond and constructed wetland systems, trickling filters and other forms of treatment which use biological activity to break down organic matter.

3. **Tertiary** treatment is simply additional treatment beyond secondary. Tertiary treatment can remove more than 99 percent of all the impurities from sewage, producing an effluent of almost drinking-water quality. The related technology can be very expensive, requiring a high level of technical know-how and well trained treatment plant operators, a steady energy supply, and chemicals and specific equipment which may not be readily available. An example of a typical tertiary treatment process is the modification of a conventional secondary treatment plant to remove additional phosphorus and nitrogen.

Disinfection, typically with chlorine, can be the final step before discharge of the effluent. However, some environmental authorities are concerned that chlorine residuals in the effluent can be a problem in their own right, and have moved away from this process. Disinfection is frequently built into treatment plant design, but not effectively practiced, because of the high cost of chlorine, or the reduced effectiveness of ultraviolet radiation where the water is not sufficiently clear or free of particles

1.3. Characteristics of Waste Water

Waste water is characterised in terms of its physical, chemical and biological constituents. The strength of waste water is normally measured using accurate analytical techniques. The more common analyses used to characterise waste water entering and leaving a plant are:

- BOD
- COD
- TSS
- pH
- Total phosphorus
- Total nitrogen

1.4. Parameters By Which Waste Water Is Measured

- **Biochemical oxygen demand (BOD)**: BOD is the amount of oxygen used by organisms while consuming organic matter in a waste water sample. It is possible to assess the performance of a waste water treatment plant by measuring the BOD of the inflow and the outflow. Many factors can influence this test, such as temperature of incubation, dilution rate, nitrification, toxic substances, nature of bacterial seed and presence of anaerobic organisms. The method of measurement for the BOD test in the WWT Regulations requires:
- that the sample is homogenised, unfiltered and undecanted; and
- a nitrification inhibitor is added.

The UWWT Regulations allow for the BOD5 test to be replaced by another parameter, total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD and the substitute parameter.

Chemical oxygen demand (COD): The COD test uses the oxidising agent potassium dichromate (specified in the UWWT Regulations) to oxidise organic matter in the sample. The test is extensively used because it takes less time (about 3 hours) than other tests such as the BOD, which takes 5 days. The COD test does not, however, differentiate between biodegradable and non-biodegradable organic matter. For municipal waste water it is generally possible to establish a relationship between COD and BOD. Once a correlation has been established, the COD test can be a very useful indicator for the operation and control of the plant.

Total suspended solids (TSS**):** This is the sum of the organic and inorganic solids concentrations and can be subdivided into:

- **Suspended solids:** which represent the solids that are in suspension in the water? Generally comprised of 70% organic and 30% inorganic solids and can be removed by physical or mechanical means.

- **Organic solids:** about 50% of solids present in urban waste water derive from the waste products of animal and vegetable life. Sometimes it is called the combustible fraction or volatile solids as these can be driven off by high temperature.

- **Inorganic solids:** these substances are inert and are not subject to decay. Include sand, gravel and silt.

pH: This is the concentration of hydrogen ions in solution and indicates the level of acidity or alkalinity of an aqueous solution. If the pH of the waste water is outside the range 5-10, there may be considerable interference with biological processes. Figure 2.1 illustrates the effect of pH on bacterial growth.

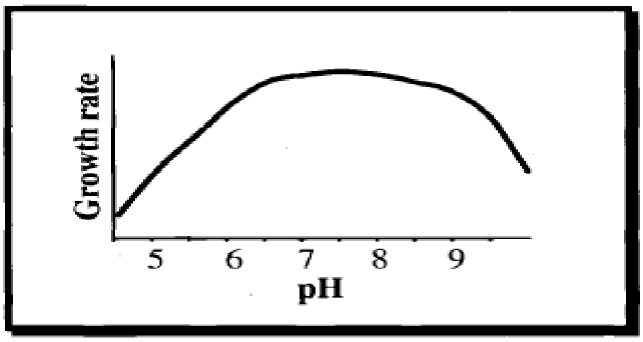


Fig.1.1 Growth rate of micro-organisms as a function of pH

Total phosphorus: This parameter is normally divided into two fractions, namely:

*orthophosphate***:** dissolved inorganic phosphate (P043)

polyphosphates: complex compounds generally derived from detergents

Total phosphorus analysis requires two steps:

- conversion of polyphosphates and organically bound phosphorus to dissolved orthophosphate, and
- colometric determination of the dissolved orthophosphate.

Total Nitrogen: This refers to the sum of measurements of total oxidised nitrogen (nitrate and nitrite) and total Kjeldahl nitrogen (ammonia and organic nitrogen). This parameter is a growth limiting nutrient in marine environments and a limit is specified in the UWWT Regulations for discharges to sensitive water bodies.

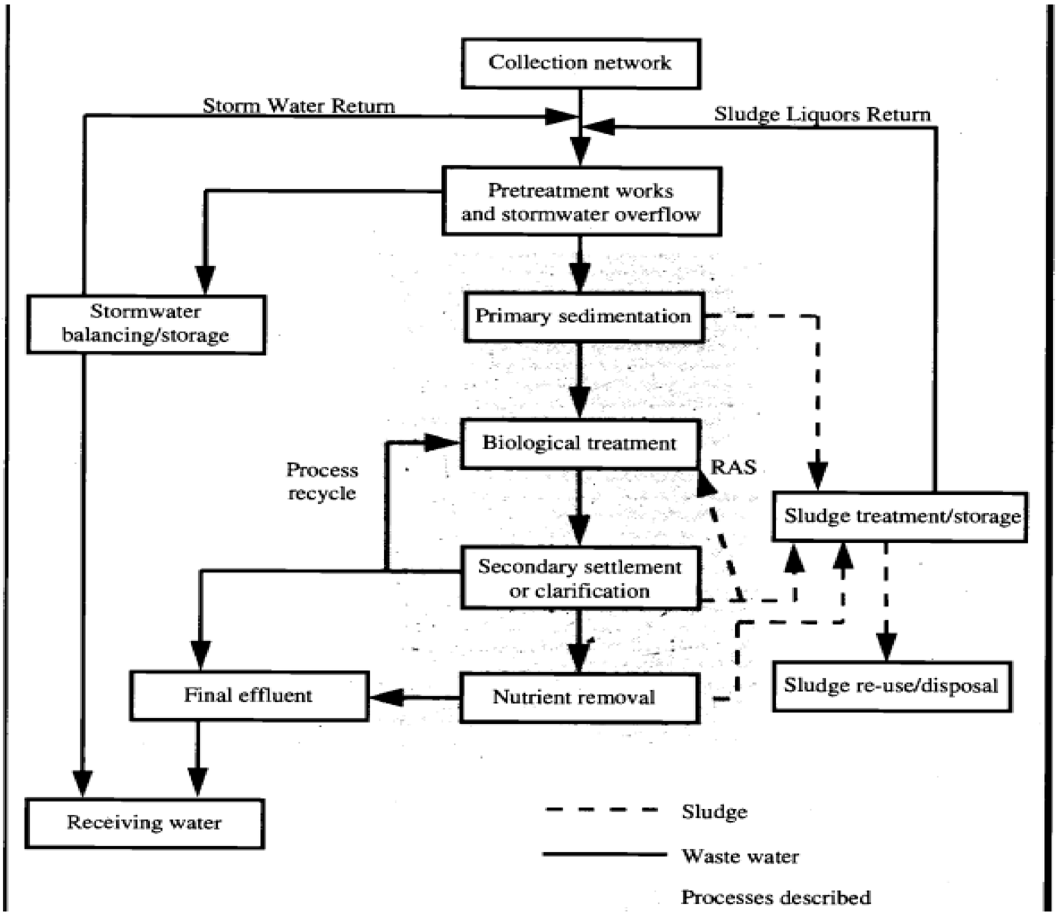


Fig 1.2. Waste water treatment Overview

1.5. Need For Project

Tertiary treatment is the next wastewater treatment process after secondary treatment. This step removes stubborn contaminants that secondary treatment was not able to clean up. Wastewater effluent becomes even cleaner in this treatment process through the use of stronger and more advanced treatment systems. Tertiary treatment can remove more than 99 percent of all the impurities from sewage, producing an effluent of almost drinking-water quality. The related technology can be very expensive, requiring a high level of technical know-how and well trained treatment plant operators, a steady energy supply, and chemicals and specific equipment which may not be readily available. An example of a typical tertiary treatment process is the modification of a conventional secondary treatment plant to remove additional phosphorus and nitrogen.

While the success of chlorine disinfection cannot be denied, there is concern that present chlorination practices, while appropriate for controlling bacterial disease, are inadequate to address viral agents present in industrial effluent. Importantly, widespread use of bacterial indicators, i.e. coli forms, is inadequate for assessing risks of viral exposure. This difference is further exaggerated following typical chlorination of wastewater (PWG, 1990) and has prompted environmental managers to consider disinfection methods other than chlorination.

1.6. Objectives

The purpose of these guidelines is to set environmental performance objectives for the treatment of industrial wastewater and suggest best practice measures to achieve these objectives. The guidelines target wastewater from sewage treatment plants.

- To characterize the waste water effluent such as secondary and tertiary effluent from different industrial sources.
- To compare the different treatment process of different industries.
- To check the efficiency of waste water of all the industries.

CHAPTER 2

LITRETURE REVIEW

2.1 Pulp and Paper Mill

Pulp and paper mill effluents are heterogeneous of their origin and composition. The analytical methods which are used in order to characterize the organic matter provide just limited information of the nature of the organic matter (SS, TOC, COD, BOD) or they are very selective, laborious and expensive (e.g. GC/MS). Size exclusion chromatography was used to asses the concentration of dissolved organic matter and molecular size distribution of the various effluent streams in a mechanical pulp and paper mill. Particular attention was paid to the transformation of dissolved organic matter during the primary, secondary and tertiary treatment stages of waste water treatment. According the conventional analyses the removal efficiencies were COD and BOD were 85 and 99 percent, respectively. The HPLCSEC method indicated much lower removal efficiencies for dissolved organic carbon removal. The method is simple, rapid and widely used in drinking water treatment plants but needs further testing and modification for forest industry effluents**. (Tuhkanen and Merta, 2006)**

2.2 Treatment of Herbal Pharmaceutical Industry Wastewater

Herbal pharmaceutical industries generate moderately concentrated wastewater in huge volumes in terms of COD, BOD, and SS in the range of 21960-26000 mg/L, 12200-15660 mg/L and 5460-7370 mg/L respectively. It is not feasible to treat this wastewater in a single stage to meet the stipulated standards instead a combination of suitable treatments is required. Physicochemical treatment studies were carried out using various conventional coagulants individually and in combination with six polyelectrolytes of three different charges. Among ten combinations, Alum 300 mg/L + Oxyfloc-FL-11 was found to be the best combination with respect to COD, BOD, and SS removals of 6266 mg/L (64.00%), 2867 mg/L (69.40%) and 637 mg/L (80.82%) respectively. Further this treated effluent was selected for secondary biological Activated Sludge Process (ASP) using optimal parameters like organic/ hydraulic loadings.

Removals of organics in terms of absolute value of COD, BOD, and SS were found in the range with an absolute value of 896-944 mg/L, 156-174 mg/L and 66-74 mg/L respectively. Finally ASP treated effluent was subjected to tertiary Fenton's oxidation process where the removals of COD, BOD, SS, and TOC were found to be efficient with 138 mg/L (85.19%), 20 mg/L (88.10%), 21 mg/L (70.00%), and 98 mg/L (78.22%) respectively on optimum conditions, which is well below the prescribed standards. This article discusses in details the results obtained on Primary Physico-chemical, secondary biological and advanced oxidation treatment. (**Vanerkar et al. 2013)**

2.3 Removal of Heavy Metals from Wastewater

This research concerns the further characterisation and establishment of adsorption behaviour of the South African clinoptilolite. Synthetic single- and multi-component wastewaters were used, and experiments conducted in both batch and column systems at 25oC ± 2. Wastewaters containing heavy metals ions Cu^{2+}, Co^{2+}, Ni^{2+} and Cr^{3+}, were used at different feed concentrations (50 - 500 mg/L), and adsorbed onto natural and homoionic (Na^{+}, K^{+}, Ca^{2+}, NH+ 4) forms of the zeolite. The Na+-form clinoptilolite had an improved cation exchange capacity over the natural one, and the selectivity series of metal ions by these two forms varied. Brunauer Emmett Teller surface area analysis carried out also confirms that preconditioning clinoptilolite with Na+ ions results in an increase in pore diameter, allowing for easier diffusion of ions and more adsorption. An atomic adsorption spectrophotometer (AAS) was used to analyse metal ions in solution. Adsorption efficiencies with over 75% of metal ions adsorbed in the first hour of contact were recorded, and complete adsorption equilibrium being reached in 4 hrs. Regeneration of Na+-form and natural clinoptilolite (using 0.5M NaCl stripping solution) initially showed an increase in loading capacities, then a decrease with the subsequent cycles. A comparison between two particle sizes revealed that smaller particle sized clinoptilolite have slightly higher adsorption capacities. The equilibrium data also fitted well with the linear form of the Langmuir and Freundlich isotherms at lower concentrations of 50 mg/L. **(Kapanji, 2009)**

2.4 Performance Evaluation of Wastewater Treatment Plant for Milk Based Food Industry

Dairy industry is one of the major industries causing water pollution. In India, dairy industry generates about 6-10 L wastewater/L of milk processed depending upon the process employed and product manufactured. Considering the increased milk demand by 2020 A.D., the milk based food industries in India is expected to grow rapidly and have the waste generation and related environmental problems are also assumed increased importance. Poorly treated wastewater with high levels of pollutants caused by poor design, operation or treatment systems creates major environmental problems when discharged to surface water or land. Considering the above stated implications an attempt has been made in the present project to evaluate one of the WWTP for dairy waste. Samples were collected from six points; Raw effluent [P-1], Oil and grease trap [P-2], Equalization tank [P-3], Aeration tank 1 [P-4], Aeration tank 2 [P-5] and Secondary clarifier [P-6] to evaluate the performance of WWTP. Parameters analyzed for evaluation of performance of WWTP are COD, BOD_5 at 20° C, TSS, Total Nitrogen, Phosphorous, oil and grease, Chloride and Sulphates. Mass balance of COD, TSS and Nitrogen was performed to find the fate of pollutants in WWTP.

Parameters like SAR, Na, Salinity, RSC, pH and oil & grease were used to access the suitability of secondary effluent for reuse in irrigation. The COD, BOD_5 at 20° C and TSS removal efficiency of WWTP were 96%, 95%and 94% respectively. The TDS, SAR, RSC, Chloride, Potential salinity of secondary effluent were 966.7 mg/L, 0.06 meq/L, -2.1 meq/L, 209.9 mg/L and 10.7 meq/L respectively, which are in acceptable range for irrigation. **(Sharma 2008)**

2.5 Textile Industrial Waste Water in Sholapur City

Six textile industries have been selected in East region of Solapur city based on field analysis and characterization studies. Textile effluent from these selected industries is collected and characterized for major pollution indicator parameters namely BOD, COD, TDS, sulphide, sulphate, chloride, hardness, alkalinity, calcium and magnesium.

The effluent is dark colored with alkaline pH. The values of BOD and COD are found to be higher than Central Pollution Control Board, Government of India and also ratio of BOD : COD lies between 0.2 – 0.35 indicates that effluent contains large proportion of non-biodegradable matter. The concentration of total dissolved solid are observed to be higher than 5000 mg/L. The effluent also contains high concentration of sulphate, sulphide, chloride, calcium and magnesium, which are responsible for higher hardness of waste water. The results showed that, the textile industries under study area emanate effluent containing pollution indicator parameters considerably higher than standards stipulated by Central Pollution Control Board. Based on these characteristics, it is suggested that the effluent is not be suitable for discharge into environment without treatment**. (PAUL et al. 2012)**

2.6 Improvements on Industrial Wastewater Treatment

The thesis study consists of two main experimental analyses for chemical pre-precipitation and acid hydrolysis. Chemical pre-precipitation of primary effluent been done using the chemicals Ca2+ and Mg2+ as in Ca(OH)2 and MgCl2 within the concentrations range, 10-30 mg/l for Ca2+ and 10-40 mg/l for Mg2+ with measurements done on percentage reductions of COD, total phosphorus and total nitrogen, and percentage increases of conductivity and alkalinity. The feasibility evaluation of the integration of local Sri Lankan industries to the particular novel wastewater treatment technology was done following a literature analysis as well as by means of the authors’ experience and knowledge on the aspects, obtained by living in Sri Lanka for over twenty six years.

The results of the experimental study on chemical pre-precipitation with Ca2+ and Mg2+ have been discussed for; the deviations when observed over the expected results and the possible causes as well as the suggestions for improvements, while comparisons for the other conventional solutions and similar processes were done. The pros and cons of these alternatives are also discussed in brief. The Integration of the local Sri Lankan industries to the wastewater treatment was also discussed assessing the present context and potential of expansion of these chemicals industries. A brief cost evaluation was also done comparing the study focuses against other common and conventional solutions. In addition, several recommendations for future studies have also been offered, to continue or to improve the study focuses. **(Gunasekara 2011)**

2.7 Study for Industrial Wastewater Treatment Using Some Coagulants

The motivations for treatment of wastewater are manifold. Treatment and reuse of wastewater conserves the supply of freshwater and this presents clear advantages with respect to environmental protection. The main objective of this paper was to perform a preliminary comparative study between some coagulants on the removal of suspended solids and organic matter from mixed industrial wastewater. Samples were collected from the inlet of 10th of Ramadan City stabilization ponds, Egypt. The 10th of Ramadan City, as one of the major industrial cities in Egypt, suffer from serious environmental problems arise from the flooding of polluted wastewater to the Shabab Canal and Wady El Waten Drain.

Standard jar test with minor modification was used in the laboratory experiment. The procedures included rapid mixing, followed by slow mixing and settling. Supernatant was taken for determination of transitivity and chemical oxygen demand (COD) tests. The coagulants used included aluminium sulphate, ferric sulphate, lime, and ferric chloride with wide dosages range up to 250 mg/l. The best transmittance of treated wastewater was 100% with the use of alum and ferric chloride coagulant. It was found that the aeration of the coagulant and settled samples improved the COD removal efficiency than that the samples were not coagulated by about 41%. **(Karamany, 2010)**

2.8 Pharmaceutical Wastewater Treatment

A physicochemical study for the treatment of pharmaceutical wastewater was performed. Objective of the laboratory investigation was to study the removal of color, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), turbidity and phenol and bring them up to the allowable limits for reuse purposes. Efficiency of coagulation, flocculation, sedimentation, sand filtration followed by activated carbon adsorption was determined. It was found that tested coagulants (alum, ferric chloride, and ferrous sulphate) are not much effective and required high dosage for the removal; of TSS, BOD, COD and turbidity. Alum was found to be more effective among tested coagulants and reduce TSS, BOD, COD and turbidity 79.6%, 34.8, 48.6% and 69.2% respectively. Sand filtration further reduced the studied parameters 97.7%, 95.7%, 93.9% and 76.9% respectively. As the concentration of phenol in the studied pharmaceutical wastewater was

100 mg/l, granular activated carbon was used to remove phenol up to the allowable limit for reuse purpose. Activated carbon adsorption further reduces phenol, TDS, TSS, BOD, and COD up to 99.9%, 99.1%, 21.4%, 81.3% and 71.1% respectively. High removal of colour observed after activated carbon adsorption. It was concluded that the suggested treatment scheme is suitable to bring the effluent quality up to the water quality standards. **(Muhammad, 2008)**

2.9 Textile Wastewater Treatment

A treatability study of textile wastewater using coagulation by adding polyelectrolytes ((1-2 ppm) at pH (6.7-7.5) and primary sedimentation followed by aeration and final settling gave a good results. COD decreased from 1835 to 120 ppm, SS decreased from 960 to 120 ppm and sulphate from 1350 to 125 ppm. In the full-scale treatment plant filtration is used to improved results by decreasing COD, from 263 to 55 and SS from 295 to 10 and Sulphate from 158 to 100 ppm respectively. (**Seif and Moheb, 2005)**

2.10 Effects of Conventional Treatment, Tertiary Treatment and Disinfection Processes on Hygienic and Physico-Chemical Quality of Wastewaters

The aim of this study was to evaluate the efficiency of different wastewater treatment processes on the removal of enteric microorganisms, phosphorus and organic matter from municipal wastewaters. The treatment efficiency of conventional biological-chemical wastewater treatment processes was studied in four Finnish municipal WWTPs. The effect of tertiary rapid sand filtration (RSF) and dissolved air flotation (DAF) processes, as well as chemical and biological-chemical contact filtration processes, on wastewater quality was studied in pilot-scale experiments. The applicability of the DAF process for treatment of primary wastewater effluents was also studied in pilot-scale experiments to assess the applicability of the process for treatment of WWTP by-passes. Some experiments were carried out in two full-scale tertiary DAF plants. The disinfection efficiencies of peracetic acid (PAA), hydrogen peroxide (H2O2), sodium hypochlorite (NaClO) and ultraviolet (UV) disinfection treatments as well as the synergistic effects of combined use of chemical disinfectant and UV were investigated in laboratory-scale experiments, followed by pilot-scale PAA disinfection experiments of municipal primary, secondary and tertiary effluents.

Primary and secondary wastewater treatment with simultaneous phosphorus precipitation achieved around 95 % reductions of organic matter and phosphorus from the municipal wastewaters. The numbers of enteric microorganisms were typically reduced by between 90 and 99.9 %, but the secondary effluents still contained high microbial numbers, including pathogenic salmonellae. The tertiary RSF or DAF processes efficiently removed residual organic matter and phosphorus, and removed 90-99 % of enteric microorganisms from the secondary effluents. Increasing the coagulant dose (from 2 to 10 gAl3+/m3) and the dispersion water recycle ratio (from 11 to 22 %) improved the purification results, whereas changing the flocculation conditions (G-value, retention time) or increasing the hydraulic surface load (from 5 m/h to 10 m/h) did not clearly affect the tertiary DAF process efficiency. The DAF process achieved significant reductions of enteric microorganisms, phosphorus and organic matter in the treatment of primary wastewater effluents, demonstrating that the process can tolerate high loads of suspended solids and could be used for the treatment of WWTP by-pass wastewaters during the WWTP over-loading situations. **(Koivunen, 2007).**

2.11 Biological Aerated Filters (Bafs) For Carbon And Nitrogen Removal

Biological aerated filters (BAFs) are an emerging wastewater treatment technology designed for a wide range of municipal and industrial applications. This review paper presents and discusses of the influence C/N ratio, nitrification and denitrification principle, effect of pH, DO and alkalinity on the nitrification and denitrification systems, organic and hydraulic loading of BAF reactor, etc. Results from upflow and downflow biofilter pilot at different condition, with nitrification and denitrification are reviewed. Under the optimal conditions, significant amount of COD, ammonia-nitrogen and total nitrogen were removed. Removal rates based on reactor volume for different carbonaceous COD and ammonia loading rate are reported. The BAF system for the nitrification and denitrification processes for carbon and nitrogen removal from the wastewater need to be evaluated and applied properly to protect of our environment and resources. **(Fatihah and Shahrom, 2012)**

2.12 Phosphorous Removal from municipal wastewater

The purpose of this report is to give an overview of different methods for phosphorus removal from municipal wastewater. Focus is given to chemical precipitation and enhanced biological phosphorus removal although also other methods are discussed, namely, local treatment methods and ecological and natural treatment systems. The basic removal mechanisms, process schemes and treatment results are described. In the report, a historical background is also given of phosphorus removal methods and trends in research and process design. Important factors for process design is hereby also treatment requirements for other components in the wastewater and interactions with sludge handling. The need for better evaluation methods of different phosphorus removal processes is pointed out. **(Stockholm, 1997)**

2.13 Nitrogen Removal from dairy manure wastewater

The purpose of this research was to characterize a flushed dairy manure wastewater and to develop the kinetic and stoichiometric parameters associated with nitrogen removal from the wastewater, as well as to demonstrate experimental and simulated nitrogen removal from the wastewater. The characterization showed that all the wastewaters had carbon to nitrogen ratios large enough for biological nitrogen removal. Analysis of carbon to phosphorus ratios showed that enough carbon is available for phosphorus removal but enough may not be available for both nitrogen and phosphorous removal in anaerobically pretreated wastewater. In addition, kinetic and stoichiometric parameters were determined for the biological nitrogen removal in sequencing batch reactors for the dairy manure wastewater. Results showed that many parameters are similar to those of municipal wastewater treatment systems. This characterization and the derived kinetic and stoichiometric parameters provided some of the information necessary for development of a nitrogen removal process in a sequencing batch reactor. Lab scale treatment of a 1:2 dilution of the anaerobically pretreated wastewater was demonstrated. (**David P. Whichard**, **2004)**

Treatment was able to achieve between 89 and 93% removal of soluble inorganic nitrogen as well as up to 98% removal of biodegradable soluble and colloidal COD. In addition, a solids removal efficiency of between 79 and 94% was achieved. The lab scale treatment study demonstrated that sequencing batch reactors are capable of achieving high nitrogen removal on wastewaters with the carbon to nitrogen ratios of the dairy manure wastewater. Model simulations of the treatment process were used to develop a sensitivity analysis of the reactor feed configuration as well as the kinetic and stoichiometric parameters. The analysis of the feed configuration demonstrated the advantage of decreasing the amount of feed that is fed in the last feed period so that the effluent nitrate will be minimized. The analysis indicated that the autotrophic growth rate is one of the most important parameters to measure while error in the heterotrophic decay or yield values can lead to miscalculations of oxygen required for treatment.

2.14 Nitrogen removal from wastewater by an aerated subsurface flow constructed wetland

The purpose of this research was to assess the ability of subsurface flow wetlands, with aeration and vegetation, to remove nitrogen in cold weather climates. Aeration was shown to enhance the wetland cell's ability to remove not only nitrogen but also CBOD, COD, and phosphorus (retention) more effectively. There was a significant difference ($p< 0.05$) in both total nitrogen and ammonia effluent concentrations comparing aerated to unaerated wetland cells, while no significance was found comparing planted and unplanted wetland cells.

The effluent ammonia concentrations from the aerated wetland cells ranged from 2.7 to 5.7 mg N/L, while for unaerated cells effluent concentration ranged from 22 to 23 mg N/L. The effluent total nitrogen concentrations from the aerated wetland cells ranged from 9.0 to 12 mg N/L, while those from unaerated cells ranged from 23 to 24 mg N/L. The effluent concentrations showed no significant difference ($p < 0.05$) when comparing results of three temperature ranges. There is a correlation when comparing ammonia mass removal rates to mass loading rates. Ammonia removal in the aerated wetland cells ranged from 82 to 95%, while unaerated cells ranged from 39 to 45%. The hydraulic retention times ranged from 3.13 to 4.33 days and the tanks-inseries ranged from 1.46 to 2.84. Using this information the wetland cells were modelled using both the TIS and the PkC models. The k values (PkC model) of the aerated wetlands for ammonia ranged from 131 to 221 m/d, while the unaerated wetland cells had values ranging from 20.4 to 36.7 m/d. The models appear to show a good prediction of the effluent ammonia concentration for the unaerated cells but the aerated cells show the model does not effectively capture the effects of aeration **(Redmond, 2012)**

2.15 Tertiary waste treatment and disposal system

Waste water treatment and disposal system for further treating waste water effluent from a primary treatment system in which a system controller controls the operation of the system. A dosing tank accepts effluent from a primary treatment system and is evacuated on demand by a pump which is energized in response to a fluid level switch in the dosing tank. The pump forces the effluent through altering system to remove solid waste there from, and then forces a portion of the altered effluent into a hydro-pneumatic pressure tank which, upon call, will back flush the alter to remove the trapped solids therein. The system controller will monitor the system to operate the level of the dosing tank, the operation of the pump and the various valves which control the flow throughout the system. The altered effluent will ultimately be discharged into a disposal area by any number of well known methods. One such method may be by a dripper held in which the effluent is emitted through multiple drip emitters in a plurality of pipes laid underground. The system also has the capability of back flushing the dripper field to maintain the emitters opening and operating**. (Sinclair et al., 2012)**

2.16 Removal of Emerging Contaminants from Water and Wastewater by Adsorption Process

Emerging contaminants are chemicals recently discovered in natural streams as a result of human and industrial activities. Most of them have no regulatory standard and can potentially cause deleterious effects in aquatic life at environmentally relevant concentrations. The conventional wastewater treatment plants (WWTPs) are not always effective for the removal of these huge classes of pollutants and so further water treatments are necessary. This chapter has the aim to study the adsorption process in the removal of emerging compounds. Firstly, a brief description of adsorption mechanism is given and then the study of conventional and non-conventional adsorbents for the removal of emerging compounds is reviewed with the comparison between them. **(Grassi and Kaykioglu, 2006)**

2.17 Phosphorus Removal from Wastewater via Environmentally Friendly Technologies

Stringent parameters for outlet wastewater quality lead to the development of advanced technologies for pollutant removal. It can be expected that not only nutrients, but also other pollutant as bacteria, viruses, hormones, PPCPs are expected to be subject of WWTP outlet quality standards. Phosphorus is essential nutrient for living beings, however its excessive concentration in water environment could lead to the proliferation of cyanobacteria and water bloom creation. Not sufficiently treated wastewater treatment plant outlets are important sources of the phosphorus in water environment. Many developed countries already adopted legislation dealing with phosphorus removal, however outlet standards are still high (more than 1 mg/L) and not sufficient for the elimination of excessive phosphorus elimination from the environment. Our team tested unique techniques for phosphorus removal via tertiary treatment using iron nanoparticles. We present data of phosphorus elimination from several municipal wastewater treatment plant outlets. **(Holba, et al, 2012)**

2.18 Tertiary Treatment for Textile Waste Water

Tertiary treatment is the Industrial waste water treatment process which removes stubborn contaminants that have not been removed in secondary treatment. Effluent becomes even cleaner by Tertiary treatment through the use of stronger and more advanced treatment systems. The present work is an attempt to review all possible tertiary treatment methods for removal of dyestuff from textile effluent. Conventional method for treatment of textile effluent has own certain limitations that can be well overcome by tertiary waste water treatment. (**Somashekar, 2008)**

2.19 Assessment of the Efficiency of Sewage Treatment Plants

Bangalore city hosts two Urban Wastewater Treatment Plants (UWTPs) towards the periphery of Vrishabhavathi valley, located in Nellakedaranahalli village of Nagasandra and Mailasandra Village, Karnataka, India. These plants are designed and constructed with an aim to manage wastewater so as to minimize and/or remove organic matter, solids, nutrients, disease-causing organisms and other pollutants, before it reenters a water body. It was revealed from the performance study that efficiency of the two treatment plants was poor with respect to removal of total dissolved solids in contrast to the removal/reduction in other parameters like total suspended solids, BOD and COD.

In Mailasandra STP, TDS, TSS, BOD, and COD removal efficiency was 20.01, 94.51, 94.98 and 76.26 % and respectively, while in Nagasandra STP, TDS, TSS, BOD, and COD removal efficiency was 28.45, 99.0, 97.6 and 91.60 % respectively. The order of reduction efficiency was TDS < COD < TSS < BOD and TDS < COD < BOD < TSS respectively in Mailasandra and Nagasandra STPs. Additionally, the problems associated with the operation and maintenance of wastewater treatment plants is discussed. **(Kumar and Pinto, 2010)**

2.20 Characterization of Dairy Effluents by Physicochemical Parameters

Aims: The dairy industry faces growing scrutiny of its environmental stewardship. The potential impact of an individual operation on the environment varies with animal concentration, weather, terrain, soils, and numerous other conditions. It is hoped that management practices found on dairy industry will benefit by the management practices. So properly apply the Management Practices, the factual study of dairy effluent by various Physico-chemical characters concern for environmental health and safety.

Study Design: Effluent samples were collected from dairy industries. The samples were characterized by physical parameters like pH, temperature, TS, etc. and chemical parameters BOD, COD, DO etc.

Place and Duration of Study: Effluent samples were collected from dairy industry of district Kolhapur Maharashtra (India).Physico-chemical characteristics of the effluent during the months between March to August 2011.

Methodology: Total 4 samples of dairy effluents were collected by composite sampling at the time 9, 12, 3, 6 o'clock per day and stored at 4oc for further analysis. Then on the next day in quintet it was subjected to analyze the physicochemical parameters like Temperature, pH, DO, TDS, TSS, TS, BOD, COD, chloride, Sulphate, oil and Grease.

Results: The study revealed that the dairy effluent is slightly alkaline in nature, and high temperature, BOD & COD values obtained by the analysis of dairy effluents indicate the presence of heavy load of organic substances. Also a higher temperature and oils and Greases which lower the dissolved oxygen activities can cause serious problems in disposal of waste water. Above the standard value suspended and dissolved organic solids are responsible for creating nuisance.

Conclusion: Dairy industry tested in this study was found high levels of pH, BOD, COD, TSS It is very important that proper waste water treatment systems should be installed for the protection of the environmental health and for the ecological balance**. (Sukhadev and Wani1, 2013)**

2.21 Wastewater Characterization in the Sultanate of Oman

This study focuses on characterizing the quality of domestic wastewater from six different sewage treatment plants (STP) in three regions in Oman: Muscat, Sohar and Salalah. The tested parameters are pH, electrical conductivity (EC), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), ammonia, cations, anions, solids gravimetric tests (total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS)), and microbial content. Results revealed that, the raw sewages in all STPs can be categorized as high strength concentration.

The values of pH for raw sewage (RS) and treated effluents (TE) were in the range of 6 to 7.5 for the entire sampling points in the six selected STPs. The EC values of the TEs for the six STPs were within the Omani Standards (OS) range of 2000 to 2700 µs/cm. Both BOD5 and COD values of TE were within the recommended limits by OS of 15 to 20 mg/L and 150 to 200 mg/L, respectively. Ammonia concentrations in TEs exceeded the acceptable range in most STPs. Fluoride, Chloride, Phosphate and Sulphate concentrations were within the acceptable ranges of OS. Nitrate concentration in TEs of two STPs exceeded the recommended limit. The average obtained values of the entire set of tested heavy metals were found within the stated limits by OS for TEs except for Mo. The TSS in TEs was above the acceptable range of 15 to 30 mg/L. However, the values of TDS for TEs were within the suitable range of 1500 to 2000 mg/L according to OS. The obtained values for E Coli were all acceptable except for one STP**. (Gautam et al, 2007)**

CHAPTER 3

MATERIALS AND METHODS

3.1 SAMPLING

Five types of samples were collected from different industries. From each industry two samples were taken, one from secondary outlet and the other from tertiary outlet. This study was undertaken to detection of the important pollution parameters from industry wastewater. Sample points are described below-

- **TRIDENT GROUP TEXTILES, BARNALA-** Trident Group situated in Barnala District, Sanghera is a leading diversified business conglomerate of India. Incorporated in 1990. With a modest beginning of 17,280 spindles of yarns, the group today exports to over 75 countries and is continuously striving to uphold its position as one of the largest yarn producers in India.

- **RADIANT TEXTILES, SAMANA-** Radiant Textiles Ltd. Situated in village chounth, Patiala, Samana. Mill came into operation in the year 2008. Our installed capacity is 52,800 cotton ring spindles and we are based in Punjab, one of the major cotton producing provinces in India. Our proximity to cotton producing area helps us in keeping a constant vigil on cotton quality and consistent supply of quality cotton.

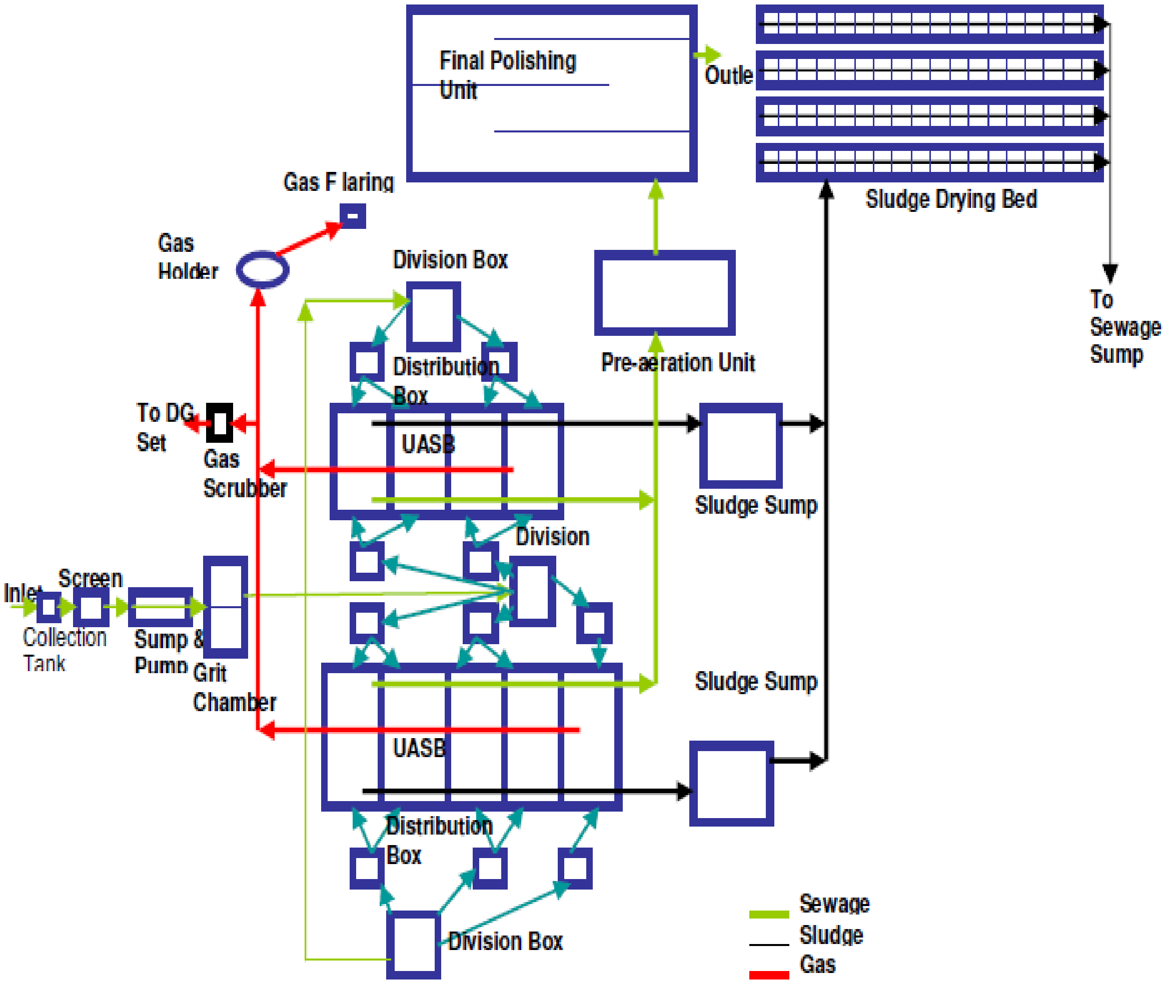
- **STP, RAIPUR KALAN, CHANDIGARH-** STP was situated near isbt sector Chandigarh**.** It is a UASB based sewage treatment plant. The sample 1 was collected from UASB unit and sample 2 was collected from final polishing unit. The sample is taken and stored.

- **CROWN MILK, MOHALI**- It is situated in Industrial area, Sector 7b, Mohali. CMSL has now grown into a leading milk industry with a handling capacity of 500,000 litres/day. CMSL is a premier dairy in private sector in North India and is marketing complete range of dairy products (Acid Casein, Demineralised whey powders, Skimmed milk powder, Whole milk powder, Ghee) under the brand name of crown.

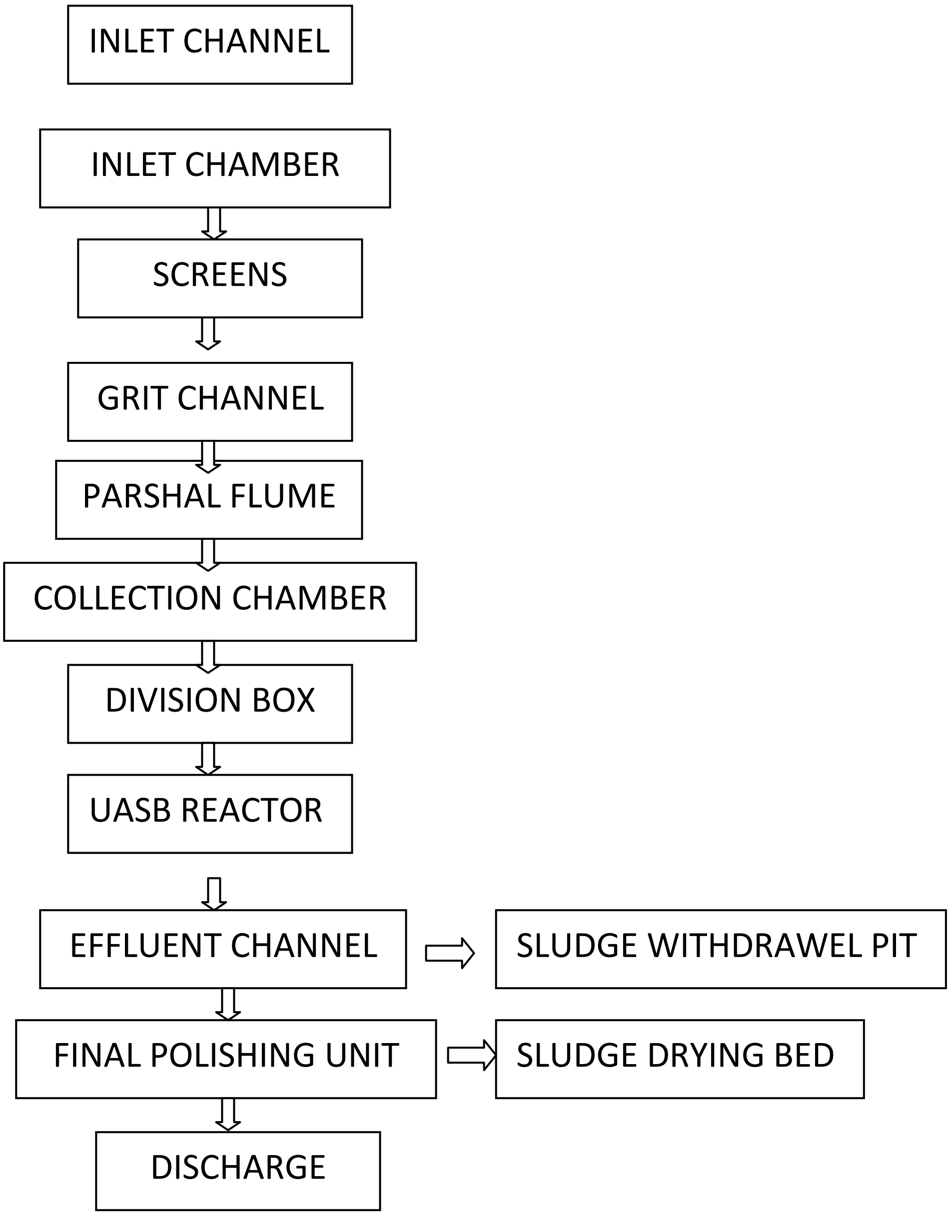
- **STP, BHATTIAN, LUDHIANA**- STP was situated at village Bhattian, Ludhiana**.** It is a UASB based sewage treatment plant. The capacity of plant is 111 MLD. The sample 1 was collected from UASB unit and Sample 2 was collected from Chlorination unit. The sample is taken and stored in the laboratories.

Flow diagrams of Wastewater Treatment Plants

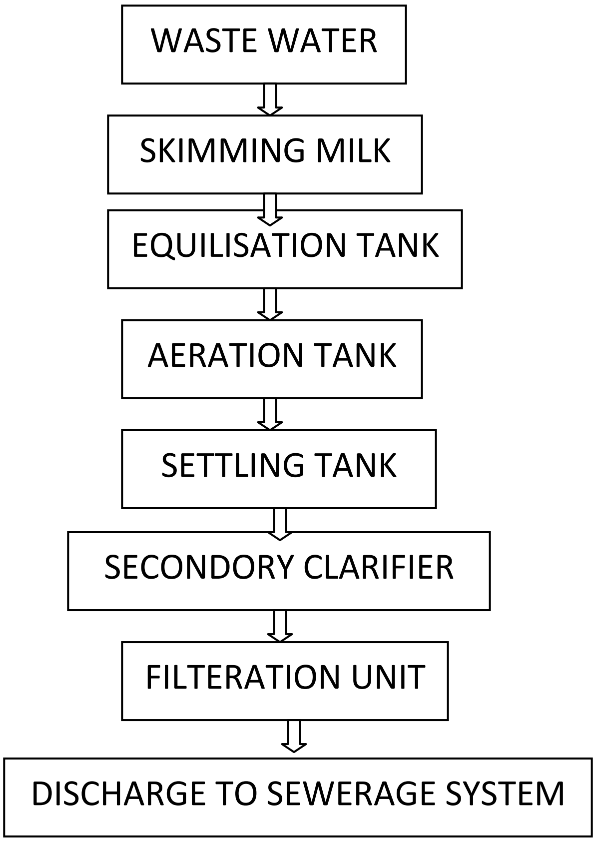
1. STP, Bhattian, Ludhaina



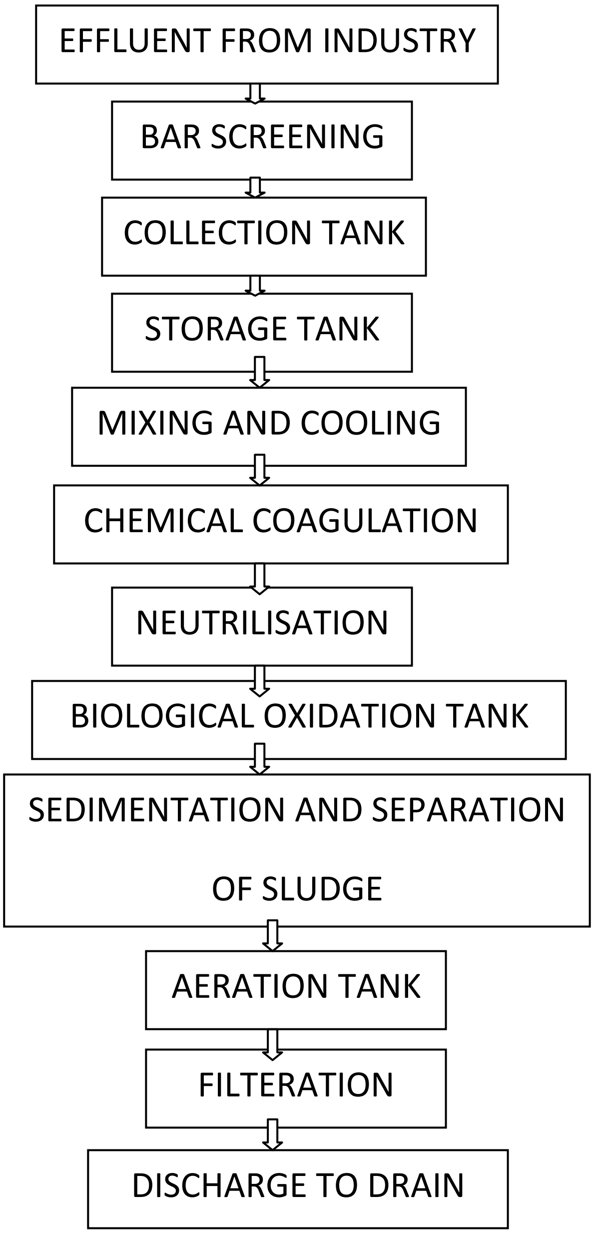
2. STP, Raipur Kalan, Chandigarh



3. Crown Milk, Mohali-



4. Radiant Textiles, Samana



3.2 METHODOLOGY

3.2.1. BOD

Apparatus

- BOD bottles, 300 mL, narrow mouth, flared lip, with tapered and pointed ground glass stoppers.
- Air incubator or water bath, thermostatically controlled at 27 ± 1°C. Light entry must be prevented in order to avoid photosynthetic oxygen production
- Accessories: plastic tube, screw-pin and a 5-10 L water container.

Reagents

- *Phosphate buffer solution*. Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4.7H_2O$ and 1.7 g NH_4Cl in 1L distilled water.
- *Magnesium sulphate solution.* Dissolve 22.5 g $MgSO_4.7H_2O$ in 1L distilled water.
- *Calcium chloride solution.* Dissolve 27.5 g $CaCl_2$ in 1L distilled water.
- *Ferric chloride solution.* Dissolve 0.25 g $FeCl_3.6H_2O$ in 1L distilled water.
- *Acid and alkali solution.* 1*N* NaOH and 1*N* H_2SO_4. Use for neutralising samples.
- *Glucose-glutamic acid solution (prepare fresh).* Dissolve 150 mg dry reagent grade glucose and 150 mg dry reagent grade glutamic acid in 1L distilled water
- *Sample dilution water*. Add 1 mL each of phosphate buffer, $MgSO_4$, $CaCl_2$ and $FeCl_3$ solutions per litre distilled water.

Procedure

- Prepare required amount of dilution water at the rate of 1000 to 1200 mL per sample per dilution. Bring the diluted water temperature to 27°C. Saturate with air by shaking in a partially filled bottle, by bubbling with organic free filtered air or by storing in cotton-plugged bottles for a day.
- Some samples do not contain sufficient microbial population (for example, some industrial wastes, high temperature wastes, or wastes with extreme pH values). For such wastes, the dilution water is seeded using effluent from a biological treatment system processing the waste. Where this is not available, use supernatant from domestic wastewater after settling for at least 1 h but not more than 36 h. Seed from a

surface water body receiving the waste may also be suitable. Add enough seed volume such that the DO uptake of the seeded dilution water is between 0.6 and 1.0 mg/L. For domestic wastewater seed, usually 4 to 6 mL seed / L of dilution water is required. Surface water samples usually do not require seeding.

- Dilution of sample. Dilutions must result in a sample with a residual DO (after 3 days of incubation) of at least 1 mg/L and a DO uptake of at least 2 mgl/L. Make several dilutions using the Table and experience with the particular sample source. Polluted surface waters may have 5 to 25 mg/L BOD

For preparing dilution in graduated cylinders, siphon dilution water, seeded if necessary, into a 1 to 2 L capacity cylinder. Siphoning should always be done slowly without bubbling, use a screw-pin on the tube to regulate the flow. Keep the tip of the tube just below the water surface as it rises. Fill cylinder half full, add desired quantity of sample and dilute to appropriate level, mix with plunger type mixing rod. Siphon mixed diluted sample in three BOD bottles, stopper without entraining any air. Determine initial DO (method 1.9) on one bottle and incubate the other two at 27°C. Determine final DO (method 1.9) in duplicate after 3days.

For direct pipetting, siphon the desired sample volume to individual bottles and fill with enough dilution water. Complete the test as in the earlier case.

- Dilution water blank. Find the DO consumption of unseeded dilution water by determining initial and final DO as in c above. It should not be more than 0.2 mg/L
- Seed control. Determine the DO uptake by seeding material according to the procedure in above.

Calculation

- When dilution water is not seeded:

  $$\text{BOD (mg/l)} = \frac{D_o - D_T}{P}$$

Where:

D0 = DO of diluted sample initially, mg/L

DT = DO of diluted sample after 3 day incubation at 27°C, mg/L

P = decimal volumetric fraction of sample used

3.2.2. COD

Apparatus

- *Reflux flasks*, consisting of 250 mL flask with flat bottom and with 24/29 ground glass neck
- *Condensers*, 24/29 and 30 cm jacket Liebig or equivalent with 24/29 ground glass joint, or air cooled condensers, 60 cm long, 18 mm diameter, 24/29 ground glass joint.
- *Hot plate* or gas burner having sufficient heating surface.

Reagent

- *Standard potassium dichromate solution, 0.0417M (0.25N)*: Dissolve 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 103^{o}C for 2 hours, in distilled water and dilute to 1L.
- *Sulphuric acid reagent*: Add 5.5g Ag_2SO_4 technical or reagent grade, per kg of conc. H_2SO_4, keep for a day or two to dissolve.
- *Ferroin indicator solution*: Dissolve 1.485g 1, 10-phenanthroline monohydrate and 695 mg $FeSO_4.7H_2O$ in distilled water and dilute to 100 mL. Commercial preparation may also be available.
- *Standard ferrous ammonium sulphate (FAS), titrant, 0.25M*: Dissolve 98g Fe $(NH_4)2$ $(SO_4)2.6H_2O$ in distilled water, add 20 mL conc. H_2SO_4, cool and dilute to 1L, standardise daily as follows.
- Standardisation: Dilute 10 mL standard $K2Cr_2O_7$ to about 100 mL, add 30 mL conc H_2SO_4, cool. Add 2 drops of ferroin indicator and titrate with FAS.
- *Mercuric Sulphate, $HgSO_4$*, powder
- *Potassium hydrogen phthalate (KHP) standard*: Lightly crush and dry potassium hydrogen phthalate ($HOOCC_6H_4COOK$), at 120^{o}C, cool in desiccators, weigh 425 mg in distilled water and dilute to 1L. This solution has a theoretical COD of 500 μgO_2/mL, stable for 3 months in refrigerator.

Procedure

- Add 50 mL of sample or an aliquot diluted to 50 mL with distilled water in a 500 mL refluxing flask. Add 1g $HgSO_4$, few glass beads, and 5 mL sulphuric acid reagent, mix, cool. Add 25 mL of 0.0417 M $K_2Cr_2O_7$ solutions, mix. Connect the flask to the condenser and turn on cooling water, add additional 70 mL of sulphuric acid reagent through open end of condenser, with swirling and mixing.
- Reflux for 2 hours; cool, wash down condenser with distilled water to double the volume of contents, cool.
- Add 2 drops of Ferroin indicator, titrate with FAS the remaining potassium dichromate, until a colour change from bluish green to reddish brown. Also reflux and titrate a distilled water blank with reagents.
- Use standard 0.00417M $K_2Cr_2O_7$, and 0.025M FAS, when analysing very low COD samples.
- Evaluate the technique and reagents by conducting the test on potassium hydrogen phthalate solution.

Calculation

$$\text{COD mg/l} = \frac{(A-B) * M * 8000}{\text{Ml sample}}$$

Where:

A = FAS used for blank, mL

B = FAS used for sample, mL

M = Molarity of FAS

3.2.3. pH

Apparatus

- *pH meter* with temperature compensating device, accurate and reproducible to 0.1 pH unit with a range of 0 to 14.

- *Reference electrode* preferably with quartz liquid junction. Follow manufacturer's instructions on use and care of the reference electrode. Refill non-sealed electrodes with correct electrolyte to proper level and make sure junction is properly wetted.
- *Glass electrode*. Follow manufacturer's instructions on use and care of electrode.

Reagents

- *Potassium hydrogen phthalate buffer, 0.05M*, pH 4.00. Dissolve 10.12 g $KHC_8H_4O_4$ (potassium hydrogen phthalate) in 1000 mL freshly boiled and cooled distilled water
- *0.025M Potassium dihydrogen phosphate + 0.025M disodium hydrogen phosphate buffer, pH 6.86*. Dissolve 3.387 g KH_2PO_4 + 3.533 g Na_2HPO_4 in 1000 mL freshly boiled and cooled distilled water
- *0.01M sodium borate decahydrate (borax buffer), pH = 9.18*. Dissolve 3.80 g $Na_2B_4O_7.10H_2O$ in 1000 mL freshly boiled and cooled distilled water.
- Store buffer solutions in polyethylene bottles. Replace buffer solutions every 4 weeks.

Procedure

- Remove electrodes from storage solution, rinse, blot dry with soft tissue, place in initial buffer solution and standardise pH meter according to manufacturer's instructions.
- Remove electrodes from the first buffer, rinse thoroughly with distilled water, blot dry and immerse in second buffer preferably of pH within 2 pH units of the pH of the sample. Read pH, which should be within 0.1 unit of the pH of the second buffer.
- Determine pH of the sample using the same procedure as in after establishing equilibrium between electrodes and sample. For buffered samples this can be done by dipping the electrode into a portion of the sample for 1 min. Blot dry, immerse in a fresh portion of the same sample, and read pH.
- With dilute poorly buffered solutions, equilibrate electrodes by immersing in three or four successive portions of the sample. Take a fresh sample to measure pH.
- Stir the sample gently while measuring pH to insure homogeneity.

3.2.4. Phosphate Estimation

Apparatus

- Hot plate.
- *Spectrophotometer with infrared phototube* for use at 880nm or filter photometer, equipped with a red filter.
- *Acid washed glassware*, use dilute HCl and rinse with distilled water.

Reagents

- Phenolphthalein indicator aqueous solution
- Sulphuric acid ,H_2SO_4 10N: Carefully add 300 mL conc H_2SO_4 to approximately 600 mL distilled water and dilute to 1 L.
- Per sulphate: $(NH_4)2S_2O_8$ or $K_2S_2O_8$, solid
- Sulphuric acid, H_2SO_4, 5N: Dilute 70 mL conc. H_2SO_4 to 500 mL with distilled water.
- *Potassium antimonyl tartrate solution*: Dissolve 1.3715g $K(SbO)C_4H_4O_6.1/2\ H_2O$ in 400 mL distilled water and dilute to 500 mL, store in glass-stoppered bottle.
- *Ammonium molybdate solution*: Dissolve 20g $(NH_4)6\ Mo_7O_{24}.4H_2O$ in 500 mL distilled water, store in a glass stoppered bottle.
- *Ascorbic acid, 0.1M:* Dissolve 1.76g ascorbic acid in 100 mL distilled water, keep at 4^oC, use within a week.
- *Combined reagents*: Mix 50 mL 5N, H_2SO_4, 5 mL potassium antimonyl tartrate, 15 mL ammonium molybdate solution, and 30 mL ascorbic acid solution, in the order given and at room temperature. Stable for 4 hours.
- *Stock phosphate solution,* Dissolve 219.5mg anhydrous KH_2PO_4 in distilled water and dilute to 1 L; 1 mL = 50µg $PO_4{}^{3-}$ - P.
- *Standard phosphate solution*: Dilute 50 mL stock solution to 1L with distilled water; 1 mL= 2.5µg P.

Procedure

- To 50 mL portion of thoroughly mixed sample add one drop phenolphthalein indicator solution. If a red colour develops, add 10N H_2SO_4 to just discharge colour. Then add 1 mL 10N H_2SO_4 and either 0.4 g $(NH_4)2S_2O_8$ or 0.5 g $K_2S_2O_8$.
- Boil gently on a preheated hot plate for 30 to 40 min or until a final volume of 10 mL is *c*. Cool, dilute to 30 mL with distilled water, add one drop phenolphthalein indicator solution and neutralize to a faint pink colour with NaOH and make up to 100 mL with distilled water. Do not filter if any precipitate is formed at this stage. It will redissolve under acid conditions of the colorimetric test.
- Take 50 mL of the digested sample into a 125 mL conical flask, add 1 drop of phenolphthalein indicator. Discharge any red colour by adding 5*N* H_2SO_4. Add 8 mL combined reagent and mix.
- Wait for 10 minutes, but no more than 30 minutes and measure absorbance of each sample at 880nm. Use reagent blank as reference.
- Correction for turbid or coloured samples. Prepare a sample blank by adding all reagents except ascorbic acid and potassium antimonyl tartrate to the sample. Subtract blank absorbance from sample absorbance reading.
- Preparation of calibration curve: Prepare calibration from a series of standards between 0.15-1.30 mg P/L range (for a 1 cm light path) by first carrying the standards through identical per sulphate digestion process. Use distilled water blank with the combined reagent. Plot a graph with absorbance versus phosphate concentration to give a straight line. Test at least one phosphate standard with each set of samples.

Calculation

$$\text{Total P as mg /L} = \frac{\text{mg Pfrom the calibration curve} * 1000}{\text{mL Sample}}$$

3.2.5. **TDS**

Apparatus

- *Evaporating dishes*, 100 mL capacity of porcelain, platinum or high-silica glass make
- *Drying oven*, 104 ± 1°C

- *Desiccators*
- *Magnetic stirrer*

Procedure

- *Dry evaporating dish* at 104 ±1°C for 1 h, cool and store in a desiccators. Weigh immediately before use.
- *Stir sample* with a magnetic stirrer. While stirring, pipette a measured volume into the pre-weighed evaporating dish using a wide bore pipette. Choose a sample volume to yield between 10 and 200mg dried residue. Evaporate to dryness in an oven at 104 ±1°C.
- If necessary add successive portions to the same dish after evaporation. To prevent splattering, the oven temperature may be lowered initially by 2°C below boiling point and raised to 104°C after evaporation for 1 h. Cool in a desiccators and weigh.

Calculation

$$\text{mg Total Solids /L} = \frac{(A - B) * 1000}{\text{mL Sample}}$$

Where:

A = weight of dish + residue, mg

B = weight of dish, mg

3.2.6. TSS

Procedure

Measure Total Solids, TS and Total Suspended Solids, TSS and obtain the data.

Calculation

$TDS = TS - TSS$

Where:

TDS = Solids, Total Dissolved, mg/L

TS = Solids, Total, mg/L

TSS = Solids, Total Suspended, mg/L

3.2.7. Sulphate Estimation

Apparatus and equipment

- Magnetic stirrer
- Colorimeter for use at 420mm or turbidimeter/nephelometer
- Stopwatch
- Nessler tubes, 100mL
- Measuring spoon 0.2 to 0.3mL

Reagents and standards

- Buffer solution A: dissolve 30g Magnesium chloride, $MgCl_2.6H_2O$, 5g Sodium acetate $CH_3COONa.3H_2O$, 1g Potassium nitrate, KNO_3 and 20mL acetic acid, CH_3COOH (99%) in 500mL distilled water and make up to 1000mL.
- Buffer solution B: (required when the sample sulphate (SO_4^{--}) is less than 10mg/L). Dissolve 30g Magnesium chloride, $MgCl_2.6H_2O$, 5g sodium acetate, $CH_3COONa.3H_2O$, 1.0g of potassium nitrate, KNO_3, 0.111 g of sodium sulphate, Na_2SO_4 and 20mL acetic acid (99%) in 500mL distilled water an make up to 1000mL.
- Barium chloride: crystals, 20-30mesh.
- Standard sulphate solution: dissolve 0.1479g anhydrous sodium sulphate, Na_2SO_4 in distilled water and dilute to 1000mL. 1L = 100 μg $SO_4^{—}$

Procedure

- Take suitable volume of sample and dilute to 100mL into a 250mL Erlenmeyer flask
- Add 20mL buffer solution, mix well
- Keep the flask constantly stirred with the help of stirrer. Add 1-spatula $BaCl_2$ crystals with stirring. Continue stirring for 1 minute after addition of $BaCl_2$
- Pour suspension into an absorption cell of photometer an measure turbidity at 5±0.5 min
- To correct for sample colour and turbidity, run a blank to which $BaCl_2$ is not added.

Calculation

mg SO4--/L = {mg (SO_4^{--}) x 1000} / {mL of sample}

CHAPTER -4

RESULTS AND DISCUSSIONS

Sampling

Sampling was done from different industries. Sample was collected from secondary and tertiary outlets. Different industries like Textile industry, Dairy industry and Sewage treatment plants were taken in consideration.

Source of Sample

- Trident Group Textiles, Barnala
- STP, Raipur kalan, Chandigarh
- Radiant Textiles, Samana
- Crown Milk, Mohali
- STP, Bhattian, Ludhiana

Samples are analyzed for Physico-chemical and bacteriological parameters. The results are shown in table 4.1 to table 4.5 of all the industries. Results of all the parameters are shown in the form of graphs from fig. 4.1 to fig. 4.7 showing pH, BOD, COD, TSS, TDS, Phosphate concentration and Sulphate concentration. Estimation and Characterization was done by using standard methods. Readings of the tests were taken and efficiency was calculated.

$$\text{Efficiency} = \frac{\text{Initial reading} - \text{Final reading}}{\text{Initial reading}} * 100$$

SAMPLE 1- Trident Group, Barnala (Textile Industry)

For the characterization of industrial wastewater, two samples were taken. Sample 1 and sample 2 were taken from outlets of UASB and chlorination system of Trident group, Ludhiana to analyze the treatment efficiency. The Table 4.1 shows the results of parameters which meet the standards given by the State Pollution Control Board.

Table 4.1:Results of parameters of trident group.

Parameter	**Sample 1**	**Sample 2**	**Efficiency (%)**
pH	7.1	6.3	-
TSS (mg/l)	632	298	52.84
TDS(mg/l)	2735	2664	2.59
COD(mg/l)	946	387	59.09
BOD(mg/l)	117	74	36.75
SULPHATE(mg/l)	5.42	5.00	7.74
PHOSPHATE(mg/l)	0.48	0.40	16.66

SAMPLE 2- STP, Raipur Kalan, Chandigarh

For the characterization of STP wastewater, sample 1 and sample 2 were taken from outlets of UASB and final polishing unit of STP, Raipur Kalan to analyze the treatment efficiency. The Table 4.2 shows the results of parameters which meet the standards given by the State Pollution Control Board.

Table 4.2. Results of parameters of Raipur Kalan

Parameter	**Sample 1**	**Sample 2**	**Efficiency (%)**
pH	8.2	7.3	-
TSS (mg/l)	139.6	32.3	76.86
TDS(mg/l)	1271.6	1168.4	8.11
COD(mg/l)	338.3	148.3	56.16
BOD(mg/l)	166.3	33.4	79.91
SULPHATE(mg/l)	14	9	35.71
PHOSPHATE(mg/l)	1.634	1.126	31.08

SAMPLE 3- Radiant Textiles, Samana

For the characterization of industrial wastewater, sample 1 and sample 2 were taken from outlets of Oxidation pond and filteration unit of Radiant textiles, Ludhiana to analyze the treatment efficiency. The Table 4.3 shows the results of parameters which meet the standards given by the State Pollution Control Board.

Table 4.3. Results of parameters of Radiant

Parameter	**Sample 1**	**Sample 2**	**Efficiency (%)**
pH	7.7	6.8	-
TSS (mg/l)	923	367	60.23
TDS(mg/l)	3946	2897	27.58
COD(mg/l)	856	762	10.98
BOD(mg/l)	247	176	28.74
SULPHATE(mg/l)	5.12	4.82	5.85
PHOSPHATE(mg/l)	0.56	0.49	12.5

SAMPLE4- Crown Milk, Mohali

For the characterization of industrial wastewater, sample 1 and sample 2 were taken from secondary clarifier and filtration unit of Crown Milk, Mohali to analyze the treatment efficiency of units. The Table 4.2 shows the results of parameters which meet the standards given by the State Pollution Control Board.

Table 4.4: Results of parameters of Crown Milk.

Parameter	**Sample 1**	**Sample 2**	**Efficiency (%)**
pH	10.1	9.8	-
TSS (mg/l)	284	217	23.59
TDS(mg/l)	1582	897	43.29
COD(mg/l)	1495	1403	6.15
BOD(mg/l)	790	627	20.6
SULPHATE(mg/l)	2.23	2.02	9.41

SAMPLE 5- STP, Bhattian, Ludhiana

For the characterization of STP wastewater, sample 1 and sample 2 were taken from outlet of UASB and chlorination unit of STP, Ludhiana to analyze the treatment efficiency of components. The Table 4.5 shows the results of parameters which meet the standards given by the State Pollution Control Board.

Table 4.5. Results of parameters of STP, Ludhiana.

Parameter	**Sample 1**	**Sample 2**	**Efficiency (%)**
pH	7.9	7.1	-
TSS (mg/l)	48.906	48.626	28
TDS(mg/l)	1370	1310	4.37
COD(mg/l)	504	163	67.65
BOD(mg/l)	187	47	74.86
SULPHATE(mg/l)	2.8	1.5	46.42
PHOSPHATE(mg/l)	1.732	1.092	36.95

Graphical Representation of Parameters of Wastewater of All Industries

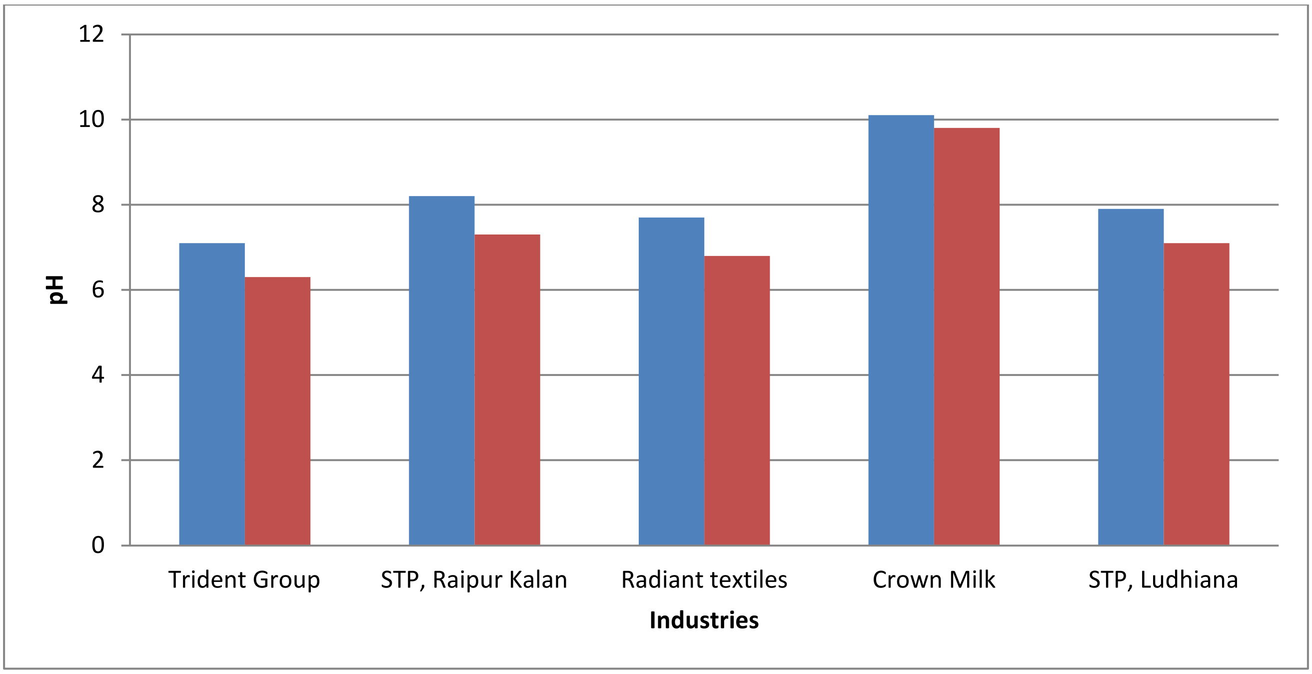


Fig.4.1. Graph showing the pH between secondary and tertiary outlet of all samples.

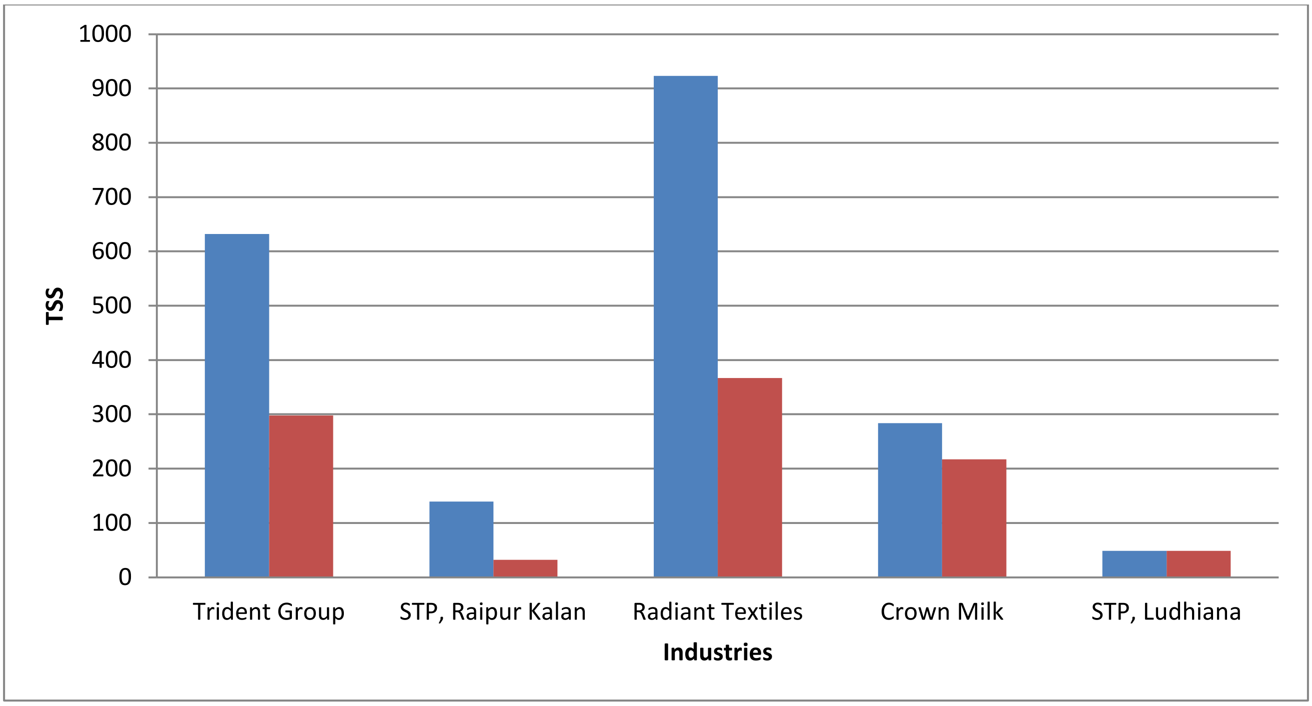


Fig.4.2. . Graph showing the TSS level between secondary and tertiary outlet of all samples.

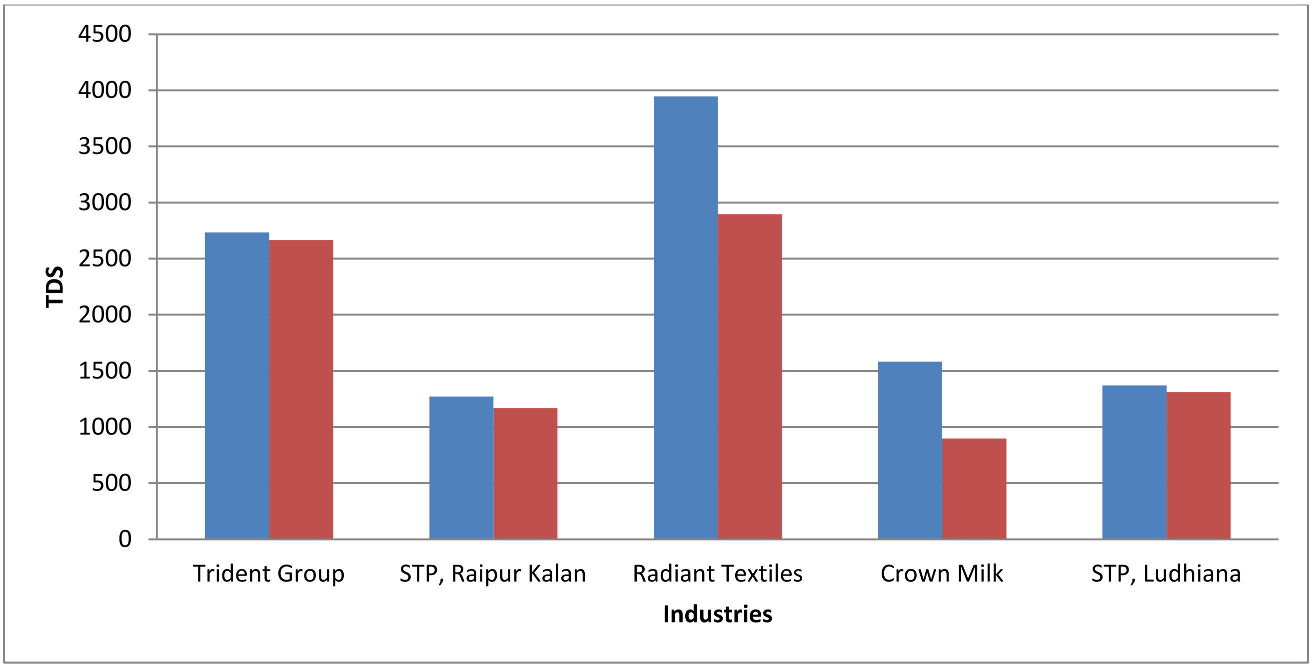


Fig.4.3. . Graph showing the TDS level between secondary and tertiary outlet of all samples.

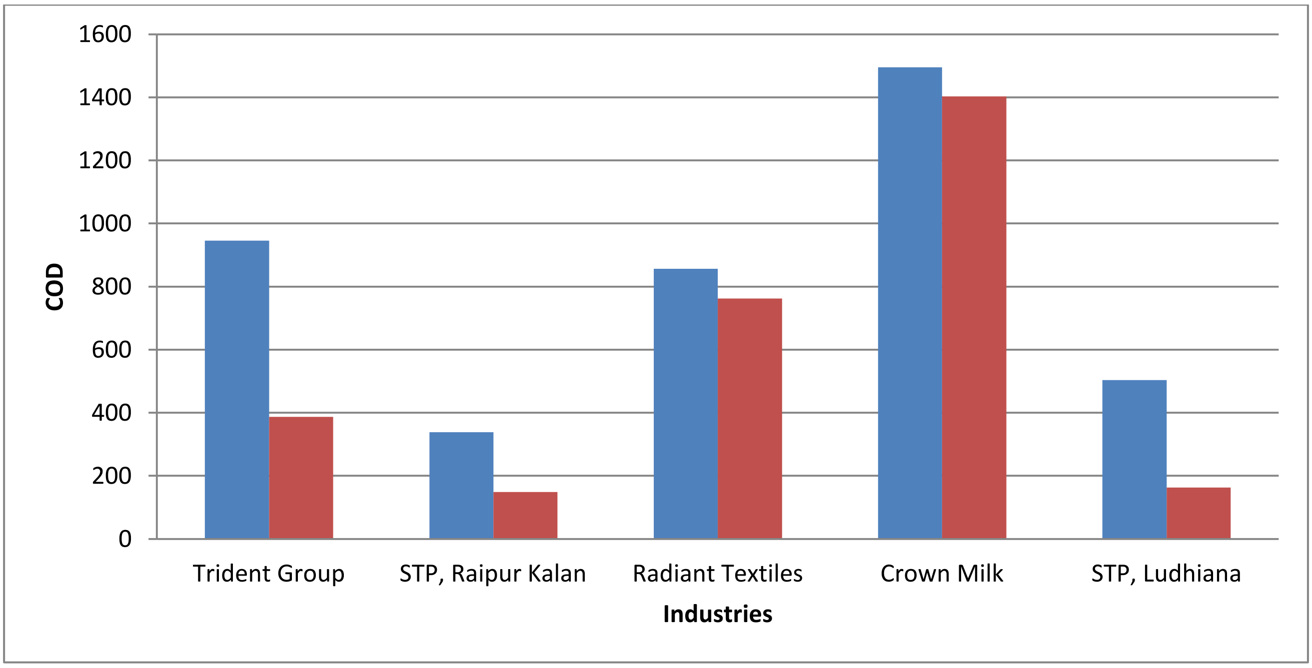


Fig.4.4. . Graph showing the COD content between secondary and tertiary outlet of all samples.

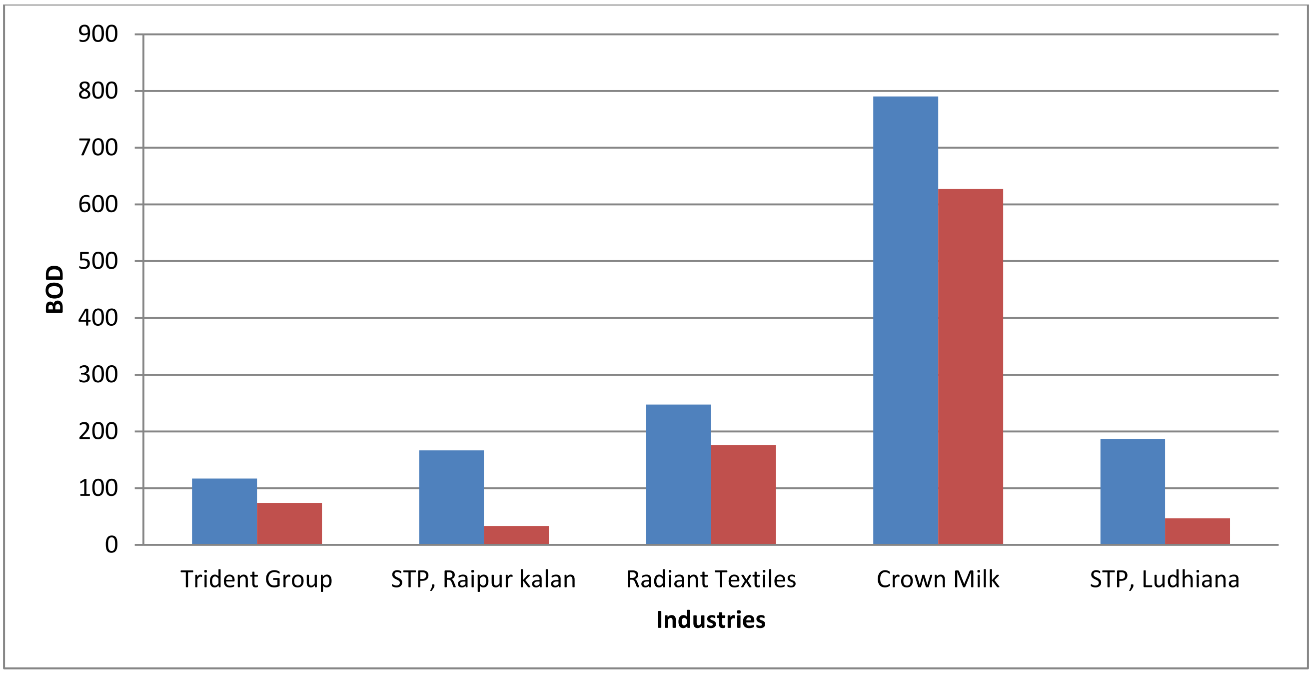


Fig.4.5. . Graph showing the BOD content between secondary and tertiary outlet of all samples.

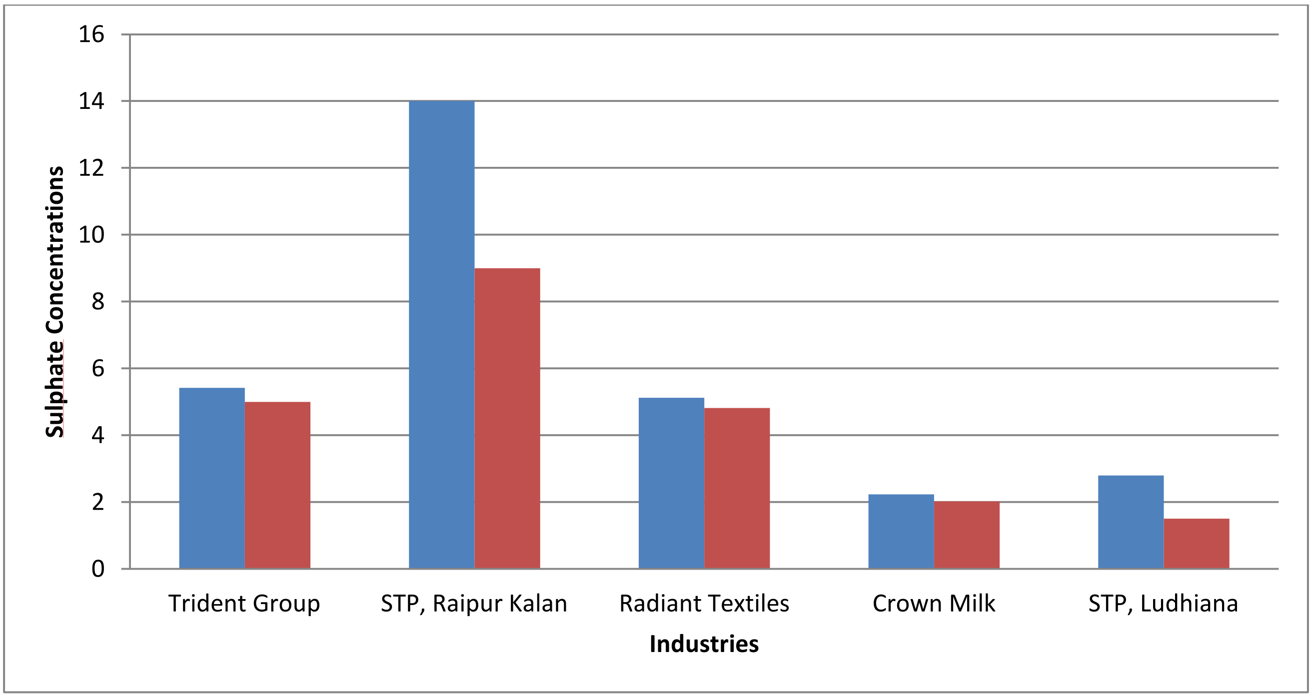


Fig.4.6. Graph showing the sulphate concentration between secondary and tertiary outlet of all samples.

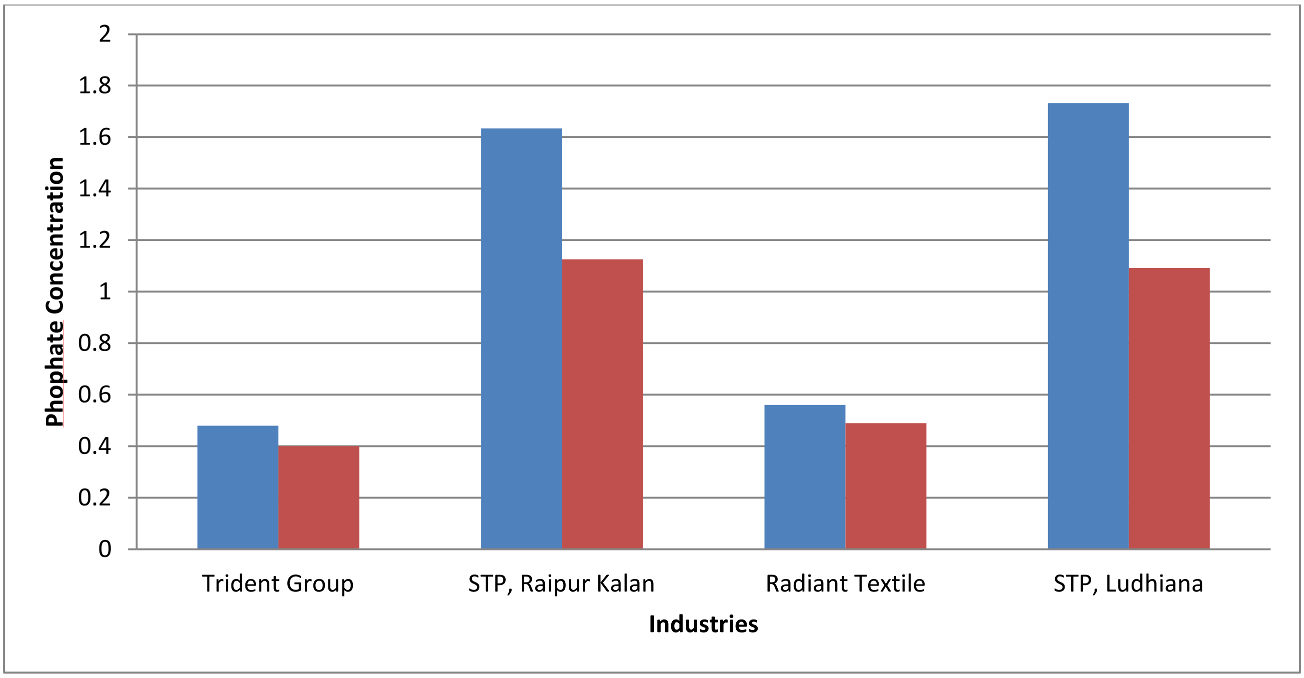


Fig.4.7. Graph showing the phosphate concentration between secondary and tertiary outlet of all samples.

CHAPTER 5

CONCLUSIONS

Based on the study performed, the results and discussion made the following Conclusions:

- Trident group, Barnala, which is a textile industry, the treatment efficiency of the components in terms of TSS, TDS, COD, BOD, Sulphate and Phosphate concentration were observed as 52.84, 2.59, 59.09, 36.75, 7.74,16.66 % respectively.
- Treatment efficiency in terms of TSS, TDS, COD, BOD, Sulphate and Phosphate in case of STP Raipur Kalan were observed as 76.86, 8.11, 56.16, 79.91, 35.71, 31.08 % respectively.
- Radiant textiles, Samana which is a textile industry, the treatment efficiency of the components in terms of TSS, TDS, COD, BOD, Sulphate and Phosphate concentration were observed were observed as 60.23, 27.58, 10.98, 28.74, 5.85,12.5 % respectively.
- Crown Milk, Mohali, which is a Dairy industry, the treatment efficiency of the components in terms of TSS, TDS, COD, BOD, Sulphate concentration were observed as 23.59, 43.29, 6.15, 20.6, 9.41 % respectively.
- Treatment efficiency in terms of TSS, TDS, COD, BOD, Sulphate and Phosphate in case of STP Bhattian, Ludhiana were observed as 28, 4.37, 67.65, 74.86, 46.42, 36.95 % respectively.

CHAPTER 6

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