BE CIVIL ENGINEERING FINAL YEAR PROJECT

TREATMENT OF WASTEWATER OF AUTOMOBILE SERVICE STATION

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NATIONAL UNIVERSITY OF SCIENCES AND TECHNOLOGY
MILITARY COLLEGE OF ENGINEERING (MCE)
RISALPUR CAMPUS, PAKISTAN

(2021)

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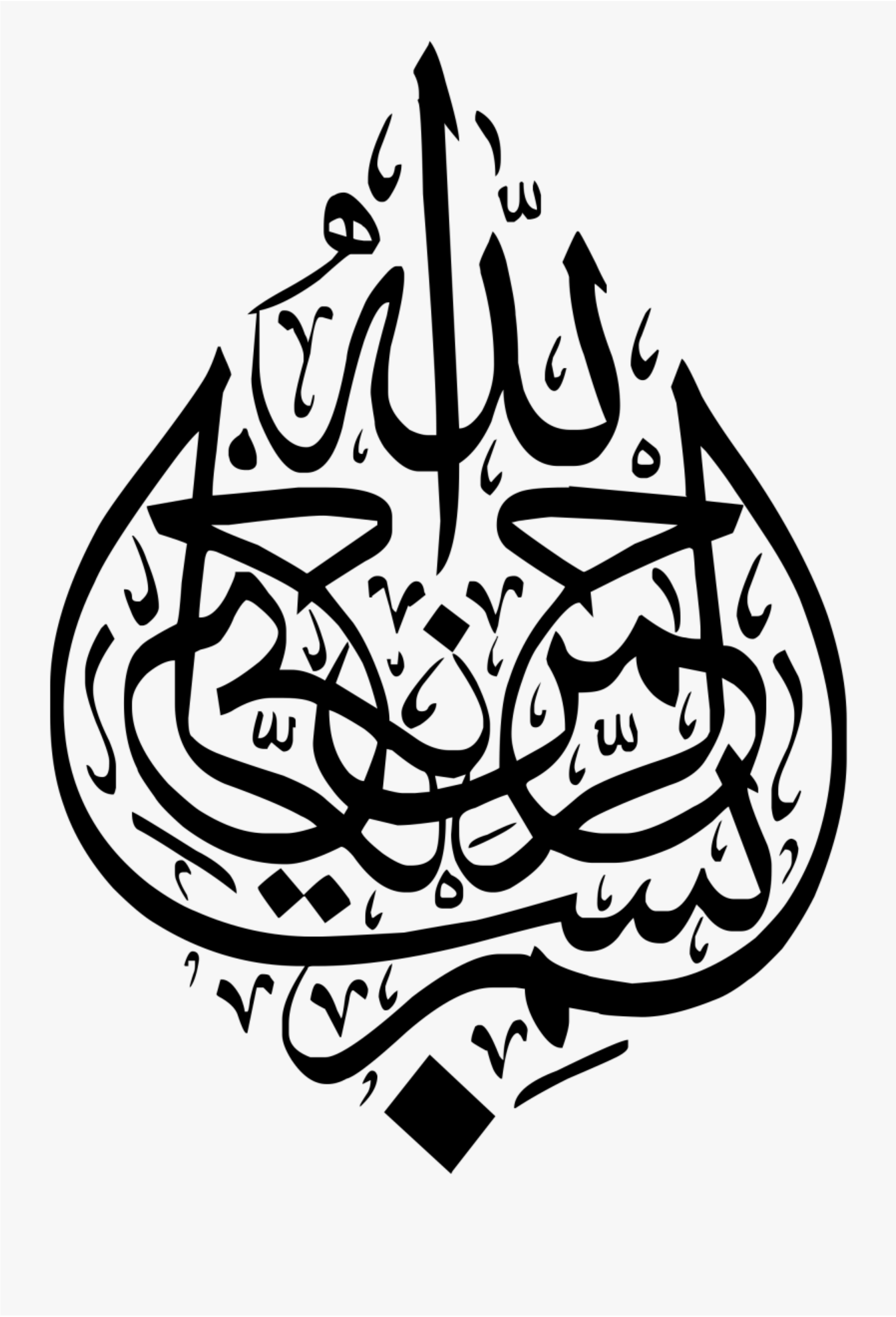
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TREATMENT OF WASTEWATER OF AUTOMOBILE SERVICE STATION

It is to certify that the

Research and Development work titled

<u>TREATMENT OF WASTEWATER OF AUTOMOBILE SERVICE STATION</u>

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Has been accepted towards the partial fulfilment

Of the requirements

For

Bachelors in Civil Engineering

____

Maj Muhammad Umair Ghazi

MCE, Risalpur

THIS WORK IS DEVOTED TO OUR RESPECTABLE PARENTS, PROJECT ADVISOR, CO-ADVISORS, TEACHERS AND ALL THOSE WHO HAVE CONTRIBUTED IN THIS PROJECT

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Beginning with the name of ALLAH who is the most merciful and the most beneficent, it is a great privilege for us to present our civil engineering knowledge in its practical form. Praises to **ALMIGHTY ALLAH** for empowering us with the strength and courage for the completion of this project.

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ABSTRACT

Poor management practices related to generation and disposal of untreated wastewater causes pollution of both surface and ground water bodies. Raw wastewater disposal from industry are some of the sources causing water pollution. Automobiles industry particularly cleaning operations produce thick layered greasy wastewater that contains very high level of organic loads. Automobile cleaning is an important process for organization involved in manufacture, repair/maintenance of automobile and shipping facility. Parts are generally covered with heavy oils and solids which are removed during washing of vehicles. An automobile washing pit facility located in 33 Supply and Transport Battalion at Risalpur cantonment was selected as case study. Samples were collected from the facility and tests were performed on the wastewater. These wastewater contained oil, high COD and solids.

The study aimed at characterization of wastewater from automobile cleaning operation, designing a treatment system and study of economic effects of proposed system. Two types of oil contents were encountered i.e. free and emulsified oil. Wastewater generated at locations where vehicles were being cleaned contained free and emulsified oil. Separation of this oil was achieved using skimming tank and chemical emulsion breaking. Solids removal was achieved through coagulation. Alum was used as coagulant. Over 95 percent removal of contaminants was achieved in the treatment process. Results revealed that wastewater from the source is treatable and pollution of water bodies can be minimized to NEQS limits. Moreover recycling of wastewater, after treatment, can achieve significant water conservation. Finally a treatment plant design was proposed for installation in the facility after considering its economic feasibility.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

MCE	Military College of Engineering
COD	Chemical oxygen demand
BOD	Biological oxygen demand
TS	Total solids
TDS	Total dissolved solids
TSS	Total suspended solids
SS	Suspended solids
DO	Dissolved oxygen
EC	Electronic Conductivity
psi	Pounds per square inch
mm	Millimeter
rpm	Revolutions per minute
PHE	Public Health Engineering

LIST OF TABLES

Appendix-V

LIST OF FIGURES

CHAPTER No 1

INTRODUCTION

Chapter - 1

INTRODUCTION

1.1 GENERAL

Water is an essential resource for sustaining life on earth; the most important aspects of water use are its quality and quantity. Once an abundant resource available in Pakistan, now lack of conservation and poor management practices are causing shortage and pollution of water sources, both surface and ground water. Most significant are activities related to generation and disposal of untreated wastewater into water bodies causing it pollution. Upper riparian of water discharge untreated wastewater into surface water bodies, same water is consumed by lower riparian with little or no treatment. Most of the pollutants in wastewater increase oxygen demand resulting in oxygen levels too low to support higher life forms such as fish. Humans ingesting this polluted water become ill. Cancer, hepatitis and birth defects in children are growing diseases (US EPA, 1995).

1.2 WORLDWIDE WATER SITUATION

World Economic Forum has listed the water crisis as world's largest threat in its latest annual risk report. Steadily increasing demand of freshwater is severe warning to sustainability of human society (World Economic Forum, 2015; Mekonnen & Hoekstra, 2016). Rise in population, expansion in living standards, development of agriculture and change in consumption patterns are the foundations of rising water demands (Ercin & Hoekstra, 2014).

About 50% population of developing countries is unable to get proper sanitation. In order to overcome this situation, specifically in developing countries, improvement in grey-water management is required on urgent basis (Ghaitidak & Yadav, 2013).

As we all know that climate change has become a global issue. Saqib *et al,* (2018) mentioned in his research article that water scarcity and climate change are interrelated. He continued that reason behind long summers is due to excessive heat and average capacity of water is decreasing due to unnecessary use of water resources. Temperature and urbanization are also major threat to environment. Rising population and urbanization are putting pressure on water supply. Due to climate change, rainfall patterns get changed and becoming a reason of water scarcity (Saqib *et al.,* 2018).

1.3 WATER AVAILABILITY AND SCARCITY CONDITIONS IN PAKISTAN

Water scarcity is hitting the globe along with Pakistan. Arid and semi-arid areas of the world are facing water scarcity issues. Many studies have been conducted to see the water quality status of Pakistan and found that water quality of Pakistan is deteriorating day-by-day (Daud *et al.,* 2017). Indus is one of the main rivers of Pakistan that originates from Karakorum ranges to the Arabian Sea. Pakistan's economy is mostly dependent on agriculture and common crops are sugarcane, maize, wheat, cotton and rice. To meet the need of rising population, chemicals and fertilizers are added a better crop yield. Nature has blessed the Pakistan with plenty of surface water resources along with the ground water. But due to rapid growth in population it has been a huge stress on ground water resources (Soomro *et al.,* 2011).

Pakistan is already a water-stressed country, with around 1200 cubic meters per capita water availability in year 2000, a drop from 5,300 cubic meters in 1951 (Ahmed, 2007). The last survey which gave the results of 1038 cubic meters was conducted almost 11 years ago in 2008. Figure 1.1 represents the per capita water availability in Pakistan over different period of time. Study conducted by PCRWR revealed that the major cities of Pakistan will soon be under water crisis due to rapid depletion of ground water, causing a drought situation. Such crisis needs to be account for as soon as possible; otherwise, a large area of Pakistan's population will be facing severe deficiency of water. As a result, there is a need to take urgent actions and to manage water resources in a sustainable manner (Zhu *et al.,* 2016).

A state experiences water insufficiency when water availability per capita is below 1000 m^3 and Pakistan almost touched this threshold of water scarcity in 2010 (Rijsberman, 2006). This will require major official modifications to manage the water resources and its usage. A recommended action is to quintessence on increasing total production of water. Otherwise, water availability will soon become major issue and restriction for agriculture.

Figure 1.1 Per Capita water Availability

Per Capita Water Availability

Year	Population (Million)	Per Capita Availability (m^3)
1951	34	5300
1961	46	3950
1971	65	2700
1981	84	2100
1991	115	1600
2000	148	1200
2013	207	850
2025	221	659

Source: Draft State of Environment Report 2005.

Per Capita Water Availability in Pakistan (Source: Ahmed *et al*., 2007)

1.4 AUTOMOBILE WASHING

Automobile washing is an important process for organization involved in automobile and shipping facility. Parts of vehicles are generally covered with heavy oils and solids which are removed through various processes during washing. Degreasing and cleaning of equipment and parts is usually carried out by using large amounts of water mixed with expensive detergents, degreasers, and harsh chemical solvents. This process introduces health and safety risks, wastewater/solvent disposal costs, with the accompanying environmental risks.

1.4.1 Process

A typical operation found at most automobile repair/ washing facilities involves cleaning of engine, body parts, tools, and other small items. The facility may use some type of cleaning equipment, such as a parts washer or a dip tank. Parts requiring cleaning are placed in a parts washer or a dip tank where these are subjected to cleaning solutions. It is important to remove caked-on grease and oil from parts with a scraper or knife before aqueous cleaning to reduce cleaning time and water usage. The soil on parts is removed by the action of cleaning solution. Rinsing water is used to wipe off any soil left on parts and to clean the solution from parts. It is important to conduct cleaning operations on a contained or indoor impervious surface and not to dispose of used cleaning solution on the ground or into a storm drain (US EPA, 2004).

1.4.2 Generation of Waste

Waste generated from washing of vehicles includes wastewater containing different polluted substances and sludge. The reason for focusing attention on minimizing waste in parts cleaning operations is because the solvents and other chemicals used in parts cleaning often result in significant air emissions, wastewater discharges, and generation of hazardous wastes.

Pakistan had an estimated 12.97 million motor vehicles of all types on road in the year 2019-2020 (GOP Economic Survey 2019-2020); this number is increasingly rapidly every year. These motor vehicles require overhauling of engine every three to five years depending on use and engine running and washing at least on weekly basis. Other parts of these vehicles are also repaired from time to time. The waste generated is disposed in sanitary system or open drains. These workshops/ service stations are also called as small scale generators of waste. Although millions of gallons of wastewater is generated at these locations which is also disposed untreated into sanitary sewers or surface water bodies but due to their limited number, much attention had so far not been paid to the environmental problems created by these organizations. The study is conducted focusing on treatment of service stations wastewaters.

1.4.3 Treatment and Management of vehicles Cleaning Wastewater

Management of cleaning wastewater varies from activity to activity. Wastewater generated from cleaning process may be treated at an industrial wastewater treatment plant, depending on the nature of dirt and grease removed. Treated wastewater may be discharging into a sanitary sewer or recycled. Recycling systems are not always the most cost-effective way to manage wastewater. However, certain pre-existing conditions may make recycling a cost-effective alternative. Favorable conditions include activities that promote water conservation, remote areas that lack readily available disposal alternatives, or when a Resource Conservation and Recovery Act permit is require for treatment prior to discharging into a sanitary sewer. Recycling systems are relatively safe systems that can be operated for years if properly maintained (Blace Filtronics. Inc, 2002).

1.5 PROBLEM STATEMENT

Oil and grease are amongst the kinds of organic pollutant which causes damage to aquatic systems by limiting the amount of oxygen that enters a body of water from atmosphere. Land application of oil and grease containing waters degrade soil and reduce agriculture production (ETPI, 2001). Raw wastewaters disposed from industries are some of the sources causing water pollution. Other sources in urban/industrial wastewaters include the automobile cosmetic cleaners (commonly known as service stations). Service stations consume large quantities of municipal water and their wastewater is a significant source of aquatic pollution. One such facility located at Risalpur was selected as a case study.

1.6 OBJECTIVES OF STUDY

The study aimed at achieving following objectives:-

a. To design a sustainable, eco-friendly, cost efficient and compact unit which can recycle the waste water of an automobile service station containing oil and grease, and make it reusable again for specific purposes.

b. Determination of optimum dosages of coagulants and other chemical used in treatment system.

c. Benefit cost analysis of the system.

1.7 SCOPE AND APPLICATION

Automobile washing is conducted at a large scale at numerous facilities in Pakistan, besides the small scale service stations in almost every major commercial area in a village, town or city. Wastewater generated at these facility is presently being disposed off untreated into sanitary/storm sewer or nearby surface water body. This study involved the removal of organic matter including oil and grease, COD and solids through skimming, coagulation, flocculation and settling from vehicles cleaning wastewater. At present variety of equipment using different technologies/methods are employed in the world to reduce the pollution caused by these wastewaters. These are expansive to install and based on imported equipment. The proposed study focus on developing a treatment system for decreasing organic matter from these wastewaters to make them suitable for disposal. Sizing of clarifiers/units and study of economic effects was also formed part of this study. The study focused on the treatment of wastewater generated from an automobile washing facility at Risalpur. The treatment system designed as a result of the study will serve as a guide for designing/installing cost effective wastewater treatment systems for other such facilities in the country.

CHAPTER NO 2

LITERATURE REVIEW

Chapter - 2

LITERATURE REVIEW

2.1 GENERAL

Industrial wastewater is liquid waste discharges resulting from industrial or commercial processes, including contact cooling water and condensing waters, but excludes non-contact cooling water, sanitary sewage and storm water runoff that does not come in contact with process materials, products or by-products. (Michigan, 2004).

2.2 AQUEOUS PARTS - CLEANING

Aqueous cleaning methods include enclosed spray washers, hot dip tanks, pressure washers and steam cleaning. Aqueous cleaners are one of the most popular choices for degreasing parts at automotive recyclers. These are classified on the basis of pH content as following (Anonymous, N.D):-

a. **Acidic Cleaners.** Common acid materials include mineral acids (hydrochloric, sulfuric, and nitric), chromic acid, carboxylic acids, and other organic acids. Acidic cleaners are generally not the best choice as degreasing agents.

b. **Neutral Cleaners.** Neutral cleaning solutions generally include surfactant, which function as wetting and emulsifying agents. Other ingredients, such as corrosion inhibitors and dispersants, are generally added as well.

c. **Alkaline Cleaners.** Alkaline cleaning solutions can be formulated by adding such materials as sodium or potassium hydroxide, carbonate, bicarbonate, phosphate, silicate, or other similar materials. Alkaline cleaning solutions employ both physical and chemical means to clean the substrate surface. Chemical action can occur via saponification of certain contaminants. In the saponification process, water-soluble soaps are produced by the neutralization of fatty acid soils. Physical cleaning occurs via wetting and emulsification provided by the addition of surfactants. While many specialty formulation of alkaline cleaners exist, most will contain caustic and surfactant as well as some other builders, the caustic is most likely in the form of sodium hydroxide (caustic soda) or potassium hydroxide (caustic potash). The caustic works in the cleaning process by penetrating oil and grease (or other soil), separating it form the substrate and suspending it in solution.

2.2.1 The Basics of Aqueous Cleaning Systems

Aqueous cleaning agents are generally used at concentrations of 0.5-5 percent active ingredients compared with typical 100 percent organic solvent solution. The operating time and temperature for an aqueous cleaning bath varies depending on the type and level of soils being cleaned. Aqueous cleaning systems in general have been shown effective for the removal of a wide range of contaminants. Considering the time and temperature dictated by the process. As a general rule, cleaning efficiency is increased with increased time, temperature, chemistry, and agitation. Each of these variables may affects other parameters (e.g., foaming, costs, health and safety considerations) and each variable needs to be optimized for each cleaning system process (Anonymous, N.D).

2.3 TREATMENT OPERATIONS FOR PARTS CLEANING WASTEWATER

Major thing in the industry today is treatment of parts cleaning wastewater (filtration and recycling of wash, rinse, and wastewater). It is a key step in saving money and saving the environment. With proper filtration and recycling techniques, manufacturers can increase wash bath life; maintain cleaner, more effective rinse water; and reduce surcharges on waste effluent. There are numerous types of available chemistries and a wide a range of soils being cleaned. Consequently, there are many types of filtration/recycling systems that can be employed and an even greater number of combinations. Making the right choice depends on the specific cleaning equipment, chemistry, and soil. There are three main categories into which a filtration/recycling system might fall (Reynolds, 1998).

a. **Closed-Loop Recycling.** Treating and recycling all wash and rinse baths for reuse in the cleaning system.

b. **Zero Discharge.** Treating or recycling all, part, or none of the wash and rinse baths, with the reminder being collected and hauled to another location for treatment and/or disposal.

c. **End-of-Pipe Wastewater Treatment/Recycling.** A system that treats all or part of the effluent from wash and rinse baths such that the final product can be discharged directly to local sewer lines or streams. The remainder of solution is either reused or hauled away for treatment.

2.4 ASSESSING CONTAMINANTS

There are a variety of contaminants that can be separated from cleaning solutions, and nature of these contaminants dictates how they can best be removed (Reynolds, 1998):

a. Tramp soils are those that immediately float to the surface of a cleaning solution.

b. Mechanically dispersed soils refer to oils, greases, and other organic soils that have been dispersed through agitation; they will eventually either float to the top of the cleaning solution or fall to the bottom within a given period of time.

c. Chemically dispersed soils refer to contaminants that are naturally soluble in water or have been chemically dispersed by surfactants, for stable emulsion.

d. Particulate soils include carbon, rust, iron filings, etc.

2.5 TYPES OF FILTRATION/RECYCLING COMPONENTS

With the advancement of technology a wide variety of recycling/filtration methods are available. Some of them have been discussed in the succeeding paragraphs (Reynolds, 1998).

a. **Conventional Filtration**

Also called macro filtration, is employed for cleaning applications that involve a particle size range of approximately 1 micron and larger. Filtration is commonly accomplished via bag filters and depth filters; however, sand filters and strainers are also used. These types of filters are generally used as a first step to remove any larger particles or debris that could be harmful to the remainder of the system.

b. **Decanting**

It is generally only applicable when there are large amounts of tramp oil present in a solution. The oil is essentially overflowed from the surface of the solution into a holding tank. The main limitations of this methods are that it does not account for any chemically dispersed soils.

c. **Skimming**

This work on the premise that a lipophilic surface (wheel, rope, or belt) passes in and out of the cleaning solution. As oils adhere to the surface, they are removed from the solution and deposited elsewhere.

d. **Absorption Technologies**

It function on the premise of passing a contaminated solution over a media (generally woven or granular), which is lipophilic and hydrophobic. In this manner, only organic material is absorbed, and all aqueous entities are retained in solution .

e. **Ion Exchange**

It is primarily used for the purification of incoming water and the treatment and recycling of rinse water. Ion exchange media is generally supplied in the form of resins contained in enclosed resin beds. The resin material generally consists of functional groups attached to naturally occurring or synthetic polymer backbones. These functional groups carry either a positive or a negative ionic charge and serve to retain anions and cations, respectively.

f. **Activated Carbon**

It can be used to remove organic materials and residual chlorine in many instances where organic contamination of baths is fairly low. Carbon is generally placed downstream from skimming and filtration processes to minimize unnecessary contamination. It is generally used only for recycling rinse water due to the presence of organic surfactants that will be removed from wash baths. Activated carbon works by selectively adsorbing certain molecules (mostly organic ones) to the inner surface of the carbon structure.

g. Ultraviolet (UV) Radiation or Catalytic Oxidation

This technique is widely used in the water-purifying arena for its biological sterilization abilities. In this process, water is treated with hydrogen peroxide and/or ozone gas. The solution is then pumped through a UV light tube that catalyzes the decomposition of ozone and peroxide into oxygen gas, water, and free radicals. Free radicals are exceptionally strong oxidizers and serve to react with and break down organic molecule.

2.6 EMULSION FORMATION

Emulsion is a mixture of two liquid phases in which one phase is dispersed into the other. Emulsions of liquids having different specific gravity may occur on their mixing. When small quantity of oil is mixed in water, oil droplets are reduced in size to such a degree that oil's normal electrical repulsion of water molecule is overcome due to its reduced size. A surfactant molecule consists of both polar and non-polar sections. The polar end of the molecule is drawn into the aqueous phase and the non polar into the oil phase. Surfactants can be classified as being anionic, cationic or non-ionic depending on the charge of the molecule that is surface active. As surfactants congregate at the interface between two phases, they increase the expanding pressure of the interface.

If the surface tension between the two phases is reduced to a low enough value, then emulsification will take place (Anonymous, 2004).

2.7 CHEMICAL EMULSION BREAKING

Emulsion breaking is termed as resolution cracking. It can be carried out by physical or chemical means. In emulsion breaking, stabilizing factors are neutralized by introducing opposite charge to the droplet by addition of chemicals. Since the dielectric characteristics of water and oil cause emulsified oil droplets to carry negative charges, therefore for stabilization of oil in emulsion, a cation (positive charge) emulsion breaker is used. Sulfuric acid (H_2SO_4) is commonly used as emulsion breaker for wastewater treatment. Coagulant such as salts of iron and aluminum are also used as breaking chemicals which agglomerate the oil droplets. Use of acid as emulsion breaker needs much care and additional chemicals for neutralizing the wastewater after the oil separation are required. Organic demulsifies are used as emulsion breaking agents; these gives better result and produce better effluent quality than acids. They are also effective in low quantity than inorganic treatment and reduce the sludge 50-75 percent. Emulsion breakers of different types are shown in the following table.

Table 2.1: Main types of emulsion breaking agents

Main Types	**Description**
Ionic Emulsifiers	Sodium, Potassium soaps and sulfides
	Sodium naphthenes and cresylates
	Precipitated sulfides and surfanctants
	Organic amines
Anionic Emulsifiers	Petroleum sulfonates, sulfonated fatty acids.
Nonionic Emulsifiers	Ethoxylated Alkyl phenols

(Source: Tehobanoglous et al, 1995)

2.8 COAGULATION, FLOCCULATION AND SETTLING

The removal of oxygen demanding and turbidity producing colloidal solids form wastewater is often called intermediate treatment, since colloidal are intermediate in size between suspended and dissolved solids. The most common method of removing these solids is by chemical coagulation. The process consists of destabilizing collides, aggregate them and bind them together for ease of sedimentation. It involves the formation of chemical flocs that absorb entrap, or otherwise bring together suspended matter, more particularly suspended matter that is so finely divided as to be colloidal. Chemicals most used are: Alum, copperas, Ferric chloride and Calcium chloride. The process of chemical coagulation involves complex equilibrium among a number of variables, including colloids of dispersed matter, water or other dispersing medium and coagulating chemicals. Driving forces such as the electrical phenomenon, surface effects, and various shear cause the interaction of these variables. Flocculation is the slow string or gentle agitation to aggregate the destabilized particles and form rapid setting flocs. These flocs are removed by sedimentation or more appropriately called as settling which occurs under quiescent conditions (Reynolds, 1982).

2.9 REVIEW SUMMARY

Automobile cleaning/ washing wastewaters usually contain free and emulsified oils; oil wet solid and very high COD. There are a number of methods available for removal of these oils. Most commonly, removal of free and mechanically emulsified oil is achieved through coalescing whereas chemical emulsion breaking is a method for separation of chemically emulsified oil. Emulsion is broken by addition of cations (Ca^{++}) which neutralizes negative charge on the oil-water emulsion. This can be achieved by addition of acid or salts of metals as coagulants. Sulfuric acid is most commonly used being cheap and easily available.

Removal of solids can be achieved through coagulation and flocculation. Aluminum sulfate is a universal coagulant.

CHAPTER NO 3

MATERIALS AND METHODS

Chapter 3

MATERIALS AND METHODS

3.1 GENERAL

The approach of this study had two thrusts (1) Characterize oil and grease containing automobile parts cleaning wastewaters (2) Conduct bench scale treatability study to design the treatment system for wastewater. Wastewater from source of automobile washing facility, located at Risalpur was brought to MCE laboratory for analysis. Analysis of water used and wastewater generation at the selected automobile washing facility was carried out to estimate the amount of pollution load added to the environment by the operation of this facility and scope of water reuse/conservation. The wastewater was analyzed for COD, TS, TDS, TSS, temperature, pH, turbidity, color, oil and grease. Economic evaluation was also carried out to determine the cost of water conserved (upon reuse of treated wastewater), cost of chemical treatment and savings through selling of used oil recovered.

3.2 PHYSICAL SURVEY OF FACILITY

The automobile washing facility selected as a case study for research work was located in Risalpur. The facility established for a specific organization, was designed to carry out complete cleaning/ washing of automobiles. Vehicles requiring cleaning were washed at a vehicles washing bay to remove dirt, oil, grease and sediments. Automobiles washed at the facility varied from 800 cc cars to jeeps and trucks. Waste generated in the cleaning activities included solid waste, wastewater and gaseous emissions. Wastewater of interest i.e. oil, grease and sediments containing wastewater was generated during automobile washing operation.

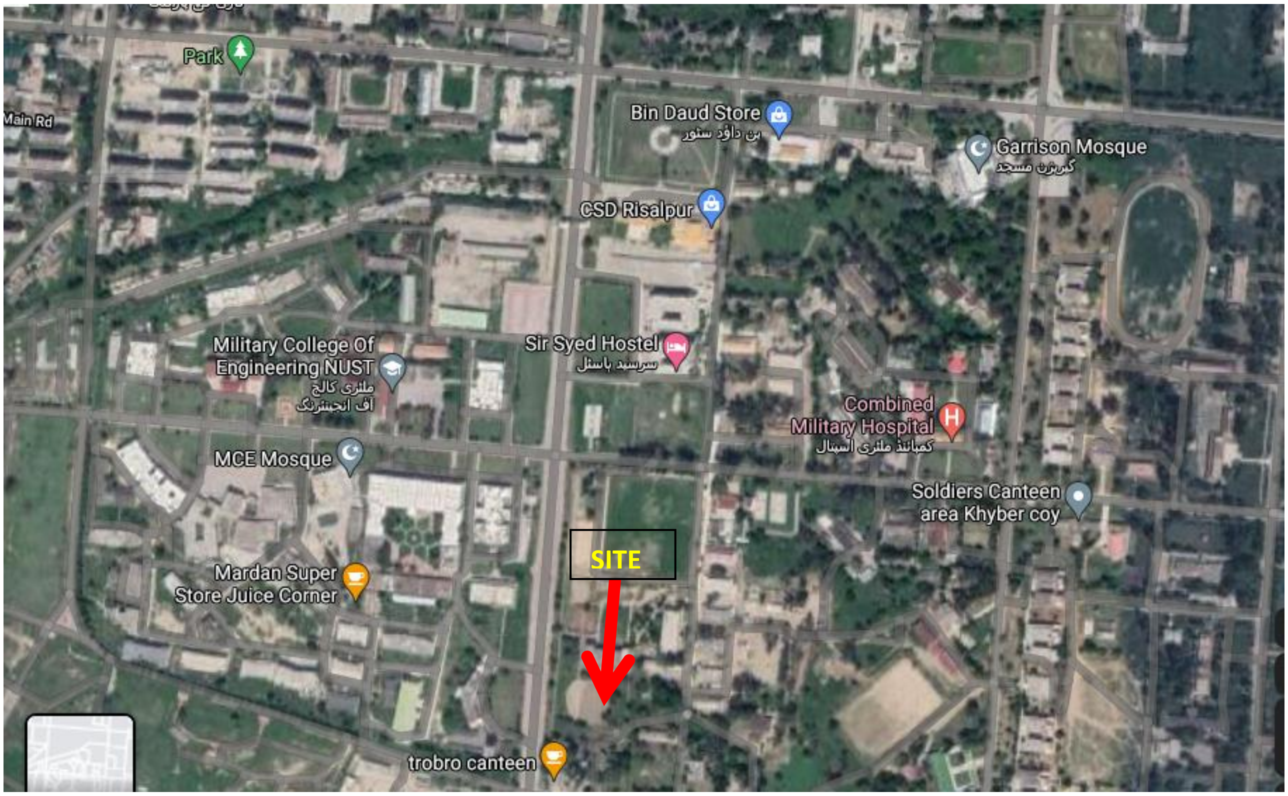


Figure 3.1- Study Area (33 S&T Battalion, Risalpur, KPK, Pakistan)

3.3 SAMPLE COLLECTION

Getting meaningful data form sample depended greatly upon proper collection. To ensure that sample truly represented existing conditions following was ensured during sample collection:-

a. Several samples were taken from different locations of washing bay and analyzed in order to eliminate chances of any irregularity in sample collection. Results from these analyses were then averaged before adoption for the study.

b. The sample were tightly sealed in the bottle immediately after collection, labeled for identification including date, time of collection.

c. Various samples were collected and analyzed for wastewater (one sample at the end of each week once wastewater was being discharged).

3.4 Laboratory analysis of sample

After the sample is collected it was taken to the laboratory for the testing of physical and chemical parameters. Testing of sample for physicochemical and biological parameters was done at Public Health Engineering (PHE) lab, MCE Risalpur. Following are the parameters which were tested for the collected samples of automobile service station wastewater.

3.4.1 Physical and Chemical Parameters

a. pH:

It is a parameter of water quality which tells about the degree of acidity or alkalinity of the solution or water. It is expressed by the negative log of hydrogen ion concentration. It is determined by the pH meter in a laboratory. The normal pH range of drinking water set by WHO standards is 6.5-8.5. In wastewater the range of pH is generally 6.3 to 8.1.

b. Turbidity:

Cloudiness and muddiness in water is due to turbidity. A turbid water is one which contains suspended particles or in which the vision through the water is restricted by a number of suspended elements i.e. silt, organic matter, clay, microorganisms etc. of varying sizes. Turbidity causes an unaesthetic look to water and people might feel guilty to use turbid water. It is measured using the turbidity meter. It is expressed as NTU or FTU.

Figure3.2- Turbidity Meter and pH Meter

c. EC:

The electrical conductivity of water is a parameter which shows its ability to conduct the electrical current. The elements like salt and different chemicals present in water breakdown to form ions, which provide the medium for electricity to flow through water, greater the number of ions present greater will be the conductivity. The salinity and TDS define the EC of water and resultantly its purity. The more the EC of water the less pure it will be and the less EC of water the purer it will be. It is measured using an EC meter.

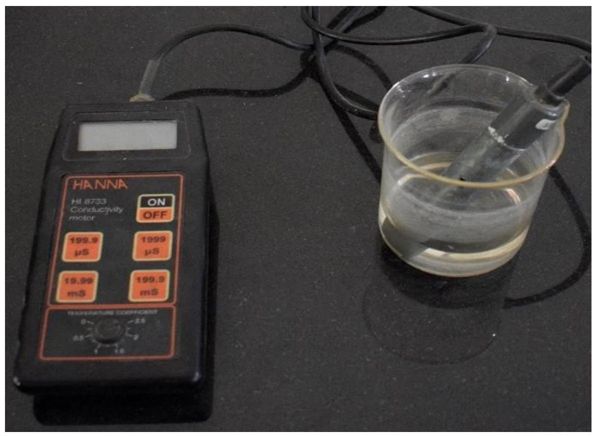


Figure 3.3 Conductivity Meter

d. Temperature:

The increase in temperature of a water body indicates the presence of waste in it, it may either be industrial or domestic waste. The presence of such waste causes increased molecular motion and as a result increased kinetic energy in water. The temperature of water is measured by a thermistor/thermometer or electrically by pH meter.

e. Sulfates:

The sulfates in water body are such a parameter which helps in getting info about the quality of water. Their concentration in water varies from a few hundred to several thousands. Usually the water gets sulfate from certain rocks or it gets contaminated by the chemicals or the sulfate compounds present in soaps and shampoos. The presence of sulfate only up to a certain amount is good, excess sulfate will affect the usage of water for irrigation and will react with plants and soil. The safe values of sulfate as per NEQS is 600 mg/L. the amount of sulfate in a water sample is determined using “spectrophotometer”, an amount of SulfaVer 4 is added to the dilute sample for testing.

f. Nitrates:

The nitrate in water is good for plant and living being use up to a certain amount. The excess amount of it will cause detrimental health impacts like “blue baby syndrome” and cancer. Usually nitrate in surface water comes from the acidic rain or from fertilizers. The amount of nitrate in water is determined using the spectrophotometer. The limit for nitrate as per WHO standards is 50 mg/L.

g. Chlorides:

Chlorides in water are like salts that come in water by a combination of the gas chlorine with a metal. Chlorides in water may come from the chemical detergents. Excess amount of chloride is also harmful for living beings. The safe amount of chloride in water as per NEQS is 1000 mg/L. The chlorides in water are determined by the process of titration and method is known as Argent metric Method.

h. COD:

COD is the amount of oxygen required by the wastewater to stabilize the organic and in organic compounds chemically. The amount of COD that is present in wastewater is always higher than BOD. In lab it is measured using the Open Reflux Method. COD reactor is used to measure COD value.

Figure 3.4 COD Reactor

i. Biochemical Oxygen Demand:

It is a very important parameter to be considered in wastewater treatment. In lab the BOD is measured using the 5-Day BOD test or the Dilution Method.

j. TDS:

TDS includes all of the dissolved inorganic and organic solids and salts in water. The substances dissolved may include sodium, calcium, magnesium, bicarbonates, chlorides and sulphates. It is measured in the lab using the Gravimetric method.

3.4.2 Optimum Coagulant dosage:

a. Selection of Coagulant:

The main objective of coagulation process is to enhance settling of small size particles by agglomeration of particles with the addition of chemical coagulants. The coagulant we selected for our treatment process is aluminum sulphate (alum). As alum is readily available in market at considerable low cost.

b. Optimum Dosage:

Optimum dosage of coagulant has significant effect. To achieve maximum removal of pollutants from waste water, optimum dosage has greater concerns. While laboratory testing, we took an amount of 200 mg/l as optimum amount of alum to get maximum removal of turbidity and other parameters.

c. Jar Test:

In lab, to achieve the process of coagulation and flocculation and to determine the optimum coagulant dosage jar test is generally conducted. Apparatus consist of six jars and different amount of coagulant has to be added in it to find optimum dosage. Rapid mixing at 100-120 rpm for 3-4 minutes is done to achieve coagulation after adding coagulant. Then slow mixing at 15-30 rpm is achieved for 40-45 minutes for flocculation process. After this treated water from each jar is tested to determine the removal percentage of turbidity and other parameters as desired. The sample which give maximum percentage removal is the one in which optimum amount of coagulant was added.

3.4.3 Methods for Laboratory Testing:

Table 3.1: Methods for Laboratory Testing

S.no	Parameters	Method	Test Name/ Main Apparatus
1	PH	Electrometric Method	PH Meter
2	EC	Electrometric Method	Conductivity Meter
3	Temperature	Electrometric Method	PH Meter
4	Turbidity	Nephelometric method	Turbidity meter
5	Sulphates	Sulfa ver 4 Method	Spectrophotometer
6	Nitrates	Cadmium Reduction Method	Spectrophotometer
7	Chlorides	Argentometric Method	Titration
8	COD	Open Reflux Method	COD Reactor
9	BOD	Dilution Method	5 Days BOD Test
10	TDS	Gravimetric Method	China Dish, Filter Paper, Oven

3.5 CHARACTERIZATION OF WASTEWATER

The challenge of characterization the oil-soil agglomeration that form during parts cleaning process was that wastewater was a non-homogeneous mixture of oil droplets, soil particles and oil-soil agglomerations. A method to differentiate these components during a particle size analyses could not be found. Any technique if used for identification of particle size distribution would have altered the character of fragile oil-soil agglomeration during the analysis. Hence it was concluded that characterizing the particle distribution was not practical and the characterization of wastewater would rely entirely on measuring the concentrations of oil and solids. The wastewater was analyzed for COD, TS, TDS, TSS, temperature, turbidity, color, oil and grease. Analytical method was used for analyses of samples in the laboratory. Characterization of source water (influent water) was also conducted for same parameters to determine true amount of various pollutants added by operations in the facility.

3.6 EXPERIMENTAL DESIGN

The experimental design followed in the treatment of wastewater included:-

a. At first, raw service station water coming from a washing bay will be stored in pre-storage tank which is also used as screening chamber. Screens/mesh will be installed in this tank to remove large particles and floating matter.

b. Oil separation/removal using skimming tank.

c. Solids removal through coagulation, flocculation and settling using alum as coagulant.

d. Flocculation basin will be followed by sedimentation tank where suspend solids will settle down by the action of gravity.

e. At the end, service station water will make its way towards sand filtration chamber for further treatment. Flocs formed in during flocculation process will settle down in sedimentation tank and they will further trapped in sand to get the maximum removal of bacteria and pathogens.

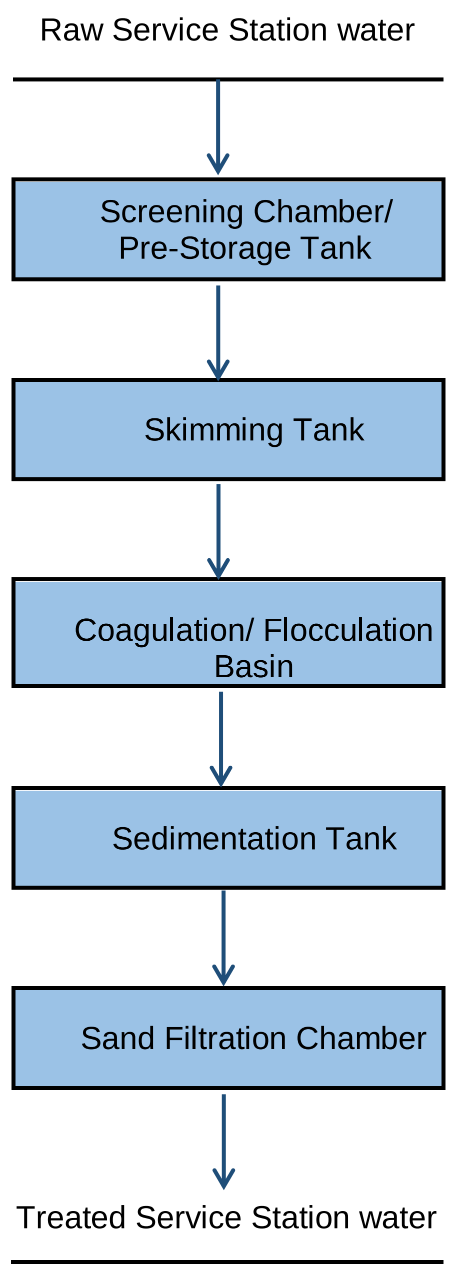


Figure 3.5-Schematic Diagram of Service Station Wastewater Recycling Plant

3.6.1 Screening

To remove larger solids particles, organic matter and floating debris form parts cleaning wastewater, a screen having opening size of one-sixteen inch was used at the intake.

3.6.2 Oil Separation / Removal

Separation and removal of oil from parts cleaning wastewaters was one of the primary aims of the research work. This was also required as a pretreatment before removal of solids. Free Oil will be removed with the help of skimming before coagulation process.

3.6.2.1 Removal of chemically emulsified oil

Oil present in the wastewater was separated through chemical emulsion breaking, a phenomenon commonly known as acid cracking. Commercial grade sulfuric acid (H_2SO_4) was used being cheap and easily available. Acid was added to the wastewater to lower its pH to value less than or equal to two. Gentle agitation was required for complete mixing of acid in the wastewater. Addition of acid to wastewater caused emulsion breaking, freeing the oil content present in wastewater. Oil separated from wastewater, floated to the surface and could be removed. Since pH of the wastewater varied over the period during which parts cleaning operation was conducted (six months) and final pH of wastewater was dependent on the number and types of parts cleaned during this period, therefore the exact amount of acid required could not be laid down. Amount of commercial grade sulfuric acid (H_2SO_4) addition and effects on pH of wastewater were also studied. Upon addition of acid, chemical reaction occurred in wastewater, resulting in foaming followed by formation of black flakes of oil which slowly rose to the surface of wastewater. The wastewater was allowed to stabilize and observed for a period of twenty four hour.

3.6.3 Coagulation, Flocculation and Settling

After removal of oil and grease form the wastewater samples, coagulation was carried out to remove remaining oil, solids, color and COD. This was followed by flocculation and settling. Jar test apparatus was used to determine optimum coagulant dosage and optimum pH. Turbidity meter was used for measurement of turbidity. Jar test was carried out on one liter wastewater samples. Test protocol followed is described below:-

a. Six jars were filled with one liter wastewater samples after pH adjustment. Coagulant dosage of varying concentration was added to five jars and the sixth jar was left without coagulant dosage, which served as control.

b. Rapid mixing was carried out at 120 rpm for two minute.

c. Slow mixing was carried out at 20 rpm for twenty minutes. Size and appearance of flocs formed were noted.

d. After slow mixing, paddles were removed from jars and flocs were allowed to settle for thirty minutes. It was noted that the flocs formed during slow mixing settled completely within the settling time.

e. Oil/grease, turbidity, COD and color of supernatant were measured.

f. The test was repeated with optimum coagulant dosage by varying pH of each wastewater sample to determine optimum pH for coagulation.

3.6.3.1 pH adjustment

Adjustment of pH was required prior to coagulation. pH meter was used for pH measurement. Increase in pH was achieved through addition of commercial grade caustic soda (NaOH) while the decrease in pH was achieved through addition of commercial grade sulfuric acid. Wastewater from automobile washing facility, after oil/water separation, required lowering of pH to optimum range for coagulant dosage. This was achieved through the addition of commercial grade sulfuric acid (H_2SO_4). Amount of acid required depended on initial pH of wastewater and final pH required for treatment.

Amount of caustic soda required depended on initial pH of wastewater and final pH required for coagulant dosage.

3.6.3.2 Coagulation of wastewater from washing bay

Wastewater was subjected to coagulation, flocculation and settling, after the removal of oil. Standard method of coagulation and flocculation was followed. Alum was used as coagulant. Stock solution of alum was prepared by mixing ten gram of alum in one liter of distilled water. Therefore, one milliliter of this stock solution contained ten milligram of alum. The stock solution was kept in a volumetric flask and stirred vigorously before use. To obtain a desired coagulant concentration, required amount of stock solution was added to jar containing wastewater. The data obtained from jar test was recorded in data sheet.

Some wastewater after acid cracking and pH adjustment, still contained sufficient amount of turbidity, color and COD. Coagulation was used for removal of these contaminants; it has been discussed in the following paragraphs.

a. Coagulation with alum

Coagulation of wastewater was carried out using alum as coagulant, after acid cracking, demulsified oil removal and pH adjustment. Required amount of stock solution was added to the jars containing wastewater. The data obtained from jar tests was recorded in data sheet.

3.7 DESIGN OF TREATMENT PLANT

3.7.1 Design Details

a. Design considerations and detailed calculation for each unit are given in Appendix-VI. Schematic of treatment system is shown in Figure. Salient of design are as following:-

b. Wastewater quantities

(1) Service station wastewater = 54,000 liters month

c. Equalization basin/Pre storage Tank.

(1) Type - Rectangular basin.

(2) Dimensions:-

(a) Length - 8.25 m

(b) Width - 1.75 m

(c) Height - 7.38 ft (including free board)

(3) Volume - 41.25 m^3 (41250 liters including free board)

d. Skimming Tank

(1) Type - Rectangular basin

(2) Dimensions:-

(a) Length - 5.25 m

(b) Width - 1.75 m

(c) Height - 1.5 m (including free board)

(3) Volume - 41.25 m^3 (12250 liters including free board)

e. Coagulation/flocculation/settling basin.

(1) Type - Circular basin

(2) Dimensions:-

(a) Diameter - 3.2m

(b) Height - 2 m (including solids accumulation zone and free board)

(3) Volume - 14.75 m^3 (14750 liters including free board)

f. Design of paddle impeller

(1) Type - 2 blade paddle impeller.

(2) Dimensions:-

(a) Diameter blade - 1.9 m

(b) Width of blade - 0.25 m

(c) Height from base - 1 m

(d) Baffles size - 0.32 m

g. Slow sand filter

(1) Type - Rectangular filter.

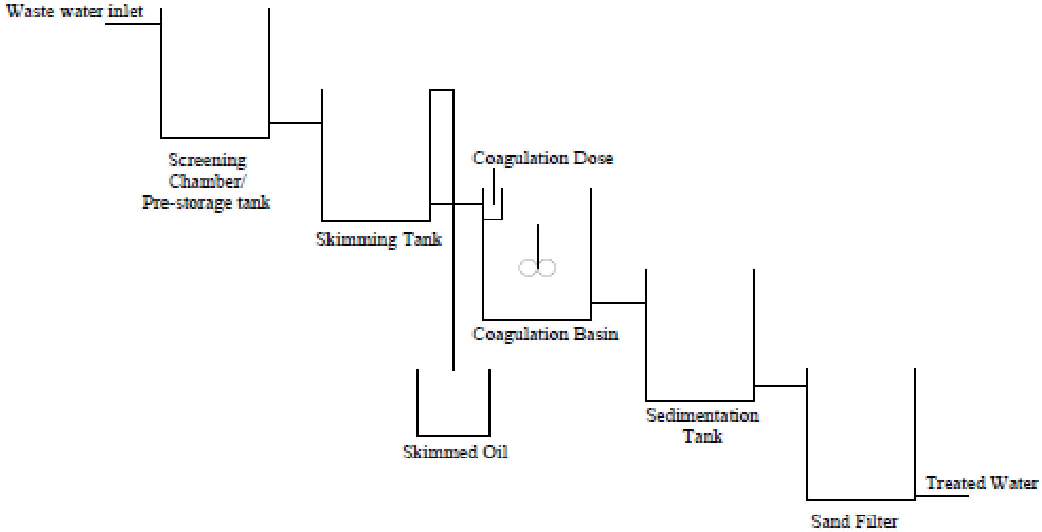
(2) Dimensions:-

(a) Length - 5.25 m

(b) Width - 1.75 m

(c) Height - 1.5 m (including free board)

(3) Volume - 12.25 m^3



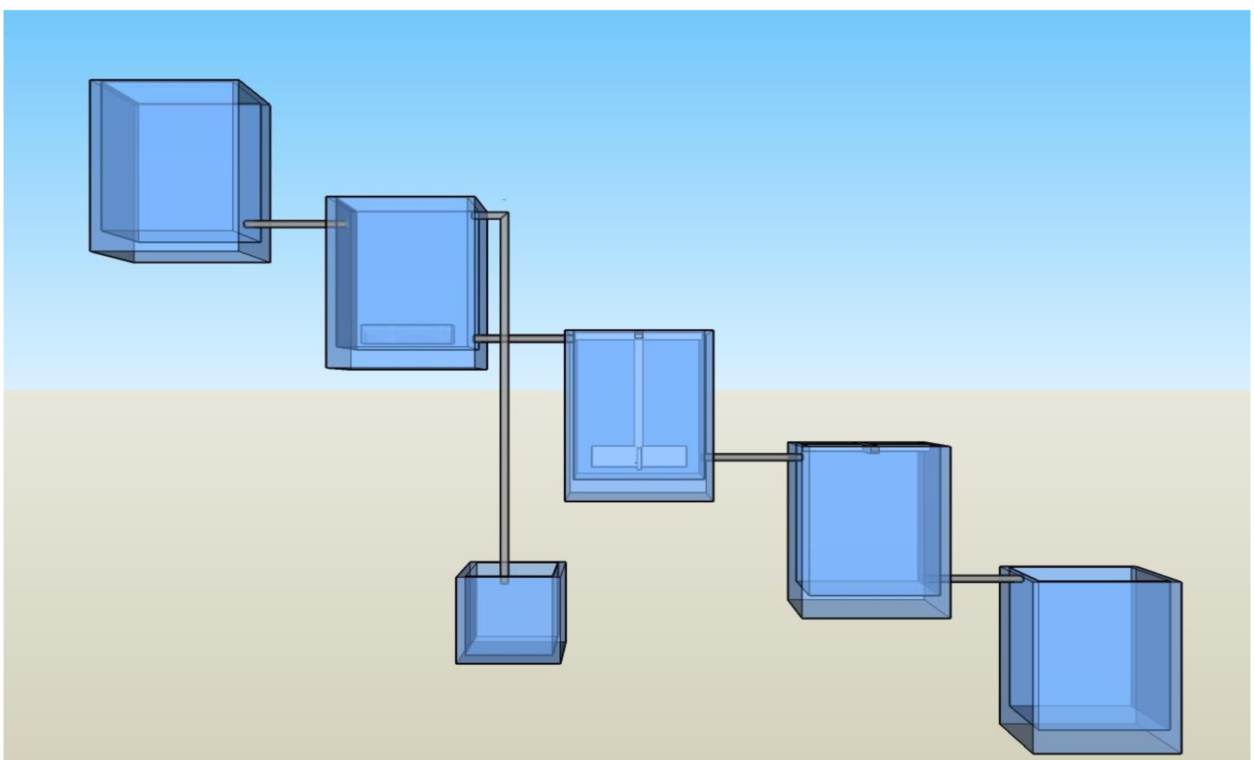


Figure 3.6-FINAL DESIGN OF TREATMENT PLANT

CHAPTER NO 4

RESULTS AND DISCUSSION

Chapter - 4

RESULTS AND DISCUSSION

4.1 PHYSICAL SURVEY

Physical survey of the facility was carried out. Details are as following:-

a. Cleaning bay

1) Length of bay - 7.63 m

2) Width of bay - 6.1 m

3) Height of bay - 0.92 m

b. No of cleaning units - 1

c. Dimension of nullah - Width 2.5 ft, Depth 2 ft

d. Sludge in nullah - 5.08 cm (average)

e. Maximum vehicles washed/ day - 4-5 vehicles/day (all type)

f. pH of cleaning solution - 7-8

g. Monthly wastewater generated - 54000 liters

h. Annual wastewater generated - 648000 liters

Data on monthly vehicles washed in the facility during year 2020 is at Table 4.3.

Table 4.1: Month wise data on vehicles washed during 2020.

Month	No of Vehicles washed
Jan	90
Feb	80
Mar	120
Apr	118
May	110
Jun	95
Jul	140
Aug	93
Sep	85
Oct	105
Nov	98
Dec	70
Total	**1204**

4.2 WASTEWATER CHARACTERISTICS

During the course of study, automobile service/ washing facility was visited for collection of samples and discussion with the staff employed at the facility, on vehicles cleaning operation. Characteristics of input water and wastewater generated at service station are summarized in Table 1 (Appendix-I). Parameters of concern in the wastewaters are given in Table 4.2.

Table 4.2: Pollutants of concern in automobile washing wastewater.

S.No	Parameter	Units	Service Station Wastewater
1.	pH	-	11.82
2.	Turbidity/*Color	NTU/ *Pt Co	1370
3.	TS	Mg/l	4420
4.	Oil and Grease	“	616
5.	COD	“	3210

Oil/grease and COD, were found to be the major pollutants in wastewater, presently being discharged untreated into a local nullah. In addition, solid content analysis (suspended and dissolved solids) indicated that the wastewater had suspended solids higher than NEQS limits. Moreover, dissolved solid were also higher than NEQS limits. COD in wastewater from the facility was mainly due to the high oil and grease content added from oily parts cleaning. The higher organic content and color in wastewater was primarily due to the paint on body parts which got dissolved in the wastewaters. Oil and grease in service station wastewater was mostly in the form of free and chemically emulsified oil.

4.3 OIL AND GREASE REMOVAL

After studying characteristics of wastewater generated from the automobile washing facility and their comparison with NEQS, it was concluded that oil and grease content in the wastewater, presently being discharged untreated, was much higher than NEQS limits. Removal of this oil and grease content was one of the primary objectives of this study.

Table 4.3: Concentration after treatment of automobile washing wastewater

Location	Parameter	Units	Initial Conc.	Conc. After treatment	Percent Removal
Vehicles washing bay wastewater	Oil/grease	“	616	66.46	89.21
	Turbidity	NTU	1370	897	34.53
	COD	mg/l	3210	2230	30.53

4.3.1 Chemical Emulsion Breaking

Since wastewater contained oil and grease in the form of chemical emulsion, in order to remove this oil, chemical emulsion breaking/acid cracking was performed using commercial grade sulfuric acid (H_2SO_4). Sixteen milliliters of acid (ninety percent pure) was required for pH reduction form pH 11.82 to 2.

Foaming effect was produced in the wastewater once pH was reduced to 3. At pH 2, emulsified oil from wastewater got separated and rose to the surface. Color of wastewater also changed after acid cracking. Initially the demulsified oil layer was found to be fragile. After a period of one hour, the oil layer stabilized and could be removed manually, using an oil skimmer or by chemical coagulation. After a period of six hours, the demulsified oil layer started disintegrating into flocs. Heavier flocs of oil settled to the bottom of container while smaller and lighter flocs remained suspended in the wastewater. Implying, after acid cracking, oil from surface of wastewater must be removed within one to six hours. Complete digestion of wastewater was allowed for twelve hours. Results from chemical emulsion breaking are given in Table 4.4.

Table 4.4: Chemical emulsion breaking for wastewater.

S.No	Parameter	Units	Initial	Final Conc.	Percent Removal
1.	Oil and grease	mg/l	66.26	26.8	6.4
2.	COD	mg/l	897	590	22.4
3.	Color	Pt Co	2230	1232	31

Wastewater, after chemical emulsion breaking, contained oil/grease and COD still greater than NEQS limits. Moreover the color of wastewater was also objectionable. Further treatment of the wastewater was required. Volume of commercial Hydrochloric Acid (HCL) required for pH adjustment, for the wastewater is given in Table 4.5.

Table 4.5: Adjustment of pH with acid in vehicles cleaning wastewater.

Description	Initial pH	Final pH	Vol. of HCL (ml/l)
Vehicles cleaning wastewater	11.82	2	2.5

4.4 COAGULATION, FLOCCULATION AND SETTLING

Comparison of solids in the wastewater with NEQS (refer Appendix-I) shows that suspended solids in the wastewater samples were much higher than the permissible limits. Moreover dissolved solids in wastewater were also higher than NEQS limits. After removal of oil using skimming process, removal of turbidity/color was achieved through coagulation. In addition to this, removal of oil and COD in these wastewaters was also studied. pH adjustment was carried out for efficient coagulation. Commercial grade caustic soda (NaOH) was used for raising pH in wastewater, after acid cracking. Table 2 (Appendix-III) shows the pH values corresponding to caustic soda (NaOH) dosage for the wastewater. 1.6 g/l of caustic soda (NaOH) was required for wastewater, for pH increase from pH 2 to 7.

4.4.1 Coagulation with Alum

Aluminum sulphate was used as coagulant for wastewater. Moreover, alum dosage for wastewater was also determined. Samples taken after jar test were analyzed for turbidity, COD, oil/grease and color. Results from jar test using alum as coagulant are given in Table (Appendix-IV). Tables 4.6 show results of alum treatment for the wastewater. Test result indicated that for wastewater, more than 99 percent turbidity removal was achieved with alum dosage of 200 mg/l. COD and oil/grease at this coagulant dose were also within the permissible limits.

Table 4.6: Coagulation of automobile cleaning wastewater with alum.

Description/Parameter		Units	Initial Conc.	Final Conc	Removal Percentage
Vehicles cleaning wastewater	Turbidity	NTU	590	4.5	42.73
	Oil/grease	mg/l	26.8	9	2.88
	COD	“	1232	210	31.83

4.5 WATER CONSUMPTION AND WASTE GENERATION

Water for use in the automobile service station was obtained from municipal water supply source. This water was treated before supply, primary for human consumption. Use of this water for industrial activity was wastage of the resource and uneconomical. Recycling/reuse of wastewater could help reduce this loss.

Table 4.7: Water consumption during cleaning operations

S.No	Description	Units	Washing facility
1.	Water per month	Liters	60,000
2.	Number of months per year	Nos	12
3.	Annual water use	Liters	720000
4.	Losses	Percent	10
		Liters	72000
5.	Total wastewater generated	"	648000

Based on the automobile washing data for year 2020 (Table 4.3), annual water use and wastewater generated per vehicles during washing in the facility was calculated as following:-

- Total number of vehicles washed (year 2020) - 1204
- Total water used for vehicles cleaning - 720000 liters
- Total wastewater generated - 648000 liters
- Water used per vehicle - 598 liters
- Wastewater generated per vehicle - 538 liters

. Analysis of solid waste generated during vehicles cleaning operations was not included in the study.

4.6 SUMMARY

4.6.1 Oil and Grease Removal

Oil from wastewater was primarily removed with the help of skimming. Remaining oil was removed by coagulation with alum. Wastewater contained chemically emulsified oil which was mainly removed by chemical emulsion breaking. Table 4.8 show the overall removal of oil from wastewater during treatment process After treatment, the wastewaters had remaining oil and grease content within NEQS limits.

4.6.2 COD Removal

COD was primarily due to oil and grease content present in the wastewater. Removal of oil and grease during various treatment processes also reduced COD from these wastewaters. Table 4.9 show the overall removal of COD from wastewater during various treatment process. After treatment, the wastewater had remaining COD content within NEQS limits.

4.6.3 Turbidity and Color Removal

Turbidity in wastewater was due to suspended and dissolved solids. Wastewater, in addition to these factors, also had dissolved color pigments form body parts. Removal of turbidity and color from the wastewater was achieved during various treatment processes. Table 4.10 shows the removal of turbidity/color. Wastewater after treatment had solid content within NEQS limits. Color from wastewater was also completely removed.

Table 4.8: Overall oil removal from parts cleaning wastewaters.

S.No	Description	Units	Service station wastewater
1.	Initial concentration	mg/l	616
2.	Removal with skimming	"	549.54
		%	89.21
3.	Removal with chemical emulsion breaking	mg/l	39.46
		%	6.4
4.	Removal through coagulation	mg/l	17.8
		%	2.88
5.	Remaining oil	mg/l	9
		%	1.46

Note: NA- not applicable

Table 4.9: Overall COD removal from parts cleaning wastewaters.

S.No	Description	Units	Service station wastewater
1.	Initial concentration	mg/l	3210
2.	Removal with skimming	"	980
		%	30.5
3.	Removal with chemical emulsion breaking	mg/l	998
		%	31
4.	Removal through coagulation with alum	mg/l	1022
		%	31.83
5.	Remaining COD	mg/l	210
		%	6.54

Note: NA – not applicable

Table 4.10: Overall turbidity/color removal from parts cleaning wastewaters

S.No	Description	Units	Service station wastewater
1.	Initial concentration	NTU Pt Co	1370
2.	Removal with skimming	NTU	473
		%	34.52
3.	Removal with chemical emulsion breaking	Pt Co	307
		%	22.4
4.	Removal through coagulation with alum	NTU Pt Co	585.5
		%	42.73
5.	Remaining turbidity/color	NTU Pt Co	4.5
		%	0.32

CHAPTER 5

ECONOMIC EVALUATION

Chapter - 5

ECONOMIC EVALUATION

5.1 GENERAL

The number of automobiles washed in the facility varied from time to time. Data on the monthly vehicles washed was obtained (Table 4.1) and on this basis average water used for cleaning of each vehicle was 658 liters. Average wastewater generate per vehicle was 538 liters. Oil /grease, paint, dirt and rust etc. attached with the parts were removed during cleaning operation which contributed towards the pollutants found in these wastewaters. Oil/grease and COD were the major pollutants in all wastewater samples. Presently this wastewater is being discharged untreated into a local water body. Treatment of it would require initial capital for the installation of treatment plant and the operation/maintenance cost as recurring expenditure. Cost could be recovered through reuse of treated water from parts cleaning and selling of recovered mineral oil from wastewaters.

5.2 WATER CONSERVATION

Conservation of water was one of the options considered, as a result of wastewater treatment study. Water used for vehicles cleaning in the facility was taken from municipal water supply source. This water was being treated for human consumption; its use for industrial activity was wastes of resource and economic burden in a country fast leading to water shortage situation. Moreover disposal of wastewater without considering the option of reuse was unjustified. As a result of wastewater treatment, water saving could be achieved to large extent. Details of water use and conservation is as following:-

a. Annual water used for automobile washing - 720,000 liters

b. Annual wastewater generated - 648,000 liters

c. Water used per vehicle - 598 liters

d.	Wastewater generated per vehicle	-	538 liters
e.	Losses during wastewater treatment	-	15 percent
f.	Annual water available for reuse	-	550,800 liters
g.	Additional water required	-	169,200 "
h.	Annual water conservation	-	76.5 percent
i.	Average cost of water	-	Rs. 0.3 per liter
j.	Annual cost of water conserved	-	Rs. 165240
k.	Cost of water conserved per vehicle	-	Rs. 137.24

5.3 OIL AND GREASE RECOVERY

The analysis results of the wastewater samples collected from automobile washing facility were viewed and average oil removed was determined as following:-

a.	Average oil concentration in the wastewater samples	-	616 mg/l
b.	Oil removal after treatment (Upto 98 percent)	-	607 mg/l
c.	Annual wastewater produced	-	648000 liters
d.	Annual oil and grease recovered	-	393.33 kg
e.	Annual cost of oil/grease recovered @ Rs.50/kg*	-	Rs. 19666.00
f.	Cost of oil/grease recovered per vehicle	-	Rs. 16.33

* Rate based on market survey of waste oil recyclers

5.4 COST OF CHEMICAL TREATMENT

Treatment was provided to wastewaters during various stages. After initial sedimentation process and oil removal, the removal of oil adhered particles by alum treatment resulted in further decrease in the concentration of oil, COD and turbidity/color in wastewater. Chemicals required for treatment on annual basis are given in Table (Appendix – V). Annual cost of treatment required for automobile washing facility wastewater is given in Table 5.1.

Table 5.1: Cost of chemical treatment for service station wastewater

S.No	Item	Quantity (kg / liters)	Rate (Rs/kg or Rs/liter)	Cost (Rs)
1.	Commercial grade Hydrochloric acid	1620	50	81000
2.	Alum	130	200	26000
3.	Caustic Soda (NaOH)	1036.8	350	362880
4.	Total cost			469,880
5.	Cost per vehicle			390.26

* Including losses/wastage

5.5 SUMMARY

Considering the cost of chemicals required for wastewater treatment, savings in the cost of water reused after treatment and the cost of recovered oil/grease, the overall economic effect of treating wastewaters from automobile washing facility was determined as following:-

a. Cost of chemical treatment - Rs. 390.26 per vehicle

b. Saving in cost of water reused - Rs. 137.24 “

c. Saving through selling of recovered oil and grease - Rs 16.33“

d. Overall cost of treatment - Rs. 236.69 per vehicle.

Approx 237 “

The overall cost of treatment for automobile washing facility wastewaters did not cater for the capital cost of treatment plant.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Following conclusions were drawn from the study:

a. Survey and analysis of wastewater from automobile washing operations revealed that this wastewater contained oil/grease, COD and solids much higher than NEQS limits. Treated/Drinking water of quantity 0.72 million liters was being utilized annually for vehicles cleaning in the automobile washing facility. 0.64 Million liters of wastewater was generated during the process containing 393.33 kilograms of used mineral oil. This oil could be recovered and used for different purposes e.g. as fuel in brick kilns.

b. Wastewater from cleaning of mechanical parts contained free and mechanically emulsified oil which could be removed using treatment processes.

c. Wastewater from cleaning of body part contained chemically emulsified oil which separated through chemical emulsion breaking.

d. Alum was found to be a suitable chemical for coagulation. 200 mg/l alum dose was required for wastewater. 3-5 percent COD removal was also observed during coagulation. Wastewater from cleaning of mechanical parts became fit for recycling/disposal after removal of oil and solids.

e. An overall cost of Rs. 237.00 per vehicle annually would incur for treatment of facility wastewater.

f. Treated waste water can be used for garden watering, car washing, house cleaning and toilet flushing. Therefore, to reduce the demand of fresh water and solve the issue of water crisis of Pakistan.

6.2 RECOMMENDATIONS

a. Use of treated municipal water for vehicles cleaning operations should be discouraged. Owners of such facilities should be made aware of hazards of disposing untreated wastewaters into bodies and benefits of reusing treated wastewater.

b. The study should be kept continued on analysis/disposal methods for solid waste generated during vehicles cleaning operations.

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* Note: To link to these pages, use the link through http://www.P2pays.org/ and type the document path in the search or go thorough
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http://www.google.com/search?q=cache:j9p78Hf_1EYJ:www.p2pays.org/ref/02/01066.pdf+wastewater+from+steam+cleaning+operations.

Appendix – I

CHARACTERIZATION OF WASTEWATER SAMPLES AUTOMOBILE WASHING FACILITY

Table 1: Characterization of service station wastewater

S.No	Parameter	Units	NEQS Limit (into inland water)	Input water	Service Station Wastewater
1.	Temperature	^0C	=<3^0C	12	27.1
2.	pH	-	6 - 9	8.3	11.8
3.	Turbidity	NTU	-	2	1370
4.	TS	mg/l	-	810	4420
5.	TDS	"	3500	540	1500
6.	TSS	"	200	270	2920
7.	Oil and grease	"	10	Nil	816
8.	COD	"	250	41	3210
9.	DO	"	-	9.1	0.17
10.	Chlorides	mg Cl^-/l	1000	90	243.92
11.	Color	Pt Co	-	Nil	15

Appendix – II

PH ADJUSTMENT
AUTOMOBILE WASHING FACILITY

Table 1: PH trends observed in service station wastewater using acid

S.No	Volume of Acid (ml/l)	pH
1.	Initial	11.82
2.	2	11.38
3.	4	10.62
4.	6	8.88
5.	8	6.17
6.	9	5.96
7.	10	4.83
8.	11	3.33
9.	12	2.69
10.	13	2.42
11.	14	2.28
12.	15	2.16
13.	16	2.08

Appendix – III

COAGULATION AND FLOCCULATION RESULTS
AUTOMOBILE WASHING FACILITY

Table 1: Coagulation of wastewater with alum

S.No	Alum Dosage (mg/l)	Turbidity (NTU)	% Turbidity Removal
1.	0	590	NIL
2.	50	449	23.9
3.	100	324	63.9
4.	150	102	88.6
5.	***200***	***4.5***	***99.5***
6.	250	211	76.5

Initial COD = 1232 mg/l Final COD = 210 mg/l

Initial oil and grease = 16.35 mg/l Final oil and grease = 7.4 mg/l

Appendix IV

DESIGN OF SERVICE STATION WASTEWATER TREATMENT PLANT

1. Wastewater Quantities
   a. Service station wastewater - 54000 liters/month
2. Design Considerations
   a. General
      i. Wastewater is discharged on weekly basis.
      ii. Wastewater required following treatment:-
         1. Screening
         2. Oil skimming.
         3. Coagulation, flocculation and settling.
      iii. Treatment of wastewater also included:-
         1. Chemical emulsion breaking/acid cracking.
         2. Coagulation, flocculation and settling
         3. Filtration.
   b. Acid cracking/equalization basin
      i. Capacity of basin - 4000 liters
      ii. One hour detention time for wastewaters.
      iii. One to six hours detention time for wastewater after acid addition.
      iv. Equalization basin to act as storage
   c. Skimming Tank
      i. Capacity of basin - 10000 liters.
      ii. Detention time - 1 hour.
      iii. Depth of chamber - 1.22 to 2.44 m
      iv. Length to width ratio - 3 to 5
      v. Capacity for settleable solids in Skimming Tank.
      vi. Accessibility for inspection and maintenance.
      vii. Oil skimmer for removal of separated oil.

d. Coagulation/flocculation/settling basin

i. Capacity of basin - 10000 liters

ii. Single tank for coagulation, flocculation and settling.

iii. Coagulation at 120 rpm for 2 minutes.

iv. Flocculation at 20 rpm for 20 minutes.

v. Settling under quiescent conditions for 30 minutes.

vi. Paddle impeller

1. Diameter of impeller - 50 to 80 percent of tank dia.

2. Width of blade - 1/6 to 1/10 of paddle dia.

3. Baffles - 10 percent of tank dia.

4. Height of blade from base - 50 percent of tank dia.

e. Slow sand filter (McGhee, 1991)

i. Filtration rate < 6.52 liters/minute – m^2.

ii. Shape of filter - rectangular.

iii. Vertical brick masonry side walls.

iv. Filter media

1. Under drains with perforated pipes.

2. Gravel layer - 0.3 m (graded 5 mm at top, 50 mm bottom)

3. Sand layer - 1 m (size 0.1-0.3 mm, fine sand).

v. Control measures - V notch weir with regulated gate valve.

vi. Filter cleaning

1. When water depth above sand rise to 1.25 m.

2. Top sand layer removal upto 12 mm for cleaning.

3. Manual cleaning of sand by agitation in continuous flowing water.

4. Minimum depth of filter 0.5 m.

3. Design

a. Design of equalization/acid cracking basin

i.	Volume of wastewater	-	40000 liters
ii.	Length to width ratio	-	3 to 1
iii.	Minimum volume of basin	-	40 m^3

iv. For rectangular portion of tank (assuming height of 1.75m)

Length (L) X Width (W) X Height (H)	= 40
3 W X W X 1.75	= 40
Width	= 2.75
Length	= 8.25 m
Height	= 1.75 m
Volume	= 39.7 m^3

v. For settling zone (assuming height of 0.25 m)

Volume	= 1/3 (A X H)
	= 1/3 (8.25 x 2.75 x 0.25)
	= 1.89 m^3

vi. Total volume = 41.59 m^3

vii. Free board

Free board available	= 1.59 / (2.75x8.25)
	= 0.07 m
Required	= 0.25 m

viii. Final dimension

Length	= 8.25 m
Width	= 2.75 m
Total height	= 2.25 m

b. Design of Skimming Tank

i.	Volume of wastewater	-	10000 liters
ii.	Length to width ratio	-	1 to 3
iii.	Minimum volume of basin	-	10 m^3

iv. For rectangular portion of tank (assuming height of 1.25 m)

L X W X H = 10

3 W X W X 1.25 = 10

Width = 1.75 m

Length = 5.25 m

Height = 1.25 m

Volume = 11.484 m^3

v. For settling zone (assuming height of 0.25 m)

Volume = 1/3 (A X H)

= 1/3 (5.25 X 1.75 X 0.25)

= 0.766 m^3

vi. Total volume = 12.25 m^3

vii. Free board

Free board available = 2.25 / (1.75 X 5.25)

= 0.245 m

Required = 0.25 m

vii. Final dimensions

Length = 5.25 m

Width = 1.75 m

Total height = 1.5 m

c. Design of coagulation/flocculation/settling basin

i. Volume of wastewater - 10000 liters

ii. Minimum volume of basin - 10 m^3

iii. For cylindrical portion of tank (assuming height of 1.25 m)

π / 4 X (D^2 X H) = 10

π / 4 X (D^2 X 1.25) = 10

Diameter = 3.2 m

iv. For settling zone/cone (assuming height of 0.25 m)

Volume = 1/3 (π / 4 X (D^2 X H)

		=	1/3 (π / 4 X (3.2^2 X 0.25)
		=	0.67 m^3
v.	Total volume	=	10.72 m^3
vi.	Free board		
	Free board available	=	0.72 x 4/ π X 3.2^2
		=	0.895 m
	Required	=	0.5 m
vii.	Final dimensions		
	Diameter	=	3.2 m
	Height of cone	=	0.25 m
	Total height	=	2.0 m

d. Design of 2 blade paddle impeller

i.	Diameter of paddle blade	=	0.6 X D
		=	0.6 X 3.2
		=	1.9 m
ii.	Width of blade	=	1/8 X 1.9
		=	0.25 m
iii.	Baffles	=	0.1 X 3.2
		=	0.32 m
iv.	Height of paddles from base	=	½ X 1.9
		=	1 m

e. Design of slow sand filter

i.	Length of filter	-	3 m
ii.	Width of filter	-	2 m
iii.	Area of filter	-	6 m^2
iv.	Side walls	-	3.1 m from base (vertical brick masonry)
v.	Under drains	-	perforated RCC pipes 0.3 m height
vi.	Gravel layer	-	0.3 m (graded 5-50 mm)

vii. Sand layer - 1 m (fine sand, size 0.1 mm)

viii. Walls above sand layer - 1.5 m

Appendix – V

CHEMICAL REQUIRED FOR WASTEWATER TREATMENT

AUTOMOBILE WASHING FACILITY RISALPUR

Description	Wastewater Quantity (liters)	Hydrochloric Acid		Caustic Soda		Alum	
		Dose (ml/l)	Quantity (liters)	Dose (g/l)	Quantity (kg)	Dose (mg/l)	Quantity (kg)
Service Station Wastewater	648000	2.5	1620	1.6	1036.8	200	130

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