BE CIVIL ENGINEERING
PROJECT REPORT

STUDY ON THE WASTE WATER CHARACTERISTICS OF MCE RISALPUR

Project submitted in partial fulfillment of the requirements for the degree of

BE Civil Engineering

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MILITARY COLLEGE OF ENGINEERING

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This to certify that the

BE Civil Engineering Project entitled

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Has been accepted towards the partial fulfilment of the requirements for

BE Civil Engineering Degree

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Syndicate Advisor

Dedication

Special dedication to my parents
My supervisor, my beloved friends,
and all faculty members

For all support, encouragement and believe in me. Thank you so much.

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1. All gratitude is due to Almighty ALLAH and peace be upon the Holy Prophet Muhammad (SAW).

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Pakistan has now essentially exhausted its available water-resources and is on the verge of becoming a water-deficit country. The per-capita water availability has dropped from 5,600 m to 1,000 m. The public water-requirement has risen manifolds, as population is increasing, industry is growing and we are bringing more area under cultivation to meet the increasing demand for agriculture-products. The quality of groundwater and surface-water is low and is further deteriorating because of unchecked disposal of untreated municipal and industrial wastewater and excessive use of fertilizers and insecticides.

Sedimentation tanks are used to improve the quality of point and non-point sources of water pollution which includes domestic wastewater. Sedimentation tank can be used as primary treatment for wastewater and for are used as one component in a sequential treatment. The most common application of the sedimentation tank is the primary treatment of domestic sewage effluent. Wastewater is further treated in secondary stage for further removal of impurities. As the treated wastewater satisfactorily meets the Pakistan National Environmental Quality Standards (NEQS), thus it can be used for horticulture & replenishing underlying groundwater aquifer. The solid waste collected from the Sedimentation Tank after drying up can be used as fertilizer for trees & plants, thus converting the whole project into “Zero Waste”. This project presents an overview of low-cost treatment option for the treatment of waste water of MCE with sedimentation tank.

Chapter 1

INTRODUCTION

1.1 General

Every community produces both liquid and solid wastes. The liquid portion is essentially the water supply of the community after it has been fouled by a variety of uses. From the standard point of sources of generations, waste water may be defined as a combination of the liquid or water carried wastes removed from residences, institutions and commercial and industrial establishments together with such ground water, surface water and storm water as may be present.

The need for systems of waste water treatment in large towns became evident during the industrial revolution. Urban areas were developed without adequate provision of water supply or the removal of waste water. Water was taken from its shallow wells, from polluted streams or at best from leaky water mains which were kept under pressure for only a few hours each day. Accumulation of waste matter resulted in the contamination of the water supplies. High mortality from the water borne diseases, typhoid, cholera and forms of dysentery were wide spread in the densely populated areas in early 19th century.

The development of waste water engineering has paralleled and contributed to the growth of cities. Without adequate supply of safe water, a large city could not exist and life in it would be both unpleasant and dangerous unless human and other ways were promptly removed. The concentration of population in relatively small areas has made the task of sanitary engineers more complex.

Waste water engineering is that branch of environmental engineering in which the basic principles of science and engineering are applied to do problems of water pollution control. The ultimate goal - waste water management - is protection of environment in a manner commensurate with economic, social and political concerns.

Third world countries like Pakistan are facing problems of diseases like cholera, typhoid, malaria etc. All these are basically the product of poor sewerage system and inadequate water drainage. Most of the population has no sense of waste water disposal. Most of our cities have no sewerage system and if any odd area has one, it is so badly misused that it hardly works for half of its design life.

Under the growing environmental concern and depletion of scarce water resources it is essential that we preserve whatever the nature has bestowed upon us and make best use of it. Safe waste water disposal not only prevents population of our ground water resources but also helps in preservation of environments besides protecting human life from fatal diseases.

Risalpur is an old cantonment set up during British rule. As the time is passing the cantt is growing into a city which requires an adequate sewerage system. At present there is no such facility existing. Resulting waste water collection, transportation, treatment and disposal systems have nearly failed creating unhygienic environments and health hazards.

1.2 Objectives of our study

Our syndicate was assigned the task to study on the waste water characteristics of MCE Risalpur. We have made a modest effort towards reclaiming the prevailing environment which is deteriorating every day. The Objectives of our study include:

1. To estimate the amount of waste water being generated.
2. To analyze the waste water characteristics.
3. To find the optimum detention time and other parameters for the design of sedimentation tank.
4. Design sedimentation tank for MCE wastewater.

Chapter 2

LITRATURE REVIEW

2.1 General:

Water scarcity is among the main problems to be faced by many societies and the World in the 19^{th} century. Water use has been growing at more than twice the rate of population increase in the last century, and, although there is no global water scarcity as such, an increasing number of regions are chronically short of water. Water scarcity is both a natural and a human-made phenomenon. There is enough freshwater on the planet for six billion people but it is distributed unevenly and too much of it is wasted, polluted and unsustainably managed. Water scarcity already affects every continent. Around **1.2 billion** people, or almost one-fifth of the world's population, live in areas of physical scarcity, and 500 million people are approaching this situation. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage (where countries lack the necessary infrastructure to take water from rivers and aquifers).

Hydrologists typically assess scarcity by looking at the population-water equation. An area is experiencing water stress when annual water supplies drop below 1,700 m^3 per person. When annual water supplies drop below 1,000 m^3 per person, the population faces water scarcity, and below 500 cubic meters "absolute scarcity"[1].

With increasing population and depleting water resources, Pakistan is fast heading towards a situation of water shortage and threat of famine. Per capita surface water availability for irrigation was 5260 cubic meters per year in 1951. It has reduced to 1100 cubic meters per capita in 2006. The minimum water requirement to avoid being a "water short country" is 1,000 cubic meters per capita Per year. As such in the year 2012, Pakistan will have reached the stage of "acute water shortage", where people flight for every drop of water.

To fulfill the requirement we should go for new resources of water, the most important resources of water is to reuse the wastewater after some treatment. This treated wastewater has a wide applications, the most important application is that waste water may use for irrigation purpose, because it contains nutrients like nitrogen and phosphorous that are essential for plant growth, it not only fulfill the water requirement but also provide nutrients that will remove the extra cost for using fertilizers.

2.2 Composition of Wastewater:

Wastewaters consist of water in which solids exist as settleable particles, dispersed as colloids, which are materials that do not settle readily, or solids in a dissolved state. The wastewater mixture will contain large numbers of microscopic organisms, mostly bacteria that are capable of consuming the organic component (fats, proteins and carbohydrates) of the mixture and bringing about rapid changes in the wastewater. Since the sources of wastewater as well as the inputs are highly variable and since there is also an active microbial component, the composition of all wastewaters is constantly changing. Prior to entering a wastewater treatment plant, a wastewater is sometimes called raw wastewater or raw sewage.

The solid components of wastewaters actually represent a very small part of most discharges, usually less than 0.1 percent by weight. However, it is this small component of the wastewater that presents the major challenges in wastewater treatment, operation and disposal. Essentially, the water component, the other 99.9 percent can be viewed as providing the volume and the vehicle for transporting the solid and microbial component of the wastewater. Although the solid component of wastewaters was noted above as consisting of less than 0.1 percent by weight of the wastewater, the common method used to express the components of water is not percentage. The amount of materials commonly found in or added to wastewater are more easily expressed as a concentration in milligrams per liter. This is sometimes still called parts per million. For practical purposes, these terms may be considered equal. For purposes of conversion, one milligram per liter is equivalent to 8.34 pounds per million gallons.

Considered chemically, wastewater is a very complex mixture of components that would be difficult to completely define. In broad terms, it consists of an organic and an inorganic component. Although a variety of chemical tests are used to characterize wastewaters, not all of the chemical components will be discussed, only the most important. Probably the most often measured characteristics of wastewater are suspended solids and BOD. Because solids are an important category in wastewaters, their composition is explained in some detail [2].

2.3 Wastewater Treatment:

Treatment of wastewater depends upon two things

- Characteristics of raw wastewater
- Intended use of waste water

Treatment of wastewater means physical, chemical, and biological processes and operations to remove solids, organic matter and, sometimes, nutrients from wastewater. In some countries, disinfection to remove pathogens sometimes follows the last treatment step.

2.3.1 **Preliminary treatment:**

The objective of preliminary treatment is the removal of coarse solids and other large materials often found in raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units. Preliminary treatment operations typically include coarse screening, grit removal and, in some cases, comminution of large objects. In grit chambers, the velocity of the water through the chamber is maintained sufficiently high, or air is used, so as to prevent the settling of most organic solids. Grit removal is not included as a preliminary treatment step in most small wastewater treatment plants. Comminutors are sometimes adopted to supplement coarse screening and serve to reduce the size of large particles so that they will be removed in the form of sludge in subsequent treatment processes. Flow measurement devices, often standing-wave flumes, are always included at the preliminary treatment stage [2].

2.3.2 **Primary treatment:**

The objective of primary treatment is the removal of settleable organic and inorganic solids by sedimentation, and the removal of materials that will float (scum) by skimming. Approximately

25 to 50% of the incoming biochemical oxygen demand (BOD5), 50 to 70% of the total suspended solids (SS), and 65% of the oil and grease are removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected. The effluent from primary sedimentation units is referred to as primary effluent [2].

2.3.3 **Secondary treatment:**

Secondary wastewater treatment is the second stage of wastewater treatment that takes place after the primary treatment process. The process consists of removing or reducing contaminants or growths that are left in the wastewater from the primary treatment process. Usually biological treatment is used to treat wastewater in this step because it is the most effective type of treatment on bacteria, or contaminant, growth. Secondary treatment processes can remove up to 90 percent of the organic matter in wastewater by using biological treatment processes. Secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes. Aerobic biological treatment is performed in the presence of oxygen by aerobic microorganisms (principally bacteria) that metabolize the organic matter in the wastewater, thereby producing more microorganisms and inorganic end-products (principally CO2, NH3, and H2O). Several aerobic biological processes are used for secondary treatment differing primarily in the manner in which oxygen is supplied to the microorganisms and in the rate at which organisms metabolize the organic matter [2]. The important processes are

- Activated Sludge process
- Waste Stabilization ponds
- Aerated Lagoons
- Trickling Filters

2.3.4 **Tertiary or Advanced treatment:**

Tertiary and/or advanced wastewater treatment is employed when specific wastewater constituents which cannot be removed by secondary treatment must be removed. Individual treatment processes are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids. Because advanced treatment usually follows high-rate secondary treatment, it is sometimes referred to as tertiary treatment. However, advanced treatment processes are sometimes combined with primary or secondary treatment (e.g., chemical addition to primary clarifiers or aeration basins to remove phosphorus) or used in place of secondary treatment (e.g., overland flow treatment of primary effluent) [2].

- Membrane Filtration and Separation

- Reverse Osmosis (RO) Systems
- Ion Exchange
- Activated Carbon Adsorption

2.3.5 **Disinfection:**

Disinfection normally involves the injection of a chlorine solution at the head end of a chlorine contact basin. The chlorine dosage depends upon the strength of the wastewater and other factors, but dosages of 5 to 15 mg/l are common. Ozone and ultra violet (uv) irradiation can also be used for disinfection but these methods of disinfection are not in common use. Chlorine contact basins are usually rectangular channels, with baffles to prevent short-circuiting, designed to provide a contact time of about 30 minutes. However, to meet advanced wastewater treatment requirements, a chlorine contact time of as long as 120 minutes is sometimes required for specific irrigation uses of reclaimed wastewater. The bactericidal effects of chlorine and other disinfectants are dependent upon pH, contact time, organic content, and effluent temperature [2].

2.4 Wastewater reuse:

Water is a renewable resource within the hydrological cycle. The water recycled by natural systems provides a clean and safe resource which is then deteriorated by different levels of pollution depending on how, and to what extent, it is used. Once used, however, water can be reclaimed and used again for different beneficial uses. The quality of the once-used water and the specific type of reuse (or reuse objective) define the levels of subsequent treatment needed, as well as the associated treatment costs. By reducing the waste constituents from wastewater to an acceptable level, the water can be safely used for agricultural, commercial, residential and industrial purposes. This is termed direct reuse. By volume, agricultural irrigation is the largest user of reclaimed wastewater. Other major users include those who use water for industrial cooling and processing. A second category of reuse is indirect reuse. Highly treated wastewater can be used to recharge aquifers. This is an indirect reuse because the reclaimed water mixes with the groundwater which can serve as a future raw water supply [2].

- Irrigation

- Industrial reuse
- Environmental or Recreational reuse
- Urban reuse
- Aquifer recharge

2.5 History of wastewater Reuse:

For nearly 100 years, highly treated reclaimed water has been used in the United States. In the early days of water reclamation and reuse, many of the large-volume uses of reclaimed water were for applications (e.g., pasture irrigation) in the vicinity of wastewater treatment plants that did not require a high-quality effluent. These applications were often perceived as a method of wastewater disposal. In 1912, the first small urban reuse system began with the irrigation of Golden Gate Park in San Francisco. By the 1960s, landscape irrigation had become a major use for reclaimed water.

In 1977, the City of St. Petersburg, Florida, built the first large urban reuse system in the United States. With the constant increase in water demand as populations grew and water supplies became limited, purposeful reuse of high-quality reclaimed water has increased greatly in the last 30 years. Reclaimed water is now considered to be a valued resource in many parts of the world, and the trend has shifted toward higher level uses, such as urban landscape irrigation, toilet flushing, industrial uses, and drinking water augmentation [3].

2.5.6 **WORLDWIDE WASTEWATER REUSE FOR IRRIGATION:**

i. United States of America

The first ever use in the state of California was at Mc-Queen Plant operated by the city of San Francisco where secondary effluents was used to fill the Golden gate park ornamental lakes and to irrigate portions of the shrubbery and grass. A large number of cities in the United States currently use effluents from secondary treatment processes for these purposes [4].

ii. Australia

Werribee farm, Melbourne, Australia was established in 1897 and is still in operation. It discharges about 4.4 x 10^5 m^3/day to several thousand acres of cropland supporting 50,000 sheep and 20,000 beef cattle [4] [5].

iii. France

The municipal wastewater from Paris, France has been in operation since 1980, and these farms have been successful. They are receiving 100 million m^3/year over mixture of sand clay and gravel. [6].

iv. Germany

In federal Republic of Germany, apart from some small schemes there exist two large irrigation systems of Braumschwaig (40,000 m^3/day) and Wolfs burg (16,000 m^3/day) [6].

v. Israel

Israel utilizes fresh water of 1500 million m^3/year. About 75% is supplied to agriculture. As a part of planning, 10% of the agricultural water requirements will be supplied through wastewater reclamation [7].

vi. Egypt

In Cairo city, Egypt, the sewage effluents have been continuously used to irrigate Al- Gabal and Al Asfar citrus farm after primary sedimentation. The area of this farm is about 1260 ha and it lies in the eastern desert [6].

vii. Qatar

In Qatar due to limited fresh water sources, use of treated effluents for agriculture purposes has gained wide acceptance. The treatment plant at Al Naijab irrigates 7,000 ha of land with treated effluents of 6,500 m^3/day [6].

viii. Kuwait

The state of Kuwait uses treated sewage effluents to produce alfalfa, vegetables and green fodder plants, total production of these crops is about 34,000 tons per year [6].

ix. Poland

In Poland during dry year, sewage represents 50% of all surface flow. The Wrocklaw farm, 1500 ha, receives 170,000 m^3/day. It has been in operation for 100 years [7].

x. Saudi Arabia

In Saudi Arabia, the policy is to utilize all available treated municipal wastewater in the most beneficial manner for several purposes, among which the agricultural sector is given top priority. Realizing the importance of providing an adequate degree of wastewater treatment to ensure public health protection, wastewater regulations have been farmed to enforce a minimum of tertiary treatment, producing a quality level required for unrestricted irrigation. In Riyadh, a total effluent discharge of 210,000 m^3/day is used by industry and agriculture. The agriculture volume is used to irrigate 4,000 ha of fruit, cereals, vegetables and fodder crops [6].

xi. Pakistan

In Pakistan, a major fraction of untreated wastewater is used to irrigate crops, some of which, (salad crops) are eaten uncooked. Consequently 50% of crops are contaminated with pathogens. About 2,000 acres of land are being irrigated in the city of Lahore, 5,000 acres of land in Hyderabad and 6,000 acres of land in Faisalabad [7]. Moreover, in all over the country, especially in small towns, use of raw sewage effluents is a very common practice. Direct reuse without any restrictions on the types of crops poses potential health hazards and adverse environmental impacts. Use of sewage for irrigation has also affected the ground water quality. Studies conducted at Faisalabad and Lahore has indicated increased microbial count in ground water [8]. Therefore, although the use of reclaimed water offers the potential for exploiting a new resource, which can be substituted for existing sources, it must be approached with care, i.e. health risks must be considered.

A study near the town of Haroonabad in the Southern Punjab region has been conducted by 'IWMI' by taking into consideration the current wastewater practices and the related irrigation, health and environmental issues. This study reveals that an accumulation of heavy metals in the wastewater-irrigated soils, will make the land unprofitable unless it is properly managed, using reclamation and other measures.

This study confirms that wastewater irrigation offers benefits that can help many rural water-short areas increasing their agricultural productivity and profitability. But in each location the negative impacts and sustainability issues must be carefully evaluated.

IWMI's wastewater research in Pakistan is being strengthened with the launch of a new project, funded by the German Ministry for Economic and Development Cooperation. This new project will look at practices and impacts of the reuse of wastewater in semi- urban areas.

2.6 Compatibility with Community Vision:

Historically, few communities have pursued urban reuse programs. The main barrier has typically been cost of the non-potable transmission network described above. In a community where water is plentiful, these systems are very expensive compared to simply dispersing treated wastewater into the ground or into a receiving stream. Public perception of urban reuse systems has not necessarily been positive, which can be attributed to misconceptions regarding associated risks. Certainly, if they are not properly maintained, reuse systems can pose a significant odor nuisance and a health threat. The increasing commonality of droughts and warnings of global climate change are beginning to soften these attitudes. Provided that cross- connection can be prevented, reclaimed water can be used to replace potable water in any application that does not require human consumption. If the community is willing to commit to providing the money and manpower to do the job right, the system will function well and all water brought to the community as potable water can be used at least twice prior to ultimate dispersal back into the environment. As state agencies see the potential value in adopting water reuse incentives, the number of such applications will dramatically increase.

One beneficial reuse is to use treated wastewater to flush toilets. This has been implemented at several national parks and large office buildings. The visitor centers at the Great Smoky Mountains National Park and Grand Canyon National Park are examples of decentralized treatment facilities that use treated wastewater to flush toilets. Several large buildings in New York City, Tokyo, and Australia have installed wastewater treatment facilities on their premises and reuse the water for toilets and fire protection. Many state jurisdictions have been less receptive to toilet flushing as a legitimate reuse application. Irrigation reuse for agricultural crops and landscaped areas has been more widely used, but there are still issues to be addressed and constraints within which irrigation reuse must be implemented.

Table 0-1: Issues and Constraints Associated with Various Types of Wastewater Reuse

Place	Issues/ Constraints
Agricultural, crop and nursery irrigation	Surface and groundwater contamination if not properly managed Marketability of crops and public acceptance
	Effect of water quality, particularly salts, on soil and crops
Landscape irrigation: parks, school yards, freeway medians, golf courses, cemeteries, greenbelts, and residential	Public health concerns related to pathogens Effect of water quality, particularly salts, on soil and crops Use area (including buffer zone) may result in high user Costs

Given the increased areas of water shortages, increased regulatory anti-degradation activities, and other constraints, all communities should consider the reuse of both treated wastewater and storm water runoff in their overall community plans. One of the major advantages of reusing wastewater for irrigation is that nutrient removal is not required. Some arid states are requiring developers to assure an adequate water supply for 100 years. Irrigation reuse by the community, by commercial interests, and by the agricultural sector is certainly a means of maximizing water resources to meet such goals [9].

2.7 Assessment of health risk:

Three types of evaluations are used to access risk: microbial analysis, epidemiological studies and quantitative microbial risk assessment. Human faeces contain a Varity of different pathogens, reflecting the prevalence of infection in the population in contact, only a few pathogenic species may be excreted in urine. The risks associated with both reuse as a fertilizer and the use of greywater for irrigation purposes are related to cross-contamination by faecal matter. Epidemiological data for the assessment of risk through treated faeces, faecal sludge, urine or greywater are scarce and unreliable, while ample evidence exists related to untreated faecal matter. In addition, microbial analysis is partly unreliable in the prediction of the risk due to a more rapid die-off of indicator organisms such as Escherichia coli in urine, leading to an underestimation of the risk of pathogen transmission. The opposite may occur in greywater, where a growth of the indicator bacteria on easily degradable organic substances may lead to an overestimated of the risk. Based on the above limitation, QMRA is the main approach taken, due to the range of organism with common transmission characteristics and their prevalence in the population, factors accounted for includes:

- Epidemiological feature (including infectious dose, latency, hosts and intermediate host)
- Persistence in different environments outside the human body and potential for growth.
- Major transmission routes
- Relative efficiency of different treatment barriers
- Risk management measure

Table 0-2: Issues and Constraints Associated with Various Types of Wastewater Reuse

Group exposed	Health threats		
	Helminths	**Bacteria/viruses**	**Protozoa**
Consumers	Significant risks of helminth infection for both adults and children with untreated wastewater	Cholera, typhoid and shigellosis outbreaks reported from use of untreated wastewater; seropositive responses for *Helicobacter pylori* (untreated); increase in non-specific diarrhea when water quality exceeds 104 thermotolerant coliforms per 100 ml	Evidence of parasitic protozoa found on wastewater-irrigated vegetable surfaces, but no direct evidence of disease transmission
Farm workers and their families	Significant risks of helminth infection for both adults and children in contact with untreated wastewater; increased risk of hookworm infection to workers who do not wear shoes; risks for helminth infection remain, especially for	Increased risk of diarrhoeal disease in young children with wastewater contact if water quality exceeds 104 thermotolerant coliforms per 100 ml; elevated risk of *Salmonella* infection in children exposed to	Risk of *Giardia intestinalis* infection reported to be insignificant for contact with both untreated and treated wastewater; another study in Pakistan estimated a threefold increase in risk of *Giardia* infection

	children, even when wastewater is treated to <1 helminth egg per litre; adults are not at increased risk at this helminth concentration	untreated wastewater; elevated eroresponse to norovirus in adults exposed to partially treated wastewater	for farmers using raw wastewater compared with irrigation with fresh water; increased risk of amoebiasis observed from contact with untreated wastewater
Nearby communities	Transmission of helminth infections not studied for sprinkler irrigation, but same as above for flood or furrow irrigation with heavy contact	Sprinkler irrigation with poor water quality (106–108 total coliforms/100 ml) and high aerosol exposure associated with increased rates of infection; use of partially treated Water (104–105 Thermotolerant coliforms/100 ml or less) in sprinkler irrigation is not associated with Increased viral infection rates	No data for transmission of protozoan infections during sprinkler irrigation with Wastewater

to both farmers and product consumers. This is especially true for children under 15 years of age engaged in agricultural activities, who may have intense contact with fields fertilized with untreated excreta. In endemic areas where land is fertilized with untreated human faeces, workers without proper protection (e.g. gloves, shoes) are at a high risk of contracting hookworm infections. Risks of infectious diseases are significantly reduced when excreta are treated to the level suggested table 2.3, when farmers

Table 0-3: Summary of quantitative microbial risk assessment results for rotavirus infection risks for different exposures

Exposure scenario	Water quality (*E. coli*/100 ml of wastewater or 100 g of	Median infection risks per person per year	Notes
Unrestricted irrigation (crop consumers)			
Lettuce	10^3-10^4	10^{-3}	100 g eaten raw per person every 2 days 10-15 ml wastewater remaining on crop
Onions	10^3-10^4	5×10^{-2}	100 g eaten raw per person per week for 5 months 1-5 ml wastewater remaining on crop
Restricted irrigation (farmers or other heavily exposed populations)			

Highly mechanized	10^5	10^{-3}	100 days' exposure per year 1-10 mg soil consumed per exposure
Labour intensive	10^3-10^4	10^{-3}	150-300 days' exposure per year 10-100 mg soil consumed per exposure

use protection and practice good hygiene and when consumers wash and rinse their food products with clean water prior to consumption [10].

2.7.7 **Health based targets:**

Heath based targets define a level of protection that is relevant to each hazard, A health based target can be based on a standard metric of disease, such as a disability adjusted life year or DALY (i.e. 10^{-6} DALY), or it can be based on an appropriate health outcome, such as the prevention of exposure to pathogens in excreta and greywater anytime between their generation at the household level and their use in agriculture. To achieve a health based target, health protection measures are developed. Usually a health based target can be achieved by combining health protection measures targeted at different steps in the process.

The heath based targets may be achieved through different treatment barriers relate to verification monitoring, mainly in large-scale systems, as illustrated in table 2.4 for excreta and greywater. Verification monitoring is not applicable to urine.

The health based targets may also relate to operational monitoring, such as storage as an on- site treatment measure or further treatment off-site after collection. This is exemplified for faeces from small-scale in table 2.5.

For collection urine, storage criteria apply that are derived mainly from compiled risk assessment studies. The information obtained has been converted to operational guidelines to limit the risk to a level below 10^{-6} DALY, also according for additional health protection measures. The operational guidelines are based on source separation of urine (table 2.4). In case of heavy faecal cross-contamination, the suggested storage time may be lengthened. If urine is used as a fertilizer of corps for household consumption only, it can used directly without storage. The likelihood of household disease transmission attributable to the lack of hygiene is much higher than that of transmission through urine applied as a fertilizer [10].

Table 0-4: Guideline values for verification monitoring in large-scale treatment systems of greywater, excreta and faecal sludge for use in agriculture [10]

	Helminthes eggs (number per gram total solid or per litre)	E. coli (number per 100mL)
Treated faces and faecal sludge greywater for use in	<1/g total solid	<1000 g/total solid
Restricted irrigation	<1/litre	$<10^5$ [a] Relaxed to $<10^6$ when exposure is limited or re- growth is likely
Unrestricted irrigation	<1/litre	$<10^3$ Relaxed to $<10^4$ for high- growing leaf crops or drip irrigation

[a] these values are acceptable due to the re-growth potential of E. coil and other faecal coliform in greywater

Table 0-5: Recommendations for storage treatment of dry excreta and faecal sludge before use at the household and municipal level[a]

Treatment	Criteria	Comment
Storage; ambient temperature 2-20^{o}C	1.5-2 years	Will eliminate bacterial pathogens; regrowth of E. coli and Salmonella may need to be considered if rewetted; will reduce viruses and parasitic protozoa below risk levels. Some soil- borne ova may persist in low numbers.
Storage; ambient temperature >20-35oC	>1year	Substantial too total inactivation of viruses, bacteria and protozoa; inactivation of schistosome eggs (<1 month) inactivation of nematode (roundworm) eggs, e.g. hookworm and whipworm; survival of a certain percentage (10- 30%) of Ascaris eggs (2 4 months), whereas a more or less complete inactivation of Ascaris eggs will occur within 1 year.
Alkaline treatment	pH > 9 during >6 months	If temperature >35oC and moisture < 25%, lower pH and/or watter material will prolong the time for absolute elimination.

[a] No addition of new material

For all types of treated excreta, additional safety measure apply. These include, for example, a recommended withholding time of one month between the moment of application of the treated excreta as a fertilizer and the time of crop harvest. Based on QMRA, this time period has been shown to result in a probability of infection well below 10^{-4}, which is within the range of a 10^{-6} DALY level [11].

Table 0-6: Health-based targets and helminth reduction targets for treated wastewater use in agriculture [11]

Type of irrigation	Health-based target for viral, bacterial and protozoan pathogens	Microbial reduction target for helminth eggs
Unrestricted	:Sl0^{-6} DALY per person per year [a]	:Sl per litre (arithmetic mean) [b,c]
Restricted	:Sl0^{-6} DALY per person per year [a]	:Sl per litre (arithmetic mean)[b,c]
Localized (e.g.	:Sl0^{-6} DALY per person per	(a) Low-growing crops: [d]
drip irrigation)	year a	:Sl per litre (arithmetic mean) (b) High-growing crops d,e No recommendation

[a] The health-based target can be achieved, for unrestricted and localized irrigation, by a 6-7 log

unit pathogen reduction (obtained by a combination of wastewater treatment and other health protection measures); for restricted irrigation, it is achieved by a 2-3 log unit pathogen reduction. [b] When children under 15 years of age are exposed, additional health protection measures should be used.

[c] An arithmetic mean should be determined throughout the irrigation season. The mean value of

:Sl egg per litre should be obtained for at least 90% of samples in order to allow for the occasional high value sample (i.e. with >10 eggs per litre). With some wastewater treatment processes (e.g. waste stabilization ponds), the hydraulic retention time can be used as a surrogate to assure compliance with :Sl egg per litre.

[d] High-growing crops include fruit trees, olives, etc.

[e] No crops to be picked up from the soil.

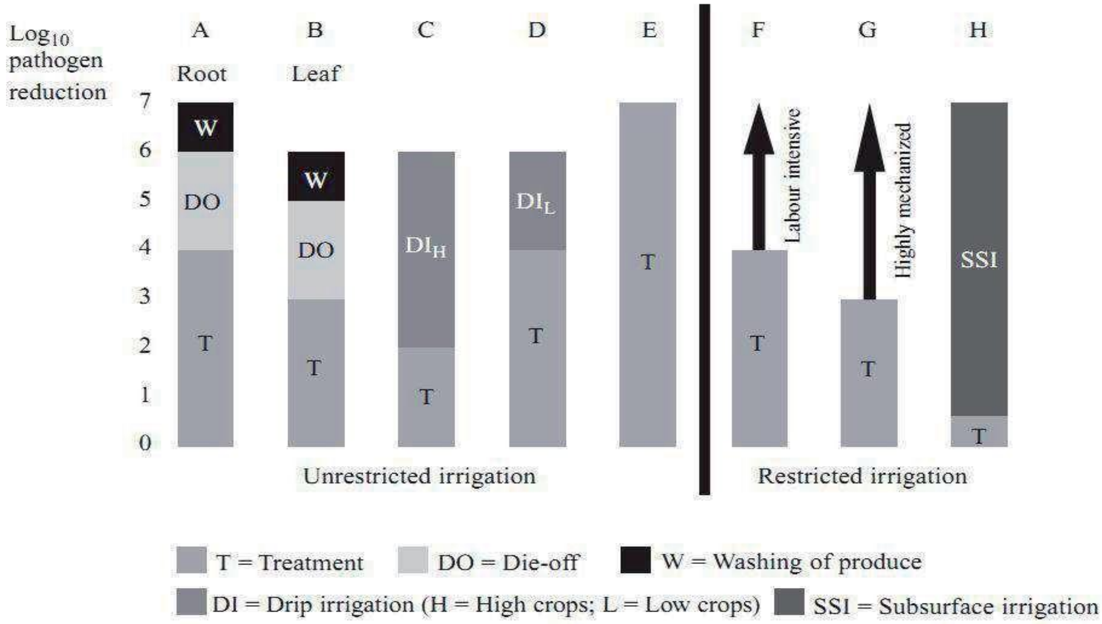

Figure 0-1: Pathogen Reduction Log

Table 0-7: Verification monitoring a (E. coli numbers per 100 ml of treated wastewater) for the various levels of wastewater treatment in Options A-G presented in Figure 2.1 [11]

Type of irrigation	Option (Figure 1)	Required pathogen reduction by treatment (log units)	Verification monitoring level (*E. coli* per 100 ml)	Notes
Unrestricted	A	4	:S10^{3}	Root crop
	B	3	:S10^{4}	Leaf crop
	C	2	:S10^{5}	Drip irrigation of high-growing crops
	D	4	:S10^{3}	Drip irrigation of low-growing crops
	E	6 OR 7	:S10^{1} OR :S10^{0}	Verification level depends on the requirements of the local regulatory agency [b]
Restricted	F	3	:S10^{4}	Labour-intensive agriculture (protective of adults and children under 15 years of age)
	G	2	:S10^{5}	Highly mechanized agriculture
	H	0.5	:S10^{6}	Pathogen removal in a septic tank

[a] "Verification monitoring" refers to what has previously been referred to as "effluent standards" or "effluent guideline" levels.

[b] For example, for secondary treatment, filtration and disinfection: five-day biochemical oxygen demand (BOD5), <10 mg/l; turbidity, < 2 Nephelometric Turbidity Units (NTU); chlorine residual, 1 mg/l; pH, 6-9; and faecal coliforms, not detectable in 100 ml (State of California, 2001).

2.7.8 **Health protection measures*:***

A variety of health protection measures can be used to reduce health risks for local communities, workers and their families and for the consumers of the fertilized or irrigated products. Hazards associated with the consumption of excreta-fertilized products include excreta-related pathogens. The risk from infectious diseases is significantly reduced if foods are eaten after proper handling and adequate cooking. The following health protection measures have an impact on product consumers [11]:

- Excreta and greywater treatment
- Corp restriction
- Waste application and withholding periods between fertilization and harvest to allow die-off of remaining pathogens
- Hygienic food handling and food preparation practices
- Health and hygiene promotion
- Produce washing, disinfection and cooking.

Table 0-8: Recommended storage time for urine mixture[a] based on estimated pathogen content[b] and recommended corps for large systems[c]

Storage temperature (^oC)	Storage time (months)	Possible pathogens in the urine mixture after storage	Recommended crops
4	1	Viruses, Protozoa	Food and fodder corps that are to be processed
4	6	Viruses	Food crops that are to be processed, fodder crops[d]
20	1	Viruses	Food crops that are to be processed, fodder crops[d]
20	6	Probably none	All crops[e]

[a] Urine or Urine and water, when diluted, it is assumed that the urine mixture has a pH of at least 8.8 and a nitrogen concentration of at least 1g/L.

assessment, but are not normally recognized as a cause of any infections of concern,

[c] A larger system in this case is a system where the urine mixture is used to fertilize crops that will be consumed by individuals other than members of the household from when the urine was collected.

[d] Not grasslands for production of fodder.

[e] For food corps that are consumed raw, it is recommended that the urine be applied at least one month before harvesting and that it be incorporated into the ground if the edible parts grow above the soil surface.

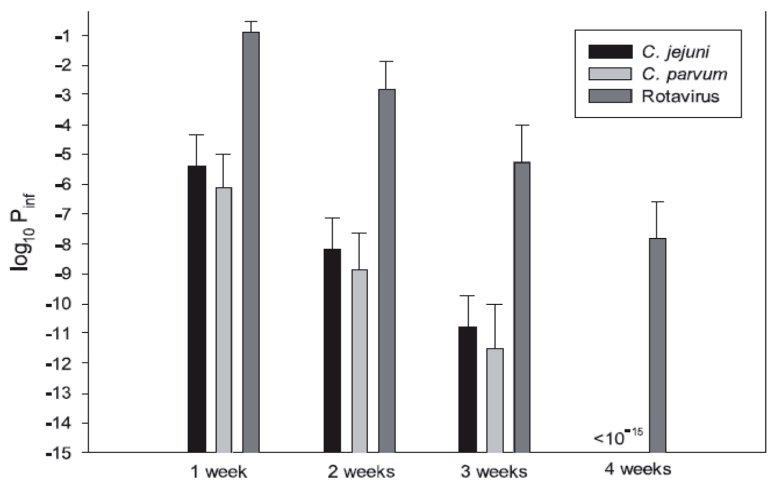

Figure 0-2: Time between crop fertilizing and consumption

(Mean probability of infection by pathogens following ingestion of crop fertilized with unstored urine with varying withholding periods (P_{inf} = probability of infection).

For all types of treated excreta, additional safety measure apply. These include, for example, a recommended withholding time of one month between the moment of application of the treated excreta as a fertilizer and the time of crop harvest (figure above shows) based on QMRA, this time period has been shown to result in a probability of infection well below 10^{-4}, which is within the range of a 10^{-6} DALY level [10].

Workers and their families may be exposed to excreta related and vector borne pathogens through excreta and greywater use activities. Excreta and greywater treatment is a measure to prevent disease associated with excreta and greywater but will not directly impact vector borne disease. Other health protection measures for workers and their families includes:

- Use of personal protective equipment
- Access to safe drinking water and sanitation facilities at farms
- Health and hygiene promotion
- Disease vector and intermediate host control
- Reduce vector contact

Local communities are at risk from the same hazards as workers. If they do not have access to safe drinking water, they may use contaminated irrigation water for drinking or for domestic purposes. Children may also play or swim in the contaminated water. Similarly, if the activities result in increase vector breeding, then vector borne disease can affect local communities, even if they do not have direct access to the fields. To reduce health hazards, the following heath protection measure for local communities may be used [10]:

- Excreta and greywater treatment
- Limited contact during handling and controlled access to fields
- Access to safe drinking water and sanitation facilities in local communities
- Health and hygienic promotion
- Disease vector and intermediate host control
- Reduce vector contact

2.8 Summary:

This Chapter includes the literature on study of waste water. Why the need for treating waste water for felt and the procedures evolved for treating waste water treatment. The history of waste water reuse and its compatibility with humans is discussed here.

Chapter 3

CHARACTERISTICS OF WASTE WATER

3.1 Introduction:

The public health engineer is called upon two distinct tasks, the first is of collecting sewage or sewerage, and second is disposal or purification of sewage at the out fall and it is more difficult. For this quality and characteristics of the sewage are of important value Because it has to be seen that the sewage is purified to such an extent, that before discharging into the stream, not only the suspended solids but also the organic impurities are removed from it to such an extent as to render secondary decomposition impossible after the effluent is discharged and mixed with the volume of diluting water of the stream. The properties of sewage may be classified under three categories i-e Physical, Chemical and Biological.

3.2 Physical properties:

These are in respects of smell colour, temperature. Turbidity and solid contents.

3.2.1 Smell: -Normal fresh sewage has a musty odor, which is not especially offensive, but as it begins to get stale jn an hour or so, in tropical countries like ours, it begins to give off offensive smell, which is very pronounced in 3 to4 hours This is particularly due to emotion of hydrogen sulphide gas (H2S). Odor is produced by gas production due to the decomposition of organic matter or by substances added to the wastewater. Odor is measured by special instruments such as the Portable H2S meter which is used for measuring the concentration of hydrogen sulfide. [2]

3.2.2 Colour:- Fresh domestic sewage is grey, some what resembling a weak solution of soap. It begins to get black as purification starts, and septic sewage is definitely black in colour. [2]

3.2.3 Temperature:- An observation of temperature is useful in indicating the antecedents of sewage. The temperature of sewage is slightly greater than that of water supply. Inside the sewer it is still higher in this country. As the temperature rises; its viscosity increases with a corresponding increase in its tendency to precipitate. The bacterial activity in sewage is greater at high temperature up to 60 C. After which again it falls. affects chemical reactions during the wastewater treatment process. Temperature affects aquatic life. Oxygen solubility is less in worm water than cold water. Aerobic digestion and nitrification stop when the temperature rises to 50o C. When the temperature drops to about 15°c, methane producing bacteria become in active. [2]

3.2.4 Turbidity:- This depends upon the percentage of the solid matters in suspension. It's a measure of the light – transmitting properties of water. The stronger or more concentrated the sewage, the higher is the turbidity. [2]

3.2.5 Solid contents[2]**:-** Normal sewage contains 99.9 percent of water and 0.1 percent (or roughly 2 pounds in a ton) of solid in suspension. This solid matter exists in three different forms.

1. Suspended solids:- these may be further sub divided into settable solids, which can settle down or precipitate in 1 to 3 hours and non settable solids which don't settle down with more detention.
2. Colloidal solids:- even after passing through laboratory filters sewage is not clear. The turbidity is due to colloidal matter, the particles of which are so finally divided as even to pass the laboratory filters. They consist of gelms, emulsion and foam, and usually don't exceed 10 percent.
3. Dissolved solids:- When sewage which has through the laboratory filters is heated so that all the water is evaporated, a residue is left which is actually dissolved solids.

3.3 Chemical properties [2];

Points of concern regarding the chemical characteristics of wastewater are:-

3.3.1 Organic matter (Ca Hb Oc) :- 75% SS organic. (Suspended Solids) 40% FS organic. (Filtered Solids) Organic matter is derived from animals & plants and man activities. Proteins (40-60%). Carbohydrates (25-50%). Fats, Oils, and Grease (10%). It is the organic matter forming less than 50 percent of the total i.e. about 1.1 pound per ton of raw sewage.

3.3.2 Measurements of organic matter :- Many parameters have been used to measure the concentration of organic matter in wastewater. The following are the most common used methods:

3.3.3 Biochemical oxygen demand (BOD) :- BOD is the oxygen equivalent of organic matter. It is determined by measuring the dissolved oxygen used by microorganisms during the biochemical oxidation of organic matter in 5 days at 20^{o}C.

3.3.4 Chemical oxygen demand (COD) :- It is the oxygen equivalent of organic matter. It is determined by measuring the dissolved oxygen used during the chemical oxidation of organic matter in 3 hours.

3.3.5 Total organic carbon (TOC) :- This method measures the organic carbon existing in the wastewater by injecting a sample of the WW in special device in which the carbon is oxidized to carbon dioxide then carbon dioxide is measured and used to quantify the amount of organic matter in the WW. This method is only used for small concentration of organic matter.

3.3.6 Theoretical oxygen (ThOD) :- If the chemical formula of the organic matter existing in the WW is known the ThOD may be computed as the amount of oxygen needed to oxidize the organic carbon to carbon dioxide and a other end products.

3.3.7 Inorganic Matter :- The following are the main inorganic materials of concern in wastewater treatment:

1. <u>Chlorides:-</u> High concentrations indicate that the water body has been used for waste disposal. • It affects the biological process in high concentrations.
2. <u>Nitrogen:-</u> TKN = Total Kjeldahl nitrogen. = Organic Nitrogen + ammonia Nitrogen (120 mg/l).
3. <u>Phosphorus:-</u> Municipal waste contains (4-15 mg/l).

3.3.8 Toxic inorganic Compounds:- Copper, lead, silver, chromium, arsenic, boron.

3.3.9 Heavy metals :- Nickels, Mn, Lead, chromium, cadmium, zinc, copper, iron mercury.

3.3.10 Gases :- The following are the main gases of concern in wastewater treatment: N_2 , O_2 , CO_2 , H_2S, NH_3 , CH_4.

3.3.11 pH :- The hydrogen-ion concentration is an important parameter in both natural waters and wastewaters. It is a very important factor in the biological and chemical wastewater treatment. Water and wastewater can be classified as neutral, alkaline or acidic according to the following ranges:

PH = 7 neutral

PH > 7 Alkaline

PH < 7 Acidic.

The mineral matter in sewage consists of sand, gravel, debris from street washing, salts and alkalis either originally occurring in water supply or introduced by wastes from kitchens and bathrooms, industrial plants or infiltration water.

The organic matter in sewage consists of urea, from urine, proteins from animals, and a little from vegetable wastes, carbohydrates such as sugar, starches and celluloses from plants, fats from meat, seeds, nuts grease, and oil from kitchens, baths and industrial plants, and soaps from bathrooms, laundry establishments etc. In the process of decomposition, all these pass through various stages, resolving into simpler matters such as nitrogen, hydrogen, sulpher, carbon, oxygen and phosphorous; these elements ultimately combine by means of chemical reactions to form inorganic substances.

3.4 Biological properties [2]:

The environmental engineer must have considerable knowledge of the biological of waste water because it is a very important characteristics factor in wastewater treatment. The Engineer should know:-

1. The principal groups of microorganisms found in wastewater.
2. The pathogenic organisms.
3. Indicator organisms (indicate the – presence of pathogens).
4. The methods used to amount the microorganisms.
5. The methods to evaluate the toxicity of treated wastewater

3.5 The Main Forms of Microorganisms[2]

The main microorganisms of concern in wastewater treatment are Bacteria, Fungi, Algae, Protozoa, Viruses, and pathogenic microorganisms groups.

3.5.1 **Bacteria:-**

Types: Spheroid, rod curved rod, spiral, filamentous. Some important bacteria:-

1. Pseudomonas:- reduce NO3 to N2 , So it is very important in biological nitrate removal in treatment works.
2. Zoogloea:- helps through its slime production in the formation of flocs in the aeration tanks. Sphaerotilus natuns:Causes sludge bulking in the aeration tanks.
3. Bdellovibrio: destroy pathogens in biological treatment.
4. Acinetobacter: Store large amounts of phosphate under aerobic conditions and release it under an – anaerobic condition so, they are useful in phosphate removal
5. Nitrosomonas: transform NH4 into NO2 –
6. Nitrobacter: transform NO2 - to NO3
7. Coliform bacteria:- The most common type is E-Coli or Echerichia Coli, (indicator for the presence of pathogens). E-Coli is measured in (No/100mL)

3.5.2 **Fungi:**

Important in decomposing organic matter to simple forms.

3.5.3 **Algae:**

Cause eutrophication phenomena. (negative effect) • Useful in oxidation ponds. (positive effect) • Cause taste and problems when decayed. (negative effect)

3.5.4 **Protozoa:**

Feed on bacteria so they help in the purification of treated waste water. Some of them are pathogenic.

3.5.5 **Viruses:**

Viruses are a major hazard to public health. Some viruses can live as long as 41days in water and wastewater at 20 oC. They cause lots of dangerous diseases.

3.5.6 **Pathogenic organisms:**

The main categories of pathogens are Bacteria, Viruses, protozoa, helminthes

3.6 Classification of Bacteria [2]:-

Bacteria are further classified as,

- Aerobic
- Anaerobic
- Facultative

The first two require oxygen for their metabolism or life process. But the difference is that aerobics draw oxygen from free air, the anaerobic derive it by splitting up chemically the organic compounds in sewage contain oxygen. The third group of bacteria called facultative, acts both in the presence or absence free air.

The work done by the anaerobic bacteria viz. Decomposition of organic matter is called putrefaction, and the result is called liquefaction, as the solid organic matter is dissolved by the enzymes. The work of aerobic bacteria viz. Of combination with oxygen is called oxidation. Though each group works in opposite direction- the former by splitting up and latter by building up there is coordination between them. The anaerobes decompose complex organic matter into simple compounds at first stage, and the aerobes oxidize them to form stable compounds as the second stage of purification.

That all the above chemical are brought about by can be proved by the fact that if some sterilizing agent like chlorine, is added, which kills bacteria, no chemical action will takes place.

Constituents of sewage:- These are organic matter, mineral matter and living organisms. The organic matter may be nitrogenous or nitrogen-free. The mineral matter may be sand clay etc. The living organisms may be divided into plant life, such as algae, fungi, etc. And the animal life consisting of micro- organisms, they can be seen with the aid of a microscope.

3.7 Summary

This chapter entails the characteristics of waste water. The physio-chemical and biological characteristics are explained which are vital for the treatment of waste water. The main forms of bacteria and micro-organisms are also described for understanding the necessity of waste water treatment.

Chapter 4

WASTE WATER ANALYSIS

Waste water analysis are made to determine those constituents of waste water that may cause trouble in treatment and disposal to aid in selecting the correct treatment, in the operation of treatment plant, to determine the efficacy of treatment process, or to show the progress of pollution and self-purification of a body of water. A complete waste water analysis can be divided into a survey, physical and bio-chemical analysis.

4.1 Survey

To determine the characteristics of waste water, a survey is made to supply the information concerning:-

1. Source of waste water whether it is domestic, commercial or industrial.
2. Amount of waste water from these resources.
3. Relative freshness of waste water, as affected by the time duration for which it has been in the sewer.

4.2 Chemical Analysis [2]

Chemical analysis furnishes the most useful and specific information with respect to the state of decomposition and strength of waste water for the control of an operation of a treatment plant and for other purposes of waste water disposal and stream pollution control.

In making a chemical analysis of waste water only those chemical compounds, radicals and elements are determined that are indicative of significant sanitary characteristics. A complete quantities formula chemical analysis showing the weight of each compound present is not made.

4.2.1 **Solids.**

Solids are the residues that are left on evaporation and they show the strength of waste water and treatment amount which is required. The reduction of total solid by treatment process serves as measures of its efficiency total solids are broken down into volatile and fixed matter. Volatile portion is generally taken as organic matter. Fixed solids have little significance. Solids can be further subdivided into dissolved solids and suspended solids. Each of one is broken into volatile and fixed portions. The removal of suspended solids gives us the adequacy of sewage treatment device, because dissolved solids are not affected by treatment of sewage. It is generally assumed that the dissolved volatile solids are most difficult to remove. In special cases this may not be true Colloidal matter is included in dissolved solids and it is produced by the abrasion of the fine suspended matter during flow through a turbulent sewer. High dissolved solids may, therefore indicate a stale sewage or the presence of particular industrial waste. Settle able or settling solids, as the name indicates are a direct indication of the solids removable by plain sedimentation and they are an index of the sludge forming characteristics of waste water.

4.2.2 Oxygen

Oxygen is reported in sewage in three forms as dissolved oxygen, as oxygen consumed and as oxygen demand.

i. Dissolved Oxygen

Dissolved oxygen represents the amount of oxygen dissolved in the liquid. Normal sewage contains no dissolved oxygen unless the sewage is very fresh or very weak. The amount of dissolved oxygen present may be expressed in parts per million, by weight or as the percentage of saturation with each method, it is desirable to state the temperature since the solubility of oxygen is dependent on it. If dissolved oxygen is found in sufficient concentration in a polluted water or in the effluent from a treatment plant it means that as long as oxygen remains, putrefactive odors will not be given off. It is possible however, for different concentrations of dissolved oxygen and putrefaction may be proceeding in one stratum before the oxygen is exhausted from other strata.

ii. Oxygen demand

Biochemical Oxygen Demand. The biochemical oxygen demand (B.O.D) of polluted water, sewage or other substance is the amount of oxygen required to maintain aerobic conditions during decomposition and self purification. The B.O.D. test is the most important made in waste water analysis to determine the amount of polluted water, or strength of polluted water, for it serves as a measure of amount of clear diluting water required for successful disposal by dilution of the substance. B.O.D reduction in a body of water as stream, differ somewhat from B.O.D reduction in waste water treatment devices because in the body of water or stream the reduction is due to biological decomposition of all organic matter in the treatment devices the organic matter that can evict intermediate B.O.D is decomposed, the remainder being discharged in the effluent.

The quantity of oxygen required for the complete stabilization of polluted water may be taken as the measure of extent of organic matter. Since polluted water will continue to absorb oxygen after months of incubation it is impracticable to attempt the determine the ultimate oxygen demand of a sample. In the most samples oxidation process is in two stages. The first stage lasting for 7 to 10 days are more, mainly the carbonaceous matter is oxidized and then purification, sets in. during the first stage the rate of deoxygenation at any instant is directly proportional to the amount of oxidized organic matter present. The action is an example of uni-molecular reaction that occurs in decomposition of sewage the interchange of gasses at a liquid interface and the disinfection of sewage. In the unimolecular reaction involving B.O.D the rate of oxygen consumption is proportional to the amount of oxidized organic matter present. Hence during the incubation period the rate of oxygen consumption is decreasing.

Chemical oxygen demand

Chemical oxygen demand (C.O.D.) tests have devised in an attempt to overcome objection to the B.O.D test. The tests involve chemical digestion of the sample with an oxidizing agent commonly Potassium di chromate . No C.O.D. have been standardized are widely adopted. Some test have been found useful in the control of sewage treatment plant, but an attempt to correlate the results of C.O.D. and B.O.D. is not promising since the two tests do not determine the same thing . Richford and Moore have concluded that where a given industrial waste is fairly constant and contains toxic materials, a satisfactory C.O.D. to B.O.D ratio may be determined.

Oxygen Consumed.

The oxygen consumed test is a standard method. It involves chemical digestion with Potassium per magnate. It may be considered as a special form of chemical oxygen demand test. It is primarily an index of Carbonaceous matter readily oxideable by Potassium per magnate. It is of little general value for comparison of sewages having different putrefactive characteristics. The test have been found of limited value for quick information as an aid in the control of treatment plant operation where tests are made under similar conditions.

4.2.3 **Nitrogen.**

There are five basic nitrogen determinations that may be in a sanitary sewage analysis. Free ammonia, albuminoidal ammonia, nitrates and nitrate constitute total nitrogen. Organic nitrogen and free ammonia taken together, are an index of organic nitrogenous matter present in sewage and albuminoidal ammonia may be taken as measure of the decomposable organic nitrogen present. Free ammonia or ammonia nitrogen is a result of bacterial decomposition of organic matter A fresh cold sewer be relatively high in organic nitrogen and low in free ammonia. A stable warm sewage should be relatively high in free ammonia and low in organic nitrogen. The sum of two should be unchanged in the same sewage unless ammonia is given off in septic action. The total concentration of the two is valuable index of the strength of the sewage and is important in consideration of the types of treatment to be adopted.

4.2.4 Chlorides and Chlorine

Chlorides in sewer should not be confused with free residual chlorine resulting from the addition of chlorine gas. Chlorides are inorganic substances commonly found in the urine of man and animals. The amount of chlorides above the normal chloride contents of pure water in the district is used as an index of the strength of sewage. The chloride contents may be affected by certain trade wastes, as from ice-cream factories or meat salting plants, which will increase the amount of chloride materially since the chlorides are inorganic substance in solution. They are not affected by biological process or sedimentation. Their diminution in a treatment plant or in a flowing stream is indicative of dilution and reduction of chlorides will be in proportion to the amount of chlorides free diluting water added.

4.2.5 Fats

Fats have recoverable market value when present in sufficient quantity to be skimmed off the surface of sewage as they precipitate in and clog the interstices in filtering material and form objectionable scum in tanks and streams. Although fats are carbonaceous matter they are not indicated by the oxygen consumed test because they are not easily oxidized.

4.2.6 Gases

The three gases of special interest in the sewage problems are hydrogen sulphide, methane and carbondioxide. Traces of hydrogen sulphide are detectable by smell. The presence of this odor indicates a stale sewage and usually active septicization under anaerobic conditions. High concentrations are toxic. Hydrogen sulphide in the presence of moisture will attack cement and other materials and certain metals. Methane and carbon dioxide are determined in routine control of sludge digestion tanks.

4.2.7 **Alkalinity and Acidity.**

Ordinary sewages are normally slightly alkaline, although the presence of an industrial waste may cause acidity. An alkaline condition is desirable in biological treatment process as bacterial life flourishes better under slightly alkaline conditions within normal limits the exact amount of alkalinity found in sewages has little significance. An abnormal alkalinity or acidity may indicate the presence of industrial waste calling for a special method of treatment._The alkalinity and acidity is generally expressed by PH value with H+ ion concentration. The acidity is due to charged hydrogen ions and alkalinity is due to a charged hydroxyl ions (OH), The product of H ions and OH is a constant and which has been found to be 10^{A}-14 Since neutral water contains equal number of both the ions the concentration of each must be 10^{A}-7. For convenience H+ ions concentration is expressed as the logarithm of reciprocal of H ions i.e. log/10- 7. Thus the PH value equal to 7 indicates the neutrality while values above 7 signify alkalinity and value below 7 indicates acidity.

4.3 Biological Analysis Of Waste Water For Bacteria & Microscopic Organisms. [2]

Analysis of waste water for the study of biological life include bacteriological and microscopic analysis. Standard waste water bacteriological analysis are made in the study of sewage, because it is known that intentmal bacteria are present, that the concentration of bacteria is high and that bacterial counts are not a guide to interpretation of strength, to determination of method of treatment of the control of treatment processes. The absence of bacteria may be interpreted as an indication of the presence of bactericidal industrial waste.

4.4 Analysis Of Waste Water Of Risalpur.

For the purpose of analysis two samples of waste water were taken one from training area (sample1) and other from Military Transport Washing area (sample2).The laboratory results and Analysis is given below

4.4.1 **Electrical Conductivity**

Chemical Symbol or Formula: Not Applicable [Physical parameter].

Units Used for Analytical Results: µS/cm

Standard Value : 1000 microsec/cm

Risalpur water : Sample1(1500), Sample2(2500)

Normal Method of Analysis : Electrometric [A].

Occurrence/Origin: Reflects mineral salt content of water.

Health/Sanitary Significance: No direct significance.

Background Information: Also referred to as electrical conductivity and, not wholly accurately, as specific conductance, the conductivity of a water is an expression of its ability to conduct an electric current. As this property is related to the ionic content of the sample which is in turn a function of the dissolved (ionisable) solids concentration, the relevance of easily performed conductivity measurements is apparent. In itself conductivity is a property of little interest to a water analyst but it is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solids content of the water. While a certain proportion of the dissolved solids (for example, those which are of vegetable origin) will not be ionized (and hence will not be reflected in the conductivity figures) for many surface waters the following approximation will apply: Conductivity (µS/cm) x 2/3 = Total Dissolved Solids (mg/l). In samples from a source which is regularly tested a rapid conductivity analysis may be an adequate replacement for other, longer determinations.

Comments: Our samples values are higher from the standard value of conductivity which shows presence of more salts than the desired. But it has little or no significance on environment so it can be neglected.

Table 0-1: Conductivity : Recommended or Mandatory Limit Values

EU Directive	Units of Analysis	Standard Value
Waste water regulation 1989	µS/cm	1,000

The unit is micro-Siemens/centimeter.

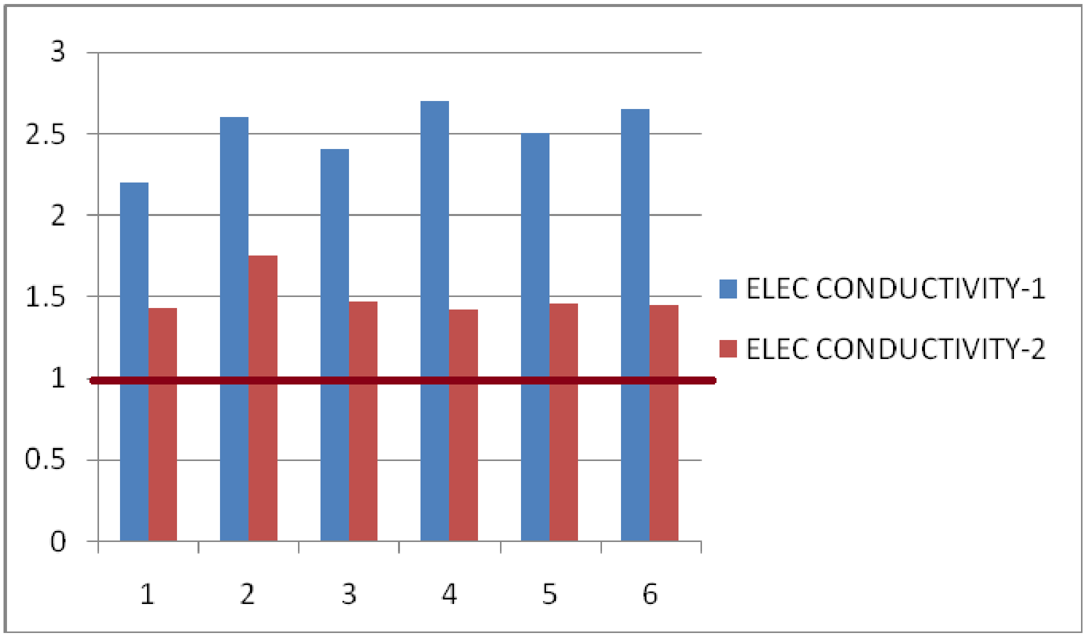

Figure 0-1: Plot Showing Elec Conductivity Vs Time

4.4.2 **Turbidity**

Chemical Symbol or Formula: Not applicable [Bulk physical parameter].

Units Used for Analytical Results: Nephelometric Turbidity Un its [NTU]

Norm al Method (s) of Analysis : Turbid meter or Nephelometer [B/C]

Standard Value : 300 NTU

Risalpur water : Sample1(110), Sample2(62)

Occurrence/Origin: Clay particles, sewage solids, silt and sand washings, organic and biological sludge etc.

Health/Sanitary Significance : Direct health effects depend on the precise composition of the turbidity-causing materials, but there are other implications, as discussed below

Background Information: Turbidity in water arises from the presence of very finely divided solids (which are not filterable by routine methods). The existence of turbidity in water will affect its acceptability to consumers and it will also affect markedly its utility in certain in industries. The particles forming the turbidity ma y also interfere with the treatability of waters and in the case of the disinfection process the consequences could be grave. As turbidity can be caused by sewage matter in a water there is a risk that pathogenic organ isms could be shielded by the turbidity particles and hence escape the action of the disinfectant.

Comments: As the sample values are well within the range that indicates no hazard from turbidity for secondary and tertiary treatments.

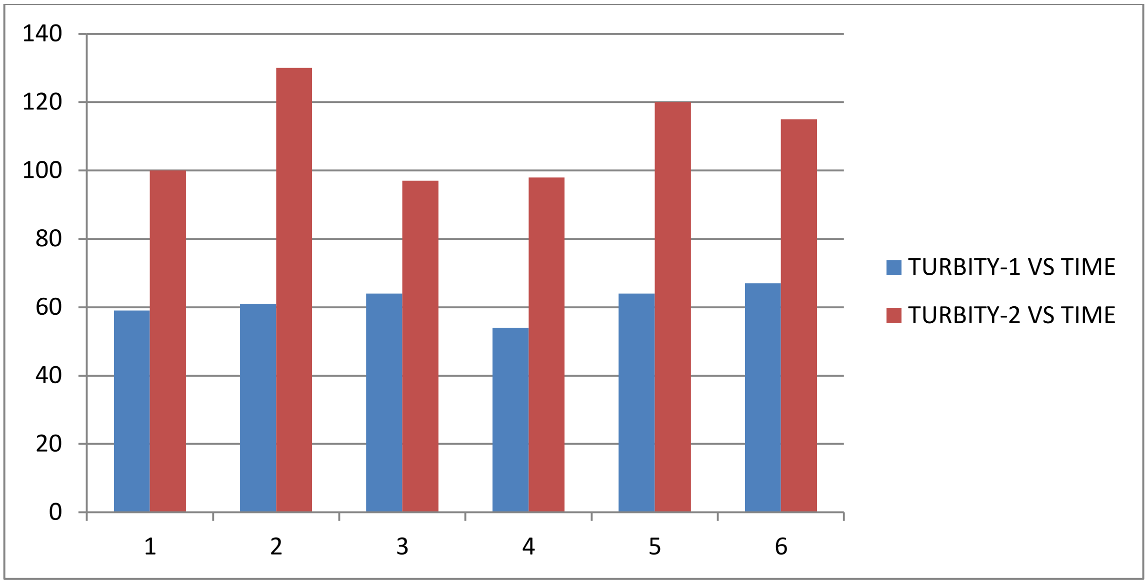

Figure 0-2: Plot Showing Turbidity Vs Time

(Limit is 300 NTU which is beyond this plot)

4.4.3 **Temperature**

Normal Method(s) of Analysis: Thermometry [A]

Occurrence/Origin: Generally climatologically influenced (in the absence of thermal discharges)

Health/Sanitary Significance: None.

Standard Value : 40 C

Risalpur water : Sample1(20), Sample2(20)

Background Information: The effect of temperature, and especially changes in temperature, on living organisms can be critical and the subject is a very wide and complex one. Where biochemical reactions are concerned, as in the uptake of oxygen by bacteria, a rise of 10°C in temperature leads to an approximate doubling of the rate of reaction. Conversely, such reactions are retarded by cooling, hence the recommendation often made that waters be cooled to 4°C in the interval between sampling and analysis. Another most important factor is that some key constituents of a water either change their form (as in the ionization of ammonia) or alter their concentration (as with dissolved oxygen) when temperature changes. In fact, the primary interest in the temperature of surface waters is due to the inverse relationship between it and oxygen solubility. However, elevated temperatures and, more importantly, steep temperature gradients can have directly harmful effects on fish. It is for the latter reason that changes in temperature are subject to limits.

Comments: The laboratory tests indicate water temperature is well within the range which has no harmful effect on aquatic life. However if samples were taken in summer the temperature can reach to 30o C maximum which is also acceptable.

Table 0-2: Temperature : Recommended or Mandatory Limit Values

EU Directive	*Units of Analysis*	*Standard Value*
Waste water regulation 1989	ºC	40

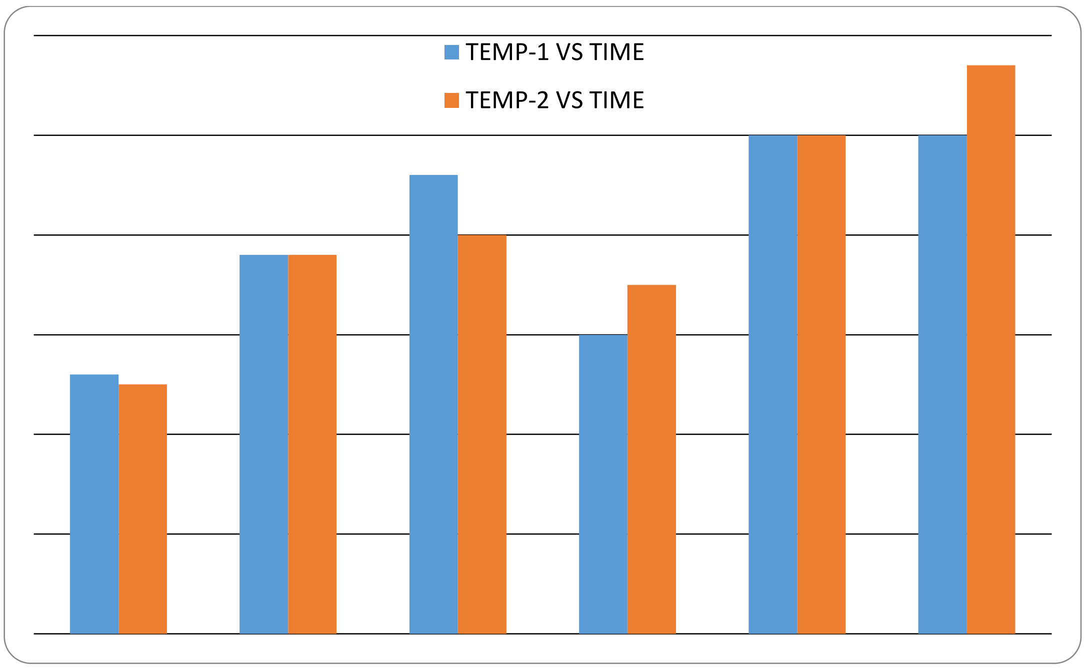

Figure 0-3: Plot Showing Temp Vs Time

(Limit is 40^{o}C which is beyond the plot)

4.4.4 **Chloride**

Chemical Symbol or Formula: Cl.

Units Used for Analytical Results: mg/l Cl.

Standard Value : 1000 mg/l cl

Risalpur water : Sample1(510), Sample2(350)

Occurrence/Origin: Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l -Cl). In fresh waters the sources include soil and rock formations, sea spray and waste discharges. Waste water contains large amounts of chloride, as do some industrial effluents.

Health/Sanitary Significance: Chloride does not pose a health hazard to humans and the principal consideration is in relation to palatability.

Background Information: At levels above 250 mg/l-Cl water will begin to taste salty and will become increasingly objectionable as the concentration rises further. However, external circumstances govern acceptability and in some arid areas waters containing up to 2,000 mg/l Cl are consumed, though not by people unfamiliar with such concentrations. High chloride levels may similarly render freshwater unsuitable for agricultural irrigation.

Comments:. The water can be used for agricultural purposes as the values are well within the range . However the harmful effects of waste water reuse as discussed in chapter2(table 2.1) should be kept in mind.

Table 0-3: Chloride : Recommended or Mandatory Limit Values

EU Directive	*Units of Analysis*	*Standard Value*
Waste water regulation 1989	mg/l Cl	1000
Drinking Water Directive [98/83/EC]	mg/l Cl	250

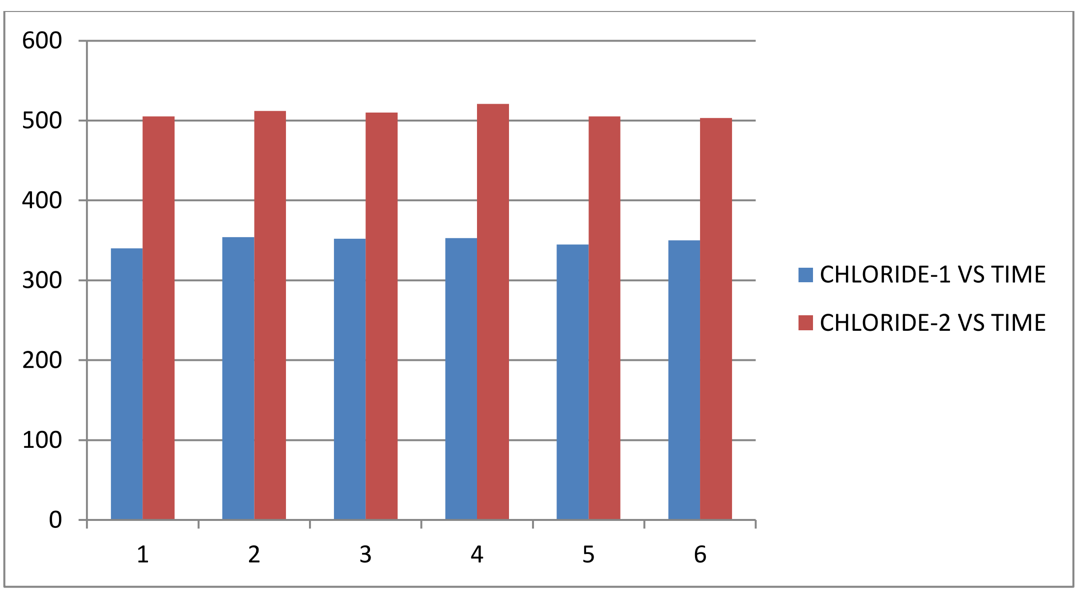

Figure 0-4: Plot Showing Chloride Vs Time

(Limit is 1000 mg/l Cl which is beyond this plot)

4.4.5 **Sulphates**

Chemical Symbol or Formula: SO_4

Units Used for Analytical Results: mg/l SO_4

Normal Method (s) of Analysis : Turbidimetric (Barium Sulphate) [B/G]; Ion Chromatography [C].

Standard Value : 600 mg/l

Risalpur water : Sample1(180), Sample2(460)

Occurrence/Origin: Rocks, geological formations, discharges and so on

Health/Sanitary Significance: Excess sulphate has a laxative effect, especially in combination with magnesium and/or sodium.

Background Information: Sulphates exist in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals (iron, nickel, copper and lead). Iron sulphides are present in sedimentary rocks from which they can be oxidized to sulphate in humid climates; the latter may then leach into watercourses so that ground waters are often excessively high in sulphates. As magnesium and sodium are present in many waters their combination with sulphate will have an enhanced laxative effect of greater or lesser magnitude depending on concentration. The utility of a water for domestic purposes will therefore be severely limited by high sulphate concentrations, hence the limit of 250 mg/l SO_4.

Comments: Other problems are associated with sulphate. In polluted waters in which the dissolved oxygen i.e. zero, sulphate is very readily reduced to sulphide causing noxious odours. Waters containing sulphates in excess will also attack the fabric of concrete sewer pipes. The samples sulphate content is within the range so no such harmful effects will occur.

Table 0-4 Sulphate : Recommended or Mandatory Limit Values

EU Directive	*Unit of Analysis*	*Standard Value*
Waste water regulation **1989**	mg/l SO4	600
	mg/l SO4	250

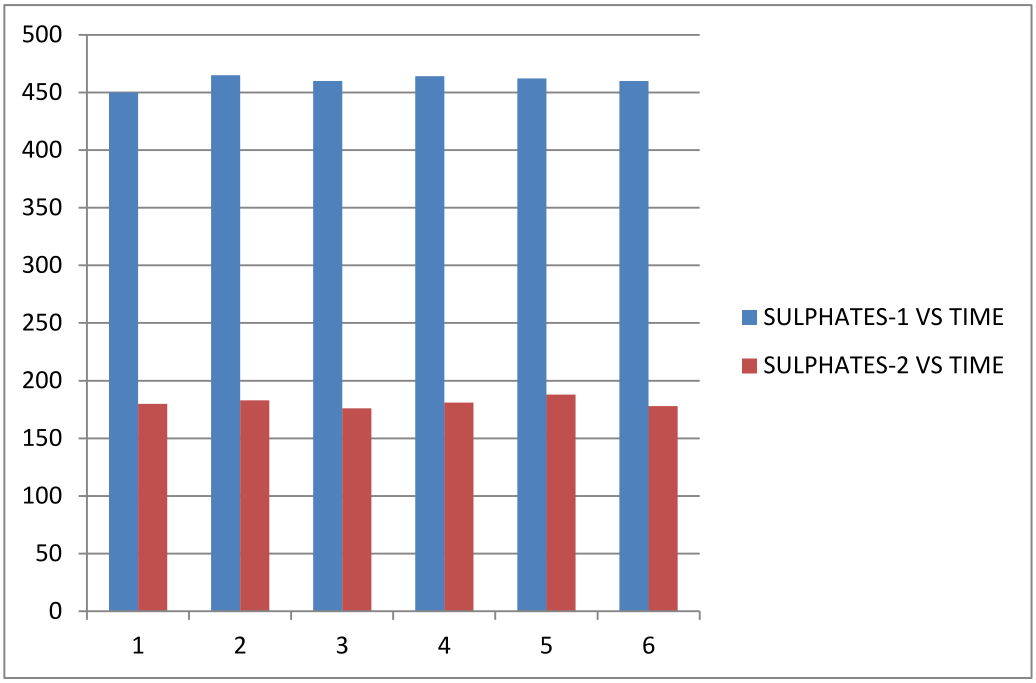

Figure 0-5: Plot Showing Sulphate Vs Time

(Limit is 600 mg/l S04 which is beyond this plot)

4.4.6 **Phosphates**

Formula: P_2O_5

Occurrence/Origin: Phosphorus occurs widely in nature in plants, in micro-organisms, in animal wastes and so on. It is widely used as an agricultural fertilizer and as a major constituent of detergents, particularly those for domestic use. Run-off and sewage discharges are thus important contributors of phosphorus to surface waters.

Health/Sanitary Significance: None.

Standard Value : 5 mg/l

Risalpur water : Sample1(4.5), Sample2(1.5)

Background Information: The significance of phosphorus is principally in regard to the phenomenon of eutrophication (over-enrichment) of lakes and, to a lesser extent, rivers. Phosphorus gaining access to such water bodies, along with nitrogen as nitrate, promotes the growth of algae and other plants leading to blooms, littoral slimes, diurnal dissolved oxygen variations of great magnitude and related problems. There is considerable debate as to the availability of the various forms of phosphorus (orthophosphate, polyphosphate, organic phosphate and so on) for the growth of algae although it is considered that orthophosphate is the most readily used form. Phosphorus may be in true solution, in colloidal suspension or adsorbed onto particulate matter, and it is very difficult to differentiate between the various fractions by separation (e.g. filtration) or analysis. A useful parameter is orthophosphate (strictly, total filterable and non-filterable orthophosphate) which is the phosphate responding to the analytical procedure without any pre-treatment such as hydrolysis or oxidative digestion. Caution must be exercised in considering the results of phosphorus analysis as the element exists in bound and unbound forms which are very difficult to separate totally in analysis. There is always the likelihood, for example, of some of the bound polyphosphate forms being changed by hydrolysis to orthophosphate under the actual analytical conditions. However, the determination of orthophosphate as specified is of great use in highlighting the presence of one of the most important nutrients and the results are of special interest in waters receiving sewage discharges.

Comments: The relatively higher value of phosphates in waste water from training area indicates the use of detergents for washing and bathing purposes. And low value in MT area indicates limited usage of detergents.

Table 0-5: Phosphates : Recommended or Mandatory Limit Values

EU Directive	Units of Analysis	*Standard Value*
Waste water regulation [1989]	mg/l P2O5	5

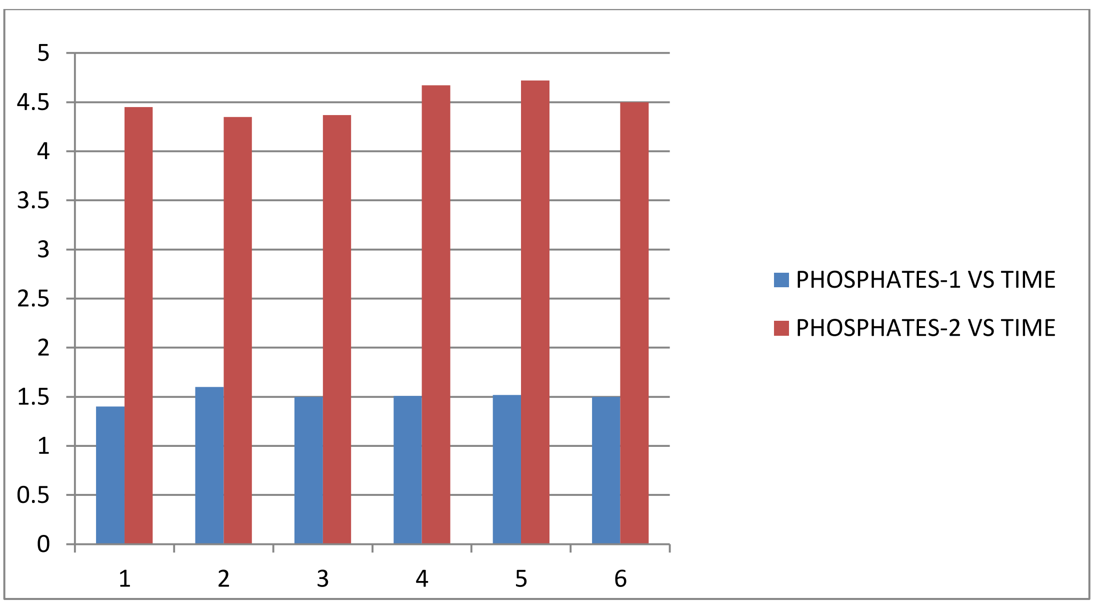

Figure 0-6: Plot Showing Phosphate Vs Time

(Limit is 5mg/l which is the top of this plot)

4.4.7 **Nitrates**

Chemical Symbol or Formula: NO_3^-

Units Used for Analytical Results: mg/l N or mg/l NO_3

Occurrence/Origin: Oxidation of ammonia: agricultural fertilizer run-off.

Health/Sanitary Significance: Hazard to infants above 11 mg/l N.

Standard Value : 20 mg/l

Risalpur water : Sample1(2.5), Sample2(1.5)

Background Information: Relatively little of the nitrate found in natural waters is of mineral origin, most coming from organic and inorganic sources, the former including waste discharges and the latter comprising chiefly artificial fertilizers. However, bacterial oxidation and fixing of nitrogen by plants can both produce nitrate. Interest is centered on nitrate concentrations for various reasons. Most importantly, high nitrate levels in waters to be used for drinking will render them hazardous to infants as they induce the "blue baby" syndrome (methaemoglobinaemia). The nitrate itself is not a direct toxicant but is a health hazard because of its conversion to nitrite [see also below] which reacts with blood hemoglobin to cause methaemoglobinaemia. Of increasing importance is the degree to which fertilizer run-off can contribute to eutrophication problems in lakes. Sewage is rich in nitrogenous matter which through bacterial action may ultimately appear in the aquatic environment as nitrate. Hence, the presence of nitrate in ground waters, for example, is cause for suspicion of past sewage pollution or of excess levels of fertilizers or manure slurries spread on land. (High nitrite levels would indicate more recent pollution as nitrite is an intermediate stage in the ammonia-to-nitrate oxidation). In rivers high levels of nitrate are more likely to indicate significant run-off from agricultural land than anything else and the parameter is not of primary importance. However, it should be noted that there is a general tendency for nitrate concentrations in rivers to increase as a result of enhanced nutrient run-off, this may ultimately lessen their utility as potential sources of public water supply. Nitrite concentrations in rivers are rarely more than 1-2 per cent of the nitrate level so that it may therefore be acceptable to carry out the analytically convenient determination of nitrate + nitrite at the same time. This determination is correctly referred to as total oxidized nitrogen.

Comments: No harmful effects from nitrites as the value of nitrates is within limits which prevents formation of nitrites.

Table 0-6: Nitrate : Recommended or Mandatory Limit Values

EU Directive or National [Ministerial] Regulations	*Units of Analysis*	*Standard Value*
Waste water regulation [1989]	mg/l NO3	20
Drinking Water Directive [98/83/EC]	mg/l NO3	20

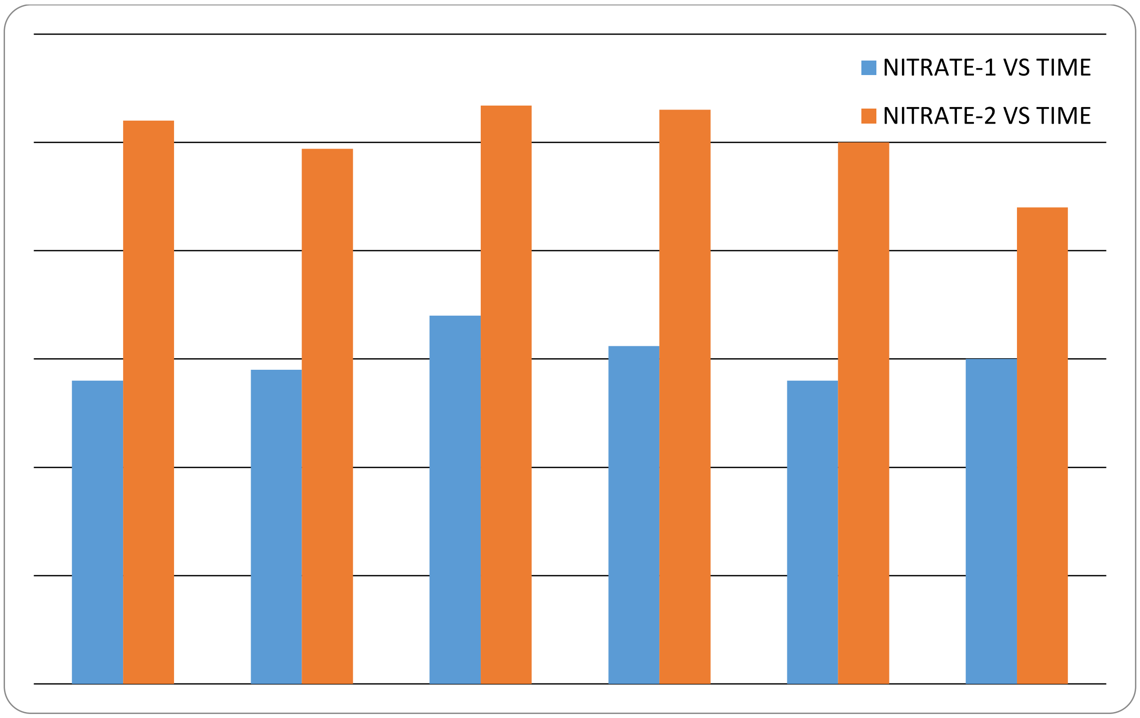

Figure 0-7: Plot Showing Nitrate Vs Time

(Limit is 20mg/l which is beyond this plot)

4.4.8 **Total Dissolved Solids**

Chemical Symbol or Formula: Not applicable [Bulk parameter].

Units Used for Analytical Results: mg/l solids (Dried at stated temperature).

Normal Method (s) of Analysis : Gravimetric (Dried at stated temperature after filtration)

Occurrence/Origin: Natural or added solutes present in a water.

Sanitary Significance: Principally organoleptic implications.

Standard Value : 3500

Risalpur water : Sample1(834), Sample2(1260)

Background Information: The parameter is determined as for total solids except that the sample is filtered through a defined medium (membrane or glass fiber paper; cf. "Solids, Suspended") beforehand. The term Total Filterable Solids is also used. It is often convenient and acceptable to use the very rapid determination of conductivity (q.v.) to give an estimation of the total dissolved solids.

Comments : Since it has only organoleptic consequence and in waste water it has no importance therefore TDS has no impact on these samples.

Table 0-7: Solids, Total Dissolved : Recommended or Mandatory Limit Values

EU Directive or National [Ministerial] Regulations	*Units of Analysis*	*Standard Value*
Waste water regulation 1989	mg/l	*3500*

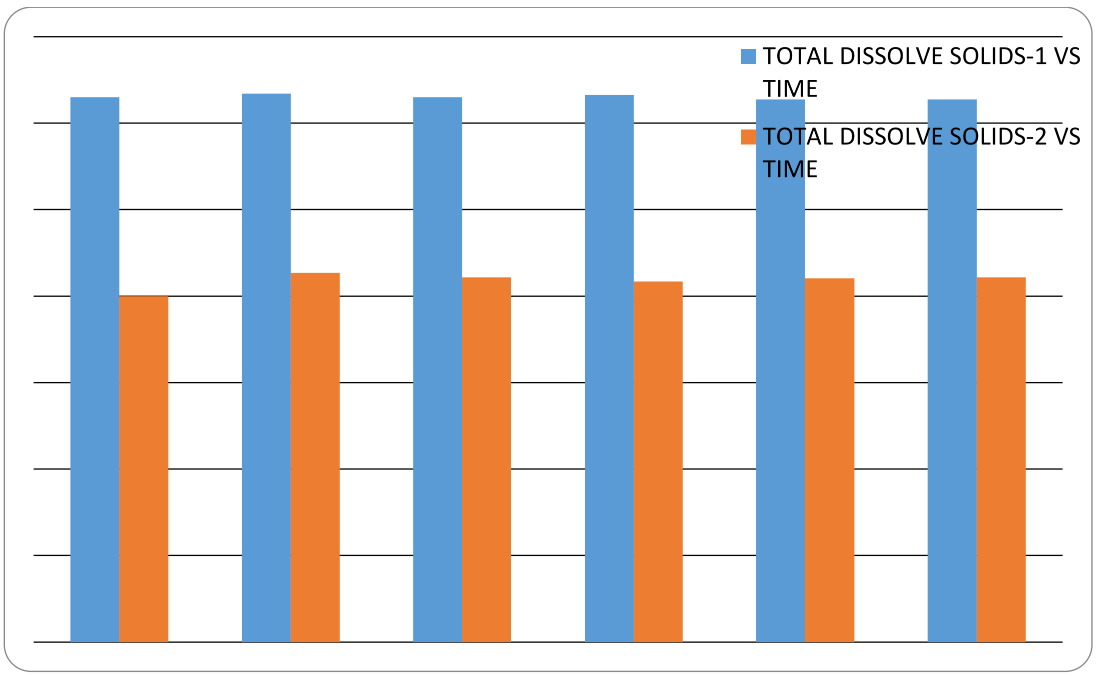

Figure 0-8: Plot Showing TDS Vs Time

(Standard Value is 3500 which is beyond this plot)

4.4.9 **Total suspended Solid**

Chemical Symbol or Formula: Not applicable [Bulk parameter].

Units Used for Analytical Results: mg/l solids (Dried at stated temperature).

Normal Method (s) of Analysis : Gravimetric (Filtration, with drying at stated temperature) [A].

Standard Value : 500

Risalpur water : Sample1(100), Sample2(160)

Occurrence/Origin: Natural deposition in or discharges to water.

Health/Sanitary Significance: No direct significance.

Background Information: Matter which is suspended in quiescent water consists of finely divided light solids which may never settle or do so only very slowly. Indeed, the net effect may be one of apparent turbidity without any discernible solids. In flowing water, on the other hand, the solids which are kept in suspension by the turbulence may be settle able if the water is let stand. While the latter would be determinable as "Solids, Settle able," and the former could possibly be assessed as "Turbidity," there will be those solids of intermediate grading which also require estimation. To determine as much as possible of the solids present (not in solution), the determination of "suspended" solids is carried out. The procedure consists of filtering the sample through a defined medium (a common specification is through a 0.45 μm membrane) and drying at a specified temperature (commonly 105°C) with gravimetric estimation of the concentration. Failing the use of a membrane fitter, glass-fiber paper (grade GF/C) may be used although its porosity is much greater than the former. It is important that the temperature of the drying be adhered to and also quoted with the results. It is clear that the term "suspended solids" is in fact defined by the filtration conditions. The significance of suspended solids in water is great, on a number of grounds. The solids may in fact consist of algal growths and hence be indicative of severely eutrophic conditions; they may indicate the discharge of washings from sandpits, quarries or mines; they will reduce light penetration in surface waters and interfere with aquatic plant life; they will seriously damage fishery waters and may affect fish life; they may form deposits on the bed of rivers and lakes which will in turn give rise to septic and offensive conditions; and they may indicate the presence of unsatisfactory sewage effluent discharges.

Comments: Suspended solids measurements are most relevant as they are good indicators of both the pollution potential of an effluent and the performance efficiency of treatment plant. The samples indicate values within range which will not cause pollution and other harmful effects.

Table 0-8: Solids, Suspended : Recommended or Mandatory Limit Values

EU Directive	*Units of Analysis*	*Standard Value*
Waste water regulation 1989	mg/l	500

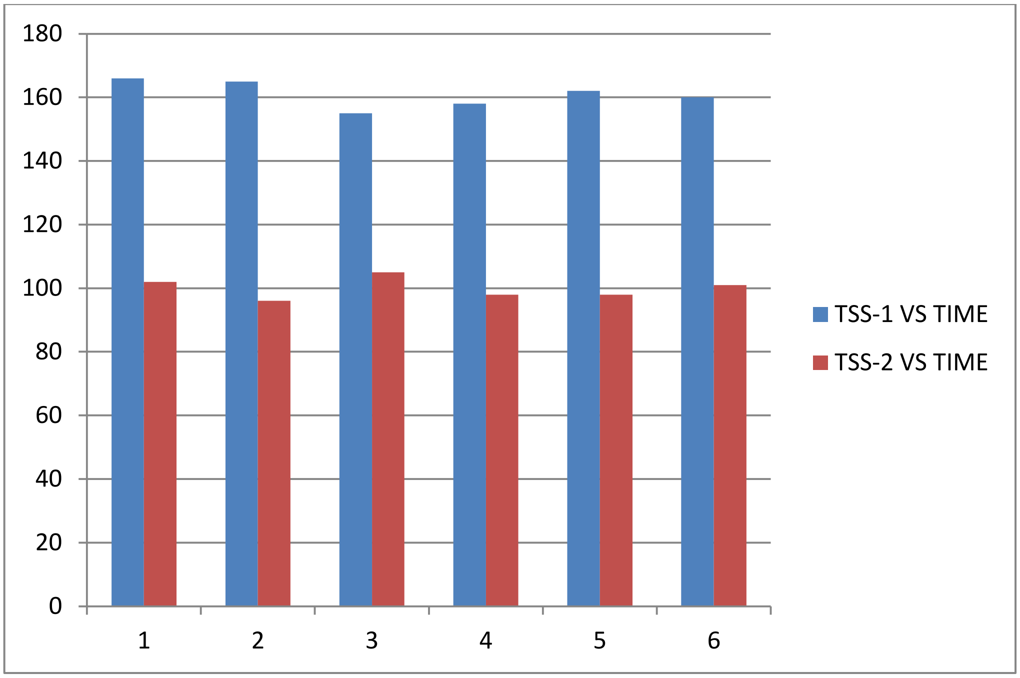

Figure 0-9: Plot Showing TSS Vs Time

(Limit is 500 mg/l which is beyond the plot)

4.4.10 **COD**

Chemical Symbol or Formula: Not applicable [Bulk para meter].

Units Used for Analytical Results: mg/l O_2.

Normal Method (s) of Analysis: Micro digestion an d colorimetric [A]; Titrimetric following Reflux Dis till at ion with Acid Potassium Dichromate [B].

Standard Value : 150

Risalpur water : Sample1(680), Sample2(1200)

Occurrence/Origin : Natural or, more probably, added organic matter.

Health h/Sanitary Significance : No direct hazard implications; COD is an indicator of overall water quality.

Background Information: Except in special cases, the five-day BOD analysis gives a measure of the oxygen demand of biodegradable carbonaceous matter in a sample. The oxidation is not complete and the five-day BOD value in a properly conducted test usually amounts to some 65 percent of the total carbonaceous oxygen demand. To measure the latter in the BOD test would take some four times as long and would involve special measures to counter the side-effects of oxidation of nitrogenous matter, the nitrification referred to above (cf. "Oxygen Demand, Biochemical"). The ideal approach is to obtain a rapid, accurate measurement of the total carbonaceous oxygen demand and, in an attempt to reach this goal, chemical methods have been devised. The first point to consider is that in any such method the only organic compounds affected will be those amenable to oxidation by the particular chemical agent used. There is a wide variety of chemical oxidants and hence there will be a correspondingly wide range of effects. Potassium permanganate has been widely used to measure the oxygen demand of river waters but there may be little or no correlation with BOD figures. As mentioned above, peaty waters of low BOD often have very high permanganate values, reflecting the intense colour caused by the presence of biologically inert but chemically oxidisable vegetable matter. However, for any one type of sample the permanganate values may be useful (in indicating changes in the performance of a treatment plant, for example), and it may be possible to correlate the figures with those for BOD after a sufficiently large number of analyses have been carried out. The reagent favored in U.S. methods is potassium dichromate and although the term chemical oxygen demand (COD) is a general one, which should be qualified by the mention of the actual oxidant used, in practice the abbreviation COD refers specifically to the test in which potassium dichromate is used to carry out the oxidation. A drawback is that the standard test procedure is in practice applicable only to very heavily polluted waters or to effluents, though its use for the latter makes it a most valuable method. Comparisons have been made between the permanganate value test and the COD and have indicated the variability of the former as a general oxidant . The COD test procedure involves the use of additional reagent s to catalyze the oxidation of organic matter and to suppress the effects of interfering substances such as chloride, and, as a result, in many cases the oxidation achieve d is at or very near the maximum level. As pointed out earlier, for biodegradable compounds the five-day BOD level corresponds to some 65 per cent oxidation of the total organic matter present so that , if for such compounds the chemical oxidation is fully efficient, the COD/BOD ratio should be 100:65 or 1.54: 1. This is the case for domestic sewage for which COD values around 480-500 mg/l an d BOD figures in the region of 310 mg/l give a good correspondence with the ratio. It is possible to work out the applicable ratio for wastes which do not change their composition but which are only partially affected in either oxygen demand test. Application of the COD/BOD ratio to the results of a quickly performed COD test is very useful for the analyst and for the plant manager.

Comments: The presence of high COD in training area is due to detergents and even higher value in Washing area is due to presence of lubricants along with small quantity of detergents. This will cause detrimental effects to aquatic life leading to problems of septic conditions.

Table 0-9: Oxygen demand , Chemical : Recommended or Mandatory Limit Values

EU Directive	*Units of Analysis*	*Standard Value*
Waste water regulation [1989]	mg/l O2	600

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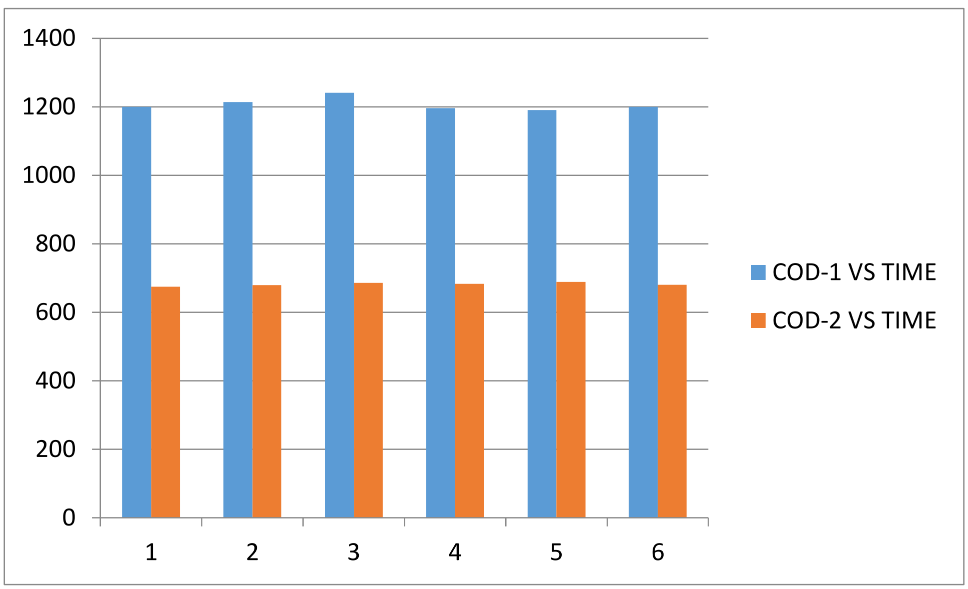


Figure 0-10: Plot Showing COD Vs Time

4.4.11 **BOD**

Chemical Symbol or Formula: Not applicable [Bulk parameter]

Units Used for Analytical Results: mg/l O_2.

Normal Method (s) of Analysis : Incubation technique with oxygen determinations by Winkler Method or by Oxygen Meter [A].

Occurrence/Origin: Natural or introduced organic matter in water.

Standard Value : 80 mg/l

Risalpur water : Sample1(125), Sample2(80)

Health/Sanitary Significance : No direct health implications, but an important indicator of overall water quality.

Background Information: When organic matter is discharged into a watercourse it serves as a food source for the bacteria present there. These will sooner or later commence the breakdown of this matter to less complex organic substances and ultimately to simple compounds such as carbon dioxide and water. If previously unpolluted, the receiving water will be saturated with dissolved oxygen (DO), or nearly so, and the bacteria present in the water will be aerobic types. Thus the bacterial breakdown of the organic matter added will be an aerobic process - the bacteria will multiply, degrading the waste and utilizing the DO as they do so. If the quantity of waste present is sufficiently large, the rate of bacterial uptake of oxygen will outstrip that at which the DO is replenished from the atmosphere and from photosynthesis, and ultimately the receiving water will become anaerobic.

Bacterial degradation of the waste will continue but now the products will be offensive in nature -for example, hydrogen sulphide. Even if the uptake of oxygen is not sufficient to result in anaerobic conditions there will be other undesirable effects as DO level falls, notably damage to fisheries and, ultimately, fish deaths. Where levels are around 50 per cent saturation for significant periods there may be adverse, though non-lethal, effects on game fish. Coarse fish will be likewise affected if levels are regularly around 30 per cent saturation. Because of the potential danger to the oxygen levels in receiving waters from waste discharges considerable emphasis is placed in the laboratory on the estimation of the oxygen demand of wastes: i.e. the amount of oxygen which will be required in their break down. This is done chemically an d biologically, by a variety of tests which are also employed to assess the actual effects of waste discharges on receiving water, as discussed below. As in most cases the oxygen demand of a waste on the DO level of a receiving water results from biological action, it follows that the most important analytical method should also depend on a biological process, to measure the biochemical oxygen demand or BOD. The principle of this test, which was devised some 85 year s ago, is straight forward. The (five-day) BOD of a water is the amount of dissolved oxygen taken up by bacteria in degrading oxidisable matter in the sample, measured after 5 days incubation in the dark at 20°C. The BOD is simply the amount by which the DO level has dropped during the incubation period. This technique is the basis of BOD analyses for all types of sample even though considerable extensions of procedure are necessary in dealing with wastewaters and polluted surface waters. BOD data are normally required for one of two purposes. Firstly, it is necessary to know the strength of a waste which is to be treated by biological means, as in an oxidation ditch or percolating filter. This is essential so that adequate treatment capacity may be provided for in the design of the plant . Secondly where wastes are being discharged to receiving waters a knowledge of their strength and the magnitude of the river discharge will perm it the dilution to be calculated and hence the maximum potential change in the river BOD at the boundary of the mixing zone. A factor which must be borne in mind in obtaining and in assessing BOD results is nitrification. This is the oxidation of ammonia to nitrate by suitable micro-organ isms and if the process is occurring under test conditions high oxygen uptake values will be recorded. For normal river waters the onset of nitrification under BOD test conditions does not occur within the 5-day period of th e analysis but in the case of waters or wastewaters containing nitrifying organ isms this phenomenon will take place much more promptly. Unless suitable precautions are taken the result is an apparently very high BOD level which, if the analysis is being used to check the performance of a waste treatment works (with respect to the removal of organic matter), for example, may lead to serious errors in the interpretation and use of the data.

Comments: Biochemical oxygen demand of the waste water produced is 80-150 mg/lit which is a fair value. BOD is the measure of degree of treatment required by the sewage. As the BOD value is within limits, so no further treatment is required otherwise it should be adequately treated before disposing off.

Table 0-10: Oxygen Demand , Biochemical : Recommended or Mandatory Limit Values

EU Directive	*Units of Analysis*	*Standard Value*
Waste water regulation [1989]	mg/lO2	250

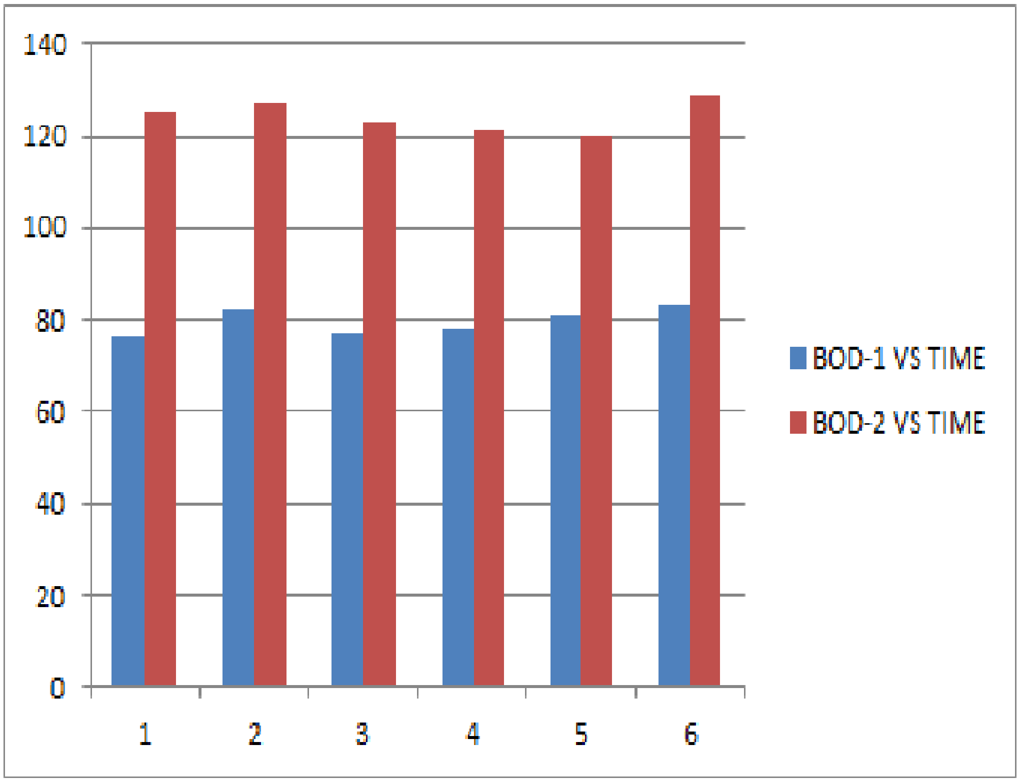


Figure 0-11: Plot Showing BOD Vs Time

(The Standard value of BOD is 80)

4.4.12 **pH**

Chemical Symbol: Not applicable [Physical para meter].

Units Used for Analytical Result s: p H units.

Normal Method (s) of Analysis : Electrometry [p H electrode] [A/B]

Standard Value : 6-10

Risalpur water : Sample1(7.2), Sample2(8)

Occurrence/Origin: Physical characteristic of all waters/solutions.

Health/Sanitary Significance : None - except that extreme values will show excessive acidity/alkalinity, with organoleptic consequences.

Background Information: By definition pH is the negative logarithm of the hydrogen ion concentration of a solution an d it is thus a measure of whether the liquid is acid or alkaline. The pH scale (derived from the ionization constant of water) ranges from 0 (very acid) to 14 (very alkaline). The range of natural pH in fresh waters extends from around 4.5, for acid, peat y upland waters, to over 10.0 in waters where there is intense photosynthetic activity by algae. However, the most frequently encountered range is 6.5-8.0. In waters with low dissolved solids, which consequently have a low buffering capacity (i.e. low internal resistance to p H change), changes in pH induced by external causes may be quite drama tic. Extremes of p H can affect the palatability of a water but the corrosive effect on distribution systems is a more urgent problem (see Appendix 4). The effect of pH on fish is also an important consideration an d values which depart increasingly from the normally found level s will have a more and more marked effect on fish, leading ultimately to mortality. The range of pH suitable for fisheries is considered to be 5.0-9.0, though 6-10 is preferable.

Comments: Apart from the aspects just mentioned, pH values govern the behavior of several other important parameters of water quality. Ammonia toxicity, chlorine disinfection efficiency, and metal solubility are all influenced by pH. Our Values are within range so no such effects are likely to occur.

Table 0-11: Recommended or Mandatory Limit Values

EU Directive or National [Ministerial] Regulations	*Units of Analysis*	*Standard Value*
Waste water regulation 1989		**6-10**

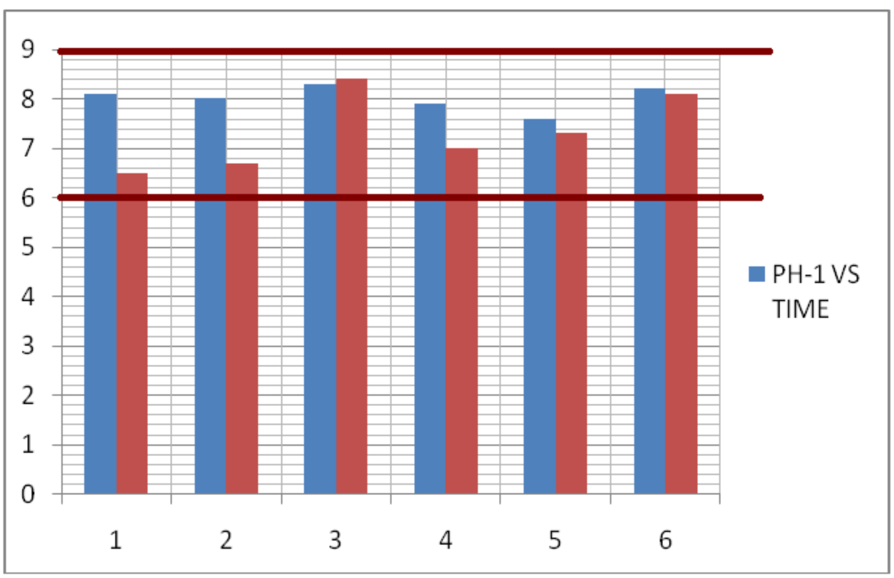


Figure 0-12: Plot Showing Ph Vs Time

4.5 Summary

This chapter encompasses the Analysis techniques and the analysis of waste water of risalpur. Our samples values are higher from the standard value of conductivity which shows presence of more salts than the desired. But it has little or no significance on environment so it can be neglected. The sample values of Turbidity are well within the range that indicates no hazard from turbidity for secondary and tertiary treatments. The laboratory tests indicate water temperature is well within the range which has no harmful effect on aquatic life. However if samples were taken in summer the temperature can reach to 30^o C maximum which is also acceptable. So the water can be used for agricultural purposes as the values are well within the range . However the harmful effects of waste water reuse as discussed in chapter2 (table 2.1) should be kept in mind. The .relatively higher value of phosphates in waste water from training area indicates the use of detergents for washing and bathing purposes. And low value in MT area indicates limited usage of detergents. No harmful effects from nitrites as the value of nitrates is within limits which prevents formation of nitrites. Since TDS has only organoleptic consequence and in waste water it has no importance therefore TDS has no impact on these samples.

The presence of high COD in training area is due to detergents and even higher value in washing area is due to presence of lubricants along with small quantity of detergents. This will cause detrimental effects to aquatic life leading to problems of septic conditions. Biochemical oxygen demand of the waste water produced is 80-150 mg/lit which is a fair value. BOD is the measure of degree of treatment required by the sewage. As the BOD value is within limits, so no further treatment is required otherwise it should be adequately treated before disposing off. pH values govern the behavior of several other important parameters of water quality. Ammonia toxicity, chlorine disinfection efficiency, and metal solubility are all influenced by pH. Our Values are within range so no such effects are likely to occur. In polluted waters in which the dissolved oxygen i.e. zero, sulphate is very readily reduced to sulphide causing noxious odours. Waters containing sulphates in excess will also attack the fabric of concrete sewer pipes. The samples sulphate content is within the range so no such harmful effects will occur. Suspended solids measurements are most relevant as they are good indicators of both the pollution potential of an effluent and the performance efficiency of treatment plant. The samples indicate values within range which will not cause pollution and other harmful effects.

Since all the parameters are within control except COD and conductivity so design of primary sedimentation tank would be a suitable and economic option.

Chapter 5

PRILIMINARY TREATMENT OF WASTE WATER

5.1 GENERAL

Wastewater is not just sewage. All the water used in the home that goes down the drains or into the sewage collection system is wastewater. This includes water from baths, showers, sinks, dishwashers, washing machines, and toilets. Small businesses and industries often contribute large amounts of wastewater to sewage collection systems; others operate their own wastewater treatment systems. In combined municipal sewage systems, water from storm drains is also added to the municipal wastewater stream. The average Pakistani contributes 265-568 liters (66 to 192 gallons) of wastewater each day. Wastewater is about 99 percent water by weight and is generally referred to as influent as it enters the wastewater treatment facility. “Domestic wastewater” is wastewater that comes primarily from individuals, and does not generally include industrial or agricultural wastewater.

At wastewater treatment plants, this flow is treated before it is allowed to be returned to the environment, lakes, or streams. There are no holidays for wastewater treatment, and most plants operate 24 hours per day every day of the week. Wastewater treatment plants operate at a critical point of the water cycle, helping nature defend water from excessive pollution. Most treatment plants have_**primary** treatment (physical removal of floatable and settleable solids) and **secondary** treatment (the biological removal of dissolved solids).

Primary treatment involves:

1. **Screening** - to remove large objects, such as stones or sticks that could plug lines or block tank inlets.
2. **Grit chamber** - slows down the flow to allow grit to fall out.
3. **Sedimentation tank** (settling tank or clarifier) .Settle able solids settle out and are pumped away, while oils float to the top and are skimmed off. [2]

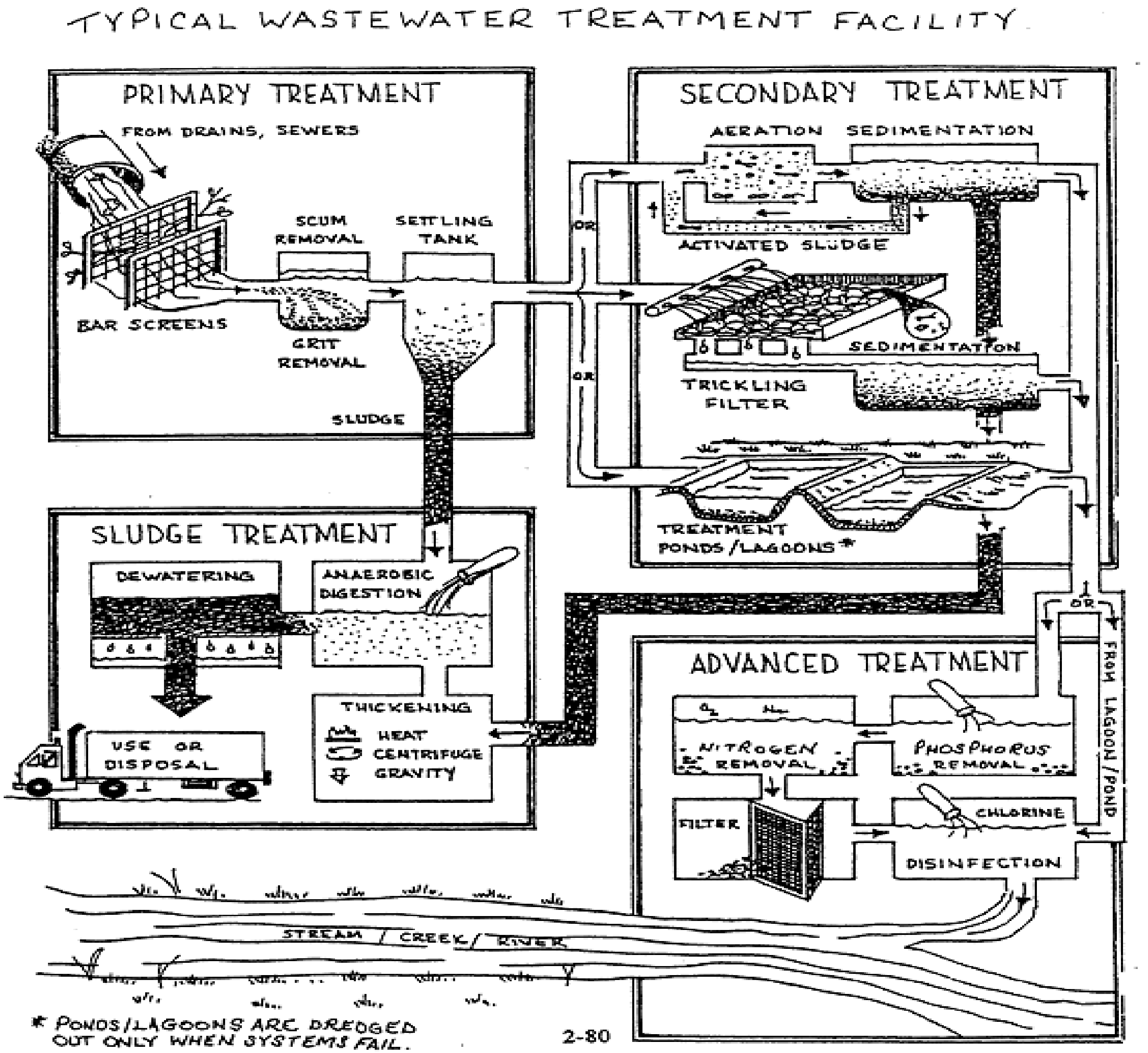


Figure 0-1: Typical Waste Water Treatment Facility[2]

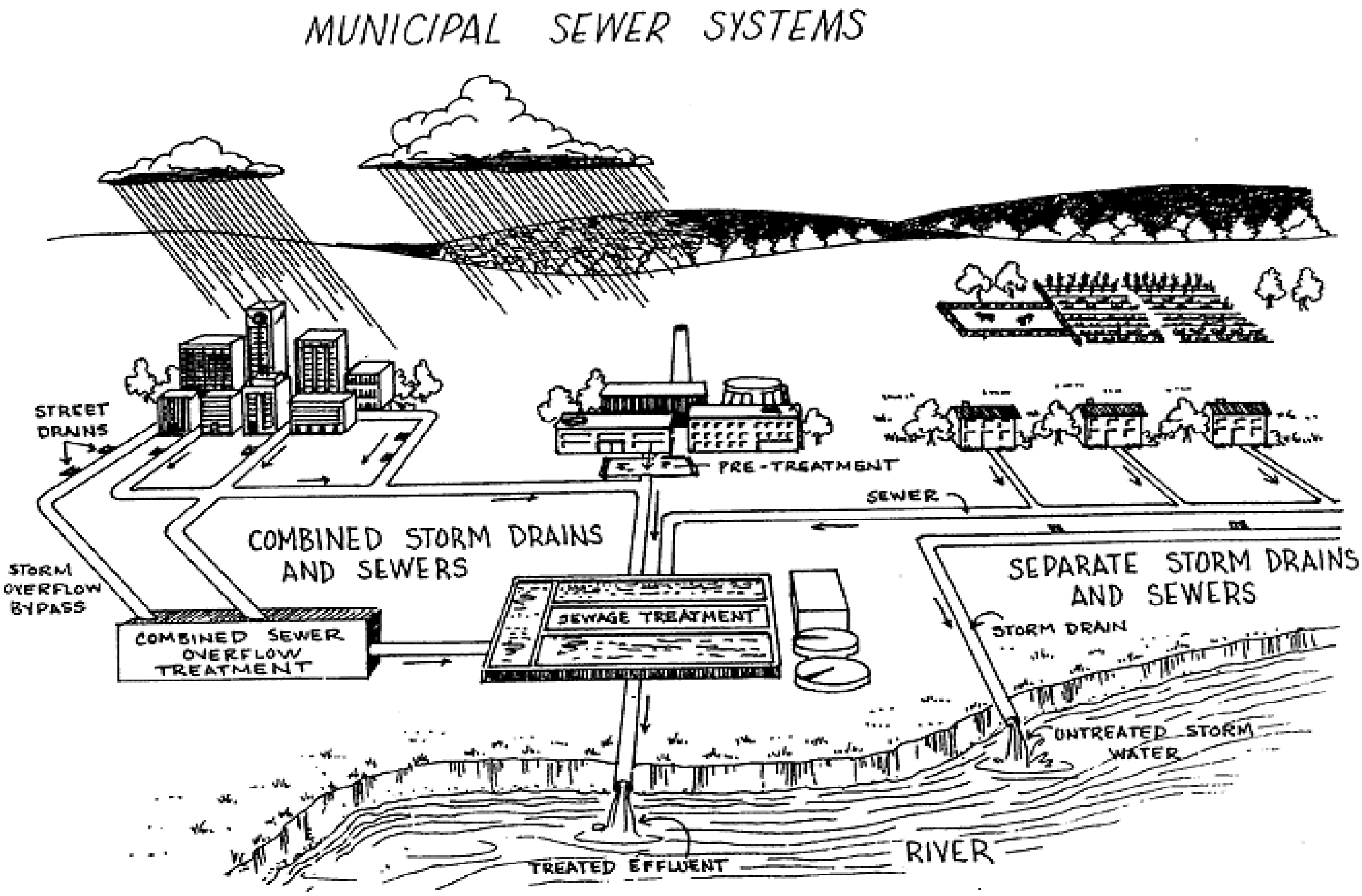


Figure 0-2: Municipal Sewer System[2]

5.2 PRIMARY SEDIMENTATION TANK

5.3 Classification of Settling Behavior [2]

Several cases of settling behaviour may be distinguished on the basis of the *nature* of the particles to be removed and their concentration. Thus, individual particles may be discrete (sand grains) or flocculent (most organic materials and biological solids). Particle concentrations may vary from very low through to high in which case adjacent particles are actually in contact. Common classifications of settling behaviour are:

Class I - Unlimited settling of discrete particles

Class II - Settling of dilute suspensions of flocculent particles

Class III - Hindered settling and zone settling

Class IV - Compression settling (compaction)

5.3.1 **Sedimentation Class I - Unlimited Settling of Discrete Particles**

Sedimentation is removal of discrete particles in such low concentration that each particle settles freely without interference from adjacent particles (that is, unhindered settling).

5.3.2 **Sedimentation Class II - Settlement of Flocculent Particles In Dilute Suspension**

It should be recognized that particles do collide and that this benefits flocculation and hence sedimentation. In a horizontal sedimentation tank, this implies that some particles may move on a curved path while settling faster as they grow rather than following the diagonal line. This favors a greater depth as the longer retention time allows more time for particle growth and development of a higher ultimate settling velocity. However, if the same retention time were spread over a longer, shallower tank, the opportunity for collision would become even greater because the horizontal flow rate would become more active in promoting collisions. In practice, tanks need to have a certain depth to avoid hydraulic *short-circuiting* and are made 3-6 m deep with retention times of a few hours.

The advantage of low depths is exploited in some settling tanks by introducing baffles or tubes. These are installed at an angle, which permits the settled sludge to slide down to the bottom of the settler, even though any angle effectively increases the vertical displacement between two plates.

5.3.3 **Sedimentation Class III - Hindered Settling And Zone Settling And Sludge Blanket Clarifiers**

As the concentration of particles in a suspension is increased, a point is reached where particles are so close together that they no longer settle independently of one another and the velocity fields of the fluid displaced by adjacent particles, overlap. There is also a net upward flow of liquid displaced by the settling particles. This results in a reduced particle-settling velocity and the effect is known as hindered settling.

The most commonly encountered form of hindered settling occurs in the extreme case where particle concentration is so high that the whole suspension tends to settle as a 'blanket'. This is termed zone settling, because it is possible to distinguish several distinct zones, separated by concentration discontinuities. Fig 2.6 represents a typical batch-settling column test on a suspension exhibiting zone-settling characteristics. Soon after leaving such a suspension to stand in a settling column, there forms near the top of the column a clear interface separating the settling sludge mass from the clarified supernatant. This interface moves downwards as the suspension settles. Similarly, there is an interface near the bottom between that portion of the suspension, which has settled and the suspended blanket. This interface moves upwards until it meets the upper interface, at which point settling of the suspensions is complete.

It is apparent that the slope of the settling curve at any point represents the settling velocity of the interface between the suspension and the clarified supernatant. This once again leads to the conclusion that in designing clarifiers for treating concentrated suspensions (Class III), the surface loading rate is a major constraint to be considered; unless the surface loading rate adopted is less than the zone-settling velocity (v_{sz}) of the influent suspension, solids will be carried over in the effluent.

5.3.4 **Sedimentation Class IV - Compression Settling (Compaction)**

Very high particle concentrations can arise as the settling particles approach the floor of the sedimentation tanks and adjacent particles are actually in contact. Further settling can occur only by adjustments within the matrix, and so it takes place at a reducing rate. This is known as compression settling or consolidation and is illustrated by the lower region of the zone-settling diagram. Compression settling occurs as the settled solids are compressed under the weight of overlying solids, the void spaces are gradually diminished and water is squeezed out of the matrix.

Compression settling is important in gravity thickening processes. It is also particularly important in activated-sludge final settling tanks, where the activated sludge must be thickened for recycling to the aeration tanks and for disposal of a fraction of the sludge.

5.4 ZONES OF SEDIMENTATION TANK

The ideal rectangular horizontal flow sedimentation tank is considered divided into four zones

1. **Inlet Zone** - in which momentum is dissipated and flow is established in a uniform forward direction.

2. **Settling Zone** - where quiescent settling is assumed to occur as the water flows towards the outlet.

3. **Outlet Zone** - in which the flow converges upwards to the decanting weirs or launders.

4. **Sludge Zone** - where settled material collects and is moved towards sludge hoppers for withdrawal. It is assumed that once a particle reaches the sludge zone it is effectively removed from the flow.

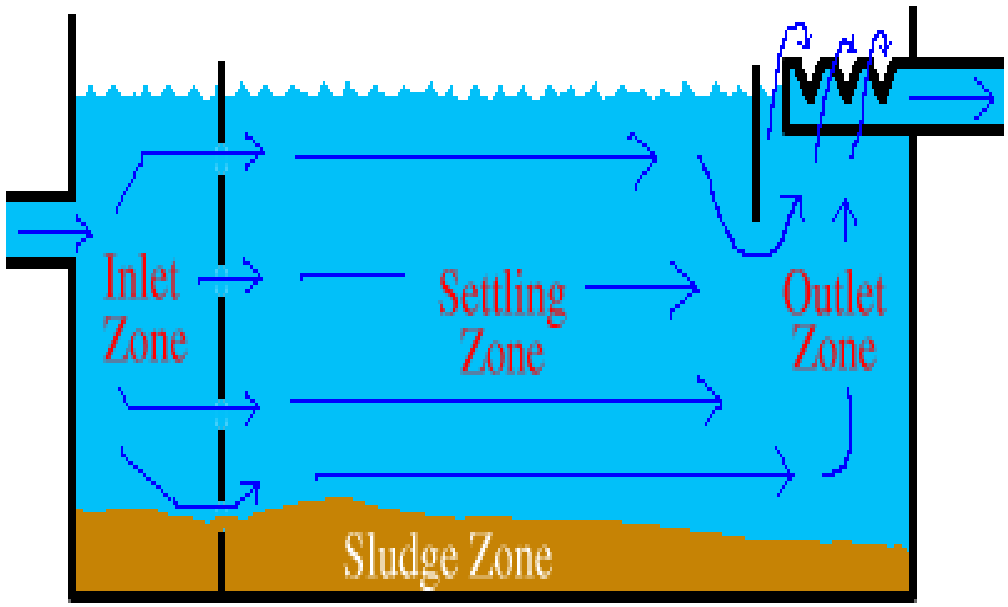


Figure 0-3: Zones of Sedimentation Tank

5.5 Types of Primary Sedimentation Tanks

5.5.5 **Rectangular Tank**

These are most commonly used for primary sedimentation, since they

1. Occupy less space than circular tanks.
2. They can be economically built side-by-side with common walls.
3. The maximum forward velocity to avoid the risk of scouring settled sludge is 10 to 15 mm/s (06 to 09m/min or 2 to 3 ft/ min), indicating that the ratio of length to width l/w should referrals be about.
4. The maximum weir loading rate, to limit the influence of draw-down currents, is preferably about 300 m^3/d-m, this figure is sometimes increased where the design flow is greater than 3 ADWF.

5. Inlets should be baffled to dissipate the momentum of the incoming flow and to assist in establishing uniform forward flow.
6. Sludge is removed by scraping it into collecting hoppers at the inlet end of the tank.
7. Some removal is essential in primary sedimentation tanks because of the grease and other floating matter which is present in wastewater. The sludge serapes can return along the length of the tank on the water surface. As they move towards the outlet end of the bank, the flights then move the sum towards a skimmer located just upstream of the effluent weirs.

5.5.6 **Circular Radial Flow Tanks**

These are also used for primary sedimentation.

1. Careful design of the inlet stilling well is needed to active a stable radial flow pattern without causing excessive turbulence in the vicinity of the central sludge hopper.
2. The weir length around the perimeter of the tank is usually sufficient to give a satisfactory weir loading rate at maximum flow, but at low flows, very low flow depths may result.
3. To overcome the sensitivity of these tanks to slight errors in weir level and wind effects, it is common to provide v-match weirs.
4. Sludge removal is effected by means of a rotary sludge scrapper who moves the sludge into a central hopper, from which it is withdrawn.
5. Scum removal is carried out by surface skimming board attached to the sludge scrapper mechanism and positioned so that scum is moved towards a collecting hopper at the surface.

5.5.7 **Up Flow Tanks**

These are also used for primary sedimentation.

1. Up flow tanks, usually square in plan and with deep hopper bottoms, are common in small treatment plants.
2. Their main advantage is that sludge removal is carried out entirely by activity and no mechanical parts are required for cleaning them.
3. The steeply sloping sides usually to horizontal concentrate the sludge at the bottom of the hopper.

4. Weir loading rate is a problem only at low flows. So that v-match weirs are desirable.
5. The required up flow pattern is maintained by weir troughs.
6. True up flow tanks have an disadvantage on that hydraulic over loading may have more serious effects than in horizontal flow tanks.
7. Any practical with a velocity lower than VP = Q/A will not be removed in an up flow tank, but will escape in the effluent.

5.5.8 **Horizontal Flow Tanks**

In a horizontal flow tank assuming that such particles were uniformly distributed to the flow, particle with Vp=Q/A still be removed in proportion.

1. Purpose/Advantages:

a. Removal of 40 - 60 % of suspended solids.
b. Removal of 25 - 35 % of B.O.D.
c. Sediment the organic and inorganic matters to improve the properties of the sewage and prepare it for the biological treatment.
d. Reduction in the amount of waste activated sludge (WAS) in the activated-sludge plant.
e. Removal of floating materials (oil and grease).
f. Partial equalization of flow rates and organic load.

2. Factors affecting sedimentation efficiency:

a. Viscosity
b. Concentration of suspended solids
c. Retention period
d. Horizontal velocity
e. Temperature
f. Surface loading rate = 24 - 48 $m^3/m^2/day$
g. Dimension of tan
h. Dead zones

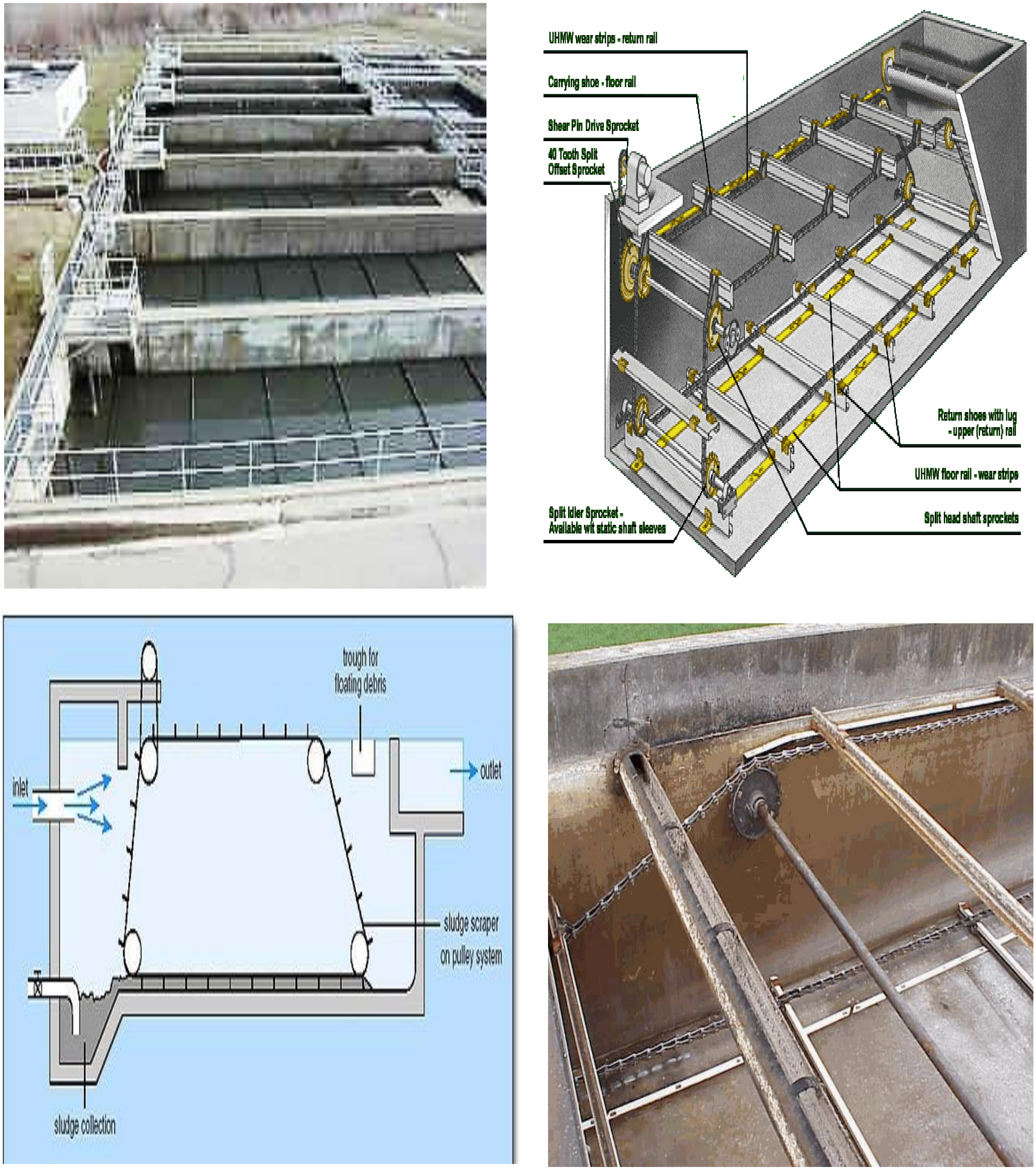


Figure 0-4: Primary Sedimentation Tank

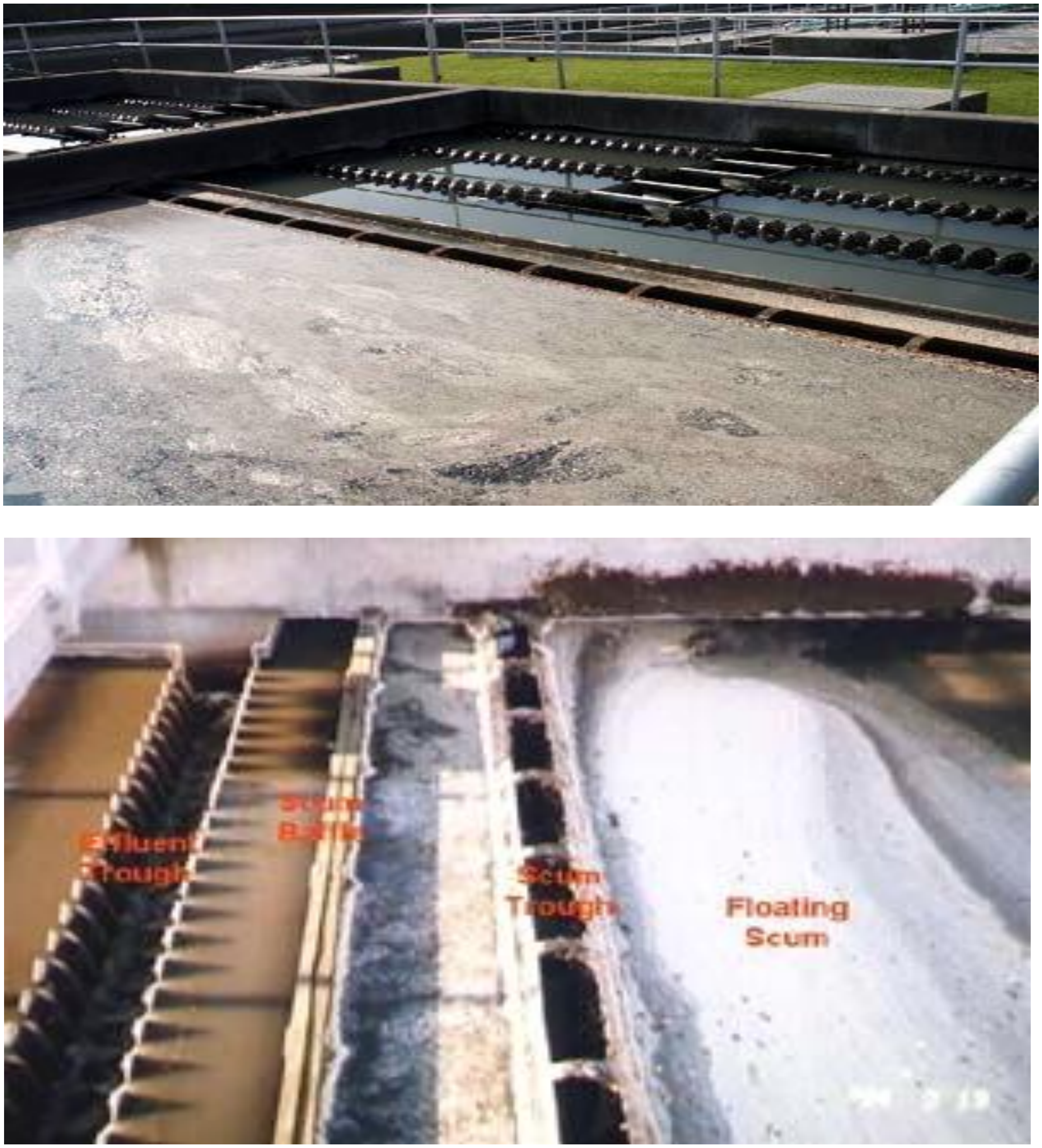


Figure 0-5: Effluent weir of rectangular sedimentation tank[2]

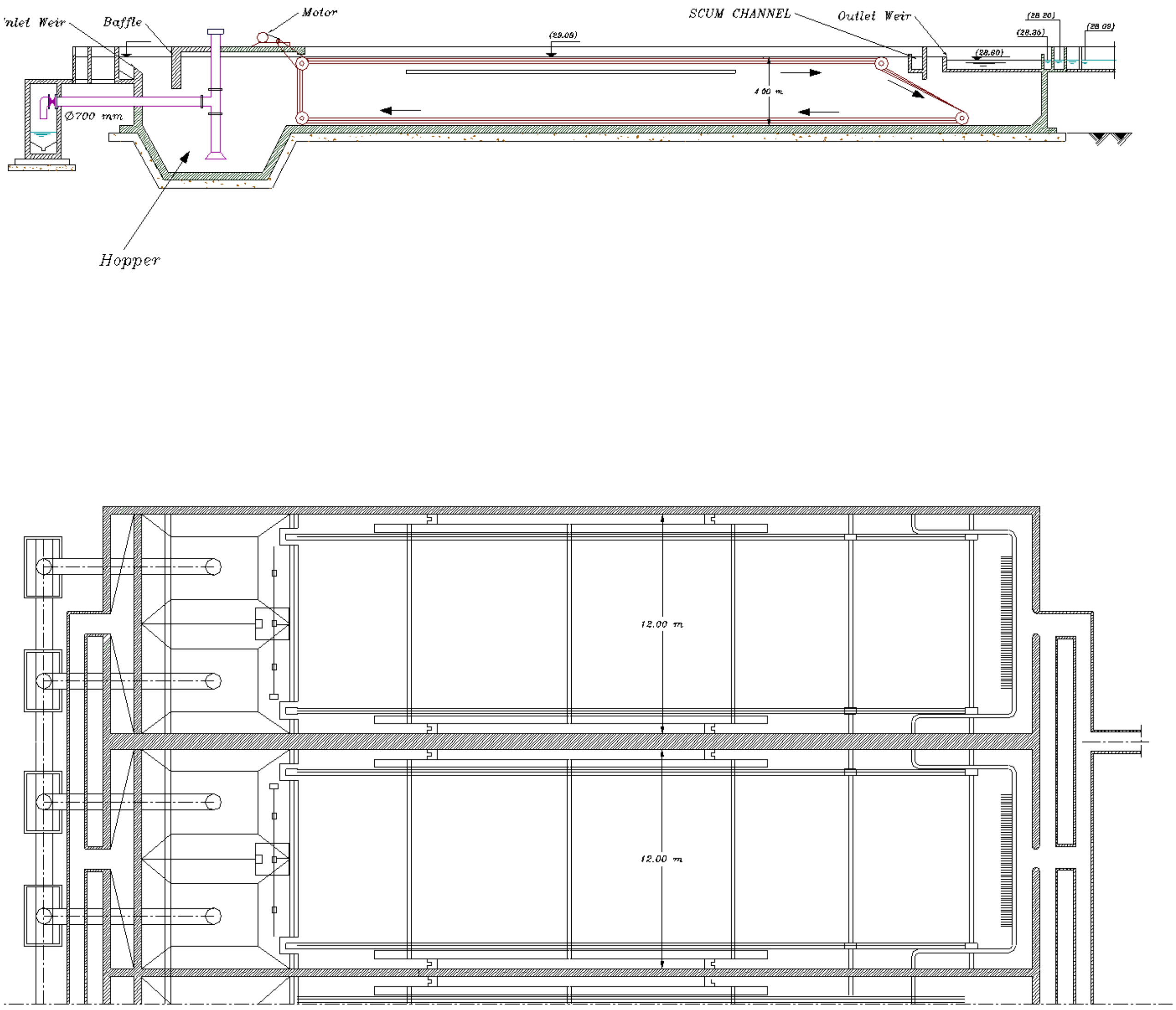


Figure 0-6: Rectangular primary sedimentation tank[12]

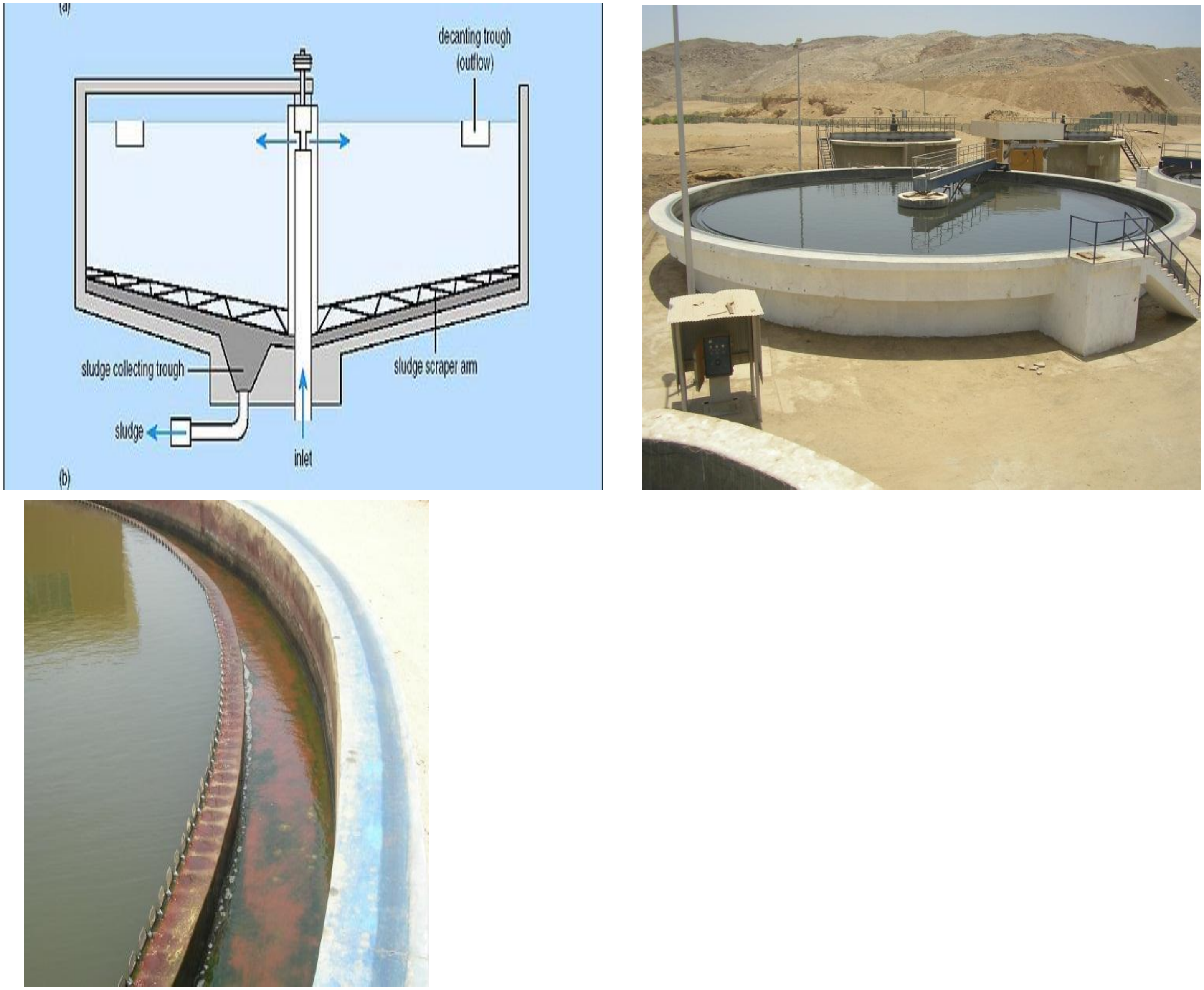
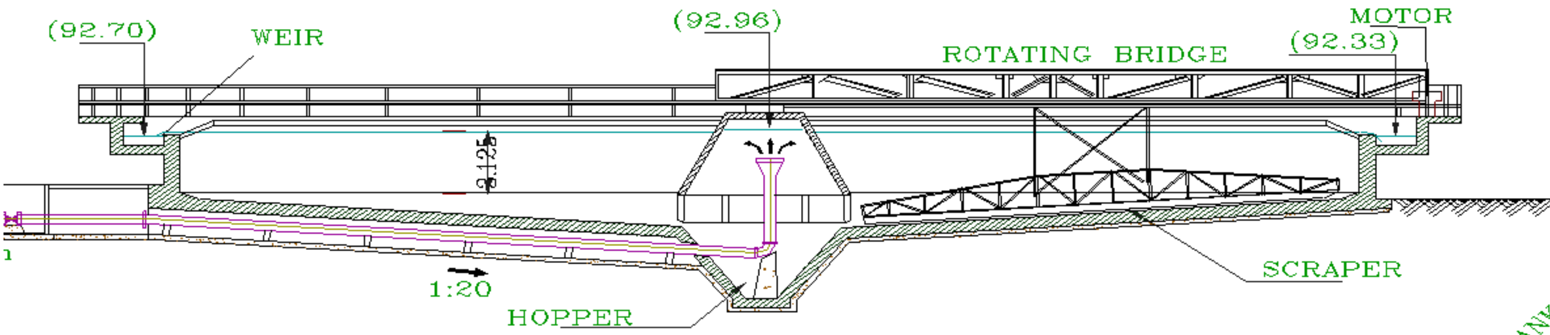
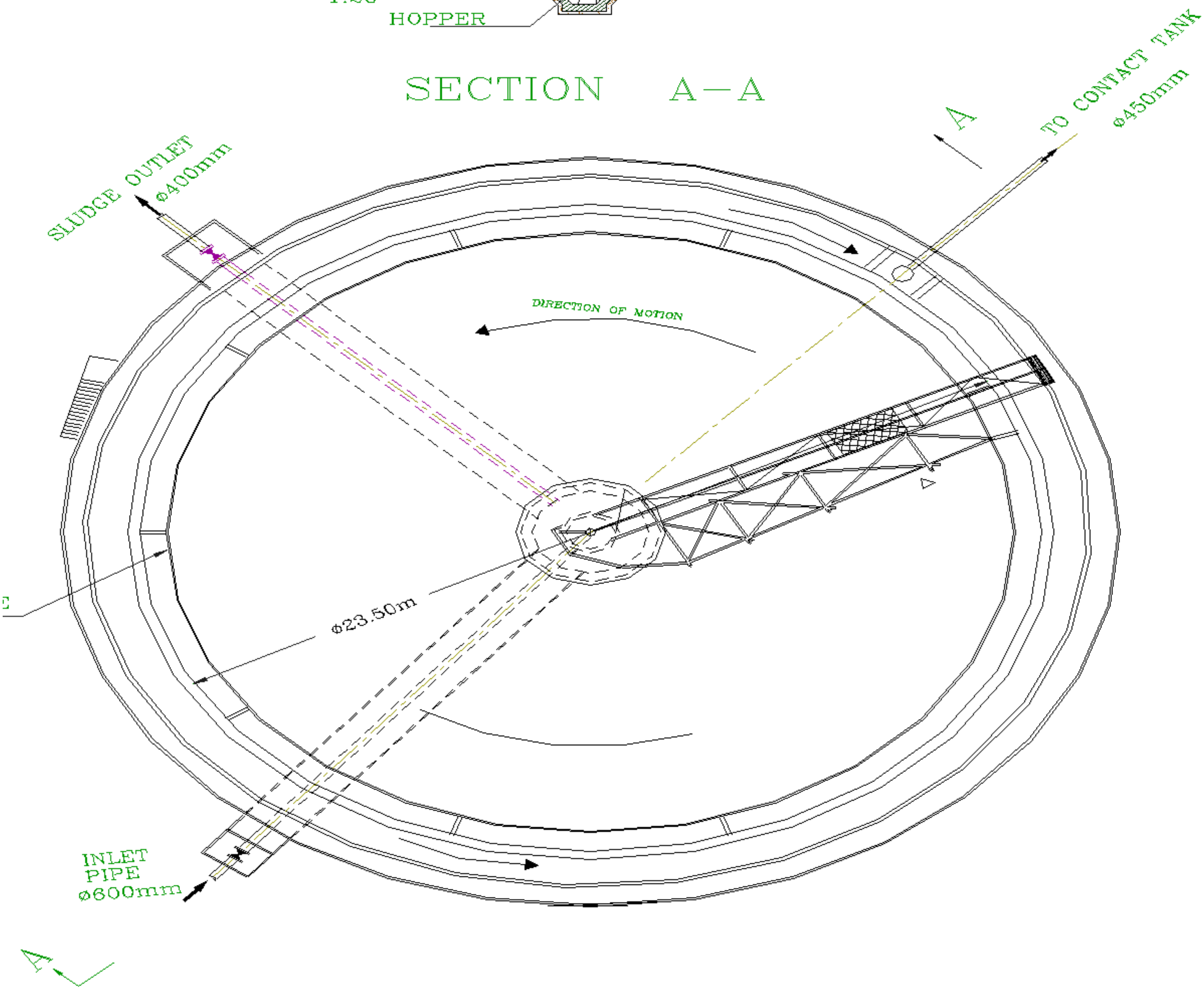


Figure 0-7: Primary sedimentation tank



SECTION A–A



PLAN

5.6 Summary

This chapter encompasses the layout of sedimentation tanks. Different zones of sedimentation are explained along with the settling behaviors in sedimentation tanks. The types of sedimentation along with design perimeters of settling tanks are also elaborated.

Chapter 6

Design of Sedimentation Tanks

6.1 Design criteria:

1. Retention period = T = 3-4 hrs

2- Surface loading rate (S.L.R.) = 24 - 48 $m^3/m^2/day$

3- Horizontal velocity ≤ 0.3 m/min

4- Effluent weir loading (E.W.L.) ≤ 600 $m^3/m/day$ (≤ 25 $m^3/m/hr$)

5- L = 3 – 5 B

L ≤ 40 m

6- d = 3 - 5 m (Additional 15-20% for freeboard, sludge storage)

7- B = 2 – 3 d

8- Φ ≤ 40 m

9- Bottom slope for circular tank = 4 - 10 %

for rectangular tank = 1 - 2 %

10- V = Qd x T

11- S.L.R = Qd / S.A

12- Estimate average and peak hourly flow rate, Qavg and Qpk(Qpk=2.5-2.75qavg)

13- Maximum area is selected A. = Q /SLR

14- Scrapper movement: 0 .02 -0 .0 5rpm

15- Sludge removal frequency = 4 -6hrs

16- BOD /TSS removal is 20-30 % and 60 - 70 %, respectively

17- Rectangular tank:

$$V = Q_d \times T$$

$$S.L.R = \frac{Q_d}{S.A}$$

$Check:$

$$1 - v_h = \frac{Q_d}{n \times \pi \times \phi \times d}$$

$$\prec 0.3\, m/\min \; safe$$

$$2 - E.W.L = \frac{Q_d}{n \times \pi \times \phi}$$

$$\prec 600 \; safe$$

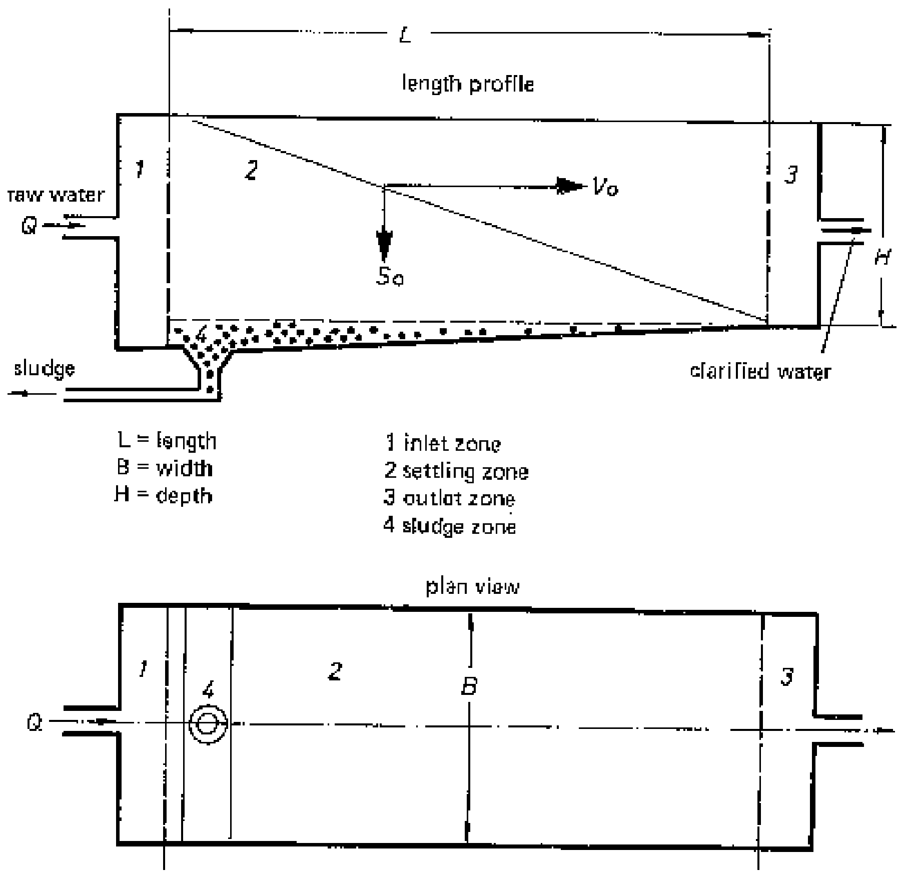


Figure 6.1: Plan and Cross Section of Sedimentation Tank[12]

6.2 Design-1(Training Area)

Dimensions

1. Raw Water Quantity = 35910 ft^3 /day = 269217 gallons/day
   = 1223885lit/day
2. Detention period = 3 hours
3. Assumed Depth = 6 ft (1.8m)
4. L/B Ratio = 3
5. Volume of Tank = 152985.7 Lit (Flow x Detention period)
   = 152.98 m^3
6. Surface Area = 900 ft^2 = 83.63 m^2(Volume/Depth)
7. B = Square Root (900/3) =17.32ft = 5.3m (Sfc Area/Ratio)
8. L = 3 x 17.32 =52 ft = 15.8 m
9. Over flow rate = 1223885/83.63
   = 14634.52lit/day/ m^2<40000 OK

Volume of concrete

1. Assume Thickness of slab = 10 inch = 0.8 ft
2. Assume percentage of steel = 2
3. Volume of Concrete = ((3x17.3x6)+(2x52x6)+(17.3x52))x0.8
   = 1468 ft^3 = 41.60 m^3
4. Amount of Steel = 7.85 x 41.6x2/100 = 6.85 Tons
   (7.85xVolume of concrete x percentage of steel)

6.3 Design-2(MT Area)

Dimensions

1. Raw Water Quantity = 8125.92 ft^3 /day = 60786.1 gallons/day
   = 276339.2 lit/day
2. Detention period = 3 hours = 0.125 day
3. Assumed Depth = 6 ft (1.8m)
4. L/B Ratio = 3
5. Volume of Tank = 3454208 Lit (Flow x Detention period)
   = 34.54 m^3
6. Surface Area = 203 ft^2 = 18.883 m^2(Volume/Depth)

7. B = Square Root (203/3) =8.2ft = 2.5m (Sfc Area/Ratio)
8. L = 3 x 8.2 =24.6 ft = 7.5 m
9. Over flow rate = 276339.2/18.883

= 14634.15lit/day/ m^2<40000 OK

<u>Volume of concrete</u>

1. Assume Thickness of slab = 10 inch = 0.8 ft
2. Assume percentage of steel = 3.5
3. Volume of Concrete =((3x8.2x24.7)+(2x24.7x6)+(8.2x24.7))x0.8
   = 539.6 ft^3 = 15.3 m^3
4. Amount of Steel = 7.85 x 15.3x3.5/100 = 4.2 Tons
   (7.85xVolume of concrete x percentage of steel)

6.4 Summary

This chapter includes the design criteria for sedimentation tanks. Than the sedimentation tanks are designed for training area and military transport washing area. The design includes the dimensions of sedimentation tanks and the amount of steel and concrete required. In light of above calculations the cost estimation can also be done with ease.

Chapter 7

ANALYSIS AND RECOMMENDATIONS

7.1 Analysis

1. Tests show higher value of conductivity which shows presence of more salts than the desired. But it has little or no significance on environment so it can be neglected.
2. The sample values of Turbidity are well within the range that indicates no hazard from turbidity in secondary and tertiary treatments.
3. The laboratory tests indicate water temperature is well within the range which has no harmful effect on aquatic life.
4. The relatively higher value of phosphates in waste water from training area indicates the use of detergents for washing and bathing purposes. And low value in MT area indicates limited usage of detergents.
5. No harmful effects from nitrites as the value of nitrates is within limits which prevents formation of nitrites.
6. Since TDS has only organoleptic consequence. And our samples have TDS within limits.
7. The presence of high COD in training area is due to detergents and even higher value in washing area is due to presence of lubricants along with small quantity of detergents. This will cause detrimental effects to aquatic life leading to problems of septic conditions.
8. Biochemical oxygen demand of the waste water produced is 80-150 mg/lit which is a fair value. As the BOD value is within limits, so no further treatment is required otherwise it should be adequately treated before disposing off.
9. pH values govern the behavior of several other important parameters of water quality. Ammonia toxicity, chlorine disinfection efficiency, and metal solubility are all influenced by pH. Our Values are within range so no such effects are likely to occur.
10. In polluted waters in which the dissolved oxygen i.e. zero, sulphate is very readily reduced to sulphide causing noxious odours. Waters containing sulphates in excess will also attack the fabric of concrete sewer pipes. The samples sulphate content is within the range so no such harmful effects will occur
11. Suspended solids measurements are most relevant as they are good indicators of both the pollution potential of an effluent and the performance efficiency of treatment plant. The samples indicate values within range which will not cause pollution and other harmful effects
12. The Sedimentation Tanks are the most effective in terms of its treatment efficiency and cost.
13. The design procedure of Sedimentation Tanks is comparatively easy.
14. Sedimentation Tanks can effectively remove microbial pollution up to 90%.
15. Lesser operating skills are required for the Sedimentation Tanks.

16. The Sedimentation Tanks are the most viable solutions for the developing countries, like Pakistan.
17. We are lacking in two aspects, RESEARCH and AWARENESS in the field of environmental studies.

7.2 Recommendations

1. Since all the parameters are within control except COD and conductivity so construction of primary sedimentation tank would be a suitable and economic option
2. The water should be used for agricultural purposes after primary treatment as the parameters are well within the range . However the harmful effects of waste water reuse should be kept in mind
3. Awareness and Capacity building program should be arranged for the community to understand environmental concerns of waste water.
4. The up gradation of PHE (Public Health Lab) Lab is an essential element.
5. The present study should be re-conducted in depth for secondary and tertiary treatment
6. Use of alum for treating the higher values of COD. Alum is also an economical solution to reduce COD especially in MT area
7. Use of coagulants FeCl(3) or Fe(SO(4))(3) between 50 mg per Lit to the water in order to reduce COD
8. Increasing the detention would also help in improving the quality of waste water

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Appendix-A Results

S/No	Parameter	Unit	NEQ Standards	Sample1 (Training Area)	Sample2 (MT Park)
1	pH	-	6-10	7.2	8
2	Electric Conductivity	mS/cm	-	1.50	2.5
3	Turbidity	NTU	300	110	62
4	Temp	C	40	20	20
5	Chloride	mg/L	1000	510	350
6	Sulphate	mg/L	600	180	460
7	Phosphates	mg/L	5	4.5	1.5
8	Nitrates	mg/L	20	2.5	1.5
9	Total Dissolved Solids(TDS)	mg/L	3500	834	1260
10	Total Suspended Solids(TSS)	mg/L	500	100	160
11	Total Volatile Solids(TVS)	mg/L	100	40	45
12	COD	mg/L	600	680	1200
13	BOD	mg/L	250	125	80

Appendix-B Important Definitions

1. For the purpose of this project the following definitions apply.
2. Activated sludge. A flocculent microbial mass, usually chocolate brown in color, produced by the aeration of wastewater. A long aeration time in contact with this sludge effectively oxidizes wastewater.
3. Aerobic action. A biological process promoted by the action of bacteria in the presence of dissolved oxygen.
4. Anaerobic action . A biological process promoted by the action of bacteria in the absence of dissolved oxygen.
5. Baffle .Construction that minimizes the discharge of floating matter.
6. Bio filter (also known as biological, rotating or trickling filters) A durable bed of aggregate or discs made of suitable inert material on which bacteria and other organisms flourish. The bacteria on the surface of this material oxidizes the organic matter in the effluent applied to the filter.
7. Biochemical oxygen demand (BOD). A measure of the oxygen demanding substances in wastewater. It is expressed as the number of milligrams of oxygen required by micro-organisms to oxidise the organics in a litre of water over a period of time. It is expressed as mg/L.
8. Dosing device. A device that receives effluent from a settling tank or a septic tank and from which this effluent is automatically discharged to the filter distribution pipes in intermittent doses.
9. Effluent. The liquid discharged from a treatment unit. It may be qualified according to type of treatment for example, septic tank effluent, filter effluent or final effluent.
10. Humus tank. A tank through which filter effluent is passed to settle suspended solids, which should be removed from the tank at frequent intervals.
11. Maximum daily flow (MDF). The maximum quantity of wastewater to be treated in any 24 hour period, including any permanent infiltration flow in a sewer during dry weather.
12. Mixed liquor. Mixture of pretreated wastewater and activated sludge undergoing activated sludge treatment in an aeration tank.
13. ‘Polishing’ stage. Treatment stage used to upgrade the standard of effluent discharge. Its purpose is to reduce the residual solids in the effluent and the BOD associated with such solids.
14. Settling tank. A tank through which wastewater is passed to settle solids. The solids should be removed automatically by pump or other device at frequent intervals.
15. Waste water. Any human excrete or domestic waterborne waste, whether untreated or partially treated, but does not include trade waste. The water carrying wastes from residences and other premises.

16. Sludge. The accumulated settled solids deposited from wastewater and forming a semi-liquid mass.
17. Supernatant liquor. The layer of liquid overlying the settled solids after separation.
18. Suspended solids (SS). All particle matter suspended in wastewater or effluent. Expressed in milligrams per litre (mg/L).
19. Trade waste. The wastewater (other than wastewater) that comes from manufacturing, processing, or other commercial or industrial premises.
20. 20/30 standard. An effluent satisfying a standard of BOD not exceeding 20 mg/L and suspended solids not exceeding 30 mg/L