# INDUSTRIAL WASTEWATER TREATMENT AND DESIGN - A CASE STUDY OF SUGAR MILL


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It is to certify that the Research and Development work titled

**INDUSTRIAL WASTEWATER TREATMENT AND DESIGN - A CASE STUDY OF SUGAR MILL**

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# ABBREVIATIONS

| | | |
|---|---|---|
| 1. | EPA | Environmental Protection Agency |
| 2. | Alk | Alkalinity |
| 3. | BOD | Biochemical oxygen demand |
| 4. | COD | Chemical oxygen demand |
| 5. | WHO | World Health Organization |
| 6. | TDS | Total Dissolved Solids |
| 7. | DO | Dissolved Oxygen |
| 8. | NTU | Nephelometric Turbidity Unit |
| 9. | TSS | Total Suspended Solids |
| 10. | mg/l | milligram per liter |
| 11. | ppm | Parts per million |
| 12. | NEQS | National Environmental Quality Standards |
| 13. | SIWW | Sugar Industry Wastewater |
| 16. | ppt | Precipitates |
| 17. | WWT | Wastewater Treatment |

# ABSTRACT

Sugar is commonly used in our daily life as an important ingredient to our food. When the sugar is being produced, large volume of wastewater is generated because of sugar processing and cane crushing. This wastewater has various parameters which defines its suitability or unsuitability of discharging it into the river. These parameters include COD, BOD, pH, organic compounds, color, TDS etc. Discharging of wastewater without prior treatment will have harmful effects for plants, animals & human being. This forms the basis for having a treatment unit in the industries for the treatment of wastewater.

The treatment of wastewater includes Physio-Chemical & Biological treatment in order to bring the above-mentioned parameters within the permissible limits of NEQS. Wastewater must go through a physical treatment e.g., Screening; followed by chemical & Biological treatment. This study focuses on designing a treatment unit that takes sugar mill wastewater and then makes it dischargeable to nearest water channel. It will include the explanation of basic concepts and parameters involved in the treatment unit. This study also aims at providing a ready reckoner for those who wish to design a treatment unit. From the past papers it was found that treatment options were discussed but the basic designing of treatment unit was not provided. Moreover, detail about the treatment unit installed in sugar mills is not kept public. Here, we have tried our best to provide a complete guideline of designing a treatment unit and this is preceded with all the basic concepts involved in it.

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# CHAPTER NO: 1
# INTRODUCTION

## 1.1 GENERAL

Advent of modern technologies is ushering rapid growth in industry. Domestic and economic lives of people and governments, respectively, rely largely on industries of all types. Notwithstanding the utility this phenomenon has a cost. Environment and eco system are fast depreciating due to adverse effects of industry. With increasing demand and reliance on synthetic and industrial products natural resource is becoming scarce while adding to environmental pollution. The byproducts of industrial utility include chemically harmful and biologically contaminated waste and toxic smoke. As a result, the air is getting polluted and so is water. Humans are at stake and so are animals, plants, and aquatic life. We as inhabitant of earth are slowly and gradually depreciating the overall environment for our generations to suffer. Every year, 1 billion tons of waste is produced in the south Asia, and it is increasing by 10% per year, while emission of $CO_2$ from our houses and vehicles is increasing, as is our consumption of polluting energy. Therefore, the preservation of environment is one of the major challenges that world is facing today than ever before.

Water is abundant and vital resource of planet. It is an essential for the survival of life. Seas and oceans possess more than 70% of the earth's surface and produce nearly 75% of the oxygen that we breathe. It is important to all types of lives and makes 40-95% of plants by weight and about 65-70% of human bodies (Allan, 1995). It is made of two elements namely hydrogen and oxygen, both being vital to life in all its forms. It is present in human, animal, and plants/crops. It carries out all the biological functions in lives stated above. Even though water is covering 70% of earth, clean drinking water remains scarce. Only 1% of the available water is directly being used by humans, and many human activities have considerable pressure on this resource. Water, in all its forms, can be contaminated or polluted by various sources. The illegal disposal of wastewater contributes towards bad quality of water. Most of the water bodies are being contaminated in developing countries due to effluents discharged from various industries. It has also been reported that total number of industries which are registered in the Pakistan are 6630 out of them 1220 are highly polluting industries. These are old records which have presumably been increased many folds by now, although, Pakistan Bureau of Statistics does not show as much of industry growth. An approximated 15-20% increase in registered and non-registered industrialization and associated contamination of water is expected. Industries and factories are major contributor in water pollution in Pakistan due to high degree of organic and toxic ingredients in their productions. A very meager number of industries are treating their waste and many of the industries dispose off their wastewater directly into the nearby nullahs, Rivers or fields. For example, in Khyber Pakhtunkhwa, river Kabul receives over 80,000 cubic meters of industrial waste daily and contributes vastly to polluting the atmosphere.

Modern research show that if the impurities in water increase beyond a safe limit, as set by WHO and other National Standards, water is said to be contaminated and consumption of such water has harmful effects on human body and growth of all forms of life. The industrial waste either flows out into Rivers/Seas and used for agriculture and domestic use including drinking or percolates down through soil to become part of ground water, which is again consumed by population for various purposes. Hence all such effluents are essential to be removed through Chemical and Biological treatments. The Physio-Chemical characteristics of a water body not only reflect the type and diversity of aquatic life but also the water quality and related pollution (Birley and Lock, 1999).

## 1.2 PROBLEM STATEMENT

In Pakistan, environment and ecological system is fast depreciating due to adverse effects of industry. With increasing demand and reliance on synthetic and industrial products, environmental pollution, specifically water pollution, is increasing at a rapid pace. As a result of rapid industrialization, the water is getting polluted and so is air. Humans are at stake and so are animals, plants, and aquatic life. Additionally, there is a growing demand and shortage of quality water to meet population surge. Notwithstanding the fact that industry is essential to national growth and economy, there is a pressing need to harness the flawed design and treatment procedures of rendering industrial waste, specifically waste produced by Sugar Mills.

### 1.2.1 ENVIRONMENT PROBLEMS

Since present procedures and designs to ensure treated effluents are flawed and inadequate resulting in depreciating of environment. Environment is being polluted due toxicity of effluents being waived into water bodies or open lands, which are causing degradation. Foul smell and torn aesthetics are also caused by effluents being left into open or into water bodies (Kulkarni, 1979). The foul odor is a result of decomposition of waste material and this polluted water is eventually being used by population in one form or other.

### 1.2.2 HEALTH PROBLEMS

Wastewater essentially contains bacteria and parasites, which are forms of pathogenic microorganism. These pathogens have the tendency to cause harm to all forms of biological life. Human parasites particularly are of special importance, in this regard, as they prove to be most harmful. These need to be eradicated by treatment or else they cause many diseases.

Untreated waters used in agriculture cause diseases, specially, when the agricultural products are used by humans or consumed by soil. Recently, many deadly diseases found their root causes in polluted water used in agriculture.

## 1.3 LITERATURE GAP

To our knowledge, majority of previous research on similar topic have given vast analysis but guideline for designing of wastewater treatment unit including the calculation was missing. This study intends enabling us to design an effective treatment unit from which every sugar mill can seek help and can use it for designing a wastewater treatment.

## 1.4 OBJECTIVES

Primary objectives of this study include the following:

- To study the wastewater characteristics of Sugar Mills.
- To design wastewater treatment unit based on the data analyzed from previous researches.

## 1.5 SCOPE

Keeping in view the base of this study we shall analyze effluent of sugar mill and basing on results obtained we shall suggest design and procedural recommendations for efficacy of existing treatment settings. The wastewater samples were collected from outlet of main drain of Sugar Mill, as well as, from the inner drains. The Physio-Chemical properties like pH, alkalinity, BOD, COD, TSS, TS, TDS, Phosphates and Nitrates were studied.

# CHAPTER NO: 2
# LITERATURE REVIEW

## 2.1 OVERVIEW OF SUGAR MILL IN PAKISTAN

Sugar Cane production in 2019-20 on plantation areas of over 1.0 Mn hectares stayed at 67 mln tons. The region in 2019-20 came around about 5.6 % nonetheless, with no huge change in production.

*Table 2.1 Sugarcane crop Area & Production*

| **Sugarcane crop area and Production 2019-20** | | | |
|---|---|---|---|
| | **Area** | **Production** | **Yield** |
| Punjab | 643,430 | 43,346,580 | 67.37 |
| Sindh | 286,090 | 17,233,832 | 60.24 |
| KP | 19,359 | 5,753,957 | 52.62 |
| Total | 1,038,879 | 66,334,369 | 63.85 |

**Source: CRD-PG**

Since end of year 2017-18 there has been persistent expansion in sugar costs which can be ascribed to the accompanying reasons:

1. Rupee depreciation
2. Increase sales tax from 8 % to 17%
3. Significant expansion in sugarcane costs
4. Increase in discount rate from 7% to 13.5%

*Table 2.2 Area Production of Sugarcane Crop for last five Years*

| **Area Production of Sugarcane crop for the last five years** | | | | |
|---|---|---|---|---|
| | **Area (hectares)** | **Production (Tonnes)** | **Yield (Tonnes / hectare)** | **Sucrose Recovery** |
| 2015-16 | 1,131 | 65,451 | 57.88 | 10.16 |
| 2016-17 | 1,217 | 75,450 | 62.00 | 09.87 |
| 2017-18 | 1,341 | 83,289 | 62.11 | 10.02 |
| 2018-19 | 1,101 | 67,129 | 60.97 | 10.47 |
| 2019-20 | 1,039 | 66,334 | 63.85 | 09.90 |

**Source: PG**

Industry is the second most noteworthy area of nation's economy and contributes around 38% in complete GDP. The primary areas in big business are little to medium scale in producing, mining, quarrying, development, power, and gas dissemination.

Services area is yet any other important area due to the fact of its large contribution in the country's financial system and contributes about sixty one percent of the total GDP. It is by and large containing Wholesale & retail trade, transport & storage, communication, community & social offerings, and private services.

## 2.2 MAJOR ENVIRONMENTAL ISSUES OF INDUSTRIES

### 2.2.1 GLOBAL VIEW.

Countries in different parts of the world have gone through an extensive transition in controlling or influencing the effect of industrial activities on the environment. Initially, efforts have been focused on the formula of legislation together with enforcement. The reaction of businesses used to be generally responsive. As the improvement of guidelines in the field, principally these being attempted via the worldwide business endeavor for normalization (ISO). For environment administration, IS0 14000 pre-requisites are most suitable.

### 2.2.2 NATIONAL VIEW

Demand for environmental solution received momentum in the industrial zone of Pakistan in 1990 and has been consistently increasing. In 1991, the authorities of Pakistan approved the Pakistan country wide conservation strategy. It is the environmental coverage of the country. During the identical period, the government hooked up federal and provincial environmental protection companies underneath the Pakistan environmental protection ordinance, 1983.This got genuine consideration in Pakistan Environmental Protection Council (PEPC). They approved the National Environmental high-quality requirement (NEQS) for industries.

In response, some industrial affiliation such as federation of chamber of commerce and industry and local chamber mounted its environmental sub committees in 1993. By 1995, it became obvious that EPA is dealing with acute issues of capability for implementation of environmental legislation.

# CHAPTER NO: 3
# PARAMETERS OF INDUSTRIAL EFFLUENT

## 3.1 PARAMETERS

The parameter analyzes the number of inorganic particles suspended in water. This shows its value because these substances may be mineral, or microbes that make water look turbid. Tests results declare this water for domestic or agricultural use. It is human instinct to favor clear water. Aesthetically TSS makes water bodies look unpleasant makes its surroundings prone to garbage disposal eventually converting them into sewerage nullahs. These could be eroded fine particle of rocks. This will eventually settle down and raise bed of water body. Rocks pores can get filled and cause microbe living. These can also be microbes i.e., bacteria, viruses etc. that may cause disease like cholera, dysentery, Nausea, kidney failure, diarrhea etc. therefore testing it is very important.

### 3.1.1 CHLORIDES

Mostly water contains small amount of chlorides. Settlement of marine sediments can cause increase in the number of existing chlorides due to pollution from sea water, salt water, industrial or domestic waste. Chloride within limits is not harmful to people however, animals and plants can get affected. In regions where salt water and wastewater are released, chloride assurance gives magnificent front view for regularity purposes. The measure of chloride in the water used to inundate crops is by and large affected by the general salinity of $H_2O$. The agent that produces salts present in $H_2O$ are sodium chloride and calcium chloride. This smell and taste are because of chloride ion and related ion in $H_2O$.

### 3.1.2 THE pH VALUE

We need pH test to check the acidity and alkalinity of water. These are measures of positive hydrogen ion and negative hydroxyl ion that are in concentration. The pH chart list 7 as neutral. Less than 7, acidity increases till one as the most acidic in nature like Hcl and $H_2SO_4$ etc. Similarly, basic or alkaline behavior increases from 8 till 14.

a. **pH 6.5:** 90% of the chlorine will be hypochlorous acid.

b. **pH 7.5:** 50% of the chlorine will be hypochlorous acid.

c. **pH 8.5:** 20% of the chlorine will be hypochlorous acid.

Around night water will in general get acidic due to ingest carbon dioxide in water to make carbonic corrosive because of oceanic plants. Acidic or fundamental sort of water is overpowering to life. No plant, fish or microorganisms can endure when it passes as far as possible. Wellsprings of such debasements are enterprises like cleanser makers, material units, leather tanning and Rubber producers. It gives severe taste and awful smell.

### 3.1.3 TOTAL DISSOLVED SOLIDS

As visible from name TDS counts for total soluble material that exists in solution. They may include salts and other minerals, in fact anything other than pure water. We determined hardness of water through presence of cations. These cations are part of salts like sulfates and carbonate of Calcium and magnesium etc.

### 3.1.4 BIOCHEMICAL OXYGEN DEMAND (BOD)

It is the demand of dissolved oxygen required for microbial colonies to decompose organic matter in wastewater. Industrial effluent may contain proteins, carbohydrates, and fats etc. These substances are readily biodegradable through the actions of natural microbial populations. Some of the organic matter is oxidized to carbon dioxide and water while the rest is assimilated and used for synthesis of new microbial cells. In due course, these organisms will also die and become food for other decomposers. Eventually all the organic carbon will be oxidized (Lamb,1985).

### 3.1.5 CHEMICAL OXYGEN DEMAND (COD)

It is a quick and effective way of decomposition of organic matter by oxidizing agent like potassium permanganate. Unlike BOD it is an effective process in which results can be obtained in hours rather than days. As it includes chemistry therefore, we can adjust things as per our desired results but that comes on a cost of economy.

Potassium dichromate and potassium iodide are utilized subsequently for deciding COD. From these agent, potassium dichromate ($K_2Cr_2O_7$) is the best for example it is generally simple to get, efficient to decontaminate and can intently finish oxidizing larger part of organic matter.

### 3.1.6 TEMPERATURE

Temperature is a physical parameter in determining the effluent characteristics but largely effects other parameters of effluent. Wastewater temperature is usually higher than that of clean water ($H_2O$) for domestic use. It is important to measure temperature because mostly treatment unit of wastewater include biological lives which are dependent on it. The wastewater temperature changes depending upon weather conditions and climate of the region. Temperature will vary from -14 to 25 degree Celsius in cold places, while temperature will vary from 12 to 45 degree Celsius in warmer regions (Ron and George, 1998). Bio-chemical reactions of aquatic life are dependent upon temperature.

### 3.1.7 PHOSPHATES

According to perry *et al*, (2007) phosphorus may cause aquatic biological productivity to increase, resulting in low dissolved oxygen in lakes, rivers and marine waters. Other than adding to nutrient-content of the water, option of certain kinds of phosphorus will build BOD and COD (Mahdieh and Amir hossein, 2009). Normally phosphorous never exist in pure structure and accessible as phosphates. Phosphorous is a key development component for of animals and plants. Phosphorus in its pure structure it exists in white color. Enterprises utilize white phosphorous to make different synthetic substances and when the military uses it as ammo. Phosphates are utilized in uncommon glasses, in steel make, in military applications like exceptional ammo for example distraction and incendiary bombs and so on, and in different applications like toothpaste, detergents, fireworks and pesticides. Phosphates enter streams from creature and human waste, clothing cleaning, fertilizer spillover and significantly mechanical effluents. These phosphates become hazardous when they are in abundance in oceanic plants. Effluents have more phosphorous mixtures. Creatures utilize phosphorous as a nutrient for their development. This occurs in wastewater and regular clean water bound to oxygen to shape phosphates. Phosphates are named organic Phosphates, orthophosphates, and polyphosphates separately.

### 3.1.8 NITRATES

The most oxidizing nitrogenous compounds are commonly present in the surface and ground water because it is the byproduct of aerobic decomposition. The EPA (1995) states that "Forman environmental perspective, nitrate is the most basic type of nitrogen. Its solubility, mobility and stability means that it readily infiltrates to groundwater."

# CHAPTER NO 4
# EXPERIMENTAL PROCEDURE

## 2.3 STUDY AREA

Versatile data was required on sugar mill wastewater parameters for designing of treatment unit to be used as guidelines across Pakistan. The effort was to collect data from sugar mills located at different climatic zones in the country. We came across a research by Mr. Aijaz Panhwar who is a member of Pakistan Council of Scientific and Industrial Research. He collected samples from different sugar mills across the country, experimented on them and obtained parameters for 10 x samples.

## 4.2 METHODOLOGY OF CONDUCT

We have analyzed data from research of Mr. Aijaz Panhwar and used average value of the experimental results of all samples for designing of treatment unit. The design steps and guidelines may be used as reference and on-ground parameters value may be used for designing for a particular mill. This chapter includes all experimental procedures required to obtain different parameter values used in designing of wastewater treatment unit.

## 4.3 SAMPLING

Sampling refers to the collection of representative wastewater from a region to determine its quality and characteristics. Wastewater samples can be collected from treatment units, landfills, and contaminated rivers or soils. Sampling holds significance importance in wastewater analysis. Samples to be collected wisely for analysis to ensure that the most representative model is obtained. To minimize the impact of the drainage system, sampling should be as close as possible to the emission source. The sample container should be filled slowly to avoid air bubbles. In general, the shortest possible time should elapse between the collection of samples and the execution of the analysis. Depending on the nature of the test, special precautions may also be required when handling samples to avoid natural disturbances, such as loss or increase of organic growth or dissolved gases. Sewage samples are taken in glass bottles or plastic bottles, washed in advance with vim or rinsed with tap water several times, immersed in HCl (concentrated) and finally rinsed with distilled water, and then the bottle is dried. Different sampling procedures are used for different types of water, and all necessary precautions have been taken. To obtain accurate results, the samples must be analyzed on the same day.

## 4.4 GENERAL CONSIDERATION

Modern wastewater mainly has various pollution profiles. Given the conditions, there is a lot of interest in the variety, transition and proficiency of the assigned test. Samples should be collected and stored to protect against contamination, taking into account the location, type, frequency and duration of on-site sampling. Knowledge of each process to ensure that all samples collected reflect real-world conditions. It is important to process sampling, taking into account factors such as the impact of production or property changes, daily and seasonal variations, sample size for specific analyses, additional preservatives required, and sampling and allowable residence times.

Samples should be collected and stored in completely clean 1.5-liter plastic containers, washed with distilled water prior to use and then sealed. Before taking the final sample, the bottles were washed with significant sample. Samples be placed in the refrigerator, kept below 4 °C, and transferred to the lab for analysis.

## 4.5 TYPES OF SAMPLES

The type of sample taken will depend on the type of drainage, quality of drainage, required accuracy and availability of resources required to run the sampling and analysis program.

The type of the sample to be collected is determined by various factors such as:

1. The objective of the study, including the variables of interest and the accuracy and precision needed.
2. The characteristics of the system being analyzed and nonpoint inputs and homogeneity of the system.
3. The resources available such as manpower, time, equipment and the materials etc.

Three main types are:

i. Grab samples
ii. Composite sample
iii. Integrated samples

### 4.5.1 GRAB SAMPLE

Grab samples were taken for analysis from the following selected localities of mill:

1. **Mill Water.** Mill Water is coming from crushing plant of the Mill. It is that water which has been used in removing mud and clay attached to sugar cane also carrying oil and grease. It is usually sprinkled over the sugar cane in crushing plant.

2. **Injection Water.** Injection water is used for cooling of boilers and after two or three cycles when it becomes dirty and hot, is discharged to the main drain of Mill. During circulation through boilers in pipes, it gets polluted due to leaching and corrosion of pipes.
3. **Feed Water.** Feed water is mixture of distilled water in combination with various chemicals like NaCl and NaOH etc., used for purification purpose. All the drains carrying these three types of water, combined together in a single drain leading to the nearby canal.

Figure 4.1: Feed water sprinkling in Mill

Figure 4.2: Injecting water for cooling in atmosphere

Figure 4.3: Mill water discharging from Mill

Figure 4.4: Combine (Feed+Mill+Injecting) water discharging from Mill

## 4.5.2 COMPOSITE SAMPLE

Sample formed by mixing single samples taken at regular intervals or at a constant rate is called composite samples. The number of individual samples of a compound depends on impurity concentrations and flux changes. Sustained adhesion is defined as a series of generic samples, placed in separate containers and collected over a long period of time. Six methods are used to modify the sample. The choice of type of combination depends on the program and the relative strengths and weaknesses of each type of combination.

## 4.5.3 INTEGRATED SAMPLES

An integrated sample may be a composite over depth of a system rather than time. The grab sample collected at various points and at different depths across the width may be mixed in proportion to relative flows at these points. The results of the analysis will provide average values. In such cases, grab samples should be analyzed separately rather than integrating them.

## 4.6 SELECTION OF SAMPLING LOCATION

The following consideration should be taken into account while selecting location for sampling:

1. At locations upstream and downstream of sugar mill, having significant discharges into a flowing stream.
2. At most representative points such as before entering tank 1 and after entering into exit drain.
3. Required information was obtained from various exit points.
4. Keeping in view the intensity of flow and temperature, sampling location may vary.

## 4.7 METHOD OF SAMPLING

Samples can be taken manually or automatically. Sampling success or failure is directly related to sample handling.

### 4.7.1 MANUAL SAMPLING

Manual sampling has minimal upfront costs. Manual sampling software is useful for small-scale sampling, but it is expensive and time-consuming for both routine and large-scale sampling applications.

## 4.8 VOLUME OF SAMPLE

Analysis to be performed using sufficient volume of sample, with volumes available to meet quality control, sample delivery, or review requirements. The required sample size will depend on the analysis performed, but the volume required for a complete logical analysis is usually around 2 liters. Sampling laboratories should be used for special quantitation requirements. Each portion of the mixed sample should be at least 200 mL to minimize differences in sample solids. The total sample of the mixed sample should be at least 2 liters depending on the sampling frequency and sample size.

## 4.9 HANDLING AND PRESERVATION OF SAMPLES

After collection, immediate analysis be performed and samples stored in containers with preservatives to maintain sample integrity. Complete sample storage and sanitation of industrial waste or general water is impossible. Absolute consistency of all parts cannot be achieved regardless of the sample type. At best, preservation techniques can only be used to prevent chemical and biological changes in samples removed from their original source. Correct container selection, container purification, and storage time are important parts of a sample storage program to avoid sample errors.

The storage time, storage time, and material belonging to the sample depend on the parameters analyzed. In general, the shorter the time between sampling and analysis, the more reliable the analysis results. We cannot say exactly how long it will take from collection to analysis. It depends on the nature of the sample, the specific analysis performed and the storage conditions.

## 4.10 METHODS OF PRESERVATION

The purpose of preservation is limited to:

1. Slow down biological processes.
2. Inhibit chemical reactions and hydrolysis.
3. Make constituents less volatile.
4. Preservation methods includes chemical addition, pH control, refrigeration and freezing. Sometimes a combination of above method may be necessary.

### 4.10.1 CHEMICAL ADDITION

The best storage method is chemical preservation that can be added to the sample vials prior to sampling. When the sample is added, the preservative is immediately dispersed, providing a long-term stabilization of the preservation. If the added preservative is measured by other parameters, additional samples should be taken for those parameters. For example, concentrated nitric acid added to preserve certain minerals may affect BOD, requiring additional samples to be taken for BOD.

### 4.10.2 THE pH CONTROL

PH control for storage depends on adding chemicals. For example, to keep the metal ions in the transition phase, lower the pH to less than 2 by adding concentrated nitric acid.

### 4.10.3 FREEZING

Freezing has been the subject of numerous conservation studies. Some believe that cryopreservation is a way to extend retention time and collect single samples for full analysis. However, the remaining solid components of the sample (filtered and crude) change during freezing and thawing. Therefore, it is necessary to return to equilibrium before performing the analysis and then perform subsequent homogenization at high speed.

### 4.10.4 REFRIGERATION

Cooling or freezing has also been studied and various results have been obtained. This is a commonly used method in field investigations and has no effect on sample composition. This does not preserve the integrity of all parameters but does not affect the method of analysis.

## 4.11 EXPERIMENTS PERFORMED

### 4.11.1 COLOUR

General condition of wastewater can be assessed using its color. Light gray wastewater has a lifespan of less than 6 hours, but light brown to medium brown wastewater degrades to some extent or remains in the collection system for some time. Finally, dark brown or black wastewater is wastewater that typically degrades markedly by bacteria under anaerobic conditions. This happens when Hydrogen sulfide produced under anaerobic conditions combines with a divalent metal such as iron.

### 4.11.2 ODOUR

In the food industry, anaerobic decomposition of organic matter causes unpleasant odor in wastewater due to gases. The most common odor is hydrogen sulfide, and the characteristic odor is the smell of rotten eggs. Sulfur is required for protein synthesis and is released during hydrolysis. Under anaerobic conditions, sulfates are biologically reduced to sulfides and can combine with hydrogen sulfide ($H_2S$). This gas is easily soluble in water, colorless, flammable, but toxic. Most common gas produced by the anaerobic decomposition of organic matter is Hydrogen Sulphide, but other volatile compounds such as indoles, skatoles, and mercaptans can cause greater odors than H2S when characterized by a foul odor. In addition, dissolved organic matter in the atmosphere and carbon dioxide from the decomposition of nitrogen also cause odors. Odor control is becoming increasingly important in the planning and operation of wastewater collection, treatment and treatment systems. Odor is a major concern for people in the wastewater treatment process. Often, the psychological stress caused by smell outweighs the harm to human health.

### 4.11.3 TEMPERATURE

Temperature is especially important in aquatic and semi-aquatic environments, due to the effect of certain chemical and biological rays. The temperature of the untreated wastewater was observed to be 40 °C and the temperature of the purified wastewater was observed to be 30 °C. The outlet temperature should not exceed 35 °C. The higher the temperature, the softer the bitumen compound and the discoloration of the holes in the pipe itself. High temperatures accelerate the chemical reaction of oxygen.

### 4.11.4 pH

The pH value is the negative logarithm of the hydrogen ion concentration. The range was 0 to 14, 7 neutral, less than 7 acidic, and 7 or more basic or alkaline. The detailed history of wastewater pH can influence the biological dynamics and survival of various microorganisms. The presence or absence of certain ions can be directly related to the pH of the wastewater. This wastewater can affect soil quality.

### 4.11.5 DISSOLVED OXYGEN

It is one of the most important criteria for evaluating water quality. Dissolved oxygen is an indicator of the physical and biological processes of water. Aquatic ecosystems are completely dependent on dissolved oxygen. Many biochemical changes and their effects on microbial metabolic activity are well documented. The atmospheric solubility of oxygen in fresh water is about 7.0 mg/L at 35 °C and 14.6 mg/L at 0 °C. Being an incompressible gas, its solubility depends on atmospheric pressure at a particular temperature.

### 4.11.6 TOTAL SOLIDS

The term solid refers to a purified or permeable substance that remains as a residue at a certain temperature after combustion, evaporation and subsequent drying. Total solids, total soluble solids and total suspended solids in wastewater mainly contain contaminant solid particles like bicarbonate, chloride, sulfate, nitrate, calcium, magnesium, sodium, potassium, manganese, sludge, organic matter, etc.

### 4.11.7 TOTAL SUSPENDED SOLIDS

Intensity of light in water is dependent on total suspended solids and they cause affect turbidity and transparency of wastewater. Whether it is suspended solids or total dissolved solids, different industries have different amounts of solid particles.

### 4.11.8 TOTAL DISSOLVED SOLIDS

The total solids concentration in the waste effluent represents the colloidal form and dissolution spectrum. It can be the sum of the fluctuations or values of subsequent solids; the value of dissolved solids is due to regular collisions of colliding particles. The collision rate of the aggregate mixture is also affected by the pH of these effluents. In the rainy season, because the residual sewage is diluted by rainwater, the total dissolved solids concentration obtained is lower.

### 4.11.9 CHLORIDES

Chlorides are common in natural water. The presence of chlorides in natural waters is due to the discharge of wastewater from oil well/ tanks in the chemical industry, contamination from flooding and the dissolution of salt deposits from river water.

### 4.11.10 BIOCHEMICAL OXYGEN DEMAND (BOD)

It is the amount of oxygen that microorganisms require to stabilize decomposable biological organic matter under aerobic waste conditions. Biological oxygen demand indicates the degree of pollution in water by oxidizable organic matter and amount of oxygen required to oxidize inorganic materials (such as sulfides and ferrous ions). In natural sources, oxidizable substances enter the biogeochemical cycle.

### 4.11.11 CHEMICAL OXYGEN DEMAND (COD)

The COD test uses a strong chemical oxidizing agent to determine the oxygen required for the chemical oxidation of organic substances. COD is a test used to measure the contamination of household and industrial waste. Waste is measured by the quality of oxygen needed to oxidize organic matter to produce carbon dioxide and water. The combination of BOD and COD studies helps to determine toxic conditions and biological tolerance.

### 4.11.12 SULPHATE

Sulfate is a polyatomic ion that exists in natural water and has been used in different industries. Wastewater from certain industries may also be an important source of sulfate for receiving water. Sulfur itself has never been a limiting factor in aquatic systems. The normal sulfate level is sufficient to meet the needs of plants; when the organic waste in the water is overloaded to the degree of deoxygenation, the odor conditions are easily increased. Therefore, $SO_4$ is often used as an electron acceptor for the decomposition of organic matter, producing $H_2S$ and odor.

### 4.11.13 OIL AND GREASE

Oil and concentrated fat (OG) concentrations are important parameters for water quality and safety. Oils and fats, along with other impurities, are among the most complex impurities to be removed. Determining the concentration of oil or fat in a wastewater does not determine the presence of a particular substance, but rather a group of substances that can be removed from a particular wastewater sample. Oils, fats and waxes are dissolved in a suitable solvent and separated from the aqueous phase. After that, the solvent layer evaporates and the residue is weighed into fats and oils.

## 4.12 PARAMETERS FOR EXPERIMENT

*Table 4.2: Water quality parameters analyzed and technique used*

| PARAMETRES | TECHNIQUE |
|---|---|
| COD | Open Reflux |
| pH | pH meter |

| | |
|---|---|
| BOD | Dilution method |
| TSS | Gravimetric meter |
| TDS | Gravimetric meter |
| Arsenic and Chromium | electrochemical reactor (EC). |
| Chemical Coagulation | Jar Test |

## 4.13 EXPERIMENTAL METHODS

### 4.13.1 ANALYTICAL PROCEDURE

All physical and chemical parameters such as COD, color, solids, total soluble solids, total suspended solids, sulfate, chloride, etc. are determined using standard analytical methods. The color of the samples was measured as absorbance using a 420 nm UV spectrophotometer. Residual organic matter in the treated wastewater was analyzed through temperature analysis.

#### 4.13.1.1 EXPERIMENT NO: 1 Determination of "pH

**Apparatus & chemicals:**

1. Stand
2. Beaker and colorimetric paper and water sample
3. Probe pH meter
4. Standard pH solution
5. Buffer tables (pH4, pH7)

**Procedure:**

**Colorimetric Method**

1. Dip the calorimetric paper in water samples.
2. Comparing color of paper against pH of water from table gives the pH

value for sample.

**Electrometric Method**

1. Bring the meter in working condition by pressing 1 key on the pH meter.
2. Calibrate so that is shows 00.00 readings by pressing the pH key and calibrate key.
3. Press 'Standard Key' after dipping probe into standard solution of pH=7. The screen will give reading of 7.
4. Press 'Dispersed Key' after dipping the probe in sample. This will give pH of the sample.
5. Read the value of pH from the screen.

## 4.13.1.2 EXPERIMENT NO: 2 Determination of Biochemical Oxygen Demand

### Apparatus

1. B.O.D bottle
2. Burette
3. Pipit
4. Pipit filter
5. Graduated cylinder
6. Alkali iodide acid
7. Star itch indicator
8. Concentrated $h_2so_4$
9. Manganese sulphate

### Procedure

1. Half fill two B.O.D tubes with distilled water.
2. Use pipit to add 3ml of wastewater to the B.O.D tubes.

3. Completely fill tube with distilled water and fix stopper on it.
4. Place one tube in an incubator for 5 days at 20$^{o}$ C.
5. Now use pipit to add 2ml of Manganese sulfate (MnSo4) for other tubes.
6. Add 2 ml of alkali iodide oxide and shake well (if oxygen is present, the color will be brown otherwise white)
7. Add 2 ml of concentrate H2SO4and shake well, which will give a color, which is in resemblance to mustard oil.
8. Take 200 ml of this solution in a graduated cylinder and add 1 ml of a starch indicator to it which will give a yellowish color.
9. Put the graduated cylinder below the burette containing standard solution of sodium sulfate and note the initial reading.
10. Fill dissolved oxygen by substituting initial reading from final reading.
11. After incubation of the first tube, the dissolved oxygen is found in similar ways.
12. B.O.D can be calculated using:.

**B.O.D (mg/L) = (Zero-day D.O -5 days D.O) X 300/ml of sample**

### 4.13.1.3 EXPERIMENT NO: 3 Determination of suspended solids

#### Apparatus

1. Filter glass, Suction motor and pumps
2. Filter media paper

#### Procedure

1. Take a filter glass of known size and weight and pour 50 ml wastewater sample in it. Let the weight of filter glass be W1.
2. Switch on the water pump.
3. Now weigh filter glass and sample in it. Let it would be W2.
4. Suspended solids can be calculated using below formula.
5. Weight of suspended solids:

{(weight of filter + sample)- (weight of filter) X 100}/W1

$$V = ((W_2 - W_1) \times 100)/W_1$$

## 4.13.1 .4 EXPERIMENT NO:4 Determination of total dissolved solids.

**Apparatus:**

1. Water bath
2. Oven
3. graduate cylinder
4. Analytical balance
5. Evaporation dish
6. Filer
7. Dish tongs
8. Crucible tongs
9. Desiccators
10. Vacuum pump
11. Forceps smooth-tipped

**Procedure:**

1. Use an analytical balance to weigh an empty evaporating dish. Let its weight be W1.
2. Use pipet to transfer unfiltered sample in porcelain dish. Mix sample well and pour into a funnel with filter paper. Filter approximately 80 -100 ml of sample.
3. Regulate the oven to reach 105°C.
4. Place sample in the hot air oven. Avoid splattering of the sample during evaporation or boiling.
5. Dry for long duration, usually 1 to 2 hours to eliminate the necessity of checking for constant mass.
6. Cool the container in a desiccator.

7. Weigh the dish as soon as it has cooled to avoid absorption.
8.

### 4.13.1.5 EXPERIMENT NO: 5 Determination of COD

**Apparatus and Chemicals**

1. COD reactor
2. Potassium dichromate $K_2Cr_2O_7$
3. Silver sulphate $AgSO_4$
4. Sulphuric acid $H_2SO_4$
5. Ferrous indicator
6. Standard ferrous ammonium sulphate Fe $(NH_2)_2(SO_4)_6H_2O$

**Procedure**

1. Take a measured amount of wastewater sample in one tube and distilled water in another tube.
2. Admeasured amount of potassium dichromate (K2Cr2O7) say 1.5ml in both the tubes in the presence of sulfuric acid (H2SO4) and is boiled for 2 hours at 120 OC.
3. Then after cooling it to room temperature the samples are transferred to the conical flask.

### 4.13.1.6 EXPERIMENT NO: 6 Removal of Arsenic and Chromium

**Apparatus:**

1. Electrochemical reactor (EC).
2. Copper electrode
3. DC power source

**Procedure:**

**Electrocoagulation Experiment.**

1. An Electrochemical reactor (EC) is used to perform this experiment. EC is

made of transparent fiber glass having capacity of 1.5 $dm^3$ (10.7×10.7×13.7 cm).

2. Use a copper squared electrode having dimension 7.5 cm x 7.5 cmx 2 mm (effective area 56.25 $cm^2$) in the reactor.
3. Maintain a space of 1–2.5 cm between the two electrodes and 1.5 cm gap at the bottom of the reactor for the movement of magnetic stirrer.
4. Supply a DC power in range of 0–30 (V) and 0–5 (A) current to respective terminals in parallel arrangement.
5. Amount treated at given time can be analyzed and recorded.

### 4.13.1.7 EXPERIMENT NO: 7 Chemical Coagulation Experiment

**Apparatus:**

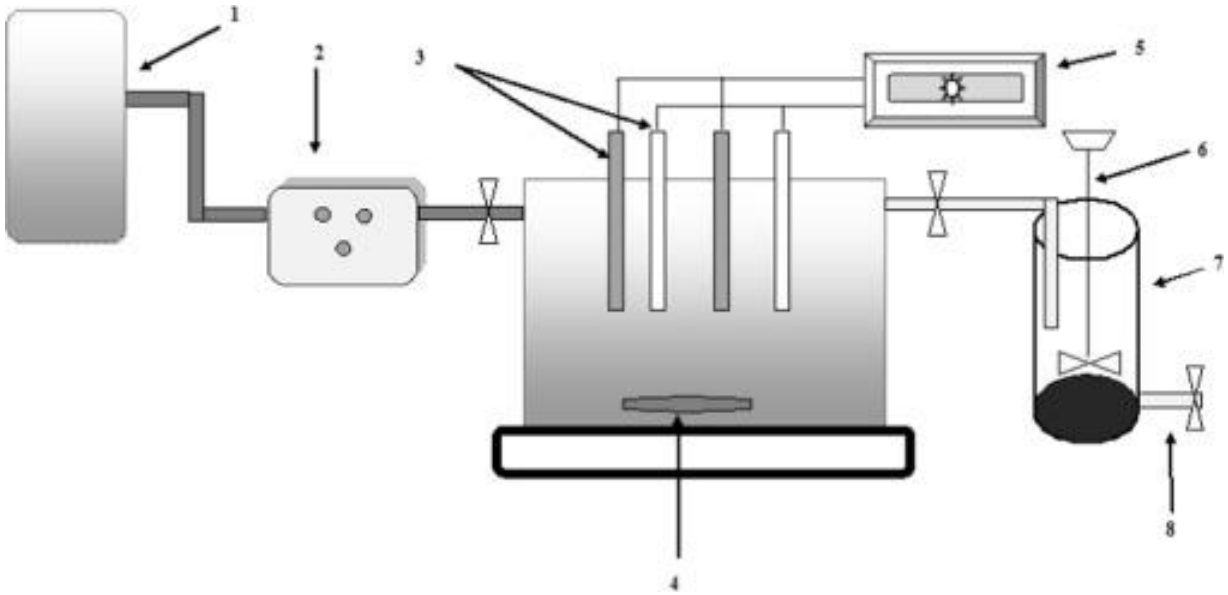
1. Jar Test Apparatus
2. Sample Wastewater
3. Glass beaker

**Procedure:**

1. Jar test apparatus is used for Chemical coagulation process.
2. Take 200 ml of wastewater sample in a 500 ml glass beaker.
3. Note down first pH of the sample and adjust initial pH by adding aqueous sodium hydroxide or sulfuric acid solution.
4. Add a measured weight of the coagulant to the sample, agitate at 110 rpm for 5 min, and thereafter slowly agitate at 60 rpm for 30 min.
5. Let the wastewater sample settle for 6 hours.
6. Collect the clean liquid and analyze for chemical oxygen demand (COD) and color removal.
7. The percentage removal of COD and color can be calculated by below equation. The experimental setup for treatment of sugar industry wastewater is shown in Fig. 4.5.

**Removal % = ((Ci-Cf) x100)/Ci**

Where,




Ci= Initial concentration (mg/l).

Cf= Finial concentration (after treatment; mg/l).

*Fig. 4.5: Experiment setup (1) wastewater sample, (2) pump, (3) electrode, (4) magnetic stirrer, (5) DC supply, (6) agitator, (7) beaker for coagulation, (8) discharge.*

# CHAPTER NO 5
# RESULTS & DISCUSSION

Note: All Sample values are the depiction of trends found in studies of Wastewater treatment in sugar industries of Pakistan.

## 5.1 THE pH OF WASTEWATER.

"pH is the logarithmic value of hydrogen ion concentration in water. It ranges from 0-14. 7 is the neutral value whereas less than 7 is acidic and greater than 7 till 14 would be basic".

*Table 5.1*

| S/No | Sample | Value |
|---|---|---|
| *1.* | W1 | 5.2 |
| *2.* | W2 | 4.1 |
| *3.* | W3 | 8.9 |
| *4.* | W4 | 7.1 |
| *5.* | W5 | 6.9 |
| *6.* | W6 | 6.2 |
| *7.* | W7 | 5.7 |
| *8.* | W8 | 5.9 |
| *9.* | W9 | 7.4 |
| *10.* | W10 | 6.8 |
| **Average Value** | | **6.4** |

## Discussion

- **a.** The average value of pH is below neutral value this means wastewater is acidic.
- **b.** This acidic nature is due to active biomass produced as a result of nitrification during treatment of wastewater.
- **c.** This acidic behavior will affect the biological activity in water bodies and slow down important biological process and kill essential microorganisms.

## 5.2 BOD OF WASTEWATER

"Biochemical oxygen demand is the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic conditions." (Tuser, 2020)

*Table 5.2*

| S/No | Sample | Value(mg/L) |
|---|---|---|
| 1. | W1 | 639 |
| 2. | W2 | 809 |
| 3. | W3 | 2362 |
| 4. | W4 | 1573 |
| 5. | W5 | 2056 |
| 6. | W6 | 1912 |
| 7. | W7 | 810 |
| 8. | W8 | 918 |
| 9. | W9 | 612 |
| 10. | W10 | 907 |
| Average Value | | 1260 mg/L |

## Discussion

**a.** Values of all the samples are above the standard values of even the untreated wastewater (200-600 mg/l). This indicates that either the samples were not treated at all or were treated using improper techniques. (NEQs Standard = 80 mg/l)

**b.** These high values also indicate the poor water quality as more oxygen is being removed from water. This also indicates high organic matter in the form of sugarcane or beet root waste.

## 5.3 COD OF WASTEWATER

"Chemical Oxygen Demand (COD) analysis is a measurement of the oxygen-depletion capacity of a water sample contaminated with organic waste matter. Specifically, it measures the equivalent amount of oxygen required to chemically oxidize organic compounds in water." (Monegotto, 2017)

*Table 5.3*

| S/No | Sample | Value(mg/L) |
|---|---|---|
| *1.* | W1 | 1480 |
| *2.* | W2 | 1207 |
| *3.* | W3 | 3602 |
| *4.* | W4 | 3516 |
| *5.* | W5 | 2800 |
| *6.* | W6 | 1310 |
| *7.* | W7 | 1208 |
| *8.* | W8 | 1629 |

| | | |
|---|---|---|
| *9.* | W9 | 1738 |
| *10.* | W10 | 2216 |

**Average value = 2070 mg/L**

**Discussion**

- **a.** The sample values indicate that all the samples are untreated due to high COD values. **(Range 75-150 mg/L)**
- **b.** High COD values of samples also indicate the presence of oxidizable organic matter.
- **c.** COD test can be used alternatively to BOD test due to less time required for testing.
- **d.** Such high values create anaerobic conditions which are harmful for aquatic life

## 5.4 TSS OF WASTEWATER

” TSS stands for total suspended solids and refers to waterborne particles that exceed 2 microns in size. Any particle that is smaller than 2 microns, on the other hand, is considered a total dissolved solid (TDS). Most total suspended solids comprise of inorganic materials; however, algae and bacteria may also be considered TSS.” (Campbell, 2021)

*Table 5.4*

| S/No | Sample | Value(mg/L) |
|---|---|---|
| *1.* | W1 | 187 |
| *2.* | W2 | 570 |
| *3.* | W3 | 514 |
| *4.* | W4 | 921 |
| *5.* | W5 | 289 |

| | | |
|---|---|---|
| ***6.*** | W6 | 210 |
| ***7.*** | W7 | 306 |
| ***8.*** | W8 | 704 |
| ***9.*** | W9 | 809 |
| ***10.*** | W10 | 706 |

**Average Value = 522 mg/L**

### Discussion

**a.** We can see that a variation exists in the samples in case of TSS. Samples 1,5,6,7 are within the acceptable range of TSS. Other samples exceed the limit of 400 mg/L. (NEQs standard 200-400 mg/L)

**b.** The above trend shows that the sugar mill did not filtered the waste before discharging it into the sewerage line.

**c.** These pollutant materials will mix with solid particles i.e., Clay, metals etc. and will be discharged into mainstream with storms.

## 5.5 TDS IN WASTEWATER

"Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water." (Oram, n.d.)

*Table 5.5*

| S/No | Sample | Value(mg/L) |
|---|---|---|
| ***1.*** | W1 | 1298 |
| ***2.*** | W2 | 1841 |
| ***3.*** | W3 | 3808 |
| ***4.*** | W4 | 1870 |
| ***5.*** | W5 | 2626 |

| | | |
|---|---|---|
| *6.* | W6 | 2011 |
| *7.* | W7 | 1840 |
| *8.* | W8 | 1957 |
| *9.* | W9 | 2002 |
| *10.* | W10 | 3840 |

**Average Value = 2310 mg/L**

### Discussion

- **a.** We see that generally all samples are within range of the required standards **(250-3500 mg/L).**
- **b.** High value of TDS effect the treatment unit operation capability, it can also cause salinity issues if the wastewater is discharged into irrigation water.
- **c.** This high value of TDS can also be attributed to less rainfall in winter season in Pakistan which results in low level of surface runoff and vice versa.

## 5.6 SUMMARY

Sugar industries are contributing towards the economic development of country but the amount of organic discharge produced by these industries is in polluting the water and soil bodies to degree where human, aquatic life and microorganisms are all affected. Results of all the above samples show that all physio-chemical parameters are relatively higher than the permissible standards. Industries claim to treat the effluents but such results clearly show that the industrial waste is discharged without treating them. Hence, there is a dire need to treat these effluents properly.

# CHAPTER NO 6
# DESIGN OF TREATMENT UNIT

## 6.1 DESIGN OF WWT UNITS FOR SUGAR MILL

Treatment unit is a combination of various units having unique function which collectively gives us the desired output. These units are designed based on the design parameters given in Associate Professor Dr Arshad Ali's book **"A TEXTBOOK OF ENVIRONMENTAL ENGINEERING"**. Following units are designed here:

6.1.1 Collection Sump
6.1.2 Pumping station
6.1.3 Screening chamber
6.1.4 Grit Chamber
6.1.5 Skimming Tank
6.1.6 Primary Sedimentation tank
6.1.7 Activated Sludge System (Biological Treatment Unit)
6.1.8 Summary of complete Design

Based on average value of the data, which is consulted for our research, a design is proposed. There can be many possibilities of treatment units that can be installed based on various factors like budget, waste quality, ease of operation, maintenance & monitoring. We have proposed the very basic treatment unit which is easy to operate and gives out the reasonable output. In Pakistan only 1 % of Wastewater receives treatment. Water quality that originates from sugar mills of Pakistan is very poor therefore, a very basic treatment unit or a minimum possible treatment unit is proposed that works efficiently and gives out the optimum result.

The design values which are being considered are as following:

*Table-6.1: Sugar Mill Effluent of Selected Sugar Mills*

| Parameters | W-1 | W-2 | W-3 | W-4 | W-5 | W-6 | W-7 | W-8 | W-9 | W-10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | 5.2 | 4.1 | 8.9 | 7.1 | 6.9 | 6.2 | 5.7 | 5.9 | 7.4 | 6.8 |
| **BOD** | 639 | 809 | 2362 | 1573 | 2056 | 1912 | 810 | 918 | 612 | 907 |
| **COD** | 1480 | 1207 | 3602 | 3516 | 2800 | 1310 | 1208 | 1629 | 1738 | 2216 |
| **TSS** | 187 | 570 | 514 | 921 | 289 | 210 | 306 | 704 | 809 | 706 |
| **TDS** | 1298 | 1841 | 3808 | 1870 | 2626 | 2011 | 1840 | 1957 | 2002 | 3840 |

Source (Aijaz Panhwar, 2019)

We will consider the mean value of these results to design the treatment unit.

Capacity of cane crushing = 4500 Tons (Discharge of waste @ 1 – 0.7 $m^3$ / Ton of cane crushed)

Discharge Rate, $Q_{avg.\ ww}$ = 4500 * 0.7 $m^3$ / Day = 3150 $m^3$ / Day = 0.0365$m^3$ / sec

BOD Concentration = 1260 mg / Lits = 1.26 kg / $m^3$

$Q_{pk}$ = 2.75 * 3150 = 8662.5 $m^3$ / Day = 0.1 $m^3$ / sec {$Q_{avg.\ ww}$ = 2.75 $Q_{pk}$}

### 6.1.1 COLLECTION SUMP

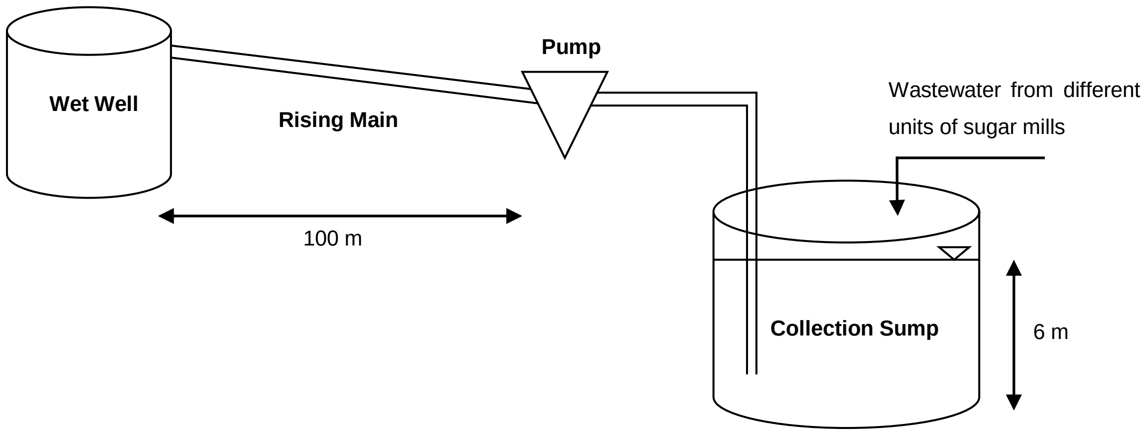
Volume in a single day = 3150 $m^3$ / Day Assuming Depth of sump = 6 m

Area of collection Sump = 315 $m^3$ / 6 m = 525 $m^2$

Diameter of Sump = 25.85 m ≅ **85 ft**

We can either construct one sump of 85 ft diameter or two sump of 42.5 ft diameter with depth of 6m. Wastewater from all different units of sugar mill will first be collected in this collection sump and then it will be sent to screening chamber using a pumping station.

## 6.1.2 PUMPING STATION




**Design of pumping station requires designing of following: -**

- Collection Sump
- Suction Pipe
- Pump
- Rising Main
- Wet Well

## Step 1: Rising Main Diameter Design

Assuming Velocity through Rising Main = 0.75 m / sec

We know that we use Peak Discharge for calculation of Pipe Diameter

$\therefore$ Area of Rising Main $= Q_{pk}$ / Velocity

$= (0.1\ m^3 / sec) / (0.75\ m / sec)$

$= 0.134\ m^2$

As it is a Circular Pipe

$\therefore$ Area $= \pi * D^2 / 4 = 0.134\ m^2$

Diameter = D = 0.413 m

= 1.354 ft = 16.24 in

≅ **18 in** = 0.457 m

So, Volume of Rising main = $(\pi * 0.457^2 / 4) * 100$ m = 16.42 $m^3$

## Step 2: Dimensions of Wet Well

Wet well will be designed for the volume of peak discharge and volume in Rising main

∴ Volume = $(Q_{pk} * t_D)$ + Volume of Rising Main

Assuming, $t_D$ = 25 min

= (0.1 $m^3$ / sec * 1500 sec) + 16.42 $m^3$ = 166.81 $m^3$

Assuming, Wet Well Depth = 4 m

Surface area of Wet Well = 166.81 $m^3$/ 4m = 41.70 $m^2$

Diameter = 7.29 m ≅ **7.5 m**

## Step 3: Diameter of Suction Pipe

Assuming, velocity through suction pipe = 1 m / sec

Surface Area = $Q_{pk}$ / Velocity = 0.1 / 1

= 0.1 $m^2$

Diameter = 0.357 m = 1.17 ft = 14.04 in ≅ **16 in**

## Step 4: Design of Pipe

Power, P $= (\gamma_{ww} * Q * H_T \ / (75\eta_{Pump})$

$= (1000 * 0.1 * 6.0927) / (75 * 0.65)$

$= 12.5\ h_p$

$\cong$ **13 $h_p$**

$\gamma_{ww} =$ 1000 Kg/$m^3$

$\eta_{Pump}$ = 60-65 %

$H_T = H + H_L$

**H = 6 m (Collection Sump)**

Where,

$H_1 = f*L*V^2 / 2gD$

$= 0.01*100* 0.75^2 / 2*9.81* 0.457$

= 0.0627 m

## Step 5: Summary of Design

| SUMMARY | |
|---|---|
| Rising Main Diameter Design | 18 in |
| Dimensions of Wet Well | Diameter x Depth = 7.5 m x 5 m {including Sludge storage & Freeboard} |
| Diameter of Suction Pipe | 16 in |
| Pipe | 13 $h_p$ |

### 6.1.3 SCREENING CHAMBER

Designing of screening chamber requires designing of following:

- Approach Channel
- Bar Size of Screens

## Step 1: Design of Approach Channel

Assuming, Velocity in Channel = V = 0.75 m / sec

Surface Area = A = $Q_{Design}$ / Velocity

= (0.0365 $m^3$ / sec) / 0.75 m / sec

= 0.049 $m^2$

Assuming, W: D:: 1 : 1

So, width = Depth = W = D = 0.221 m = 0.724 ft ≅ 0.75 ft = **0.229 m**

Actual Area = 0.229 * 0.229 = 0.052 $m^2$

**CHECK**

Velocity, $V_a$ = Q / A= 0.0365 / 0.052 = 0.7 m/sec > 0.45 m /sec OK!

## Step 2: Selecting Bar Size of Screen

We will keep, Inclination of bar = 45°

Clear Opening = 40 mm

Square Bar = 20 mm x 20 mm

Clear Opening (n+1) + Width of Bar (n) = Width of Channel

0.04 (n + 1) + 0.02 (n) = 0.229 m So, n = 3.15 ≅ **4**

so, if there are 4 x Bars than, **Clear Opening = 29.8 mm**

Length of Bar , $L_b$ = Depth /sin $\theta$ = 0.229 / sin 45°= **0.324 m**

## Step 3: Effective Cross Section of Channel

Effective Width $W_e$ = W – (n * Single Bar Width) = 0.229 m – (6 * 0.02 m) = 0.109 m

Effective Cross Section $A_e$ = $W_e$ * Depth = 0.109 * 0.229 = 0.025 $m^2$

Velocity through Screens, $V_s$ = 0.0365 / 0.025 = 1.46 m / sec

Head Loss $H_L$ = $0.08 (V_s^2 – V_a^2) = 0.08(1.46^2 – 0.7^2)$

= 0.13 m {< 0.3 m, OK!}

## Step 4: Quantity of Screens Produced

Assuming, Frequency of removing screens = 4 Days

Amount of wastewater flowing in four days = 4 * 3150 $m^3$ / Day

= 12600 $m^3$ = 3.334 MG

Assuming, amount of screens are produced at the rate of 0.05 $m^3$ per million Gallons of wastewater.

∴ = 3.334 * 0.05 = 0.167 $m^3$

### Step 5: Perforated plates

They are installed above the surface of wastewater

Assume, Height = 6 in = **0.152 m**

Length = ($L_b$ / cos$\theta$ + $L_{perforated\text{-}plate}$+ 30-50% addl on both side)

Where,

$L_{perforated\text{-}plate} \leq$ 1.6 Length of bar

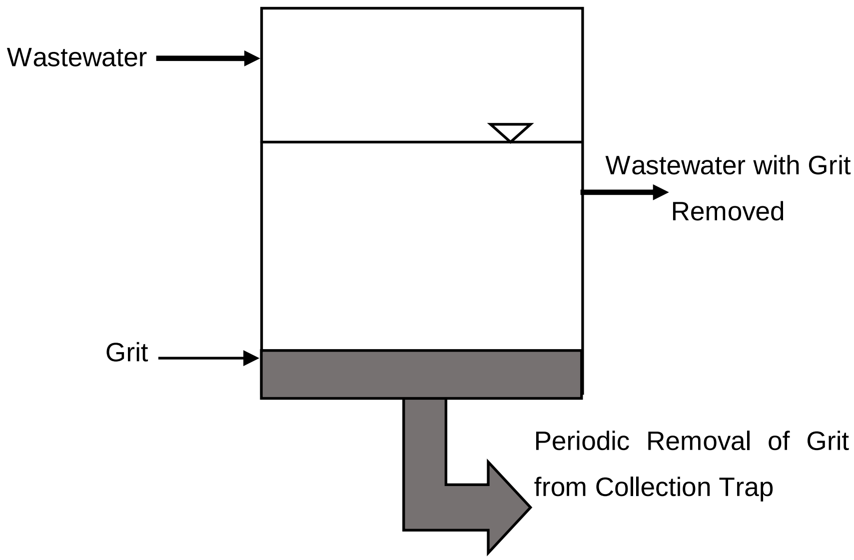
= (0.324 / cos 45° + 1.6 * 0.324 + 2*0.3*0.324) = 1.17 m

≅ **1.5 m**

### STEP 6: Summary

| SUMMARY | |
|---|---|
| Clear Opening | 29.8 mm |
| Inclination of bar | 45° |
| Length of bar, $L_b$ | 0.324 m |
| Amount of screens | 0.167 $m^3$ |
| Bar Size | 20 mm x 20 mm |
| Perforated Plate L * W * H | 1.5m x 0.229m x .152m |

## 6.1.4 AERATED GRIT CHAMBER




## STEP 1: Dimensions

Assuming a detention time, $t_D$ = 5 min

Volume of Basin, V = $Q_{Design} * t_D$ = 2.1875 $m^3$ / min * 5 min = 10.9375 $m^3$

Assuming Depth of Tank = **4 m** (Add 1 m for freeboard at the end)

Surface Area = 10.9375 $m^3$ / 4 m = 2.734 $m^2$

L: W :: 1 : 2

W = 1.17 m ≅ **1.25 m**

L = 2.34 m ≅ **2.25 m**

Actual Area, $A_s$ = 1.25 * 2.25 = 2.8125 $m^2$

Actual Volume = 3.75 $m^2$ * 4 m = 11.25 $m^3$

## STEP 2: Check Surface Loading Rate (SLR)

SLR = $Q_{Design} / A_s$

= 2.1875 $m^3$ / min / 2.8125 $m^2$

= 0.778 $m^3/m^2$.min

= 1120 $m^3/m^2$.Day {1200-1700 OK!}

## STEP 3: Amount of Grit Required

Assuming,

Cleaning Freq = 4 Days & Grit Produced @ 0.04 $m^3$ / ML of Wastewater

Waste Produced = 0.04 (4 days * 3150 $m^3$ /Day * 1000 L * $10^{-6}$)

= 0.504 $m^3$ {1$m^3$ = 1000 L}

## STEP 4: Amount of Air Required

Assuming, @ 0.4 $m^3$ /meter. min

Thus, Air Requirement = 0.4 $m^3$ /meter. min * 5 m = 2 $m^3$ /min

## STEP 5: Summary

| SUMMARY | |
|---|---|
| Dimensions, L * W * D | 2.25 m * 1.25 m * 5 m (Including Freeboard) |
| SLR | 1120 $m^3/m^2$.Day |
| Amount of Grit req | 0.504 $m^3$ |
| Amount of air req | 2 $m^3$ /min |

### 6.1.5 SKIMMING TANK

Assuming Retention Time = 15 min

Vol of Tank = V = $Q_{Design} * t_D$

= $2.1875\ m^3$ / min * 15 min

= $32.8125\ m^3$

Assuming Depth of Tank = 4 m

@ 250 $m^2$ of surface area for 1 $m^3$ / sec of wastewater

$\therefore$For, 0.0365 $m^3$ / sec of wastewater discharge = 250 * 0.0365 = 9.125 $m^2$

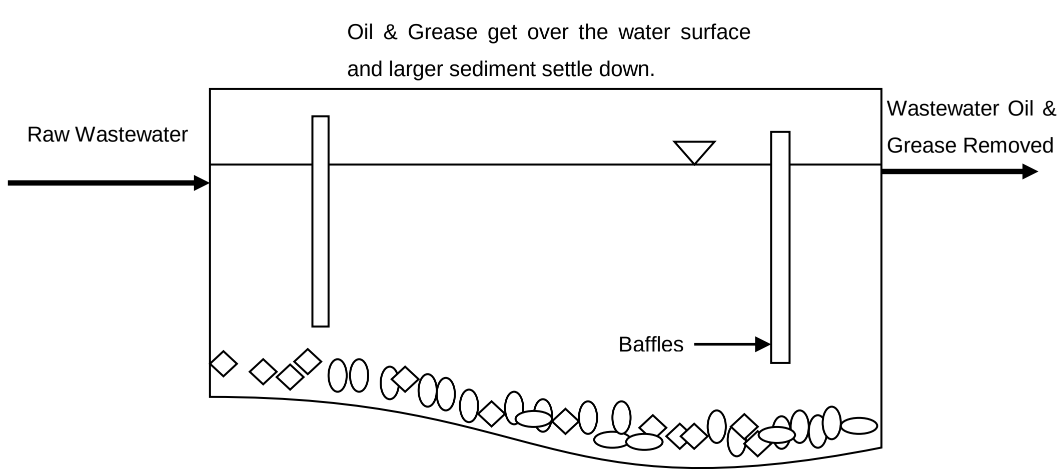
L : W :: 1 : 2,

W = 2.14 m ≅ **2.25 m** L = 4.27 m ≅ **4.5 m**

Actual Area, $A_s$ = 4.5 * 2.25 = 10.125 $m^2$

Depth of Tank = 32.8125 $m^3$ / 10.125 $m^2$= 3.24 m

≅ **3.5 m** {Including Freeboard}



### 6.1.6 PRIMARY SEDIMENTATION TANK (PST)

**Step 1: Selection of surface**

$SOR_{avg}$ = 1.8 $m^3 / m^2 . hr$ (Assumption)

$Q_{avg}$ = 131.25 $m^3 / hr$

Area = $Q_{avg} / SOR_{avg}$ = 131.25 $m^3 / hr$ / 1.8 $m^3 / m^2 . hr$ = 72.917 $m^2$

$SOR_{pk}$ = 4 $m^3 / m^2 . hr$ (Assumption)

$Q_{pk}$ = 360.9375 $m^3 / hr$

Area = $Q_{pk} / SOR_{pk}$ = 360.9375 $m^3 / hr$ / 4 $m^3 / m^2 . hr$

= 90.234 $m^2$ {Greater value of surface area governs}

**Step 2: Dimensions of Circular PST**

A = $\pi * D^2 / 4$ = 90.234 $m^2$

Dia = 10.719 m $\cong$ **11 m**

Vol = $\pi * D^2 / 4$ * Depth = $\pi * 11^2 / 4 * 3$

= 285.1 $m^3$ {Assume, Depth = 3m}

**CHECK $t_D$ & WLR**

$t_D$ = Vol / $Q_{pk}$

= 285.1 $m^3$/ 360.9375 $m^3 / hr$

= 0.790 hr = 47.39 min {20 min- 3 hr}

WLR = $Q_{pk}$ / Peripheral Circumference

= 360.9375 $m^3/hr$ / $\pi * 11\ m$ = 10.44 $m^3/ m. hrs$

= 10.44 * 24 hrs

= 250.67 $m^3$/ m. Day {WLR Range is 125 – 500 $m^3$/ m. Day – OK!}

## Step 3: Percentage Removal of SS & BOD

Corresponding to $SOR_{pk,}$ we have 16 % BOD removed and 33 % SS removed.

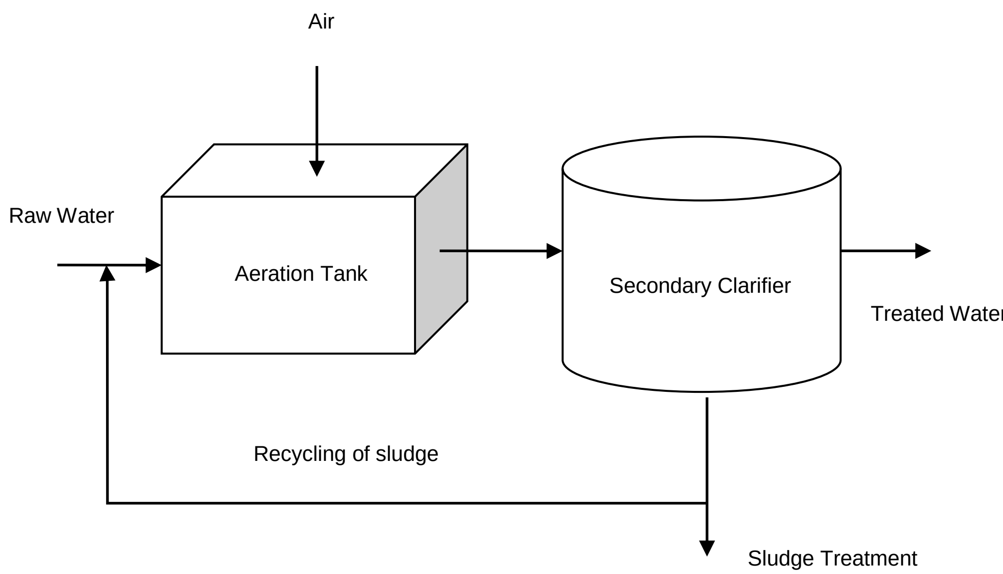
## Step 4: Summary

| SUMMARY | |
|---|---|
| Dia * Depth | 11 m * 4 m {including Sludge storage & Freeboard} |
| $SOR_{avg}$ | 1.8 $m^3$ / $m^2$ . hr |
| $SOR_{pk}$ | 4 $m^3$ / $m^2$ . hr |
| WLR | 250 $m^3$/m . Day |
| BOD Removed | 16 % |
| SS Removed | 33 % |

**16 % of BOD is removed in primary sedimentation tank and the remaining 84 % will be removed in the biological treatment unit.**

### 6.1.7 ACTIVATED SLUDGE SYSTEM (BIOLOGICAL TREATMENT UNIT)

This system has aeration tank and settling tank as shown:




## Step 1: Aeration Tank Dimensions

Assume, $t_D$ = 6 hrs

Vol = Q Design x $t_D$

= 131.25 * 6 = 787.5 $m^3$

Assume, Depth = 4 m

Surface Area = 787.5/ 4 = 196.875 $m^2$

Say, L : W :: 3 : 1 {Rectangular Tank}

∴ Width = 8.1 m ≅ **8 m**

Length = 24.3 m ≅ **25 m**

So, Actual Area = 25 * 8 = 200 $m^2$

Actual Vol = 200 * 4 = 800 $m^3$

**CHECK**

∵ BOD applied per Day = Q * BOD Concentration

= 3150 $m^3$/Day * 1.26 kg / $m^3$

= 3969 Kg-BOD / Day

VLR or OLR = BOD applied per Day / Volume of Basin

= 3969 Kg-BOD / Day / 800 $m^3$

= 4.96 Kg-BOD / $m^3$.Day {0.8 – 3.2 NOT OK!}

So, organic matter applier over a unit surface area of treatment basin exceeds the limit so we will increase the surface area of basin. By trial we have the following dimension of Aeration Tank:

Volume = 31 x 10 x 4 = 1240 $m^3$

{L = 31 m, W = 10 m, Depth = 4 m}

VLR or OLR = 3969 Kg-BOD / Day / 1240 $m^3$

= 3.2 Kg-BOD / $m^3$.Day

{0.8 – 3.2 OK!}

## Step 2: Secondary Sedimentation Tank

Assume,

$SOR_{avg}$ = 25 $m^3$ / $m^2$ . Day Assumption {16 – 32 $m^3$ / $m^2$ . Day}

$Q_{avg}$ = 3150 $m^3$ / Day

Area = $Q_{avg}$ / $SOR_{avg}$

= 3150 $m^3$ / Day / 25 $m^3$ / $m^2$. Day **= 126 $m^2$**

$SOR_{pk}$ = 50 $m^3$ / $m^2$ . Day Assumption {40 – 64 $m^3$ / $m^2$ .Day}

$Q_{pk}$ = 8662.5 $m^3$ / Day

Area $= Q_{pk} / SOR_{pk}$

$= 8662.5\ m^3 / Day / 50\ m^3 / m^2 . Hr$

**= 173.25 m²** {Greater value of surface area governs}

Diameter $= 14.85 \cong 15\ m$ {Circular Tank}

Actual Areal $= \pi * D^2 / 4 = \pi * 15^2 / 4 = 176.7\ m^2$

Actual Vol $= 176.7 * 3 = 530.14\ m^3$ {Assuming, Depth = 3 m}

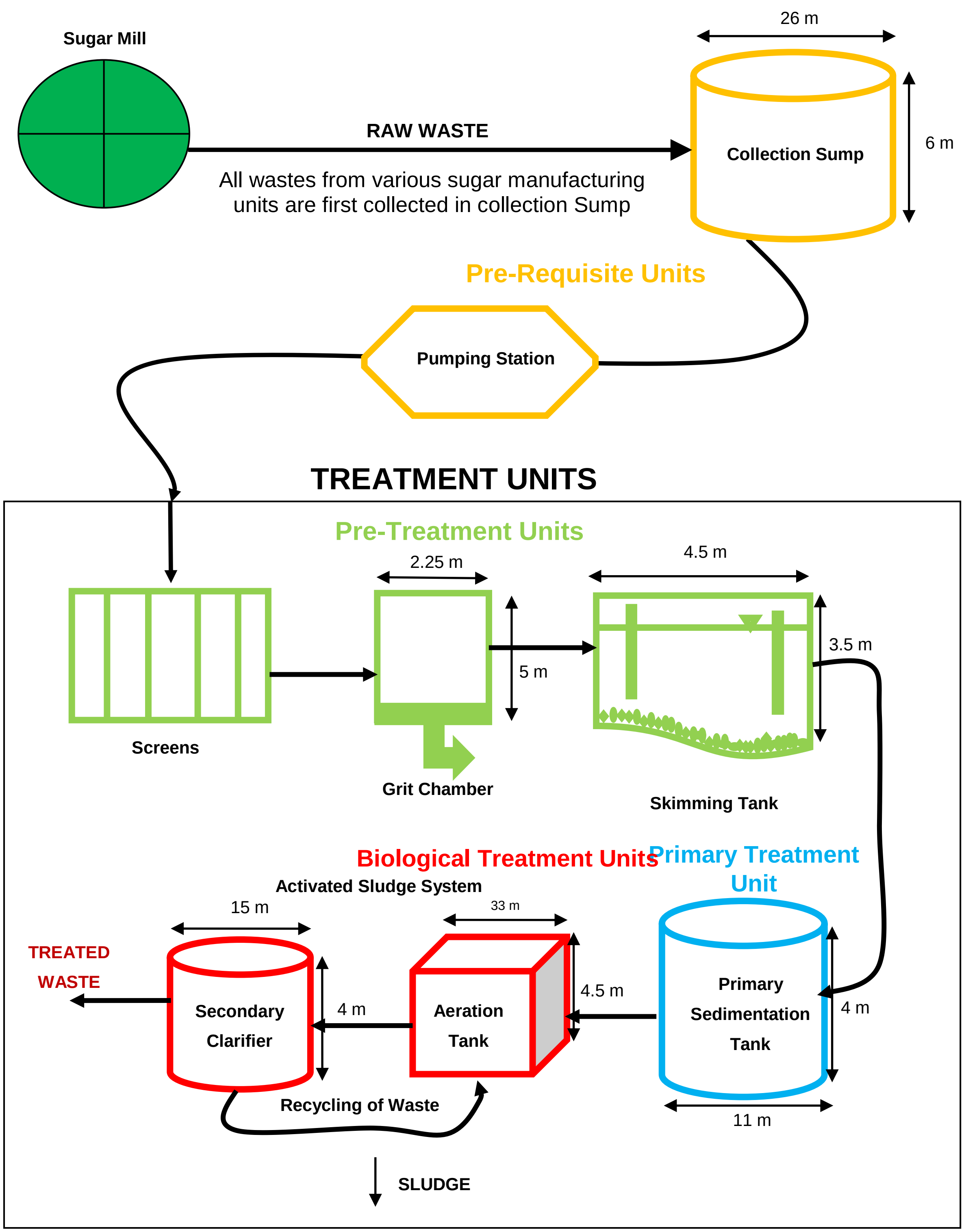
## CHECK

$t_D$ $= Vol / Q_{pk}$ $= 530.14 / 8662.5 = 0.061$ Day

= 88 min {60 – 90 min OK!}

| SUMMARY | |
|---|---|
| Aeration Tank | |
| L x W x D | 31 m x 11 m x 4.5 m {including Sludge storage & Freeboard} |
| VLR | 3.20 Kg-BOD / m$^3$.Day |
| $t_D$ | 6 hrs |
| Secondary Sedimentation Tank | |
| Dia * Depth | 15 m x 4 m {including Sludge storage & Freeboard} |

## 6.1.8 SUMMARY OF COMPLETE DESIGN



# CHAPTER NO 7
# RECOMMENDATIONS & CONCLUSION

## 7.1 CONCLUSIONS

A huge amount of wastewater is produced because of sugar production process adopted in sugar mills. The wastewater from sugar mills under study has shown high values of BOD, COD, TDS, and TSS; the values of these parameters are crossing the limits specified by NEQS. After a minimal or no treatment, the disposal of this wastewater into river water is endangering the aquatic life as well as reducing the fresh water available for drinking. A properly designed, maintained, and monitored treatment unit, if installed, can reduce the harmful effects of wastewater.

This study proposes a design of a treatment unit to reduce the harmful levels of the above-mentioned parameters to within safe limits. The proposed unit is a simple conventional treatment unit whose operation does not need much expertise for its smooth functioning. The calculations for designing different components of the treatment unit were based on obtained values of the parameters from a case study of sugar mill.

## 7.2 RECOMMENDATIONS

The following technical and at the same time environment friendly steps can be made part of treatment regime being followed by all, industries in general and sugar mills in particular, for a compliant effluent discharge: -

- There is a need to inculcate moral and social sense of responsibility among CEOs, Managers and Engineers about their roles to keep effluents in compliance for humanity and Earth itself.
- More stringent governmental policies and strict checks from Food/Environmental watch authorities is needed as, by and large, all industries are violating procedures and specifications to prevent degradation of atmosphere.
- Industries must be made to cooperate with research teams so that a link is established between graduating young minds and needs of industry. Instead of shying away and showing reluctant attitude towards visits and samples for experiments, industries must welcome any such study that helps both the industry and the atmosphere.
- This research did not touch upon environmental impacts of gaseous matter being let into atmosphere during Bagasse Combustion. Being of main cause of air pollution, a separate research should be conducted to evaluate implications of such emissions.

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