

# Characterization of sewage and design of sewage treatment plant

A THESIS SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENT FOR THE DEGREE OF

*Bachelor of Technology* in Civil Engineering

By

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**NILADRI BIHARI MAHANTY, 108CE020**



Department of Civil Engineering  
National Institute of Technology, Rourkela  
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**Under supervision of  
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2012



# **National Institute of Technology Rourkela CERTIFICATE**

This is to certify that the thesis entitled “Characterization of sewage and design of sewage treatment plant” submitted by Falguni Krishna Prasad Mishra, Roll No. 108CE001 and Niladri Bihari Mahanty, Roll No. 108CE020 in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Civil Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

Date:

(Prof. KAKOLI K. PAUL)

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## **ABSTRACT**

The National Institute of Technology Rourkela is one of the most important educational institutes in the state of Orissa with a large number of people residing in its campus consisting of a number of laboratories of various departments, residential units, academic blocks and number of hostels.

A study on domestic waste water characterization has been performed followed by the design of sewage treatment plant. The present study involves the analysis of pH value, total solids, total suspended solids, hardness, acidity, alkalinity, chloride, chlorine, BOD, DO and heavy metals such as Iron, Copper, Zinc, Magnesium, Nickel, Chromium, Lead, Calcium, Aluminium, Silicon, Potassium.

A sewage treatment plant is quite necessary to receive the domestic and commercial waste and removes the materials which pose harm for general public. Its objective is to produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).

The samplings of the domestic waste from hostels have been done in different times of the day to have an average data of the measured parameters. The average values of pH, Turbidity, Acidity, Chloride, Residual Chlorine, Hardness, Total Solid, BOD, DO, Alkalinity, Total Iron Content, Zinc Content, Potassium, Copper, Magnesium, Nickel, Chromium, Lead, Calcium, Aluminum and Silicon are found out.

A sewage treatment plant has been designed with the treatment units, a bar screen of dimension 1.7m, an aeration tank of dimension 4.5 x 4.5 x 3.7 m<sup>3</sup>, a collection pit of diameter 4m and depth 5 m.

Keywords: Characterization, sewage, treatment plant.

CHAPTER 1

**INTRODUCTION**

## 1.1 Introduction:

Pollution in its broadest sense includes all changes that curtail natural utility and exert deleterious effect on life. The crisis triggered by the rapidly growing population and industrialization with the resultant degradation of the environment causes a grave threat to the quality of life. Degradation of water quality is the unfavorable alteration of the physical, chemical and biological properties of water that prevents domestic, commercial, industrial, agricultural, recreational and other beneficial uses of water. Sewage and sewage effluents are the major sources of water pollution. Sewage is mainly composed of human fecal material, domestic wastes including wash-water and industrial wastes.

The growing environmental pollution needs for decontaminating waste water result in the study of characterization of waste water, especially domestic sewage. In the past, domestic waste water treatment was mainly confined to organic carbon removal. Recently, increasing pollution in the waste water leads to developing and implementing new treatment techniques to control nitrogen and other priority pollutants.

Sewage Treatment Plant is a facility designed to receive the waste from domestic, commercial and industrial sources and to remove materials that damage water quality and compromise public health and safety when discharged into water receiving systems. It includes physical, chemical, and biological processes to remove various contaminants depending on its constituents. Using advanced technology it is now possible to re-use sewage effluent for drinking water.

The present study comprises the study on quality of domestic waste water that is discharged from the HB Hall of National Institute of Technology, Rourkela, through the kitchen outlets and bathroom effluents. The study includes characterization tests for pH value, acidity, alkalinity, chloride, residual chlorine, turbidity & DO.

## 1.2 Objectives of the study:

The principal objective of waste water treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. An environmentally-safe fluid waste stream is produced. No danger to human health or unacceptable damage to the natural environment is expected. Sewage includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. Sewage also includes liquid waste from industry and commerce.

The objectives of the study are:

1. Physical, chemical and biological characterization of the domestic waste water from hostels of NIT, Rourkela
2. Comparison with the prescribed standard
3. Design of the sewage treatment plant.

**Observation of Study:** Waste water samples from the kitchen effluent and the bathroom waste of Homi Bhabha Hall of Residence. The presence study is designed to collect waste water sample from HBH. The study includes also MSS Hall.

The following physical characteristics were studied:

- i. Odour
- ii. Taste
- iii. Colour
- iv. Floatables
- v. Turbidity

The following chemical characteristics were studied:

- i. Total Iron
- ii. Copper
- iii. Zinc
- iv. Potassium
- v. Lead
- vi. Aluminum

For determination of inorganic non-metallic constituents we determined the:

- i. Alkalinity
- ii. Acidity
- iii. Chloride
- iv. Residual Chlorine
- v. Sulphate
- vi. Ph. of the sample
- vii. Biochemical Oxygen Demand
- viii. Dissolved Oxygen

### 1.3 Literature Review :

#### **Physical characteristic of waste water:**

**Odour:** It depends on the substances which arouse human receptor cells on coming in contact with them. Pure water doesn't produce odour or taste sensations. Thus waste water which contains toxic substances has pungent smell which makes it easy to distinguish. Odour is recognized as a quality factor affecting acceptability of drinking water.

The organic and inorganic substance contributes to taste or odour. The ultimate odour tasting device is the human nose. The odour intensity is done by threshold odour test

**Taste:** The sense of taste result mainly from chemical stimulation of sensory nerve endings in tongue. Fundamental sensations of taste are, by

convention more than by research evidence, salt, sweet, bitter, and sour. The rating involves the following steps: a) dilution series including random blanks is prepared b) initial tasting of about half the sample by taking water into mouth and holding it for several seconds and discharging it without swallowing. c) Forming an initial judgment on the rating scale d) a final rating made for the sample e) rinsing mouth with taste and odour free water f) resting.

**Colour:** Colour in water results from the presence of natural metallic ions such as Fe or Mg, humus and peat materials, planktons and weeds. It is removed to make water suitable for general and industrial applications. After turbidity is removed the apparent colour and that due to suspended matter is found out.

Tristimulus, Spectroscopic and Platinum cobalt method is used.

**Total solids:** It refers to matters suspended or dissolved in water and waste water. Solids affect the water or effluent quality adversely in a number of ways. Water with highly dissolved solids are not palatable and may cause physiological reaction in transient consumer.

A limit of 500 mg dissolved solids/L is desirable for drinking waters. Evaporation method is used to separate total solids and their weight is found out.

**Floatables:** One important criterion for evaluating the possible effect of waste disposal into surface water is the amount of floatable material in the waste. Two general types of floating matters are found

(i) Particulate matters like 'grease balls'

(ii) Liquid component capable of spreading as thin visible film over large areas.

It is important because it accumulates on the surface and may contain pathogenic bacteria and viruses.

**Turbidity:** Clarity of water is important in producing products destined for human consumption and in many manufacturing uses. It is caused by

suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. The standard method for determination of turbidity has been based on the Jackson candle turbidimeter and Nephelometer.

### **Chemical characteristic of waste water:**

Chemical characteristics of water state the presence of metals their treatment, the determination of inorganic non-metallic constituents and the determination of organic constituents. Here goes a brief description of all the experiments we have performed.

### **Biological characteristic of waste water:**

Water quality has a key role in deciding the abundance, species composition, stability, productivity and physiological condition of indigenous populations of aquatic communities. Their existence is an expression of the quality of the water. Biological methods used for evaluating water quality include the collection, counting and identification of aquatic organisms. Most microorganisms known to microbiologists can be found in domestic wastewater like Bacteria, Protozoa, Viruses, and Algae.

Planktons, Periphyton, Macro-phyton, Macro-invertebrates, Fish, Amphibians and Aquatic reptiles are the biotic group of interdependent organism. Wastewater contains vast quantities of bacteria and other organisms. Aerobic bacteria break down organic matter in the presence of available oxygen. Anaerobic bacteria disintegrate organic matter which is shut off from free oxygen, such as in the interior of a mass of feces or a dead body. The products of anaerobic decomposition have an extremely nauseating odor. Matter in which this condition exists is said to be septic. A multitude of the bacteria in wastewater are coliform bacteria: those found in the digestive tract of normal humans. It is these comparatively few pathogenic organisms that pose the greatest public health hazard. Waste water which is not properly treated may eventually find its way into a community water source and spread waterborne diseases

**CHAPTER 2**

**MONITORING PROTOCOLS**

## 2.1 Study Area:

Achievement of a safe and healthful workplace is the responsibility of an organization, the people residing in the place and the workers who are given the charge to protect the environment. Waste disposal and minimization and pollution prevention should be the preferred approach. Stringent penalties for the improper disposal of wastes should be adopted.

Rourkela is one of the most significant industrial hubs in the state of Orissa. It has got an integrated Steel Plant a number of sponge iron industries, cement manufacturing unit, chemicals, explosives, ceramics and distillery units and large number of small and medium industries.

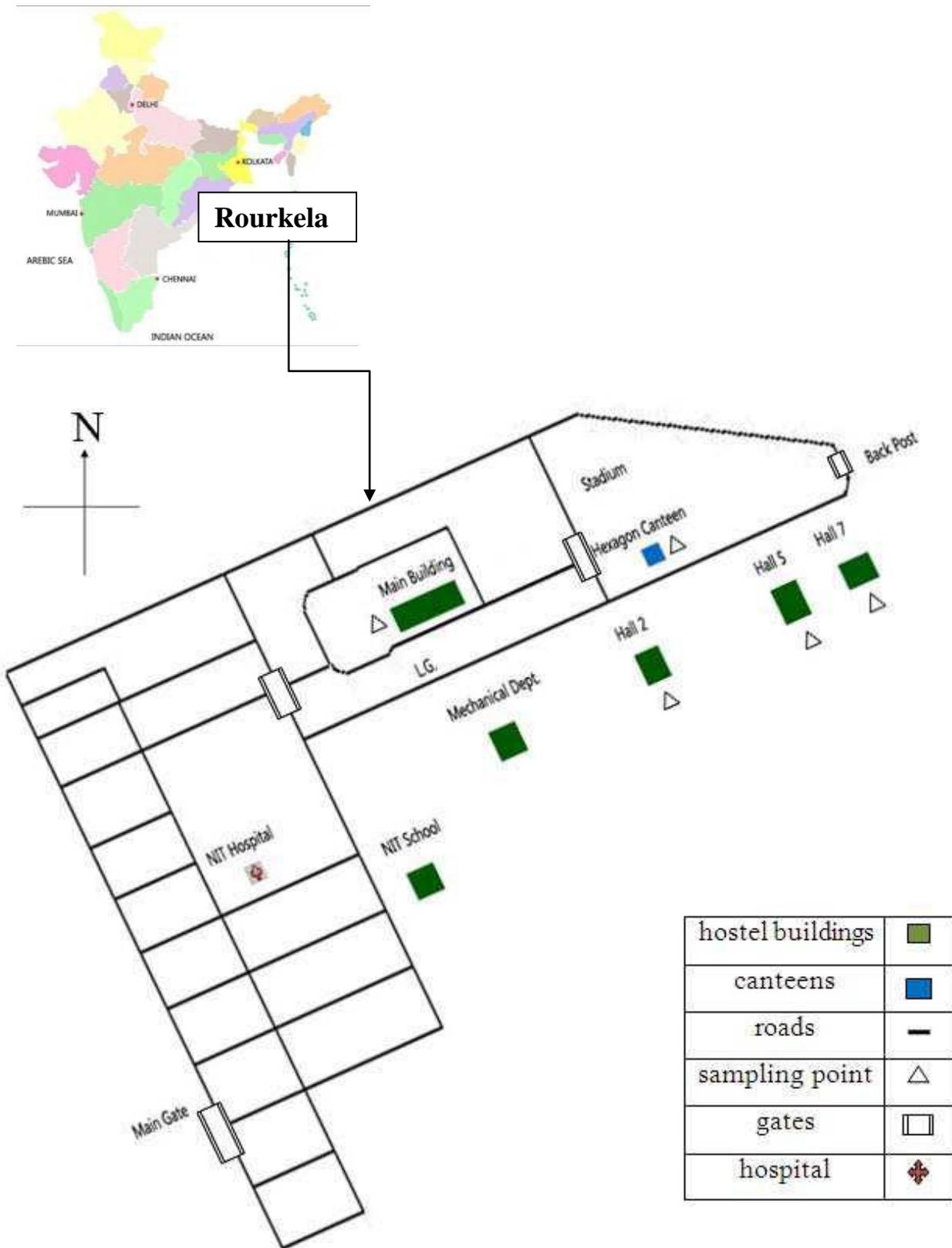
NIT Rourkela is one of the most important educational institutes in the state of Orissa which has a large number of people residing in its campus, a number of laboratories of various departments, residential units, academic blocks and number of hostels for the students studying here.

The following is the list of workplace which is the main sources of pollution generating unit in the study area:

- a) Homi Bhabha Hall of Residence NIT Rourkela,
- b) Hall 5 Nit Rourkela

## 2.2 Sampling Techniques:

Waste water samples have been collected in contamination free sampling bottles of 1000 ml (Turson make) from the kitchen effluent and the bathroom waste of Homi Bhabha Hall of Residence.



**Fig. 2.1 Map of NIT Rourkela**

**CHAPTER 3**

**ANALYSIS TECHNIQUES**

### **3.01 METHODOLOGY FOR MEASUREMENT OF pH VALUE (ELECTROMERIC METHODS)**

The negative logarithm of concentration of hydrogen ion gives the pH of a sample. pH varies from 6-8 in waste water sample, due to hydrolysis of salts of bases and acids. Carbon dioxide, Hydrogen Sulphide and Ammonia which are dissolved affect pH value of water. pH value may be more than 9 in alkaline springs and the pH may be 4 or even less than 4 for acidic ones. Industrial wastes do affect the pH as it depends on buffer capacity of water. pH value of water sample in lab changes because of loss- or absorption of gases, reactions with sediments, chemical reaction taking place within the sample bottle. Therefore pH value should preferably be determined at the time of collection of sample. pH can be determined electrometrically or calorimetrically. The electrometric method is more accurate but requires special apparatus. The calorimetric method is simple and requires less expensive apparatus, and is sufficiently accurate for general work.

#### **PRINCIPLE**

The pH value is found by measurement of the electromotive force generated in a cell. It is made up of an indicator electrode which is reactive to hydrogen ions such as a glass electrode. When it is immersed in the test solution the contact between reference electrode (usually mercury/calomel electrode), and the test solution the electromotive force is measured. A pH meter, that is, a high impedance voltmeter is marked in terms of pH. Varieties of electrodes have been suggested for the determination of pH. The hydrogen gas electrode is the primary standard. Glass electrode in coordination with calomel electrode is generally used with reference potential provided by saturated calomel electrode. The glass electrode system is based on the theory that a change, of 1 pH unit produces an electrical change of 59.1 mV at 25°C. The membrane of the glass forms a partition between two liquids of differing hydrogen ion concentration thus a potential is produced between the two sides of the membrane which is proportional to the difference in pH between the liquids.

The apparatus used are:

- pH meter - With glass and reference electrode (saturated calomel), preferably with temperature compensation.
- Thermometer - With least Count of 0.5°C.

### **PROCEDURE:**

The instrument is standardized after required warm-tip period. A buffer solution of pH near to that of the sample is used. The electrode is checked against at least one additional buffer of different pH value. The temperature of the water is found and if temperature compensation is available in the instruments it is adjusted. The electrodes are rinsed and gently wiped with solution. If necessary, the electrodes are immersed into the sample beaker or sample stream and stirred at a constant rate to provide homogeneity and suspension of solids. Rate of stirring is minimized and the air transfer rate at the air-water interface of the sample is noted. The sample pH and temperature is noted.

### **3.02 METHODOLOGY FOR MEASUREMENT OF ALKALINITY**

The sample liquid for analysis should be either free from turbidity or should be allowed to settle before analyzing it.

The apparatus used are:

- pH Meter
- Burette - 50-ml capacity.
- Magnetic Stirrer Assembly

The reagents used are:

- Distilled Water - pH must be greater than 6.0. In case the pH falls below 6.0, it shall be boiled for 15 minutes and cooled to room temperature.
- Sulphuric Acid - 5.6 ml of concentrated sulphuric acid is diluted with one liter with distilled water.
- Standard Solution of Sulphuric Acid - 0.02 N.

- Phenolphthalein Indicator - 0.5 g of phenolphthalein in 100 ml is mixed, 1: 1 (v/v) alcohol water mixture is taken.
- Mixed indicator Solution - Dissolve 0.02 g methyl red and 0.01 g bromocresol green in 100 ml, 35 %, ethyl or isopropyl alcohol.

**PROCEDURE:**

20 ml of sample is pipetted into a 100-ml beaker. 2 to 3 drops of phenolphthalein indicator is added to the sample if the pH of the sample is above 8.3. It is then titrated with standard H<sub>2</sub>SO<sub>4</sub> solution till the pink color observed by indicator just disappears (equivalence of pH 8.3). The volume of standard H<sub>2</sub>SO<sub>4</sub> solution used is recorded. 2 to 3 drops of mixed indicator is put to the solution in which the phenolphthalein alkalinity has been determined. The solution is titrated with standard acid to light pink color (equivalence of pH 3-7). The volume of standard acid used after phenolphthalein alkalinity is recorded.

**CALCULATION:**

Calculate alkalinity in the sample as follows:

$$\text{Total alkalinity (as mg/l CaCO}_3\text{)} = \frac{(A + B) \times N \times 5000}{V}$$

Where,

A = ml of standard H<sub>2</sub>SO<sub>4</sub> used to titrate to pH 8.3,

B = ml of standard H<sub>2</sub>SO<sub>4</sub> used to titrate from pH 8.3 to pH 3.7,

N = normality of acid used, and

V = volume in ml of sample taken for test.

### 3.03 METHODOLOGY FOR THE DETERMINATION OF TURBIDITY:

#### PRINCIPLE:

The intensity of light scattered by the sample under defined conditions is compared with the intensity of light scattered by a standard reference suspension under the same conditions, forms the basis of determination of turbidity.

Higher the intensity of scattered lights higher the value of turbidity. Formazin polymer is generally used as turbidity standard because it is more reproducible than other types of standards used previously. The turbidity of a particular concentration of Formazin suspension is defined as 40 Jackson turbidity units. The same suspension of Formazin has a turbidity of approximately 40 units when measured on Jackson candle turbidimeter. Thus turbidity units based on the Formazin preparation closely approximate those derived from Jackson candle turbidimeter but it may not always be identical to them.

The apparatus used are:

- Sample Tubes - The sample tubes should be of clear and colorless glass.
- Turbidimeter

The reagents used are:

- Turbidity-Free Water
- Hexamethylene Tetramine Solution
- Hydrazine Sulphate Solution
- Turbidity Standard Suspension I ( Formazin)
- Turbidity Standard Suspension II

#### PROCEDURE:

**TURBIDIMETER CALIBRATION** - The manufacturer's operating instructions is followed. The standards on turbidimeter covering the range of interest are measured. If the instrument is already calibrated in standard turbidity units, this procedure will check the accuracy of calibration.

- Turbidity less than 43 Units - The sample is shaken to disperse the solids. Air bubbles disappear gradually. Sample into turbidimeter tube is poured carefully and turbidity value is directly read from the instrument scale.
- Turbidity greater than 40 Units - If turbidity values are more than 40 units, the sample is diluted with clear distilled water to compare and bring the values within range. The readings are taken of the diluted sample. Then the turbidity is computed of the original sample from the turbidity of the diluted sample and the dilution factor.

**CALCULATION:**

Calculate the turbidity of diluted samples, using the following equation:

$$\text{Turbidity units} = A \times (B+C)/C$$

Where,

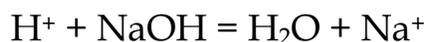
A = turbidity units found in diluted sample,

B = volume in ml of dilution water used, and

C = volume of sample in ml taken for dilution.

**3.04 METHODOLOGY FOR THE DETERMINATION OF ACIDITY:****PRINCIPLE:**

Acidity of water is the numerically expressible capacity to react with a strong base to a designated pH. It may be defined as equivalent concentration of hydrogen ions in mg/l. The equation in its simplest form is as follows:



The apparatus used are:

- pH Meter
- Burette - 50-ml capacity.
- Magnetic Stirring Device

The Reagents used are:

- Distilled Water
- Potassium Acid Phthalate
- Sodium Hydroxide Solution - 15 N.

**Sodium hydroxide solution - 1 N** 67 ml of 15 N NaOH solution is diluted to one liter with distilled water.

**Sodium hydroxide solution - 0.02 N** 20 ml of 1 N NaOH solution is diluted to one liter and is standardized using standard potassium acid phthalate

**Phenolphthalein Indicator** - 0.5 g of phenolphthalein is dissolved in 100 ml 1: 1 (v/v) alcohol water mixture and 0.02 N NaOH solution is added drop by drop till slight pink colour is observed.

**Methyl Orange Indicator** - 0.5 g of methyl orange is dissolved in distilled water and made up to 100 ml in a volumetric flask.

#### **PROCEDURE:**

**Indicator Method** - 20 ml of a suitable amount of sample is pipetted into a 100 ml beaker. Less than 20 ml of titrant shall be required for the titration that should be the volume of sample. The pH of water is determined. If pH is less than 3.7, two drops of methyl orange indicator is added into the first sample beaker. It is titrated with standard 0.02 N NaOH solution until the colour converts to the faint orange. The volume of NaOH used is recorded. 2 to 3 drops of phenolphthalein indicator is added to the second sample beaker. It is again titrated with 0.02 N NaOH solution till the colour of solution changes to faint pink colour. The volume used is recorded.

**Potentiometric Method** - 20 ml of a suitable aliquot of sample is pipetted into a 100 ml beaker. It is then titrated with standard NaOH solution to pH 3.7 and pH 8.3. The volume of standard NaOH used is measured. No indicator is required.

**Calculation** - Acidity in the sample is calculated as follows:

Acidity at pH 3.7, as mg/l  $\text{CaCO}_3 = A \times N \times 50000/V$

Acidity at pH 8.3, as mg/l  $\text{CaCO}_3 = B \times N \times 50000/V$

Where,

A = volume in ml of standard sodium hydroxide

N = normality of standard sodium hydroxide,

V = volume in ml of sample taken for test, and

B = volume in ml of standard sodium hydroxide used to titrate to pH 3.7 is used to titrate to pH 8.3.

### **3.05 METHODOLOGY FOR MEASUREMENT OF CHLORIDE**

#### **PRINCIPLE:**

Soluble and slightly dissociated mercuric chloride is formed when Chloride is titrated with mercuric nitrate. Diphenyl Carbazone within the pH range of 2.3 to 2.8 signals the end point by the formation of a purple complex with extra mercuric ions.

The apparatus used are:

- Erlenmeyer flask - 250 ml capacity.
- Microburette - 5 ml with 0.01 ml graduation intervals.

The reagents used are:

- Standard sodium chloride solution
- Nitric acid - 0.1 N
- Sodium hydroxide - 0.1 N
- Reagents for chloride concentrations below 700 mg/l
- Indicator-acidifier reagent - Nitric acid concentration of this reagent decides the success of the determination and it can be varied as indicated in (a) or (b) to benefit the alkalinity range of the sample. Reagent (a) contains sufficient nitric acid to counteract a total alkalinity of 150 mg as  $\text{CaCO}_3/l$  to the proper pH in a 100 ml sample.

a) 250 mg s-diphenylcarbazone, 4-O ml. concentration nitric acid and 30 mg xylene cyanol FF in 100 ml 95 percent ethyl alcohol or isopropyl alcohol. The sample is stored in a dark bottle in a refrigerator. This reagent is not stable indefinitely. Deterioration causes a slow end point and high results.

Standard mercuric nitrate titrant - 2.3 g mercuric nitrate [ $\text{Hg}(\text{NO}_3)_2$  or 2.5 g  $\text{Hg}(\text{NO}_3)_2 \cdot 12\text{H}_2\text{O}$ ] is dissolved in 100 ml distilled water containing 0.25 ml concentrated nitric acid. It is diluted to just less than 1 liter. Replicates are used containing 5.00 ml standard sodium chloride solution and 10 mg sodium bicarbonate ( $\text{NaHCO}_3$ ) diluted to 100 ml with distilled water. It is adjusted to 0.0141 N and a final standardization of 1.00 ml = 500  $\mu\text{g}$  Cl<sup>-</sup> is made. It is stored away from light in a dark bottle.

Mixed indicator reagent - 0.50 g diphenylcarbazone powder and 0.05 g bromophenol blue powder is dissolved in 75 ml 95 percent ethyl or isopropyl alcohol and dilute to 100 ml with the same alcohol.

0.141 N standard mercuric nitrate is used as titrant.

#### **PROCEDURE:**

100 ml sample is taken such that the chloride content is less than 10 mg. 1.0 ml indicator acidifier reagents are put. pH is conformed to about 8 for highly alkaline or acid waters before adding indicator-acidifier reagent. 0.411 N Mercuric Nitrate is titrated with the solution to a definite purple end point. The solution turns from green blue to blue a few drops before the end point.

The blank is determined by titrating 100 ml distilled water containing 10 mg of sodium bicarbonate.

$$\text{Chloride, mg/l} = \frac{(V_1 - V_2) \times N \times 35450}{V_3}$$

Where,

V1 = volume in ml of silver nitrate used by the sample,  
V2 = volume in ml of silver nitrate used in the blank titration,  
V3 = volume in ml of sample taken for titration and  
N = normality of silver nitrate solution.

### **3.06 METHODOLOGY FOR THE DETERMINATION OF RESIDUAL CHLORINE:**

It is measured as the chlorine left in the water after the required contact period which will ensure complete killing of bacteria and oxidation of the organic matter usually a free chlorine residue is considered to be sufficient. The reagents used are

- O- Toluidine - 4 drops

#### **PROCEDURE:**

O- Toluidine is added to the sample and mixed thoroughly. After 15 to 20 minutes the colour is developed. The comparator was placed to match the colour of the sample. The volume of indicator used was noted down. Generally the concentration of residual chlorine must be 1 - 2 mg/l.

### **3.07 METHODOLOGY FOR THE DETERMINATION OF TOTAL SOLIDS:**

#### **PRINCIPLE:**

The sample is evaporated in a weighed dish on a steam-bath and is dried to a constant mass in an oven either at 103-105°C or 179-181°C. Total residue is calculated from increase in mass.

Note - In general, by evaporating and drying water samples at 179-181°C values are obtained which conform more closely to those obtained by summation of individually determined mineral salts

The apparatus used are:

- Evaporating Dish
- Steam-Bath

- Drying Oven
- Desiccator
- Analytical Balance

**PROCEDURE:**

1. The clean evaporating dish is heated to 180°C for 1 hour. It is cooled, desiccated, weighed and stored in desiccator until it is ready.
2. The volume of the sample is selected which has residue between 25 and 250 mg, preferably between 190 and 200 mg. This volume may be found out from values of specific conductance. If a measurable residue has to be obtained successive aliquots of sample can be added to the sample dish.
3. This volume is pipetted to a weighed evaporating dish placed on a steam-bath. A drying oven can be used to perform evaporation. To prevent oiling and splattering of the sample the temperature should be lowered to around 98°C. The dish is taken to an oven at 103-105°C, or 179-181°C and dried to constant mass, after complete evaporation of water from the residue. It is done till the difference in the successive weighing is less than 0.5 mg. To eliminate necessity of checking for constant mass drying for a long duration (usually 1 to 2 hours) is done. The time for drying to constant mass with a given type of sample when a number of samples of nearly same type are to be analyzed can be determined by trial.
4. The dish is weighed as soon as it has cooled. Residue is avoided to stay for long time as some residues are hygroscopic and may absorb water from desiccant which may not be absolutely dry.

**CALCULATION** - The total residue is calculated using the following equation:

$$\text{Total residue, mg/l} = 1000 \times M/V$$

Where,

M = mass in mg of total residue, and

Y = volume in ml of the sample.

### **3.08 METHODOLOGY FOR MEASUREMENT OF DO:**

The apparatus used are:

- Incubation bottles
- DO meter
- Air incubator

#### **PROCEDURE:**

Water is kept in incubator and a magnetic stirrer is put inside the bottle. The magnetic stirrer is incessantly rotated inside the bottle. Then with the help of DO meter 3 readings are noted. The first reading is taken at the bottom, second at mid-point and third at top of the bottle. Thus the average of the readings will give the dissolved oxygen present in the water sample.

### **3.09 METHODOLOGY FOR MEASUREMENT OF BOD:**

#### **PRINCIPLE:**

The biochemical oxygen demand (BOD) test is based mainly on the classification of biological activity of a substance. A procedure measures the dissolved oxygen consumed by micro-organisms while capable of taking and oxidizing the organic matter under aerobic conditions. The standard test condition lets in incubating the sample in an air tight bottle, in dark at a required temperature for specific time.

The apparatus used are:

- i) Incubation Bottles: The bottle has capacity of 300 ml. It has narrow neck with even mouth and has ground glass stoppers. New bottles are cleaned with 5 N hydrochloric acid or sulphuric acid and rinsed with distilled water. In normal use, bottles once used for Winkler's procedure should only be rinsed with tap water followed by distilled water. During incubation water is added to the flared mouth of the bottle time to time, to ensure proper sealing.
- ii) Air Incubator: Air incubation with thermostatically controlled  $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$ . Light is avoided to prevent possibility of photosynthetic production of oxygen.

**PROCEDURE:**

After taking water in incubation bottles, 4 gm of NaOH is kept at the neck of the bottle. A magnetic stirrer is retained inside the bottle. The magnetic stirrer continuously revolves inside the bottle. Special caps attached with an electronic meter keep the bottle air tight. The instrument directly records BOD reading at every 24 hour. After that the bottles are preserved in the incubators for days as per need of study. The same procedure follows for BOD 3 days and BOD 5 days.

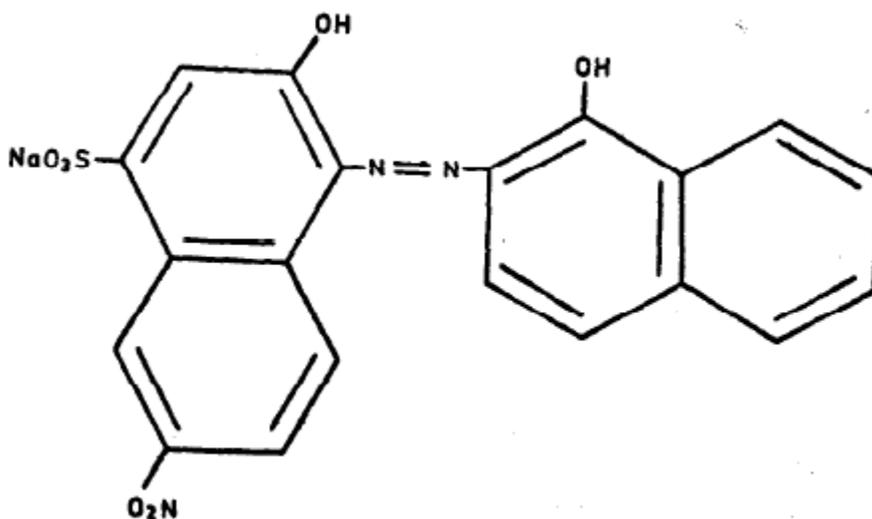
### 3.10 METHODOLOGY FOR THE DETERMINATION OF HARDNESS:

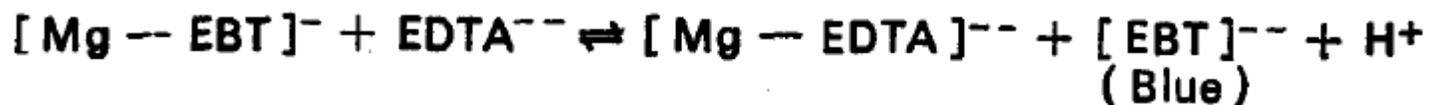
#### Principle:

This method is contingent upon the power of ethylenediamine tetraacetic acid ( $C_{10}H_{14}O_8N_2$ )



or its disodium salt to form stable complexes with calcium and magnesium ions. When the dye eriochrome black T (EBT) is added to a solution containing calcium and magnesium ions at pH 10.0 a wine red complex is formed. This solution is titrated with standard solution of disodium salt of EDTA, which extracts calcium and magnesium from the dye complex and the dye is changed back to its original blue colour. Eriochrome black T is used to indicate the end-point for the titration of calcium and magnesium together.





The reagents used are:

- i. Buffer solution ( $\text{NH}_4\text{Cl} + \text{NH}_4\text{OH}$ )
- ii. Standard calcium solution
- iii. Eriochrome black 1 indicator solution
- iv. Inhibitors
- v. Hydroxylamine hydrochloride solution
- vi. Potassium ferrocyanide crystals
- vii. Sodium sulphide inhibitor
- viii. Sodium cyanide solution
- ix. Standard EDTA solution

#### PROCEDURE:

25.0 ml of standard calcium solution is pipetted in a porcelain basin. The volume is adjusted to 50 ml with distilled water. 1 ml buffer solution is used. 1 to 2 drops of indicator is put. After continuous stirring until the reddish tinge disappears, it isn't titrated. Few drops of sample at 3 to 5 second interval are added. At the end point the colour is sky blue.

For drinking, surface and saline waters - An aliquot of water sample is pipetted, in a porcelain dish or 150-ml beaker. The volume is tuned to approximately 50 ml. 1 ml hydroxylamine hydrochloride ( $\text{NH}_4\text{OH.HCl}$ ) is added to the solution. 2 ml of buffer solution is mixed so as to achieve pH of 10.0 to 10.1. 2 ml sodium cyanide or sodium sulphide inhibitor solution is put if the end point isn't sharp. If Cu, Zn, Pb, Co and Ni are absent and if

the sample contains less than 0.25 mg of Fe and 0.025 mg of Mn the addition of NaCN or Na<sub>2</sub>S may be omitted. 2 ml of Eriochrome black T indicator solution is added and titrated with standard EDTA solution stirring rapidly in the beginning. It is stirred slowly towards the end when all the traces of red and purple colour disappear and solution is clear sky blue in colour.

For waste waters and highly polluted waters - An aliquot of the sample is digested with 3 ml of distilled conc. HNO<sub>3</sub> in a beaker on a hot plate. It is evaporated to near dryness while ensuring that the sample does not boil. Digestion with nitric acid is repeated till the digestate is light in colour. It is evaporated to near dryness and cooled. Little amount of 1: 1 hydrochloric acid (5 ml) is added and warmed on a steam-bath to dissolve the residue.

Note 1 - For water with very low hardness (less than 5 mg/l) micro burette is used.

Note 2 - Sample size may be selected such that the result lies between 200 to 300 mg/l of hardness (as CaCO<sub>3</sub>).

#### **CALCULATION:**

The hardness is calculated as follows:

$$\text{Total hardness (as CaCO}_3\text{), mg/l} = 1000 V_1/V_2$$

Where,

V<sub>1</sub> = Volume in ml of the EDTA standard solution used in the titration.

V<sub>2</sub> = Volume in ml of the sample taken for the test.

### **3.11 METHODOLOGY FOR THE DETERMINATION OF CARBONATES AND BICARBONATES: (TITRIMETRIC METHOD)**

**PRINCIPLE:**

Potentiometric method is used to do the titration. Phenolphthalein is used as an indicator. The total  $\text{OH}^-$ ,  $\text{CO}_3^{2-}$ , and  $\text{HCO}_3^-$  content is first found out by titration with standard acid using methyl orange/bromocresol green indicator. Equal portion of the sample is titrated against the same acid using phenolphthalein/metacresol purple indicator.

The apparatus used are:

- i. Electrometric Titrator
- ii. Titration Vessel
- iii. Magnetic Stirrer
- iv. Pipettes, Volumetric
- v. Flasks, Volumetric
- vi. Burettes, Borosilicate Glass
- vii. Polyolefin Bottles

The reagents used are:

- Sodium Carbonate Solution – Approximately 0.05 N
- Standard Hydrochloric Acid – 0.1N
- Standard Hydrochloric Acid – 0.02 N
- Methyl Orange/ Bromocresol Green Indicator
- Metacresol Purple Indicator Solution
- Phenolphthalein Solution

**PROCEDURE:****Sample Size**

Large amount of carbonate and bicarbonate concentrations are found in wastewater therefore a single sample size and normality of titrant is difficult to specify. If alkalinity is less than 1000 mg as  $\text{CaCO}_3$ /l, 20 ml of

sample is taken and titrated with 0.02 N HCl. If alkalinity is more than 1000 mg as  $\text{CaCO}_3$ /l, 5 ml of the sample is titrated with 0.1 N hydrochloric acid. The end point may be determined by any of the following:

- a) By colour change, and
- b) Potentiometrically.

### **Potentiometric Titration**

Distilled water is used to rinse the electrodes and titration vessel. Sample pH is measured. Standard hydrochloric acid is added in growths of 0.5 ml or less, so that a change of less than 0.2 pH units occur per increment. Magnetic stirrer is used to mix thoroughly and steadily. Splashing is avoided at all cost. The pH is recorded after reading becomes constant. The cumulative milliliters of titrant added are recorded after mixture is titrated to pH 8.3. The total amount of titrant used is recorded. As the end point borders on smaller additions of alkali are done.

### **CALCULATION:**

Phenolphthalein alkalinity is calculated by using the volume of acid used for phenolphthalein end point. It can be titrated potentiometrically to pH 8.3. The total alkalinity is found out by using the volume of acid used for bromocresol green end point or titrated potentiometrically to pH 4.5.

$$\text{Alkalinity (CaCO}_3 \text{ mg/l)} = A \times N \times 50 / \text{ml of sample.}$$

Where,

A= ml of standard acid.

N = Normality of acid.

The results obtained from the phenolphthalein and total alkalinity determinations can be used to calculate the carbonate and bicarbonate concentrations as  $\text{CaCO}_3$ . The method specifies the entire alkalinity to bicarbonate, carbonate and hydroxide. It assumes the absence of other (weak) inorganic or organic acids, such as silicic, phosphoric and boric

acids. Since the calculations are made on a stoichiometric basis, ion concentrations in the strictest sense are not represented in the results.

So they may differ significantly from actual concentrations especially at pH greater than 10. According to this outline

a) Carbonate ( $\text{CO}_3^-$ ) alkalinity is present when phenolphthalein alkalinity is not zero but is less than total alkalinity;

b) Hydroxide ( $\text{OH}^-$ ) alkalinity is present if phenolphthalein alkalinity is more than half of the total alkalinity

c) Bicarbonate ( $\text{HCO}_3^-$ ) alkalinity is present if phenolphthalein alkalinity is less than half of the total alkalinity.

These relationships may be calculated by the following scheme where  $P$  is phenolphthalein alkalinity and  $T$  is total alkalinity. The smaller value of  $P$  or  $(T-P)$  is taken into account. After that carbonate alkalinity equals twice the smaller value. If the smaller value is  $P$ , the balance  $(T-2P)$  is bicarbonate's value. When the smaller value is  $(T-P)$  the balance  $(2P-T)$  is hydroxide's value. The results are expressed as  $\text{CaCO}_3$ .

**Table 1 Alkalinity Relationships**

<b>Result of Titration</b>	<b>Hydroxide Alkalinity as <math>\text{CaCO}_3</math></b>	<b>Carbonate Alkalinity as <math>\text{CaCO}_3</math></b>	<b>Bicarbonate Concentration as <math>\text{CaCO}_3</math></b>
(1)	(2)	(3)	(4)
$P = 0$	0	0	T
$P < 1/2 T$	0	2P	$T-2P$
$P = 1/2 T$	0	2P	0
$P > 1/2 T$	$2P-T$	$2(T-P)$	0
$P = T$	T	0	0

where

$P$  = Phenolphthalein alkalinity, and

$T$  = Total alkalinity.

### **3.12 METHODOLOGY FOR THE DETERMINATION OF METALS:**

#### **PRINCIPLE:**

The Atomic Absorption Spectrometer is used to determine the contents of metals in the waste water sample. The principle associated here is a light beam is guided through the flame into a monochromator and then to a detector that measures the amount of light absorbed by the atomized element in the flame. For each metal there is one distinct absorption wavelength, so a source lamp formed of that element is used. This makes it free from spectral interference. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample. The flame emission method produces good results for determination of metals.

The effects of metals in water and waste water range from beneficial through troublesome to dangerously toxic. Some are essential but others adversely affect water consumers, waste water treatment systems and receiving waters. Flame and electro-thermal methods are generally applicable at moderate concentration levels.

1. Sampling and Sample preservation: Before collecting sample fraction to be analyzed is decided. Errors introduced during sampling and storage is taken care of. The best sampling containers are made of quartz and TFE.
2. The sample is preserved immediately after acidifying with concentrated nitric acid.
3. Contaminated metals from containers, distilled water, or membrane filters are avoided introduction.
4. For analysis of microgram-per-liter concentrations of metals, airborne contaminants in the form of volatile compounds, dust, soot and aerosols present in laboratory air become significant.

The presences of many metals were tested by atomic absorption spectrometer analysis.

The apparatus used is:

Atomic Absorption Spectrometer made up of

- Light emitting source.
- Burner - Premix type, introduces spray into condensing chamber.
- Readout - The display unit.
- Lamps - Hollow Cathode type.
- Pressure reducing valves.
- Vent.

### **PROCEDURE:**

The sample preparation depends on the metal we need to measure. The manufacturer's operation manual is studied and the instrument is operated. A hollow cathode lamp for the required metal is installed. The slit width is set as per the manual. The instrument is warmed up to 20 minutes till the energy source stabilizes. Air is turned on and the flow rate is adjusted as per the manufacturer's specification. The instrument is calibrated. 3 different concentration of standard metal solution is prepared and the blank is analyzed. The instrument is zeroed. The standard solutions are analyzed and absorbance is recorded. A calibrated curve is prepared by plotting on a linear graph paper. Absorbance of standard vs. the concentration is plotted. Then the sample is analyzed and the concentration of each metal ion (in microgram per liter) is calculated.

CHAPTER 4

**RESULTS AND DISCUSSIONS**

## 4.1 Tabulations:

Table 1: Water consumption of various residential halls of NIT Rourkela

Name of the Hall	Capacity of tank (Litres)				Total water supplied (Litres)	Strength
	1000	1500	2000	3000		
SS Bhatanagar HOR	-	27	-	-	37000	130
M Visveswaraya HOR	-	32	-	-	45500	393
GD Birla HOR	-	38	-	-	58500	529
DhirubhaiAmbani HOR	-	40	-	-	59500	514
MS Swaminathan HOR	-	38	-	-	55500	289
HomiBhaba HOR	-		10	10	45500	522
CV Raman HOR	-	14	-	-	20500	245
KiranMajumdar HOR	-	45	-	-	75000	460
Vikram Sarabhai HOR	-	17	-	-	36000	665

Table 2: Water consumption by residential quarters of NIT Rourkela

Quarter Type	Number of rooms
<b>A</b>	<b>19</b>
<b>B</b>	<b>22</b>
<b>C</b>	<b>30</b>
<b>D</b>	<b>65</b>
<b>E</b>	<b>40</b>
<b>F</b>	<b>108</b>
<b>G</b>	<b>117</b>
<b>FE type Flats</b>	<b>18</b>
<b>Bachelor Flats</b>	<b>24</b>
<b>Transit Flats</b>	<b>18</b>
<b>Director's</b>	<b>1</b>

Average water supplied = 1.5 lakh gallon

So, total waste water generated = 80 % of Supplied Water  
 =  $0.8 \times 1.5$  lakh gallon  
 = 1.2 lakh gallon

The presence of non-metallic constituents and the metallic constituents from the waste water sample was determined.

### 1. Determination of acidity content

SOURCE	CONCENTRATION IN PPM
Bath room waste water	3.6
Kitchen waste water	4.5
Tap water	2.3
Distilled water	1

### 2. Determination of chloride content

SOURCE	CONCENTRATION IN PPM	STANDARD
Bath room waste water	57.9	30 -100
Kitchen waste water	113	
Tap water	3.5	

### 3. Determination of Ph of the sample

SOURCE	PH	STANDARD
Kitchen waste	7.89	7.8
Bath room waste	7.36	
Tap water	8.01	

## 4. Determination of residual chlorine

SL NO	SOURCE	CONC. IN PPM	STANDARD
1	Kitchen waste	2	1 - 2 ppm
2	Bath room waste	2	
3	Tap water	1	

## 2 Determination of turbidity of sample

SL NO	SOURCE	VALUE IN NTU
1	Bath room waste	14
2	Kitchen waste	116
3	Tap water	10

## 3 Table for determination of alkalinity

Here utilization of sulphuric acid is used is zero. Thus it indicates presence of bicarbonate.

SOURCE	CONC. IN PPM	STANDARD CONC.
Kitchen waste	75	50 - 200
Bathroom waste	80	
Tap water	15	

## Determination of metals by atomic absorption spectrometry

### 1. Total iron content

SL NO	SOURCE	CONC. IN MG/L
1	Kitchen waste	2.863
2	Bathroom waste	0.024
3	Tap water	0

### 2. Zinc content

SL NO	SOURCE	CONC. IN MG/L
1	Kitchen waste	0.115
2	Bathroom waste	0.086
3	Tap water	1.549

### 3. Copper content

SL NO	SOURCE	CONC. IN MG/L
1	Kitchen waste	0.019
2	Bathroom waste	0.0
3	Tap water	0.007

### 4. Potassium content

SL NO	SOURCE	CONC. IN MG/L
1	Kitchen waste	11.334
2	Bathroom waste	9.285
3	Tap water	2.491

**Tabulation for physical and chemical characteristics in different time**

Time 	8 a.m.	12 p.m.	1-2 p.m.	5-6 p.m.	PERMISSIBLE VALUE
Property 					
<b>Turbidity (NTU)</b>	32	45	50	38	5
<b>pH</b>	8.76	8.01	8.22	8.4	6.5 - 8.5
<b>Acidity (mg/l)</b>	1.8	2.6	3	1.3	
<b>Alaklinity (mg/l)</b>	42	45	158	78	600
<b>Chloride (mg/l)</b>	11	17	20	15	1000
<b>Residual Chlorine (mg/l)</b>	2	2	2	2	1
<b>Hardness (mg/l)</b>	23	38	40	30	200
<b>Total Solids (mg/l)</b>	200	240	420	600	2000
<b>BOD (mg/l)</b>	1.3	1.21	1.23	1.03	10
<b>DO (mg/l)</b>	7.1	7.01	7.02	6.9	2000

**Tabulation for determination of different mineral content at different time**

<b>Time</b> 	<b>8 a.m.</b>	<b>12 p.m.</b>	<b>1-2 p.m.</b>	<b>5-6 p.m.</b>	<b>PERMISSIBLE VALUE</b>
<b>Metals</b> 					
<b>Iron (mg/l)</b>	0.077	0.213	0.532	0.052	0.3
<b>Zinc (mg/l)</b>	0.008	0.119	0.124	0.131	15
<b>Copper (mg/l)</b>	0.019	0.012	0.035	0.029	1.5
<b>Magnesium (mg/l)</b>	0.41	1.918	2.581	3.411	30
<b>Nickel (mg/l)</b>	0.01	0.011	0.044	0	0.02
<b>Chromium (mg/l)</b>	0.113	0.212	0.242	0.114	0.05
<b>Lead (mg/l)</b>	0.101	0.091	0.261	0.024	0.01
<b>Calcium (mg/l)</b>	5.41	12.1	19.76	11.23	200
<b>Aluminum (mg/l)</b>	0.07	0.05	0	0.01	0.2
<b>Silicon (mg/l)</b>	3.91	11	10.602	5.21	7-10
<b>Potassium (mg/l)</b>	1.121	1.31	2.41	3.75	-

CHAPTER 5

**DESIGN OF SEWAGE TREATMENT PLANT**

## 5.1 Design of Sewage Treatment Plant:

### Plant capacity:

Average water supply per day = 423000 lit = 0.423 mld\*

Average sewage generated per day = 85% of supplied water  
 $= 0.85 \times 0.423 = 0.36$  mld  
 $= 360$  kld\*\*

Average sewage generated per hour =  $360/24 = 15$  cum/hr

Peak factor = 3

Design flow capacity (maximum) =  $15 \times 3 = 45$  cum/hr

\*mld - Million liter per day

\*\*kld - Kilo Liter per day

### Sizing calculation for collection pit:

Retention time required = 4 h

Average design flow =  $15$  m<sup>3</sup>/h

Capacity of collection sump =  $4 \times 15 = 60$  m<sup>3</sup>

Assume liquid depth = 5 m

Area required for collection pits =  $60/5 = 12$  m<sup>2</sup>

Let it is a circular tank

$$12 = \pi r^2$$

$$\Rightarrow r = 1.93\text{m}$$

Volume of the pit provide =  $\pi/4 \times 4 \times 4 \times 5$   
 $= 62.8$  m<sup>3</sup>

Thus Area of the pit provided =  $12.6$  m<sup>2</sup>

### Sizing calculation of bar screen:

Peak discharge =  $45$  m<sup>3</sup>/h

Average discharge =  $15$  m<sup>3</sup>/h

Average velocity @ average flow isn't allowed to exceed  $0.8$  m/sec

Average spacing between bar  $20$  mm

The velocity =  $0.3 \times 60 = 18$  m/h/ m<sup>2</sup>

Cross sectional area required = flow/velocity  
 $= 45/18 = 2.5$  m<sup>2</sup>

Liquid depth required = 1 m

Velocity through screen at the peak flow = 1.6 m/sec

Clear area =  $2.5/1.6 = 1.3$

No. of clear spacing =  $1.3/0.02 = 65$

Width of channel =  $(65 \times 20) + (67 \times 6) = 1702$  mm

Width of screen = 1700 mm

### **Sizing calculation of aeration tank:**

Bod in the feed sewage = 100 ppm

No. of aeration tank = 2

Average flow =  $360/2 = 180$  kld

Total bod load to the aeration tank =  $15 \times 24 \times 100 = 36$  kgs

Let mlss = 2000 mg/l,  $f/m = 0.15$

Volume of tank required =  $(Q \times \text{bod load}) / (fm \times \text{mlss})$   
 $= (180 \times 100) / 0.15 \times 2000$   
 $= 60 \text{ m}^3$

Assume liquid depth = 3.5 m

Area =  $60/3.5 = 17.143 \text{ m}^2$

Tank size provided =  $4.5 \times 4.5 \times 3.7$

So, Volume of tank =  $75 \text{ m}^3$

### **Check for aeration period/hydraulic retention time:**

Hydraulic retention time  $t = 75 \times 24 / 180 = 10$  h

So, the tank retention time is more than the required time.

Sizing calculation for sludge drying beds

Maximum design flow rate =  $45 \text{ m}^3/\text{h}$ , 360 kld

Total feed suspended solid = 250 ppm

Total outlet suspended solid = 50 ppm

Load to the clarifier =  $250 - 50 = 200$  ppm

Sludge generated per day =  $360 \times 200 / 1000$   
 $= 72 \text{ kg/day}$

Solid content in the feed = 3%

Specific gravity of the sludge = 1.015

$$\begin{aligned}\text{Volume of sludge} &= ((72/0.03)/(1000 \times 1.015)) \\ &= 2.36 \text{ m}^3\end{aligned}$$

For Rourkela weather condition, the beds get dried out about 7 days

$$\begin{aligned}\text{No. of cycles per year} &= 365/7 \\ &= 52 \text{ cycles}\end{aligned}$$

Period of each cycles = 7 days

$$\begin{aligned}\text{Volume of sludge per cycle} &= 2.36 \times 7 \\ &= 16.55 \text{ m}^3/\text{cycle}\end{aligned}$$

Spreading a layer 1m per cycle,

$$\begin{aligned}\text{Area of bed required} &= 16.55/1 \\ &= 16.55 \text{ m}^2\end{aligned}$$

So area of 16.55 m<sup>2</sup> for 2 drying beds is provided for the above system

Hence, Sludge Drying Bed has dimensions of 4.5 m x 4.5 m x 1 m of two numbers.

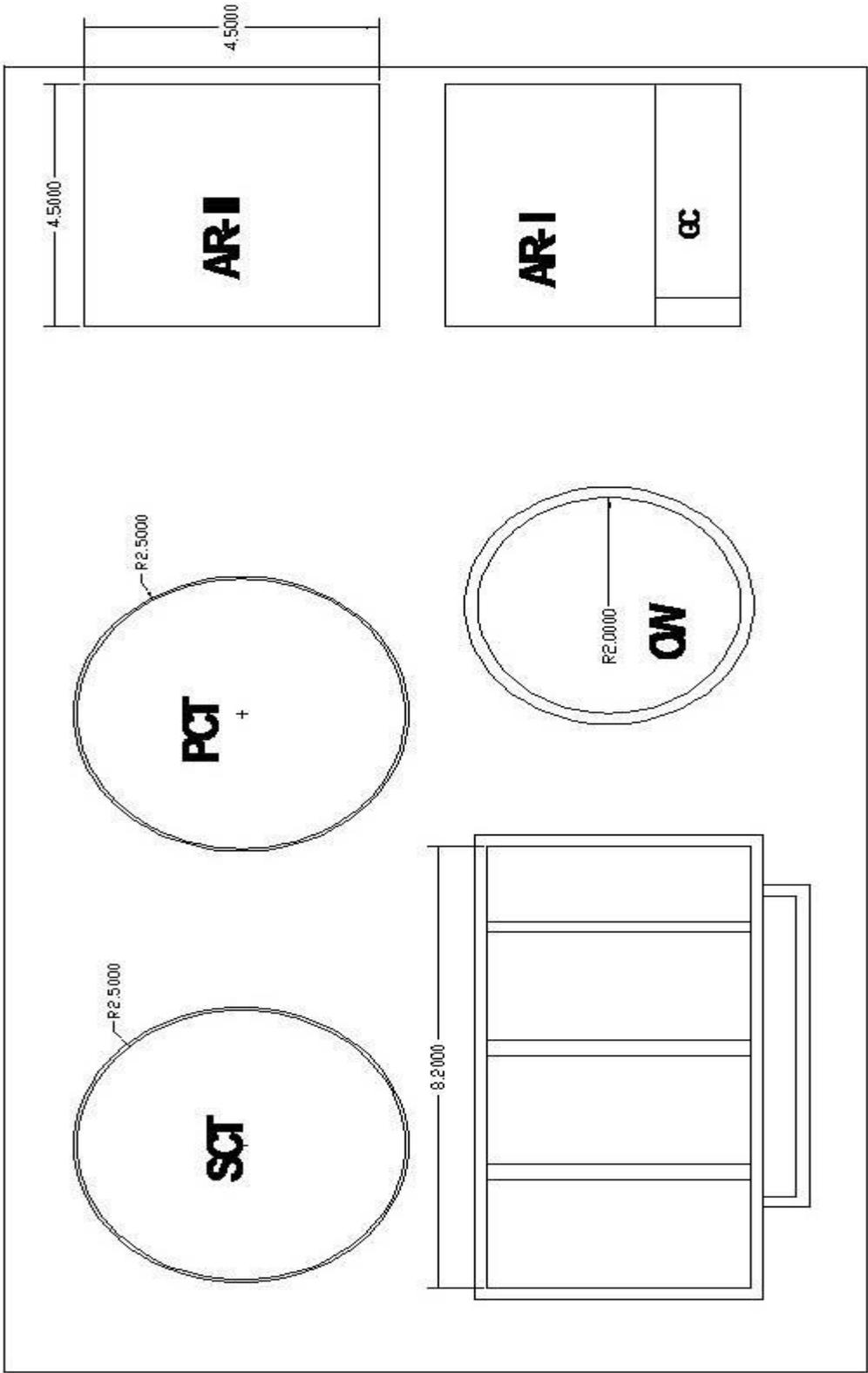
### Terms used in the model

CW  
CBD  
AT  
PCT  
SCT  
SDB

### Full Form

Collection Well  
Coarse Bubble Diffusion  
Aeration Tank  
Primary Clarifier Tank  
Secondary Clarifier Tank  
Sludge Drying Bed

Fig 5.1 Top View of Sewage Treatment Plant



PRELIMINARY DRAWING

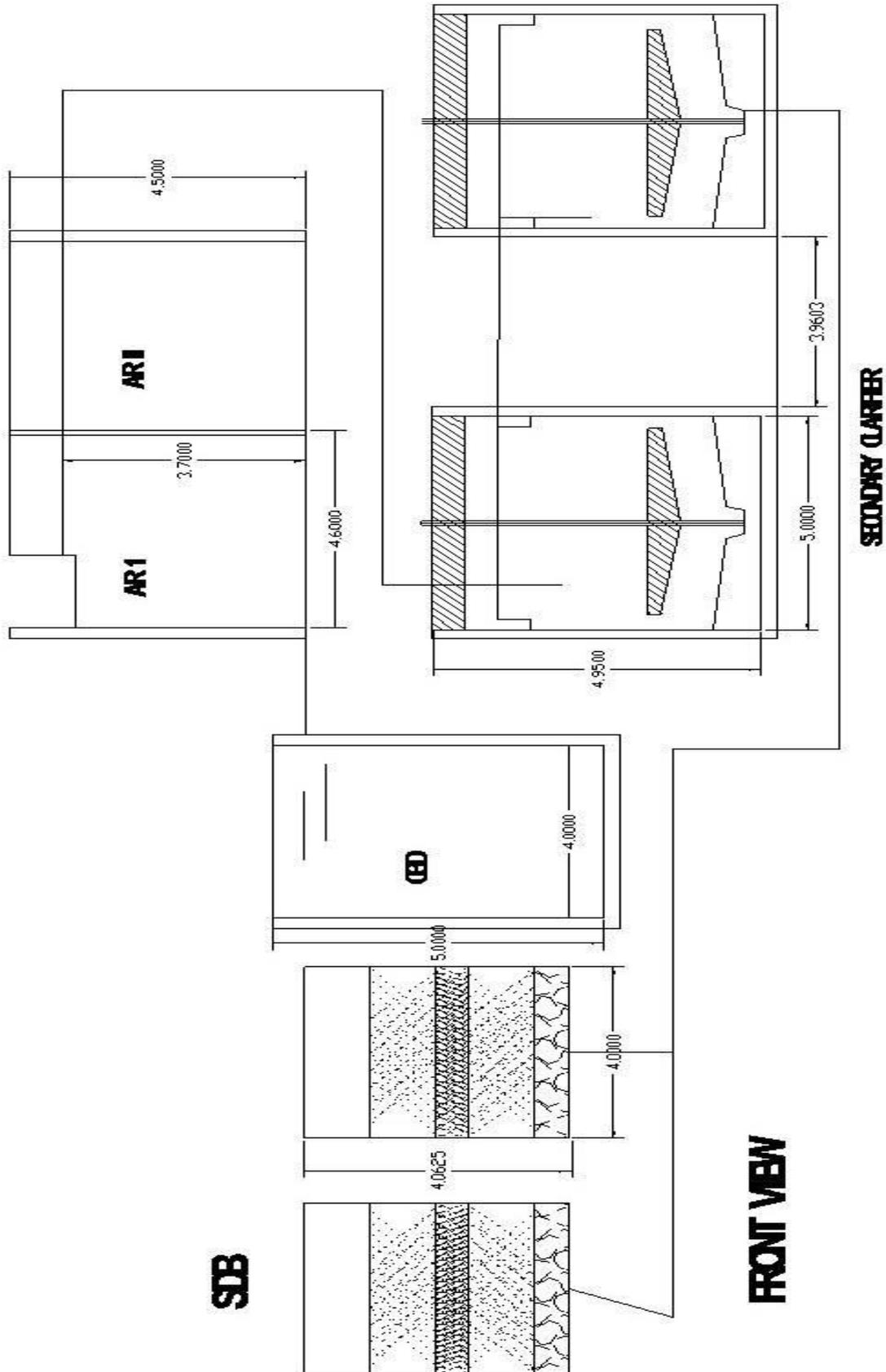


Fig 5.2 Layout of Sewage Treatment Plant

CHAPTER 6

**TIMELINE OF THE PROJECT**



CHAPTER 7

**CONCLUSION**

## 7.1 Conclusion:

- The average ranges of physical, chemical and biological characteristics of waste water quality are experimented and found out.
- The pH ranges from 7.8 to 8.01. The Turbidity ranged from 10 to 120 NTU.
- The value of Turbidity was found to be within the permissible limit.
- The Chloride and Alkalinity were in the range of 3.5 to 120 mg/l and 15 to 80 mg/l respectively.
- The Total Iron content was in the range of 0 to 3 mg/l.
- The Zinc content was in the limits of 0.1 to 2 mg/l.
- Copper content ranged from 0 to 0.2 mg/l.
- Potassium was present in the limits of 2 to 12 mg/l.
- The parameters studied resemble the waste water quality.

Total amount of waste water treated = 0.423 mld.

- Dimension of the collection pit is calculated to be 4 m in diameter and 5 m depth of the cylindrical tank.
- A bar screen of width 1.7 m is provided.
- Dimension of the aeration tank is  $4.5 \times 4.5 \times 3.7 \text{ m}^3$
- Dimensions of Sludge Drying Bed are 4.5 m x 4.5 m x 1 m of two numbers.

CHAPTER 8

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