PERFORMANCE OF MUNICIPAL SEWAGE TREATMENT PLANT AT TIRUPATI

A Project Report

Submitted to

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In partial fulfilment of the requirements for the award of the degree of

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in

CIVIL ENGINEERING

Submitted by

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SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

(Approved by AICTE & Affiliated to JNTUA, Anantapur)

(Accredited by NBA for Civil, EEE, ECE, MECH, & CSE)

(Accredited by NAAC with 'A' Grade)

Siddharth Nagar, Narayanavanam Road, Puttur- 517583, A.P

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DEPARTMENT OF CIVIL ENGINEERING

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CERTIFICATE

This is to certify that the project work entitled "**PERFORMANCE OF MUNICIPAL SEWAGE PLANT AT TIRUPATI**" ***is being submitted by***

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in partial fulfillment of the requirements for the award of BACHELOR OF TECHNOLOGY in CIVIL ENGINEERING to SIDDHARTH INSTITUTE OF ENGINEERING & TECHNOLOGY, PUTTUR (AUTONOMOUS). This project work or part thereof has not been submitted to any other University or Institute for the award of any degree.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

In India the effluent and sewage discharged from industries and urban settlements are the major source of pollution of surface water bodies like rivers, lakes, wetlands etc. resulting their environmental degradations. Therefore, proper collection, treatment and disposal of industrial wastes and domestic sewage is an essential pre-requisite for conservation of aforesaid natural water bodies in order to maintain their environmental sustainability which is also related to the general health of the public and the improvement of quality of life.

As per study carried out in 2003-04 by Central Pollution Control Board (CPCB), in India, the total waste water generation from class-I and class-II towns was 29000 million liters per day (MLD) in which only 6000 MLD received after treatment. The municipal wastewater treatment capacity developed so far in India is about 7000 MLD accounting for 24% of wastewater generation in these two classes of urban centers showing a huge gap between the sewage generation and treatment capacity.

Treated or partly treated or untreated wastewater is disposed into natural drains joining rivers or lakes or used on land for irrigation/fodder cultivation or disposed into the sea or a combination of them. The problem of treating sewage to the desired standards does not end with the construction of treatment plants. It is important that the assets created are operated and maintained properly.

Our project the Performance of Sewage Treatment Plant at Tirupati, where the plant is located at Tirupati, Andhra Pradesh., details the household sewage treatment happening at the plant i.e., source of sewage coming to the treatment plant, Sewage Treatment Plant Properties, Components of Sewage Treatment Plant, treating process of sewage, Tests done on sewage water before and after the treatment and other quantitative details, examining the treated sewage water whether it can be used for irrigation and agricultural purposes and proposing a possible method that could convert the treated sewage water into drinking water.

CHAPTER 1
INTRODUCTION

Sewerage is the art of collecting, treating and finally disposing of the sewage. Sewage is liquid, consists of any one or a mixture of liquid waste origins from urinals, latrines, bath rooms, kitchens of a dwelling, commercial building or institutional buildings.

Sewage treatment is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants.

Its objective is to produce a treated effluent and a solid waste or sludge suitable for discharge or reuse back into the environment. This material is often inadvertently contaminated with many toxic organic and inorganic compounds.

Sewage implies the collecting of wastewaters from occupied areas and conveying them to some point of disposal. The liquid wastes will require treatment before they are discharged into the water body or otherwise disposed of without endangering the public health or causing offensive conditions. As the cities have grown, the more primitive method of excreta disposal has gained place to the water-carried sewerage system. Even in the small cities the greater safety of sewerage, its convenience, and freedom from nuisance have caused it to be adopted wherever finances permit.

A large number of sewage treatment technologies have been developed, mostly using biological treatment processes. Engineers and decision makers need to take into account technical and economical criteria, as well as quantitative and qualitative aspects of each alternative when choosing a suitable technology. Often, the main criteria for selection are: desired effluent quality, expected construction and operating costs, availability of land, energy requirements and sustainability aspects.

At the global level, an estimated 52% of sewage is treated. However, sewage treatment rates are highly unequal for different countries around the world. For example, while high-income countries treat approximately 74% of their sewage, developing countries treat an average of just 4.2%.

Domestic wastewater contains both solid and dissolved pollutants including faecal matter, paper, urine, sanitary items, food residues and a variety of other contaminants. The sewer network usually also receives wastewaters from office and commercial properties and from industrial premises. Rainwater from roofs and roads may also drain into the sewer network.

The combined flow from these various sources travels through the sewer system and ultimately to a 'sewage works' where it receives treatment before discharge of the treated effluent to a stream, river, estuary or the sea. Collecting and treating wastewater has been even more beneficial to human health than the health service because it stopped water-borne diseases such as cholera and typhoid. Waste water treatment combines biological, chemical and physical unit process to purify large volumes of sewage.

Each unit process often based on a naturally occurring process- targets specific contaminants in a unique way. By analyzing waste water constituents at various stages of treatment, laboratory professionals play a vital role in the efficient operation of waste water treatment plants and thus help to protect the environmental and public health.

1.1 General:

- Storm sewage is a liquid flowing in sewer during or following a period of rainfall and resulting there from.
- A Partially Separate Sewer System is the sewerage system in which the domestic sewage is carried with the storm water in the rain season.
- Activated sludge is the active biological floc produced in activated sludge plants, largely composed of saprotrophic bacteria, protozoan flora (amoebae) and a range of other filter feeding species.
- Mixed Liquor Suspended Solids (MLSS) is the amount of suspended solids in the mix of raw water and activated sludge.
- Return activated sludge (R.A.S) is the activated sludge extracted from the system and mixed with raw water to form the mixed liquor.

- Waste activated sludge (W.A.S) or Surplus Activated Sludge (S.A.S) is excess activated sludge that is extracted from the system to be directed to sludge treatment.
- Sludge Age is the average residence time of biological solids in the system. It can be defined as the average lifespan of bacteria in the system.
- Overflow rate / Surface loading is the discharge per unit of plan area. This parameter is the design factor in designing the settling tanks.
- Food to Micro-organisms ratio (F/M ratio) is the ratio between daily BOD load applied to Aerator System and total microbial mass in the system.

1.2 Scope and Objective:

The objective of our project is to know about the working of the Municipal Sewage Treatment Plant at Tirupati and examining and getting conclusion about the water that whether it can be used for industrial and irrigational purpose or not and to come up with a idea that might convert the treated sewage water into drinking water.

CHAPTER 2

LITERATURE REVIEW

1. James R. Thompson (1987): The objectives of this study were to update information on the characteristics and management of wastes from water treatment plants and to assess the benefits and risks of alum sludge application to cropland. The report has three major sections: a literature review, a summary of results of a survey of Illinois water plant wastes, and a discussion of findings from a study of alum sludge for agricultural uses. The literature survey addresses characteristics and management of sludge. It discusses background information on sources and types of wastes, "and waste characteristics of coagulant sludge, lime sludge, iron and manganese sludge, brine wastes, filter wash wastewater, diatomite filter sludge, and sludge from saline water conversion. Minimizing sludge production can be achieved by chemical conservation, direct filtration, recycling, chemical substitution, and chemical recovery. Methods of waste treatment are co-treatment with sewage treatment, pre-treatment, and solids dewatering. Pre-treatment includes flow equalization, solids separation, and thickening. Dewatering can be achieved non-mechanically (lagooning, drying beds, freezing and thawing, and chemical conditioning) and mechanically (centrifugation; vacuum, pressure, and belt filtration; and pellet flocculation). Land application is usually used as an ultimate sludge disposal method.

2. Murni Po et al. (2003): The concept of beneficial use of treated wastewater has rapidly become an imperative for water agencies around the world. Water reclamation, recycling and reuse are now recognised as key components of water and wastewater management. Along with the technology advances in wastewater treatment, the opportunity for water reuse has never been more viable. The benefits of using recycled water include protection of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, groundwater recharge, and sustainability of water resource management. However, given these benefits, water reuse should not be treated simply as a means to an end but should be implemented in conjunction with other water conservation measures.

3. Catherine W. Kilelu (2004): This research report is part of a one-year internship with Cities Feeding People (CFP) program Initiative within IDRC. Funding for the internship was provided by IDRC’s Centre and Training Awards office. I would like to sincerely express my gratitude to all members of the CFP team who provided me with support and direction during the internship. I would especially like to thank Ana Boischio, my mentor for providing invaluable intellectual guidance. I am also grateful to other members of staff at the IDRC who assisted me at various points during my internship. My heartfelt thanks also go out to my fellow interns at the centre for their camaraderie. Outside of IDRC, I would like to thank my dear friend Taina Chahal for bringing the internship opportunities to my attention. The report benefited from comments provided by members of Cities Feeding People program. But views expressed in the report do not necessarily correspond to those of the program.

4. Karin Larsdotter (2006): Microalgae can be used for tertiary treatment of wastewater due to their capacity to assimilate nutrients. The pH increase which is mediated by the growing algae also induces phosphorus precipitation and ammonia stripping to the air, and may in addition act disinfecting on the wastewater. Domestic wastewater is ideal for algal growth since it contains high concentrations of all necessary nutrients. The growth limiting factor is rather light, especially at higher latitudes. The most important operational factors for successful wastewater treatment with microalgae are depth, turbulence and hydraulic retention time. To use microalgae for wastewater treatment is an old idea, and several researchers have developed techniques for exploiting the algae's fast growth and nutrient removal capacity. The nutrient removal is basically an effect of assimilation of nutrients as the algae grow, but other nutrient stripping phenomena also occur, e.g., ammonia volatilisation and phosphorus precipitation as a result of the high pH induced by the algae.

5. Kristen Holway (2011): The evidence presented in the literature relates to wastewater treatment processes or the sludge produced from wastewater treatment as opposed to untreated faecal sludge. However, examples of risks, failures, and opportunities for raw sludge treatment and reuse are discussed when available. In some cases, empirical evidence or case studies were not available for developing countries and alternatives are presented. Overall, we found the empirical evidence on waste treatment and reuse in developing countries is quite thin. A future literature review could examine the reuse potential of animal manures as a proxy for human waste since they possess similar characteristics and also harbour pathogens. A literature review of this nature was beyond the scope of the current brief. The purpose of this literature review is to provide qualitative and quantitative examples of technologies, constraints and incentives for efficient waste treatment and reuse in Sub-Saharan Africa and Southeast Asia. The review is structured to address several statements and questions posed by Water, Sanitation, & Hygiene project implementers; each section presents relevant case studies and expert observations and experiences.

6. Niraj S. Topare et al. (2011): Sewage/wastewater treatment technologies. The main purpose of Sewage treatment process is to remove the various constituents of the polluting load: solids, organic carbon, nutrients, inorganic salts, metals, pathogens etc. Effective wastewater collection and treatment are of great importance from the standpoint of both; environmental and public health. Sewage/Wastewater treatment operations are done by various methods in order to reduce its water and organic content, and the ultimate goal of wastewater management is the protection of the environment in a manner commensurate with public health and socio-economic concerns. In this article, Sewage/Wastewater treatment techniques, factors affecting selection and design. Sewage/Wastewater systems are discussed briefly.

7. Manoj Yadav and Dharmendra (2014): Interest in wastewater reuse is increasing all over the world. India, as a developing country also faces water crisis. Hence, reuse of wastewater is an emerging field which is attracting new researches to develop new technologies to curb this rapidly growing problem of water crisis. Implementation of wastewater reuse leads to sustainable development thereby helps in reducing the water demand and the overall sewage production. The success of water reuse projects does not depend only on the availability of technology and policy, but also on the willingness and the presence of institutional infrastructures. It should also be ensured that the treated water should be monitored and distributed safely. Most of reuse systems are found applicable to a particular wastewater or environmental and economic conditions, thus highlighting the need of system that can work in different conditions satisfactorily. So, a detailed literature review of two important chemical and biological processes used in wastewater reuse system has been done here and their efficiencies are found. The paper also examines the performance of reuse systems by taking environmental and Economic factors into account and thus the limitation and gaps in the existing works are identified and future scope of study in this field is discussed.

8. Joao Paulo Borges Pedro et al. (2016): The riverine communities of the Amazon varzea are almost devoid of environmental sanitation. This situation exposes the population to risks of diseases. One of the most serious problems is related to the lack of treatment of human waste and sewage, which causes environmental, aesthetic and health problems. Given these findings, this study is a literature review that aims to evaluate domestic effluents treatment systems that are compatible with the reality of the Amazonian varzea and thus establish a social technology that enables the promotion of basic sanitation for the riverine populations. We surveyed information on the treatment technologies most commonly used in the country, discussing the particularities of each and the limitations of the varzea ecosystems, such as the presence of wetlands and the lack of electricity. From the discussion we concluded that the set septic tank anaerobic filter and constructed wetlands were more suitable for wastewater treatment in the varzea, because theirs building materials can be adapted to the humidity, do not require electricity and can be installed individually by residents. We recommend further studies on the adaptations of these technologies to meet the regional needs.

9. Rakesh Singh Asiwal et al. (2016): Most of the river basins are closing or closed to severe water shortages, brought on by the simultaneous effects of agricultural growth, industrialization and urbanization. Performance of state-owned sewage treatment plants, for treating municipal waste water, and common effluent treatment plants, for treating effluent from small scale industries, is also not complying with prescribed standards. Thus, effluent from the treatment plants, often, not suitable for household purpose and reuse of the waste water is mostly restricted to agricultural and industrial purposes. The development of innovative technologies for treatment of wastewaters from various industries is a matter of alarming concern for us. Although many research papers have been reported on wastewater pollution control studies, but a very few research works are carried out for treatment of wastewater of steel industries, especially in reference to development of design of industrial effluent Treatment Plants (ETP) system. Another beneficial aspect of this research work will be recycling, reuse of water and sludge from steel industry The whole technologies for treating industrial wastewater can be divided into four categories: - Chemical, Physical, Biological and mathematical approaches.

10. Maaz Allah Khan et al. (2017): 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 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. Sewage / waste water treatment consist of different processes which protect the environment & human through cleansing the water pollutant. In history people used difference method of treatment for purification of water which get advance by advancement in technological world.

11. Gregorio Crini and Eric Lichtfouse (2019): During the last 30 years, environmental issues about the chemical and biological contaminations of water have become a major concern for society, public authorities and the industry. Most domestic and industrial activities produce wastewaters containing undesirable toxic contaminants. In this context, a constant effort must be made to protect water resources. Current wastewater treatment methods involve a combination of physical, chemical and biological processes, and operations to remove insoluble particles and soluble contaminants from effluents. This article provides an overview of methods for wastewater treatment, and describes the advantages and disadvantages of available technologies.

12. Ruksana T P And Priyanka T (2019): To explain the basic needs of the population we need technology to deliver secure and safe sources of water for production of food and energy. Water reclamation, recycling, and reuse address these challenges by resolving water resource issues and creating new sources of high-quality water supplies. One of the most challenging aspects of a sustainable sewage treatment system design is the analysis and selection of the treatment processes and technologies capable of meeting the requirements. This paper reviews various technologies of waste water treatment and describes the process of selection of suitable technology based on certain established criteria.

13. Zahra Aghalari et al. (2020): Examined the entry of wastewater into the environment and the transportation of microbial contaminants to humans and organisms, environmental protection requires the use of appropriate purification systems with high removal efficiency for microbial agents are needed. The purpose of this study was to determine the efficacy of current wastewater treatment systems in removing microbes and their contaminants.

14. Cui Wang et al. (2021): With the increase in industrialization and urbanization, water pollution has become increasingly serious, and wastewater treatment has become a common step in preventing this. For a greater understanding of the sustainability of different wastewater treatment systems, two processes, Anaerobic Baffled Reactor + Anaerobic-Anoxic-Oxic and Anaerobic Baffled Reactor + Cyclic Activated Sludge System, were selected, and their sustainability was evaluated based on three indicators, namely energy yield ratio, environmental load rate, and energy sustainability development index, according to energy theory. The results show that the energy yield ratio and environmental load rate of the ABR + CASS process were lower than those of the ABR + A2/O process, and the energy sustainability development index of the ABR + CASS process was higher than that of the ABR + A2/O process, showing better sustainability. The research methods and findings of this study play an important role for decision makers in selecting sustainable wastewater treatment processes.

15. Kavindra Kumar Kesari et al. (2021): The study points out the associated health concern for farmers, who are working in wastewater-irrigated fields along with the harmful effects of untreated wastewater. The consumption of crop irrigated by wastewater has leading health implications also discussed in this review paper. This review further reveals that our current understanding of the wastewater treatment and use in agriculture with addressing advancements in treatment methods has great future possibilities.

CHAPTER 3
SPECIFICATIONS OF MUNICIPAL SEWAGE TREATMENT PLANT AT TIRUPATI

3.1 Properties of Sewage Treatment Plant:

Total extent of land	-	299.50 Acres
Plant Area	-	150 Acres
Method of Treatment	-	Primary (Oxidation Ponds)
Design Capacity	-	100.00 MLD (Million Liters per Day)
Installed Capacity	-	50.00 MLD
Quantity of Sewage Generated	-	31.00 MLD
Quantity of Sewage Treated	-	33.00 MLD
Quantity of Supply of Primary Treated water to Srikalahasti Pipes Limited	-	3.00 MLD @ Rs.5.85/KL
Length of main sewer, Sub-main Sewer, Branch Sewer and Lateral Sewer	-	260 Kms
Diameter of Main Sewer	-	1200 mm
Diameter of Sub Sewer	-	150 mm
Diameter of Main Chamber	-	56 m
Depth of Main Chamber	-	18 m
Total Area of City	-	27.44 Sq. Kms
Percentage of Sewage Area Covered	-	57%
No of Lakes Present	-	06
Total Sewage Collected	-	30.00 MLD

Motors

80 HP	- 3 No’s (Head - 13 mtrs & Discharge - 1050 Cum/Hr)
40 HP	- 2 No’s (Head - 13 mtrs & Discharge - 540 Cum/Hr)

Components

Bar Screen Chamber	- For removal of Floating Matter
Grit Chamber	- For removal of Grit
Wet Well & Pump House	- To pump the water into Ponds
Facultative Pond	- Detention Period 10 Days
Maturation Pond	- Detention Period 10 Hours
Final Collection Tank	- Outfall of water through Irrigation Canal (Local Isuka Vagu)

3.2 Source of Sewage Water:

A system of sewer pipes (sewers) collects sewage and takes it for treatment or disposal. The system of sewers is called sewerage or sewerage system, where a main sewerage system has not been provided, sewage may be collected from homes by pipes into septic tanks or cesspits, where it may be treated collected in vehicles and taken for treatment or disposal

The Sewage water from all over Tirupati is pumped into the Sewage Treatment Plant’s Manhole through Main and Sub Sewers. The Sewage from the nearby village’s septic tanks is collected and carried to the Sewage Treatment Plant through Tractors and dumped into the Manhole. From the manhole, the sewage is directed to the Treatment Process.

3.3 <u>Treatment Process of Sewage and Receiving Environment:</u>

The treatment of sewage consists of many complex functions. The degree of treatment depends upon the characteristics of the raw inlet sewage as well as the required effluent characteristics. In the Sewage Treatment Plant at Tirupati, the treatment is done in four main steps which involves the process of preliminary and primary treatment followed by secondary treatment of Sewage.

3.3.1 Preliminary Treatment

Primary treatment consists in removing large suspended organic solids. It is usually accomplished by sedimentation in settling basins. The liquid effluent from the primary treatment often contains a large amount of suspended organic material and has a high BOD (about 60% of original).

The steps involved in Preliminary Treatment are

1. Desludging
2. Bar Chamber
3. Grit Chamber
4. Pumping into Ponds through Pipes.

1. Desludging:

The sewage from the manhole is sent into the Desludging tank and here the sewage water is stirred in order to make the thick, solid type sewage to loosen and to become thinned sewage water.

Fig 3.3.1.1: Desludging Tank

From this through pipes, the thinned sewage water is sent into Bar Chamber by enabling the opening valve as in fig

Fig 3.3.1.1: Opening Valve

2. Bar Chamber:

The thinned sewage from the desludging tank enters here into the Bar Chamber. Here the floating matter like Plastics, Plants, Leaves, etc., are removed. For every 30 minutes two of the working men climb down into the bar chamber and remove the floating matter manually.

Fig 3.3.1.2: Bar Chamber

From the Bar Chamber, the sewage water is sent into the Grit Chamber.

3. Grit Chamber:

Grit removal basins are the sedimentation basins used to remove the inorganic particles having specific gravity of 2.65 such as sand, gravel, grit, egg shells and other non-putrescible materials that may clog channels or damage pumps due to abrasion and to prevent their accumulation in sludge digesters. The grit chamber is designed to scour the lighter organic particles while the heavier grit particles remain settled.

Here, the Grit Chamber is used for two purposes, one is to slow down the flow of sewage from the bar chamber and to retain the sewage water temporarily so that the inorganic particles like sand, gravel, grit, egg shells and other non-putrescible materials settle down at the bottom of the chamber.

Fig 3.3.1.3: Grit Chamber

After the settling down of those inorganic particles, the Sewage water is sent into the wet well.

4. **Wet Well & Pump House:**

The Wet Well has the capacity of storing 100 MLD of sewage water and runs regularly at 50 MLD capacity daily. The wet well also have pump house which contains 3 No's of 80 HP motors and 2 No's of 40HP motors. These motors are used to pump the sewage water from the wet well to the oxidation ponds.

The 80 HP motor can pump 1.00 ML of sewage water into the ponds for the time of one hour and the 40 HP motor can pump 0.50 ML of sewage water into the ponds for the time of one hour.

Fig 3.3.1.4: Wet Well

Fig 3.3.1.4: Motors & Pump House

3.3.2 Primary Treatment:

Here the effluent from preliminary treatment is treated through biological decomposition of organic matter carried out by aerobic conditions. The effluent from the preliminary treatment contains a little BOD (5% to 10% of original) and may contain several milligrams per litre of s DO. The aerobic biological unit used here is Oxidation Ponds.

Oxidation Ponds:

Oxidation ponds, also called lagoons or stabilization ponds, are large, shallow ponds designed to treat wastewater through the interaction of sunlight, bacteria, and algae. Algae grow using energy from the sun and Carbon Dioxide and inorganic compounds released by bacteria in water. During the process of photosynthesis, the algae release oxygen needed by aerobic bacteria. Mechanical aerators are sometimes installed to supply yet more oxygen, thereby reducing the required size of the pond. Sludge deposits in the pond must eventually be removed by dredging. Algae remaining in the pond effluent can be removed by filtration or by a combination of chemical treatment and settling.

There are 6 oxidation ponds with the total combined capacity of storing 30.00 to 33.00 MLD. The detention period i.e., the period of time that the water stays in the oxidation ponds is around 10 Days in Summer and 15 Days in Winter.

Fig 3.3.2: Oxidation Ponds

3.3.3 Secondary Treatment:

After the stabilization of water at oxidation ponds, the water is pumped into the chemical treatment where the Algae present in the water is removed through chemical treatment. The water here is treated with Alum (Potassium Aluminium Sulphate i.e., $KAl(SO_4)_2 \cdot 12H_2O$) and Chlorine (Cl) to remove the Algae and other effluents present in it.

Here at this plant, this is the final process and after this process the water is sent to the receiving environment.

Fig 3.3.3: Alum used at the plant during the chemical treatment

Fig 3.3.3: Water Entering from Oxidation Ponds to Chemical Treatment Tank

Fig 3.3.3: Chemical Treatment Tank

Receiving Environment :

For a day, at this plant 31.00 to 33.00 ML of sewage water is treated. In that sewage water 3.00 ML is sent to Srikalahasti Pipes Limited through underground sewer pipes and the remaining 28.00 to 30.00 ML of treated water is sent to the Srikalahasti's nearby villages for agriculture purposes.

Fig 3.3: Our Visit to Municipal Sewage Treatment Plant at Tirupati

3.4 <u>Testing Analysis of the Treated Sewage Water</u>

In our case study, to know the properties of the treated sewage water, we've performed various tests on the collected samples of treated water in our college laboratory. The tests performed are

1. pH
2. Conductivity
3. Alkalinity
4. Acidity
5. Dissolved Oxygen
6. Biochemical Oxygen Demand
7. Total Solids, Total Dissolved and Suspended Solids

1. pH

pH is a measure of the acidic or basic (alkaline) nature of a solution (concentration of the hydrogen ion [H+] activity in a solution determines the pH). The pH scale ranges from 0 to 14, which is the most acidic, a pH of 7 is neutral, and 14 is the most alkaline. Determination of pH is one of the important objectives in biological treatment of the wastewater. In anaerobic treatment, if the pH goes below 5 due to excess accumulation of acids, the process is severely affected. Shifting of pH beyond 5 to 10 upsets the aerobic treatment of the wastewater. In these circumstances, the pH is generally adjusted by addition of suitable acid or alkali to optimize the treatment of the wastewater.

pH value or range is of immense importance for any chemical reaction. A chemical shall be highly effective at a particular pH. Chemical coagulation, disinfection, water softening and corrosion control are governed by pH adjustment. Lower value of pH below 4 will produce sour taste and higher value above 8.5 a bitter taste. Higher values of pH hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chlorine. High pH induces the formation of trihalomethanes, which are causing cancer in human beings.

Here the pH test is conducted to know whether the treated sewage water is acidic and basic.

PRINCIPLE

The pH electrode used in the pH measurement is a combined glass electrode. It consists of sensing half-cell and reference half-cell, together form an electrode system. The sensing half-cell is a thin pH sensitive semi permeable membrane, separating two solutions, viz., the outer solution, the sample to be analyzed and the internal solution, enclosed inside the glass membrane and has a known pH value. An electrical potential is developed inside and another electrical potential is developed outside, the difference in the potential is measured and is given as the pH of the sample.

APPARATUS REQUIRED:

1. pH meter
2. Standard flask
3. Magnetic Stirrer
4. Beaker
5. Wash Bottle
6. Tissue Paper
7. Buffers Solutions of pH 4.0, 7.0 and 9.2
8. Phenolphthalein indicator.
9. Methyl orange indicator.

PROCEDURE:

1. Calibrate the electrode with two standard buffer solutions of pH 7 and pH 4.0 or pH 9.2.
2. The sample temperature is determined at the time and is entered into the meter to allow for a temperature correction.
3. Rinse the electrode thoroughly with distilled water and carefully wipe with a tissue paper.
4. Dip the electrodes in to the sample solution; swirl the solution and wait ± 0.1 pH unit will be adequate for such work.
5. The reading is taken after the indicated value remains constant for about a minute.

USING INDICATORS:

1. Add two drops of Methyl orange indicator to the sample if it turns to pink, the sample has < 4.2 pH.
2. Add two drops of Methyl orange indicator to the sample, there is no colour change the sample has > 4.2 pH.
3. Add two drops Phenolphthalein indicator to the sample, there is no color change the sample has > 4.2 pH.
4. Add two drops Phenolphthalein indicator to the sample turns in to pink; the sample has> 8.3 pH.

2. CONDUCTIVITY

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity is useful as a general measure of water quality. Significant changes in conductivity could then be an indicator that a discharge or some other source of pollution has entered the aquatic resource.

Significant changes (usually increases) in conductivity may indicate that a discharge or some other source of disturbance has decreased the relative condition or health of the water body and its associated biota. Generally, human disturbance tends to increase the amount of dissolved solids entering waters which results in increased conductivity.

Water bodies with elevated conductivity may have other impaired or altered indicators as well. Electrical conductivity measurements are often employed to monitor desalination plants. It is useful to assess the source of pollution.

In coastal regions, conductivity data can be used to decide the extent of intrusion of sea water into ground water. Conductivity data is useful in determining the suitability of water and wastewater for disposal on land.

Irrigation waters up to 2 milli siemens / cm conductance have been found to be suitable for irrigation depending on soils and climatic characteristics. It is also used indirectly to fine out inorganic dissolved solids.

The electrical conductivity can be expressed as mhos (Reciprocal of ohms) or as siemens. The conductivity of water is a measure of the ability of water to carry an electric current. In most water, the conductivity is very low, so milli siemens or micro siemens are used as units for water conductivity.

The conductivity of water is directly linked to the concentration of the ions and their mobility. The ion in water acts as electrolytes and conducts the electricity.

The conductivity depends on the value of the pH, on the temperature of measurement and on the amount of CO2 which has been dissolved in the water to form ions.

The conductivity is also affected by the concentration of ions already present in the water such as chloride, sodium and ammonium. Chemical composition of water determines its conductivity. Hence this becomes the most widely used measure of the purity of water.

PRINCIPLE

Conductivity is measured with a probe and a meter. A voltage is applied between the two electrodes in the probe immersed in the sample water. The drop-in voltage caused by the resistance of the water is used to calculate the conductivity per centimeter. Conductivity (G), the inverse of resistivity (R) is determined from the voltage and current values according to Ohm's law. i.e., R=V/I then, G=1/R=I/V. The meter converts the probe measurement to micro mhos per centimeter and displays the result for the user.

1. APPARATUS REQUIRED

1. Conductivity Meter with Electrode /ATC probe
2. Magnetic Stirrer with stirring bead
3. Standard flask
4. Measuring jar
5. Beaker 250 ml
6. Funnel
7. Tissue Paper

2. CHEMICALS REQUIRED

1. Potassium Chloride
2. Distilled Water

PROCEDURE:

1. Rinse the electrode thoroughly with deionized water and carefully wipe with a tissue paper.
2. Measure 200 ml of water sample and transfer it to a beaker and place it on the magnetic stirrer.
3. Dip the electrode into the sample solution taken in a beaker and wait for a steady reading. Make sure that the instrument is giving stable reading.
4. Note down the reading in the display directly, which is expressed in milli siemens.

3. ALKALINITY

Alkalinity is a measure of the capacity of water to neutralize acids. Alkaline compounds in the water such as bicarbonates, carbonates, and hydroxides remove H+ ions and lower the acidity of the water (which means increased pH).

These alkaline compound's presence in sewage water could cause an immediate change in the pH. So, to know about the alkalinity of the sewage water, the Alkalinity test is conducted.

Alkalinity is primarily a way of measuring the acid neutralizing capacity of water. In other words, its ability to maintain a relatively constant pH. The possibility to maintain constant pH is due to the hydroxyl, carbonate and bicarbonate ions present in water.

The ability of natural water to act as a buffer is controlled in part by the amount of calcium and carbonate ions in solution.

Carbonate ion and calcium ion both come from calcium carbonate or limestone. So, water that comes in contact with limestone will contain high levels of both Ca^{++} and CO_3^{2-} ions and have elevated hardness and alkalinity.

PRINCIPLE:

The alkalinity of water can be determined by titrating the water sample with Sulphuric acid of known values of pH, volume and concentrations.

Based on stoichiometry of the reaction and number of moles of sulphuric acid needed to reach the end point, the concentration of alkalinity in water is calculated. When a water sample has a pH of greater than 4.5 is titrated with acid to a pH 4.5 end point, all OH^-, CO_3^{2-}, and HCO_3^- will be neutralized.

For the pH more than 8.3, add phenolphthalein indicator, the color changes to pink color. This pink color is due to presence of hydroxylions. If sulphuric acid is added to it, the pink colour disappears i.e., OH^- ions are neutralized.

Then add mixed indicator, the presence of CO_3^2 and HCO_3^- ions in the solution changes the colour to blue. While adding sulphuric acid, the colour changes to red, this colour change indicates that all the CO_3^{2-} and HCO_3^- ions has been neutralized. This is the end point.

1. APPARATUS REQUIRED

1. Burette with Burette stand and porcelain title
2. Pipettes with elongated tips
3. Pipette bulb
4. Conical flask (Erlenmeyer Flask)
5. 250 ml Measuring cylinders
6. Standard flask
7. Wash Bottle
8. Beakers

2. CHEMICALS REQUIRED

1. Standard sulphuric acid
2. Phenolphthalein
3. Mixed Indicator
4. Distilled Water

PROCEDURE:

1. Take 20ml of the given sample in a clean conical flask.
2. Add 2 or 3 drops of Phenolphthalein indicator and titrate this solution against the standardized sulphuric acid till the pink colour disappears.
3. Note down the volume of the H2SO4 (V1).
4. To the same solution add 2 or 3 drops of Methyl Orange indicator and continue the titration till the end point is reached (pink to yellow)
5. Repeat the titrations for concordant value.
6. Note down the total volume of H2SO4 (V2).

FORMULA:

$$\text{Phenolphthalein alkalinity (in terms of } CaCO_3) = \frac{V_1 \times 50 \times N \times 10^6}{20 \times 1000} \text{ ppm}$$

$$\text{Methyl Orange alkalinity (in terms of } CaCO_3) = \frac{(V_1 + V_2) \times 50 \times N \times 10^6}{20 \times 1000} \text{ ppm}$$

4. ACIDITY

Acidity is a measure of the capacity of water to neutralize bases. Acidity is the sum of all acid present in the water sample. Strong mineral acids, weak acids such as carbonic acid, acetic acid present in the water sample contributes to acidity of the water.

Usually dissolved carbon dioxide (CO_2) is the major acidic component present in the unpolluted surface waters.

The volume of standard alkali required to titrate a specific volume of the sample to pH 8.3 is called phenolphthalein acidity (Total Acidity).

The volume of standard alkali required to titrate a specific volume of the water sample (wastewater and highly polluted water) to pH 3.7 is called methyl orange acidity (Mineral Acidity).

Acidity interferes in the treatment of water. Carbon dioxide is of important considerations in determining whether removal by aeration or simple neutralization with lime /lime soda ash or NaOH will be chosen as the water treatment method.

The size of the equipment, chemical requirements, storage spaces and cost of the treatment all depends on the carbon dioxide present. Aquatic life is affected by high water acidity.

The organisms present are prone to death with low pH of water. High acidity water is not used for construction purposes, especially in reinforced concrete construction due to the corrosive nature of high acidity water.

Water containing mineral acidity is not fit for drinking purposes. Industrial wastewaters containing high mineral acidity is must be neutralized before they are subjected to biological treatment or direct discharge to water sources.

PRINCIPLE

Hydrogen ions present in a sample as a result of dissociation or hydrolysis of solutes reacts with additions of standard alkali (NaOH). Acidity thus depends on end point of the indicator used. The color change of phenolphthalein indicator is close to pH 8.3 at 25ºC corresponds to stoichiometric neutralization of carbonic acid to bicarbonate.

1. APPARATUS REQUIRED

1. Burette with Burette stand
2. porcelain tile
3. 500 ml conical flask
4. Pipette with elongated tips
5. Pipette bulb
6. Conical flask
7. Measuring cylinders
8. Wash Bottle and Beakers

2. CHEMICALS REQUIRED

1. Sodium Hydroxide
2. Phenolphthalein
3. Methyl Orange
4. Distilled Water

PROCEDURE

1. Take 20ml of the given sample in a clean conical flask.
2. Add two drops of Methyl orange indicator and titrate against N/50 NaOH solution until the colour changes from pink to yellow.
3. Note down the volume of the NaOH, (V_1).
4. Add 2 or 3 drops of Phenolphthalein indicator and titrate against NaOH solution until the appearance of pink colour and repeat the titrations for concordant value.
6. Note down the total volume of NaOH, (V_2).
7. Carry out the titration quickly so as to avoid any loss of CO_2 and avoid vigorous shaking and repeat the titration for concordant value.

FORMULA

$$\text{Methyl Orange acidity due to mineral acids as } CaCO_3 = \frac{V_1 \times 50 \times N \times 10^6}{20 \times 1000} \text{ ppm}$$

$$\text{Phenolphthalein acidity as } CaCO_3 = \frac{(V_1 + V_2) \times 50 \times N \times 10^6}{20 \times 1000} \text{ ppm}$$

Acidity due to Carbonic acid = Total Acidity - Mineral Acidity

5. DISSOLVED OXYGEN

Dissolved oxygen refers to the total amount of oxygen currently present in the water. A key component of water is the amount of dissolved oxygen that's in the water, which plays an important role in everything from the quality of water to the livelihood of plants and animals. Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process.

The amount of oxygen consumed by these organisms in breaking down the waste is known as the biochemical oxygen demand or BOD. Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.DO levels fluctuate seasonally and over a 24-hour period. They vary with water temperature and altitude.

The term Dissolved Oxygen is used to describe the amount of oxygen dissolved in a unit volume of water. Dissolved oxygen (DO) is essential for the maintenance of healthy lakes and rivers. It is a measure of the ability of water to sustain aquatic life. The dissolved oxygen content of water is influenced by the source, raw water temperature, treatment and chemical or biological processes taking place in the distribution system.

Hence, analysis of dissolved oxygen is an important step in water pollution control and wastewater treatment process control. There are various methods available to measure Dissolved Oxygen, which we will discuss in detail. In a healthy body of water such as a lake, river, or stream, the dissolved oxygen is about 8 parts per million. The minimum DO level of 4 to 5 mg/L or ppm is desirable for survival of aquatic life.

Drinking water should be rich in dissolved oxygen for good taste. DO test is used to evaluate the pollution strength of domestic and industrial waste. Higher values of DO may cause corrosion of Iron and Steel. It is necessary to know DO levels to assess quality of raw water and to keep a check on stream pollution.

DO test is the basis for BOD test which is an important parameter to evaluate organic pollution potential of a waste. DO test is necessary for all aerobic biological wastewater treatment processes to control the rate of aeration

PRINCIPLE:

Dissolved Oxygen can be measured either by titrimetric or electrometric method. Titrimetric method is based on the oxidizing property of DO while the electrometric method (using membrane electrodes) is based on the rate of diffusion of molecular oxygen across a membrane. It is most accurate method to determine DO.

1. APPARATUS REQUIRED

1. Burette
2. Burette stand
3. 300 ml glass stoppered BOD bottles
4. 500 ml conical flask
5. Pipettes with elongated tips
6. Pipette bulb
7. Wash bottle

2. CHEMICALS REQUIRED

1. Manganous sulphate solution
2. Alkaline iodide-azide solution
3. Sulfuric acid, Concentrated
4. Starch indicator solution
5. Sodium thiosulphate
6. Distilled or deionized water

PROCEDURE:

1. Take the BOD bottle and collect 250ml of water sample into it.
2. Add 2ml of Manganous sulphate ($MnSO_4$) and 2ml of Alkali iodide –azide solution into the sample.
3. Re-stopper with care to exclude air bubbles and mix by repeatedly inverting the bottle 2 to 3 times.
4. If no oxygen is present, results in formation of white precipitate. If oxygen present, some Mn^{++} is oxidized to M^{++++} and precipitates as brown coloured manganic oxide.

5. After shaking and allowing sufficient time for all oxygen to react, the chemical precipitates are allowed to settle leaving clear liquid within the upper portion.

6. Add 2ml of concentrated sulfuric acid (H_2SO_4) to dissolve the precipitate.

7. The bottle is re-stoppered and mixed by inverting until the suspension is completely dissolved and yellow colour is uniform throughout the bottle.

8. A volume of 100 ml is taken into a conical flask and add 2ml of starch solution and titrate against the Standard Sodium thiosulphate (0.01 N) solution until blue colour turns to colour less. Note the volume of Hypo used (V)ml

9. Repeat the titrations till the concordant value are obtained.

FORMULA:

$$\text{Dissolved Oxygen in the given sample} = \frac{\text{Titre value X Conc. of Hypo X 8 X1000}}{\text{Volume of Sample}}$$

$$= \text{Titre value X 0.01 X 8 X 1000/100}$$

6. BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand, or BOD, measures the amount of oxygen consumed by microorganisms in decomposing organic matter in stream water. BOD also measures the chemical oxidation of inorganic matter (i.e., the extraction of oxygen from water via chemical reaction). A test is used to measure the amount of oxygen consumed by these organisms during a specified period of time (usually 5 days at 20 C). The rate of oxygen consumption is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. BOD directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die.

BOD is the principle test to give an idea of the biodegradability of any sample and strength of the waste. Hence the amount of pollution can be easily measured by it. Efficiency of any treatment plant can be judged by considering influent BOD and the effluent BOD and so also the organic loading on the unit. Ordinary domestic sewage may have a BOD of 200 mg/L. Any effluent to be discharged into natural bodies of water should have BOD less than 30 mg/L. This is important parameter to assess the pollution of surface waters and ground waters where contamination occurred due to disposal of domestic and industrial effluents. Drinking water usually has a BOD of less than 1 mg/L. But, when BOD value reaches 5 mg/L, the water is doubtful in purity. The determination of BOD is used in studies to measure the self-purification capacity of streams and serves regulatory authorities as a means of checking on the quality of effluents discharged to stream waters. The determination of the BOD of wastes is useful in the design of treatment facilities. It is the only parameter, to give an idea of the biodegradability of any sample and self- purification capacity of rivers and streams. The BOD test is among the most important method in sanitary analysis to determine the polluting power, or strength of sewage, industrial wastes or polluted water. It serves as a measure of the amount of clean diluting water required for the successful disposal of sewage by dilution.

PRINCIPLE:

The sample is filled in an airtight bottle and incubated at specific temperature for 5 days. The dissolved oxygen (DO) content of the sample is determined before and after five days of incubation at 20°C and the BOD is calculated from the difference between initial and final DO. The initial DO is determined shortly after the dilution is made; all oxygen uptakes occurring after this measurement is included in the BOD measurement.

APPARATUS REQUIRED

1. BOD Incubator
2. Burette & Burette stand
3. 300 ml glass stopper BOD bottles
4. 500 ml conical flask
5. Pipettes with elongated tips
6. Pipette bulb
7. 250 ml graduated cylinders
8. Wash bottle

CHEMICALS REQUIRED

1. Calcium Chloride
2. Magnesium Sulphate
3. Ferric Chloride
4. Di Potassium Hydrogen Phosphate
5. Potassium Di Hydrogen Phosphate
6. Di sodium hydrogen phosphate
7. Ammonium Chloride
8. Manganous sulphate
9. Potassium hydroxide
10. Potassium iodide
11. Sodium azide
12. Concentrated sulfuric acid
13. Starch indicator
14. Sodium thiosulphate
15. Distilled or deionized water

PROCEDURE:

1. Take the BOD bottle and add 1%, 2%, 3%, 4% & 5% of wastewater sample into BOD bottle, dilute the sample with the tap water and mix the contents well.

2. Immediately find initial D.O of a diluted wastewater.

3. Add 1ml of Manganous sulphate and 1ml of Alkali iodide –azide solution to the sample. The tip of the pipette should be below the liquid level, while adding these reagents.

4. Restopper with care to exclude air bubbles and mix by repeatedly inverting the bottle 2 to 3 times.

5. If no oxygen is present, results in formation of white precipitate. If oxygen present, some Mn++ is oxidized to M++++ and precipitates as brown coloured manganic oxide.

6. After shaking and allowing sufficient time for all oxygen to react, the chemical precipitates are allowed to settle leaving clear liquid within the upper portion.

7. 1ml of concentrated sulphuric acid is added.

8. The bottle is restoppered and mixed by inverting until the suspension is completely dissolves; yellow colour is uniform thought the bottle.

9. A volume of 200 ml is taken into a conical flask and add 1ml of starch solution and titrate against the Standard Sodium thiosulphate (0.025 N) solution until blue colour turns to colour less.

10. Take another BOD bottle and add 1%, 2%, 3%,4% & 5% of wastewater sample into BOD bottle, Dilute the sample with the tap water and mix the contents well.

11. Incubate the other one BOD bottle at 20oC for 5 days. They are to be tightly stoppered to prevent any air entry in to the bottles

12. Determine the final D.O content in the incubated bottle at end of 5 days by above process.

FORMULA:

$$\text{Biochemical Oxygen Demand} = \frac{(D_0 - D_5) \times \text{Volume of the diluted sample}}{\text{Volume of sample taken}}$$

7. TOTAL SOLIDS, TOTAL DISSOLVED SOLIDS & SUSPENDED SOLIDS

The term total dissolved solids refer to materials that are completely dissolved in water. These solids are filterable in nature. It is defined as residue upon evaporation of filterable sample. The term total suspended solids can be referred to materials which are not dissolved in water and are non-filterable in nature. It is defined as residue upon evaporation of non- filterable sample on a filter paper.

Dissolved minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odour. Some dissolved organic chemicals may deplete the dissolved oxygen in the receiving waters and some may be inert to biological oxidation, yet others have been identified as carcinogens.

Water with higher solids content often has a laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them. High concentration of dissolved solids about 3000 mg/L may also produce distress in livestock. In industries, the use of water with high number of dissolved solids may lead to scaling in boilers, corrosion and degraded quality of the product.

Estimation of total dissolved solids is useful to determine whether the water is suitable for drinking purpose, agriculture and industrial purpose. Suspended material is aesthetically displeasing and provides adsorption sites for chemical and biological agents. Suspended organic solids which are degraded anaerobically may release obnoxious odors. Suspended solids exclude light, thus reducing the growth of oxygen producing plants.

PRINCIPLE

A well-mixed sample is filtered through a standard glass fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 179-181°C. The increase in dish weight represents the total dissolved solids.

A well-mixed sample is filtered through a weighed standard glass fiber filter and the residue retained on the filter is dried to a constant weight at 103-105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, the difference between the total solids and total dissolved solids may provide an estimate of the total suspended solids.

APPARATUS REQUIRED

1. Evaporating Dish
2. Water Bath
3. Oven
4. Desiccators
5. Analytical Balance
6. Graduated Cylinders
7. Dish Tongs
8. Gooch Crucibles
9. Filter
10. Vacuum Pumps
11. Crucible tongs
12. Forceps, Smooth -tipped

TESTING OF SAMPLE FOR TOTAL DISSOLVED SOLIDS

To measure total dissolved solids, take a clean porcelain dish which has been washed and dried in a hot air oven at 180°C for one hour

1. Now weigh the empty evaporating dish in analytical balance. Let's denote the weight measured as W_1
2. Mix sample well and pour into a funnel with filter paper. Filter approximately 80 100 ml of sample.
3. Using pipette transfer 75ml of unfiltered sample in the porcelain dish.
4. Switch on the oven and allowed to reach 105°C. Check and regulate oven and furnace temperatures frequently to maintain the desired temperature range.
5. Place it in the hot air oven and care should be taken to prevent splattering of sample during evaporation or boiling.
6. Dry the sample to get constant mass. Drying for long duration usually 1 to 2 hours is done to eliminate necessity of checking for constant mass.
7. Cool the container in a desiccator. Desiccators are designed to provide an environment of standard dryness. This is maintained by the desiccant found inside. Don't leave the lid off for

prolonged periods or the desiccant will soon be exhausted. Keep desiccator cover greased with the appropriate type of lubricant in order to seal the desiccator and prevent moisture from entering the desiccator as the test glassware cools.

8. We should weigh the dish as soon as it has cooled to avoid absorption of moisture due to its hygroscopic nature. Samples need to be measured accurately, weighed carefully, and dried and cooled completely.

9. Note the weight with residue as W_2

TESTING OF SAMPLE FOR TOTAL SUSPENDED SOLIDS

1. Place filtration apparatus with weighed filter in filter flask. Mix sample well and pour into a graduated cylinder to the selected volume.
2. Apply suction to filter flask and seat filter with a small amount of distilled water.
3. Pour selected volume into filtration apparatus.
4. Draw sample through filter into filter flask.
5. Rinse graduated cylinder into filtration apparatus with three successive 10 mL portions of distilled water, allowing complete drainage between each rinsing.
6. Continue suction for three minutes after filtration of final rinse is completed.
7. Dry filter in an oven at 103-105°C for at least 1 hour.
8. Cool filter in desiccator to room temperature.
9. When cool, weigh the filter and support.

FORMULA

$$\text{Total Dissolved Solids, TDS (mg/L)} = \frac{(W_2 - W_1) \times 10^6}{\text{Volume of taken sample}}$$

$$\text{Total Suspended Solids, TSS (mg/L)} = \frac{(W_2 - W_1) \times 10^6}{\text{Volume of taken sample}}$$

Total Solids = Total Dissolved Solids (TDS) + Total Suspended Solids (TSS)

CHAPTER 4
POSSIBILITY OF CONVERTING THE TREATED SEWAGE WATER TO DRINKING WATER

The process of converting the treated sewage water to drinking water is adopted from the Surface Water Treatment method of Pune Municipal Corporation.

The sequence of water treatment units in a water treatment plant mostly remains same, as the principle objectives are to remove turbidity and disinfection to kill pathogens.

- The first treatment unit in a water treatment plant is aeration, where water is brought in contact with atmospheric air to fresh surface water and also oxidizes some of the compounds. Many Water Treatment Plants do not have aeration system.

- The next unit is chemical addition or flash mixer where coagulant (mostly alum) is thoroughly mixed with raw water by way of which neutralization of charge of particles (coagulation) occurs.

- This water is then flocculated i.e., bigger floc formation is encouraged which enhances settlement.

- The flocculated water is then taken to sedimentation tanks / clarifiers for removal of flocs and from there to filters where remaining turbidity is removed.

- The filtered water is then disinfected, mostly with chlorine and then stored in clear water reservoirs from where it is taken to water distribution system.

- Sludge from clarifiers and filter backwash water are generally discharged into the nearby drain, however, there is a trend now to reuse / treat these wastes.

Operation	Process
Micro strainer	Remove algae and plankton from the raw water
Aeration	Strips and oxidizes taste and odour causing volatile organics and gases and oxidizes iron and manganese. Aeration systems include gravity aerator, spray aerator, diffuser and mechanical aerator.
Mixing	Provides uniform and rapid distribution of chemicals and gases into the water.
Pre-oxidation	Application of oxidizing agents such us ozone, potassium permanganate, and chlorine compounds in raw water and in other treatment units; retards microbiological growth and oxidizes taste, odour and colour causing compounds
Coagulation	Coagulation is the addition and rapid mixing of coagulant resulting in destabilization of the colloidal particle and formation of pinhead floc
Flocculation	Flocculation is aggregation of destabilized turbidity and colour causing particles to form a rapid-settling floc
Sedimentation	Gravity separation of suspended solids or floc produced in treatment processes. It is used after coagulation and flocculation and chemical precipitation.
Filtration	Removal of particulate matter by percolation through granular media. Filtration media may be single (sand, anthracite, etc.), mixed, or multi-layered.
Disinfection	Destroys disease-causing organisms in water supply. Disinfection is achieved by ultraviolet radiation and by oxidative chemicals such as chlorine, bromine, iodine, potassium permanganate, and ozone, chlorine being the most commonly used chemical

Table 4.1: Brief review of the operations and processes involved in Water treatment

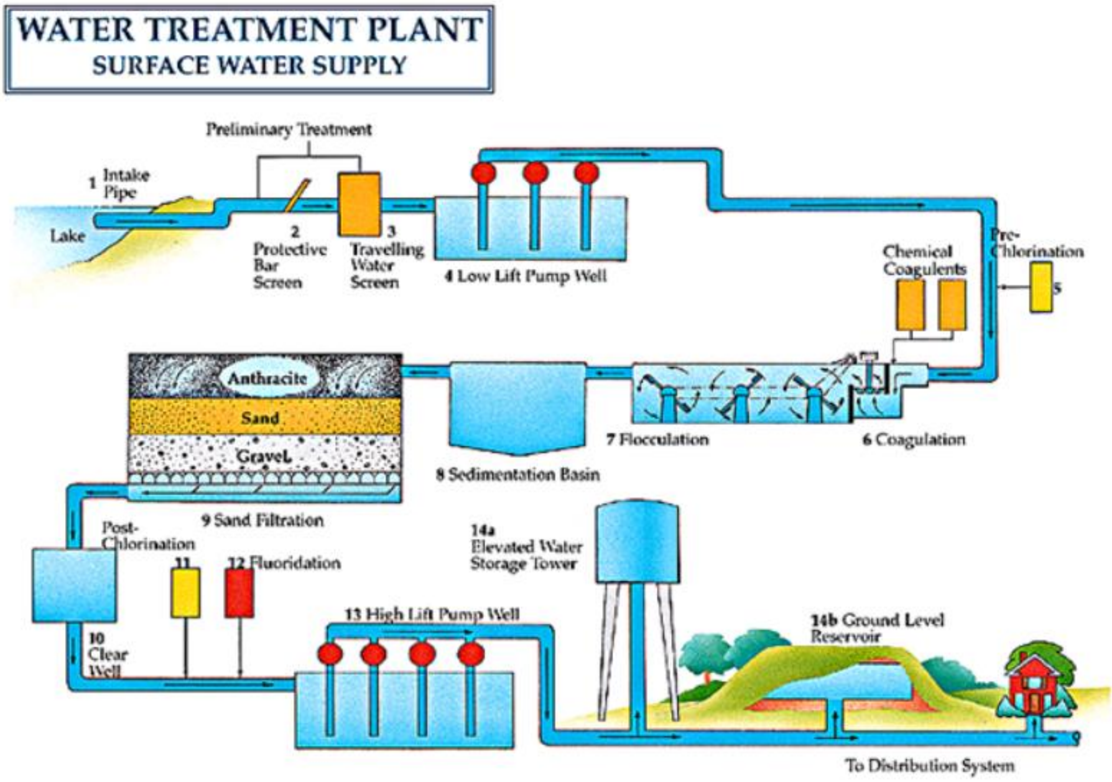

Fig 4.1: Water Treatment Plant

By the above process followed by Pune Municipal Corporation the treated sewage water could be converted into drinking water.

CHAPTER 5

RESULTS AND DISCUSSION

1. pH

The test is performed based upon the stipulations as per **IS: 3025 (Part 11) - Reaffirmed 2002**

RESULTS:

The results obtained of the samples are

pH of Raw Water	=	6.90
pH of Treated Water	=	7.99

2. Conductivity

The test is performed based upon the stipulations as per **IS: 3025 (Part 14) - Reaffirmed 2002**

RESULTS:

The results obtained of the samples are

Conductivity of Raw Water	=	3.61 µmhos/cm
Conductivity of Treated Water	=	2.79 µmhos/cm

3. Alkalinity

The test is performed based upon the stipulations as per **IS: 3025 (Part 23) - Reaffirmed 2002**

RESULTS:

The results obtained of the samples are

Alkalinity of Raw Water	=	1349.8 mg/l
Alkalinity of Treated Water	=	726.4 mg/l

4. Acidity

The test is performed based upon the stipulations as per **IS: 3025 (Part 22) - Reaffirmed 2002**

RESULTS:

The results obtained of the samples are

Acidity of Raw Water	=	0 mg/l
Acidity of Treated Water	=	0 mg/l

5. Dissolved Oxygen

The test is performed based upon the stipulations as per **IS: 3025 (Part 38) - Reaffirmed 2003**

RESULT:

The results obtained of the samples are

Dissolved Oxygen of Raw Water	=	2.45 mg/l
Dissolved Oxygen of Treated Water	=	3.21 mg/l

6. Biochemical Oxygen Demand

The test is performed based upon the stipulations as per **IS: 3025 (Part 44) – Reaffirmed 2003**

RESULTS:

The results obtained of the samples are

Biochemical Oxygen Demand of Raw Water	=	174 mg/l
Biochemical Oxygen Demand of Treated Water	=	27 mg/l

7. Total Solids, Total Dissolved Solids & Settleable Solids

The test is performed based upon the stipulations as per **IS: 3025 (Part 16 & Part 17).**

RESULTS:

The results obtained of the samples are

Total Solids of Raw water	=	104 mg/l
Total Dissolved Solids, TDS of Raw Water	=	1827 mg/l
Total Suspended Solids, TSS of Raw Water	=	104 mg/l

Total Solids of Treated water	=	79 mg/l
Total Dissolved Solids, TDS of Treated Water	=	1094 mg/l
Total Suspended Solids, TSS of Treated Water	=	79 mg/l

COMPARING THE PARAMETERS OF RAW AND TREATED WATER WITH PARAMETERS OF SURFACE WATER:

Parameter	Raw Water	Treated Water	Allowable Range on Land for Irrigation (Surface Water)
pH	6.90	7.99	6.5 to 8.5
Conductivity (µmhos/cm)	3.61	2.79	0.5 to 3
Alkalinity (mg/l)	1349.8	720.4	200 to 500
Acidity (mg/l)	0	0	0
Dissolved Oxygen(mg/l)	2.45	3.21	< 4
Biochemical Oxygen Demand (mg/l)	174	27	30
Total Solids (mg/l)	104	79	100
Total Dissolved Solids (mg/l)	1827	1094	1000 to 2000
Total Suspended Solids (mg/l)	104	79	100

Table 5.1: Comparison of Parameters of Raw and Sewage Water with Parameters of Surface Water

- The above allowable range parameters are taken with reference to the standards provided by the **Central Board of Pollution Control** for Treated Sewage water and Surface Water.
- Standards laid by **Ministry of Environment and Forests, Government of India** for Common Effluent Treatment Plants as per, (Environment Protection Rules, 1986) were also referred for better results.

CHAPTER 6

CONCLUSION

We studied the performance of Municipal Sewage Water Treatment Plant at Tirupati and examined the treated sewage water by performing the following tests.

The tests performed are done according to the prescription of Indian Standard Codes.

1. pH

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

2. CONDUCTIVITY

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

3. ALKALINITY

Remark: The obtained result is not in prescribed range.

Conclusion: The Plant's Performance is not up to the mark in this aspect.

4. ACIDITY

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

5. DISSOLVED OXYGEN

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

6. BIOCHEMICAL OXYGEN DEMAND

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

7. TOTAL SOLIDS, TOTAL DISSOLVED SOLIDS & SUSPENDED SOLIDS

Remark: The obtained result is in prescribed range.

Conclusion: The Plant's Performance is good in this aspect.

With the following obtained results, we came with the conclusion that according to the standard values of the inland surface water with reference to the **Primary Water Quality Criteria** prescribed by **Central Board of Pollution Control, India**., except the Alkalinity., the Treated Sewage Water's criteria nearly concords the criteria of Inland Surface Water and hence can be used for Industrial and Irrigation purposes.

We also came up with a process followed by the **Pune Municipal Corporation** which might possibly convert the Treated Sewage Water to Drinking Water.

CHAPTER 7
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