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Comprehensive Review of Sewage Treatment Plant for Environmental Engineering

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ABSTRACT- Buldhana Municipality has been upgraded with Corporation status. The steady incremental in the city population results in the increase of domestic sewage generation. But still now there is no treatment plant. So it is required to construct a Sewage Treatment Plant with sufficient capacity to treat the increased sewage. The project deals with the design of the Sewage Treatment plant and its major components such screening chamber, grit chamber, skimming tank, sedimentation tank, secondary clarifier, active sludge tank and sludge drying beds. The project covers the 10.54 sq.km, Buldhana Municipal Corporation for next 30 years and its increased population. Buldhana City, the Head Quarters of the Buldhana District is (Maharastra, India). With regard to Buldhana, almost the entire town and environment are plain and the general slope is from North to East. The town is situated at the altitude of 20°59°N latitude and 75°E longitude. The soil of the area is being gravel, rocky and a large proportion of sand and gravel. All the aspects of Jalgaon climate and topography, its population growth rate is to be considered while designing the project. By the execution of the project the entire sewage of the city can be treated effectively and efficiently.

Keywords: General Terms:- Sewage Treatment Plant(STP), Wastewater Treatment,Effluent Treatment, Domestic Sewage, Industrial Wastewater, Water Pollution Control, Sanitation Engineering

INTRODUCTION

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 have gain 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. DEFINITIONS 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. Storm sewage is a liquid flowing in sewer during or following a period of rainfall and resulting there from

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.

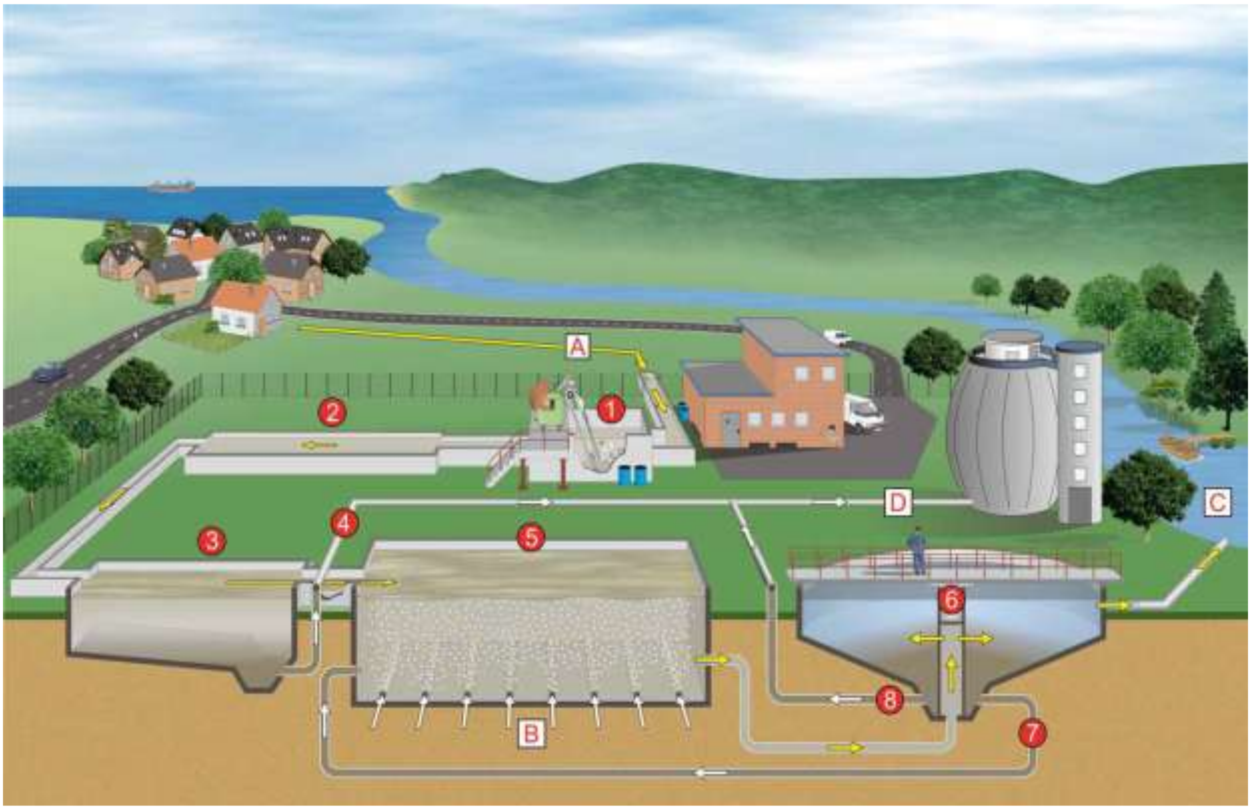
Biological characteristic of waste water:

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.

2.1 Purpose of the project

The main purpose of the project is to identify:

- current waste water disposal and treatment techniques,
- ongoing sanitation initiatives and projects,
- stakeholders in the sanitation sector,
- the administration structures related to sanitation projects,
- a possible project implementation agency,
- sites for future pilot projects.



1.BarScreen.

2.Grit Chamber.

3. Primary Clarifier.

4.Primary Sludge Biological Treatment.

5.Aeration Tank.

6. Secondary clarifier.

7. Return Sludge.

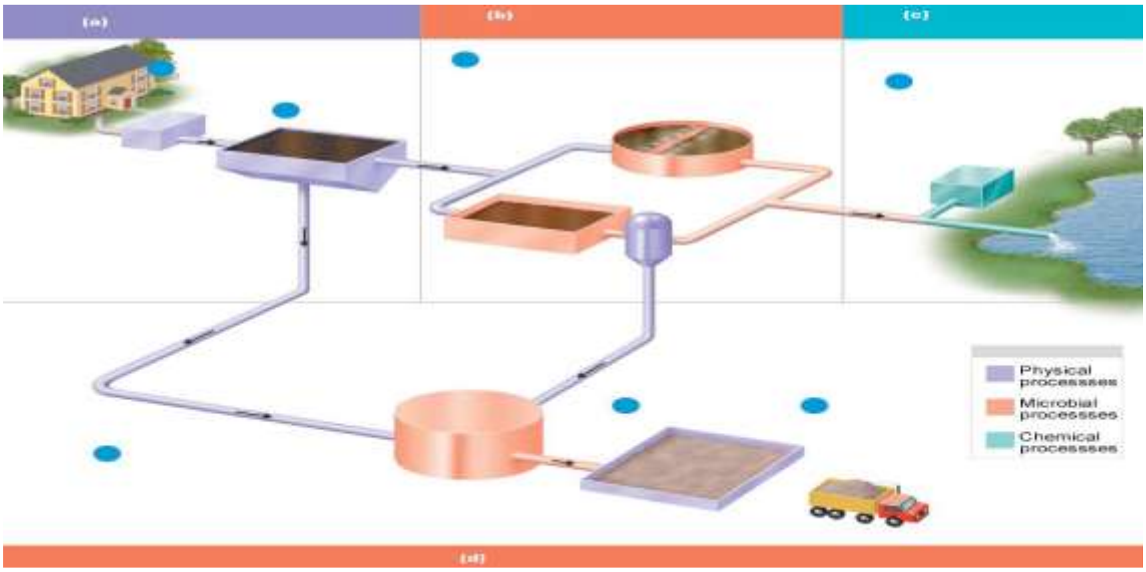
8. Surplus Sludge.

A. Wastewater.
B. Compressed Air.
C. Receiving Water.
D. Sewage Sludge.

WASTE WATER TREATMENT PROCEDURE

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. Treatment processes are often classified as:

A. Preliminary treatment
B. Primary treatment
C. Secondary treatment
D. Tertiary treatment.



The stages in typical sewage treatment. Microbial activity occurs aerobically in trickling filters or activated sludge aeration tanks and anaerobically in the anaerobic sludge digester. A particular system would use either activated sludge aeration tanks or trickling filters, not both, as shown in this figure. Methane produced by sludge digestion is Burned off or used to power heaters or pump motors

A. PRELIMINARY TREATMENT:

Preliminary treatment consists solely in separating the floating materials like tree branches, papers, pieces of rags, wood etc. and heavy settable inorganic solids. It helps in removal of oils and greases and reduces the BOD by 15% to 30%. The processes under this are:

➢Screening – To remove floating papers, rags, clothes.

➢ Grit chamber – To remove grit and sand.

➢Skimming tank – To remove oils and greases.

B. PRIMARY 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 water is left to stand so that solids can sink to the bottom and oil and grease can rise to the surface. The solids are scraped off the bottom and the scum is washed off with water jets. These two substances are combined to form sludge.

In this process, large floating materials in incoming waste water are screened out, the sewage is allowed to flow through settling chambers to remove sand and similar gritty material, skimmers remove floating oil and grease, and floating debris is shredded and ground. After this step, the sewage passes through sedimentation tanks, where more solid matter settles out. Sewage solids collecting on the bottom are called sludge—at this stage, *primary sludge*. About 40–60% of suspended solids are removed from sewage by this settling treatment, and flocculating chemicals that increase the removal of solids are sometimes added at this stage. Biological activity is not particularly important in primary treatment, although some digestion of sludge and dissolved organic matter can occur during long holding times. The sludge is remove don either a continuous or an intermittent basis, and the effluent (the liquid flowing out) then undergoes secondary treatment.

C. SECONDARY TREATMENT:

Here the effluent from primary treatment is treated through biological decomposition of organic matter carried out either aerobic or anaerobic conditions. The sludge is further treated in 'sludge digesters': large heated tanks in which its chemical decomposition is catalysed by microorganisms. The sludge is largely converted to 'biogas', a mixture of CH4 and CO2, which is used to generate electricity for the plant. The liquid is treated by bacteria which break down the organic matter remaining in solution. It is then sent to oxidation ponds where heterotrophic bacteria continue the breakdown of the organics and solar UV light destroys the harmful bacteria. After primary treatment, the greater part of the BOD remaining in the sewage is in the form of dissolved organic matter. which is predominantly biological, is designed to remove most of this organic matter and reduce the BOD. In this process, the sewage undergoes strong aeration to encourage the growth of aerobic bacteria and other microorganisms that oxide the dissolved organic matter to carbon dioxide and water. Two commonly used methods of secondary treatment are:-

1. Activated sludge systems.
2. Trickling filters.

1. Activated sludge system:-

In the aeration tanks of an **activated sludge system,** air or pure oxygen is passed through the effluent from primary treatment. The name is derived from the practice of adding some of the sludge from a previous batch to the incoming sewage. This in Colum is termed *activated sludge* because it contain sledge numbers of sewage-metabolizing microbes.

The activity of these aerobic micro organisms oxidizes much of the sewage organic matter into carbon dioxide and water. Especially important members of this microbial community are species of *Zoogloea* bacteria, which form bacteria containing masses in the aeration tanks called floc, or *sludge granules* soluble organic matter in the sewage is in corporate into the floc and its microorganisms. Aeration is discontinued after 4 to 8 hours, and the contents of the tank are transferred to a settling tank, where the floc settles out, removing much of the organic matter. These solids are subsequently treated in an anaerobic sludge digester, which will be described shortly.

Probably more organic matter is removed by this settling-out process than by the relatively short-term aerobic oxidation by microbes. The clear effluent is disinfected and discharged. Occasionally, the sludge will float rather than settle out; this phenomenon is called bulking. When this happens, the organic matter in the floc flows out with the discharge effluent, resulting in local pollution. Bulking is caused by the growth of filamentous bacteria of various types; *Sphaerotilusnatans* and *Nocardia* species are frequent offenders. Activated sludge systems are quite efficient: they remove 75–95% of the BOD from sewage.

2. **Trickling filters:-**

The other commonly used method of secondary treatment. In this method, the sewage is sprayed over a bed of rocks or molded plastic. The components of the bed must be large enough so that air penetrates to the bottom but small enough to maximize the surface area available for microbial activity. A bio film of aerobic micro besgrows on the rock or plastic surfaces. Because air circulates throughout the rock bed, these aerobic microorganisms in the slime layer can oxidize much of the organic matter trickling over the surfaces into carbon dioxide and water. Trickling filters remove 80–85% of the BOD, so they are generally less efficient than activated sludge systems. However, they are usually less troublesome to operate and have fewer problems from overloads or toxic sewage. Note that sludge is also a product of trickling filter systems. Another biofilm-based design for secondary sewage treatment is the rotating biological contactor system. This is a series of disks several feet in diameter, mounted on a shaft. The disks rotate slowly, with their lower 40% submerged in wastewater. Rotation provides aeration and contact between the biofilm on the disks and the wastewater. The rotation also tends to cause the accumulated biofilm to slough off when it becomes too thick. This is aboutthe equivalent of floc accumulation in activated Sludge systems

Aeration Tank

1. **Tertiary Sewage Treatment**

As we have seen, primary and secondary treatments of sewage do not remove all the biologically degradable organic matter. Amounts of organic matter that are not excessive can be released into a flowing stream without causing a serious problem. Eventually, however, the pressures of increased population might increase wastes beyond a body of water's carrying capacity, and additional treatments might be required. Even now, primary and secondary treatments are inadequate in certain situations, such as when the effluent is discharged into small streams or recreational lakes. Some communities have therefore developed tertiary sewage treatment plants. Lake Tahoe in the Sierra Nevada Mountains, surrounded by extensive development, is the site of one of the best-known tertiary sewage treatment systems. Similar systems are used to treat wastes entering the southern portion of San Francisco Bay.

The effluent from secondary treatment plants contains some residual BOD. It also contains about50% of the original nitrogen and 70% of the original phosphorus, which can greatly affect a lake's ecosystem. Tertiary treatment is designed to remove essentially all the BOD, nitrogen, and phosphorus. Tertiary treatment depends less on biological treatment than on physical and chemical treatments. Phosphorus is precipitated out by combining with such chemicals as lime, alum, and ferric chloride. Filters of fine sands and activated charcoal remove small particulate matter and dissolved chemicals. Nitrogen is converted to ammonia and discharged into the air in stripping towers. Some systems encourage denitrifying bacteria to form volatile nitrogen gas. Finally, the purified water is chlorinated.

Tertiary treatment provides water that is suitable for drinking, but the process is extremely costly. Secondary treatment is less costly, but water that has undergone only secondary treatment still contains many water pollutants. Much work is being done to design secondary treatment plants in which the effluent can be used for irrigation. This design would eliminate a source of water pollution, provide nutrients for plant growth, and reduce the demand on already scarce water supplies. The soil to which this water is applied would act as a trickling filter to remove chemicals and microorganisms before the water reaches groundwater and surface water supplies.

- MICROSTRAINERS
- RAPID GRAVITY SAND FILTERS
- UPWARD-FLOW “MEDUIM” SAND FILTERS
- SLOW SAND FILTERS
- PEBBLE-BED CLARIFIERS
- SETTLEMENT
- GRASS PLOTS
- LAGOONS

SLUDGE TREATMENT AND DISPOSAL

- SLUDGE IS A SEMI-LIQUID
- SLUDGE PRODUCED BY PLAIN SEDIMENTATION
- SLUDGE PRODUCED BY CHEMICAL PRECIPITATION
- TRICKLING FILTER
- ACTIVATED SLUDGE

Methods of Disposal

- DISPOSAL ON LAND
- DRYING ON DRYING BEDS
- DUMPING INTO THE SEA
- HEAT-DRYING
- INCINERATION
- LAGOONING OR PONDING
- SLUDGE DIGESTION

Sludge Digestion

- It transforms a portion of solids into liquids and gases, thereby reducing the sludge volume to be dealt with

- It breaks the organic matter of sludge into simpler compounds by the action of anaerobic bacteria.

Filtration:-

Filtration becomes necessary when suspended solid particles are to be removed that cannot be forced to settle or float within a reasonable time. Most filters have a double function, they provide a fixed surface for treatment of bacteria and they form a physical obstacle for the smaller solid particles by creating adhesion of particles to their surfaces. Filtration cans be both on the upstream and the downstream. E.g. Upstream Anaerobic Sludge Blanket. Anaerobic filters direct flow upwards through the filter material. Trickling filters allow the wastewater to descend in a downward direction through the filter material. The speed at which filtration occurs depends on the type of filter material used. Smaller grain sizes and fine mesh sizes would cause filtration to be slower than larger, wider-spaced material, but would cause the retention of many more solids and clog faster.
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
= 0.850.423=0.36 mld
= 360 kld
Average sewage generated per hour=360/24=15 cum/hr

Peak factor = 3
Design flow capacity (maximum) = 13 x 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 m3/h
Capacity of collection sump = 4 x 15=60 m3
Assume liquid depth = 5 m
Area required for collection pits = 60/5 = 12 m2
Let it is a circular tank
r = 1.93m
Volume of the pit provide = π/4 x 4 x 4 x5
= 62.8 m3
Thus Area of the pit provided = 12.6 m2

Sizing calculation of bar screen:
Peak discharge = 45 m3/h
Average discharge = 15 m3/h
Average velocity @ average flow isn’t allowed to exceed 0.8 m/sec
Average spacing between bar 20 mm
The velocity = 0.3*60=18 m/h/ m2
Cross sectional area required = flow/velocity
= 45/18 = 2.5 m2
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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 x 20) + (67 x 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 x 24 x 100 = 36 kgs
Let mlss = 2000 mg/l, f/m=0.15
Volume of tank required = (Q x bod load) / (fm x mlss)
= (180 x 100)/0.15 x 2000
= 60 m3
Assume liquid depth = 3.5 m
Area = 60/3.5=17.143 m2
Tank size provided = 4.5 x 4.5 x 3.7
So, Volume of tank = 75 m3

Check for aeration period/hydraulic retention time:
Hydraulic retention time t = 75 x 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 m3/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 = 360x 200/1000
= 72 kg/day
Solid content in the feed= 3%
Specific gravity of the sludge= 1.015 Volume of sludge= ((72/0.03)/(1000x1.015))
= 2.36 m3
For Rourkela weather condition, the beds get dried out about 7 days
No. of cycles per year = 365/7
= 52 cycles
Period of each cycles = 7 days
Volume of sludge per cycle = 2.36 x 7
= 16.55 m3/cycle
Spreading a layer 1m per cycle,
Area of bed required = 16.55/1
= 16.55 m2

4.2 SCREENING GENERAL:

Screening is the very first operation carried out at a sewage treatment plant and consists of passing the raw sewage through different types of screens so as to trap and remove the floating matter such as tree leaves, paper, gravel, timber pieces, rags, fibre, tampons, cans, and kitchen refuse etc.

PURPOSE OF SCREENING: Screening is essential in sewage treatment for removal of materials which would otherwise damage the plant, interfere with the satisfactory operation of treatment unit or equipment. • To protect the pumps and other equipments from the possible damages due to floating matter. • To remove the major floating matters from the raw sewage in a simple manner before it reaches into the complex high energy required process.

COURSE SCREENS The coarse screens essentially consist of steel bars or flat placed 30° to 60° inclination to the horizontal. The opening between bars are 50mm or above. These racks are placed in the screen chamber provided in the way of sewer line. The width of the rack channel should be sufficient so that self cleaning velocity should be available and a bypass channel should be provided to prevent the overtopping. The bypass channel is provided with vertical bar screen. A well drained trough is provided to store the impurities while cleaning the rack.

These racks are cleaned mechanically. 0.924 x 180 = 168 m^3

In order to drain the channel periodically for routine cleaning and maintenance two chambers are used.

Therefore volume of one aerated chamber = 1682 m^3 = 84 m^3

Assume depth of 3 m and Width to depth ratio 2:1

Width of the channel =2x3 = 6 m

Length of the channel = 843 x 6 23 = 4.7 m Increase the length by about 20% to account for inlet and outlet Provide length = 4.7 x 1.2 m = 5.7m

Grit chamber is designed for the size of 5.7 m X 6 m X 3 m

ACTIVATED SLUDGE PROCESS

The activated sludge process is an aerobic, biological sewage treatment system to treat the settled sewage consist a variety of mechanisms and processes that use dissolved oxygen to promote the growth of biological floc that substantially removes organic material. The essential units of the process are an aeration tank, a secondary settling tank, a sludge return line from the secondary settling tank to the aeration tank and an excess sludge waste line. CONCEPT: Atmospheric air is bubbled through primary treated sewage combined with organisms to develop a biological floc which reduces the organic content of the sewage. The Mixed Liquor, the combination of raw sewage and biological mass is formed. In activated sludge plant, once the effluent from the primary clarifier get sufficient treatment, the excess mixed liquor is discharged into settling tanks and the treated supernatant is run off to undergo further treatment. Part of the settled sludge called Return Activated Sludge (R.A.S.) is returned to the head of the aeration system to re-seed the new sewage entering the tank. Excess sludge which eventually accumulates beyond R.A.S known Waste Activated Sludge (W.A.S.) is removed from the treatment process to keep the ratio of biomass to food supplied (F:M) ratio. W.A.S is further treated by digestion under anaerobic conditions.

4.3 STORAGE:

Water demand calculation

Water demand is calculated based on the guidelines of NBC. Total quantity of water requirement for the proposed project is estimated to be about 122.09 KLD during the operation phase. By considering 85 % of the water supplied will be converted in to sewage i.e.103.77KLD. Wastewater generated from the proposed project will be treated in anSTP of 115 KLD. Detailed design write up of the STP is in the following section. The sewage generated during the operation phase will be treated up to the tertiary level in Sewage Treatment Plants (STP) The entire (100%) treated sewage from Stop 115KLD capacity will be recycled/ reused for toilet flushing, car washing and landscaping in the project site excess will be used for avenue plantation/Sewer.

Sewage Treatment Plant

Total water requirement = 122.09 m3 / day.

Assuming Diversity Factor of 0.85 = 103.77 m3

Say = 110 m3 / day

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 x 4.5 x 3.7 m3
- Dimensions of Sludge Drying Bed are 4.5 m x 4.5 m x 1 m of two numbers.

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