Analysis And Design of Sewage Treatment Plant: A Case Study on St. Ann`S College of Engineering and Technology, Autonomous

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***Abstract*—A Study has been conducted to carry out analysis and design of sewage treatment plant in SACET Campus as a part of our final year project work. The steady increase of population in campus results in the increase of sewage generation. So, it has been proposed to construct a sewage treatment plant with sufficient capacity to treat the increased sewage for next 30 years. The project deals with design of sewage treatment plant and its major components such as screening chamber, Grit chamber, skimming tank, sedimentation tank, and sludge drying beds. It is recommended that the treated water may be supplied for gardening and the remaining sludge after treatment can be used as manure. The use of treated Water will reduce the ground water use. By the execution of project, the entire sewage of the campus can be treated effectively and efficiently for next 30 years.**

***Index Terms*—Sewage Treatment Plant, Wastewater Design, Campus Water Demand, Population Projection, MLD Calculation, Sustainable Sanitation, Institutional Infrastructure, Environmental Engineering, Water Management.**

I. INTRODUCTION

More than two billion people worldwide lives in regions facing water scarcity. Water scarcity already affects every continent and more than 40 percent of the people on planet. By 2025,1.8 billion people will be living in countries regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions. Global water use has been growing at more than twice the rate of population growth in the last century. About 1.1 billion people do not have access to adequate water to meet their most basic needs. Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical water scarcity, and 500 million people are approaching this situation. India's demand for water is growing at an alarming rate. India is surrounded by water bodies on the three sides, yet we face water shortage every year. The per capita water availability in India was 3450cu.m in 1951.

By 2025 the annual per capita availability of water is expected to rise drastically from the current 1800cum per person to 1200-1500 cu, m. The quality of available water is also fast deteriorating, over extraction of ground water has led to salt water intrusion into coastal aquifer. It has also resulted into presence of excessive fluoride, iron, arsenic and salinity in water affecting about 44 million people in India. Groundwater is facing an equally serious threat from contamination by industrial effluent and fecal matter as well as pesticides and fertilizers from runoff. Unless priority is given quickly to creating an infrastructure to assure availability of water, there may be no water to meet agricultural, domestic and industrial needs of a population that has tripled in 50 years to one billion.

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.

II. IMPORTANT TERMS

- Sewage is a dilute mixture of water and liquid waste generated due to various types of wastes from the residential, public and industrial places. The sewage pollutant causes undesirable changes and it affects the land, water and air or the environment as a whole. In the modern living the heavy industrialization and increase of population increased the rate of water pollution. 3 types of sewage area) Domestic sewage b) Industrial sewage e) Storm water or Drainage or Runoff

- Sewer The pipe or conduit used for carrying sewage from one point to another point in a sewerage system.
- Sewerage system It is an entire process of collection, treatment and disposal of the sewage. Depending upon mode of collection of sewage sewerage system generally of 3 types- (1) Separate sewerage system Separate pipes are provided to carry drainage and sanitary sewage. (2) Combined sewerage system Onlyone pipe is provided to carry both sanitary and drainage sewage discharge. (3) Partially sewerage system A certain portion of drainage, obtained from roofs and paved courtyard of individual houses is allowed to mix with domestic sewage.
- Sullage Kitchen and bathroom waste taken together. 1.2.5. Sanitary sewage Domestic sewage and industrial sewage taken together. Prime impurity of sewage is Organic matter which may be either Biodegradable or nonbiodegradable. Prime impurity of drainage is inorganic matter. Sewage has 99.9% water and 0.1% solids. Such that, if 1000kg sewage sample consider then it consists only 0.45kg of total solid

III. LITERATURE REVIEW

Jillies and Kushwaha (1990) reported that liquid digested sludge can be used as soil amendment to provide low-cost fertilizer and improve tilth. Dried digested sewage sludge was mixed with soil in test plot near Saskatoon, Canada at application rate of 75 tones sludge/hectare. The plots were irrigated with decent water from the sludge drying bed.

Tripathi and Dwivedi (1990) reported that the effect of irrigation with raw urban sewage effluents mixes with industrial effluents, treated sewage effluents and tube well water potato yields an and plant and soil heavy metal content was content was studied in a field experiment at benara Hindu university, Varanasi. Very low concentrations of heavy metals were observed in rubbers from the raw sewage irrigation treatment, although Cu, Zn, Fe in soil increased.

Korentajer (1990) reported the application of sewage sludge on agricultural land may provide an economical way to dispose of the increasing amount of sludge application may be limited by its potential health.

Hundal and Sandhu (1992) reported that soil sample at varying distance along the sewage from three types of field sewage waste water irrigated and tube well irrigated were collected and analyzed for total and DTPA extractable toxic metal content.

Maiti et al. (1992) reported that the sewage effluent and sludge of Calcutta city was made to assess their manorial values. Sewage was natural to slightly alkaline in reaction and contained high level basic tons, particularly in winter, bicarbonate and chloride loans were at toxic levels. Although sewage effluents and slugged were rich in nutrient the toxicity levels.

Welch et al. (1992) reported the zinc movement in sludge treated soils as influenced by soil properties water quality and soil moisture level.

IV. METHODOLOGY

Treatment of Sewage:
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:

1. Preliminary treatment
2. Primary treatment
3. Secondary treatment
4. Tertiary treatment.

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.

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

Secondary Treatment:
Here the effluent from primary treatment is treated through biological decomposition of organic matter carried out either aerobic or anaerobic conditions.
Aerobic Biological Units
1) Filters (intermittent sand filters, trickling filters)
2) Activated Sludge Plant (feed of active sludge, secondary settling tank and aeration tank) 14
3) Oxidation ponds and Aerated lagoons.

Anaerobic Biological Units
1) Anaerobic lagoons
2) Septic tanks
3) Imhoff tanks.

The effluent from the secondary treatment a little BOD (5% to 10% of original) and may contain several milligrams per liter of DO.

Tertiary Treatment:
The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality before it is discharged to the receiving environment (sea, river, lake, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also known as "effluent polishing". The flow chart of sewage treatment plant is given in Fig.1
The collected samples were tested in the laboratory to determine physical, chemical, and biological characteristics.

Parameters Tested:
- pH
- Temperature
- Total Dissolved Solids (TDS)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Suspended Solids

Estimation of Sewage Quantity:
- Total population considered: 5000 persons

Sewage contains various types of impurities and disease bacteria. This sewage is disposed of by dilution or on land after its collection and conveyance. If the sewage is directly disposed of, it will be acted upon the natural forces, which will convert it into harmful substances. The natural forces of purification cannot purify any amount of sewage within specified time. If the quantity of sewage is more, then receiving water will become polluted or the land will become sewage sick. Under such circumstances it becomes essential to do some treatment of the sewage, so that it can be accepted by the land or receiving water without any objection. These treatment processes will directly depend on the types of impurities present in the sewage and the standard up to which treatment is required.

V. EXPREIMENTS

Laboratory Analysis of Sewage:
- Water supply: 135 LPCD
- Sewage generation: 80% of water supply

Experimental Design of Treatment Units: Screening Unit:
The screening unit is the first stage of the sewage treatment plant and plays a crucial role in protecting downstream equipment. It removes large floating and suspended materials such as plastics, rags, sticks, papers, leaves, and other debris.

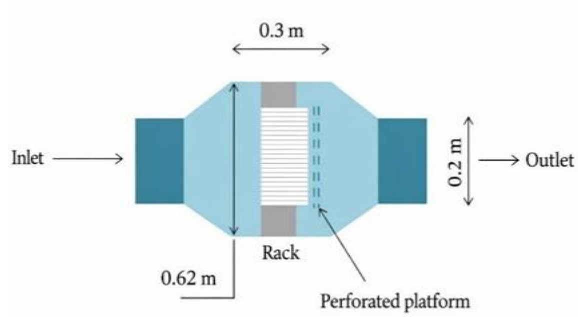

Fig 1: - Design of Coarse Screen

Grit Chamber:
The grit chamber is designed to remove heavy inorganic particles such as sand, gravel, silt, eggshells, and small stones that may cause abrasion and damage to mechanical equipment.

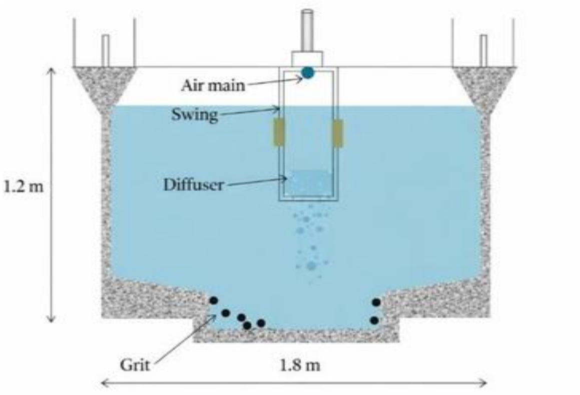

Fig 2: - Design of Grit Chamber Skimming Tank:

The skimming tank removes oil, grease, fats, and floating scum from sewage, which otherwise interfere with biological treatment processes.

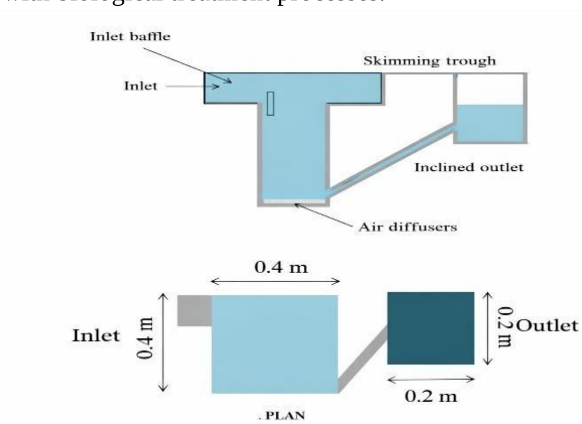

Fig 4: -Design of Skimming chamber Primary Sedimentation Tank:

This unit removes settleable suspended solids by gravity settling. It is one of the most important units in primary treatment.

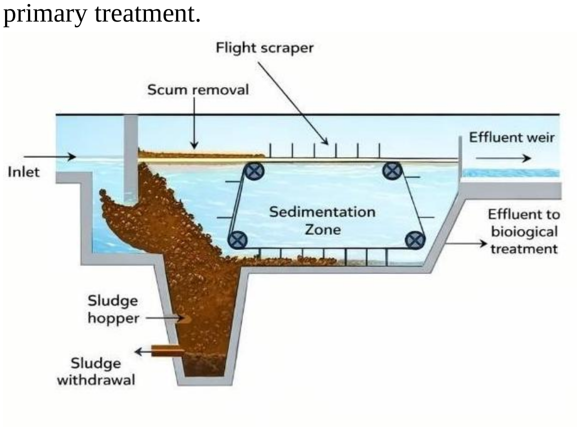

Fig 3: - Design of Primary Sedimentation Tank Trickling Filter (Secondary Treatment):

The trickling filter is a biological treatment unit where microorganisms degrade organic matter present in sewage.

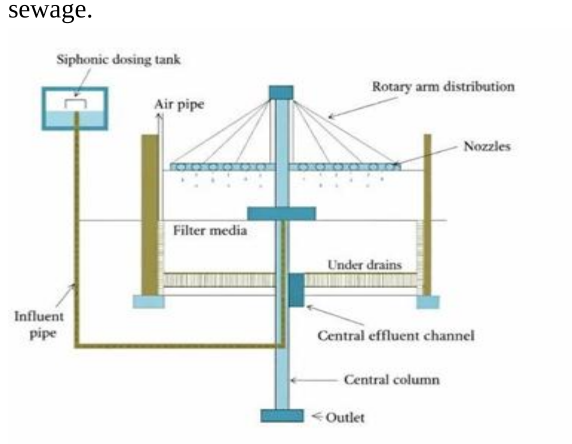

Fig 5: - High-Rate Trickling Filter Sludge Drying Beds:

Sludge drying beds are used to remove moisture from sludge generated in sedimentation tanks.
The solid content present in the sludge was assumed as 2% and the drying period of the sludge was assumed to be done in 8 days.

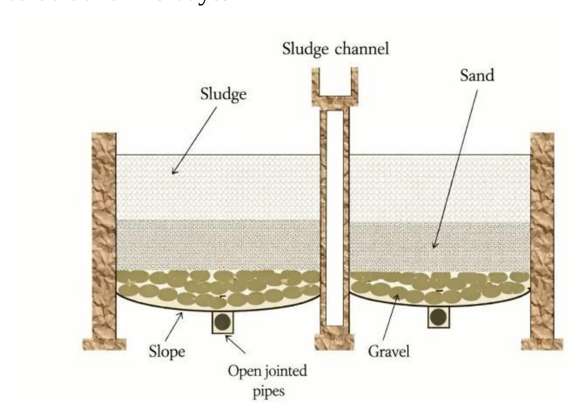

Fig 6: - Sludge Drying Beds

VI. RESULTS:

Laboratory Analysis values Observed Values

- pH: 8.1
- Temperature: 33°C
- TDS: 1600 mg/L
- BOD: 330 mg/L
- COD: 700 mg/L

Calculated Values

- Total sewage: 0.6 MLD
- Peak discharge: 0.021 m^3/s

1. Screening Unit
- Velocity through screen: 0.2 m/s
- Clear opening between bars: 20 mm
- Channel dimensions: 0.62 m width, 0.85 m depth
- Head loss: 2.1 mm

2. Grit Chamber
- Detention time: 180 sec
- Dimensions:
- Length: 1.2 m
- Width: 1.8 m
- Depth: 1.3 m
- Volume (approx): 3.78 m^3

3. Skimming Tank
- Length: 0.4 m
- Width: 0.4 m
- Depth:1.5m

4. Primary Sedimentation Tank
- Size: 13.3 × 3.4 × 4.5 m
- Detention time: 2 hours
- Removal:
- Suspended solids: 65%
- BOD: 30%

5. Trickling Filter
- Diameter: 22.5 m
- Depth: 4 m
- BOD removed: 126.6 kg/day
- Efficiency: 92.67%

6. Sludge Drying Bed
- Sludge volume: 7.38 m^3/day
- Volume per cycle: 59.04 m^3
- Total area: 196.8 m^2
- Number of beds: 2
- Each bed: 12.5 m × 8 m

7. Overall STP Efficiency
- Influent BOD: 330 mg/L
- Effluent BOD: 20 mg/L
- BOD removal efficiency: 93.94%

Water Quality
- Before Treatment (Raw Sewage)
- BOD: 200–330 mg/L
- COD: 600 mg/L
- Oil & Grease: 50 mg/L
- Suspended solids: 600 mg/L

After Treatment (Effluent)
- BOD: ≤ 20 mg/L
- COD: ≤ 250 mg/L
- Oil & Grease: ≤ 5 mg/L
- Suspended solids: ≤ 30 mg/L

VII. CONCLUSION:

In the present study, detailed design of the primary treatment and management of sewage generated in SACET campus, including its hostels and residential area has been developed. The total sewage generated per day is 0.6 MLD. The treated water will be supplied for gardening purposes inside the campus and the remaining sludge after treatment will be used as manure on farms. Some design parameters are given below

a) The design of primary sewage treatment is for the predicted population of 5000 and estimated sewage of 0.6 MLD.
b) The dimension of receiving chamber is 2 m x 1m x 0.8m(SWD) +0.3m(FB).
c) The dimension of grit chamber with aeration is 1.3 mx 1.8 m x 1.2 m+ 0.5 m (F.B)
d) The dimension of the primary sedimentation tank is 13.3 m x 3.4 m x 4.5 m.
e) The dimension of the trickling filter is diameter of 22.5 m and depth of 4 m.
f) The dimension of sludge dry bed is length of 12.5 m and width 8 m

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