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Design of Soil Biotechnology Treatment Plant for Vishwaniketan's Campus

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Abstract - *Soil biotechnology (SBT) is a green engineering approach for wastewater treatment and recycling. In the present study institutional waste water characterization has been performed followed by the design of Soil Biotechnology plant. The project of designing Soil Biotechnology plant (SBT) gives brief description of how it is different and efficient than conventional system. The collection, analysis & treatment require for waste water from Vishwaniketan's Campus. In first phase water is analyzed for pH, Turbidity, DO, Solids & BOD etc. Depending upon the test results treatment process is decided and designed treatment units for waste water & prepared the estimate and cost calculated for construction of treatment plant. A sewage treatment plant is a facility quite necessary to receive the waste water and removes the materials which pose harm for general public and also for environment. The main objective of our study to reduce the fresh water intake for college and treated effluent will use for flushing & plantation purpose and a solid waste (or treated sludge) will suitable for reuse as farm fertilizer.*

Key Words: **SBT, wastewater, characterization, efficient, facility, design, effluent**

1. INTRODUCTION

1.1 General

According to the survey quite two billion people worldwide lives in regions facing water scarcity. Water scarcity already affects every continent and quite 40 percent of the people on our planet and in future it'll be a most critical situation. By 2025, 1.8 billion people are going to be living in countries or regions with absolute water scarcity, and two-thirds of the world's population might be living under water stressed conditions. Most of the maximum water requirement is for the agricultural activities. In every domestic areas, institutions huge water demand is there. To scale back this demands and fulfil those requirements the suitable efficient and most vital that's economical waste water treatment system is required.

1.2 Introduction to Soil Biotechnology

Soil Bio- technology is a wastewater treatment system, which works on the principle of trickling filter. In SBT, a combination of physical processes comprising of sedimentation, infiltration and biochemical processes are carried out to remove the suspended solids, organic and inorganic contents of the wastewater. The main components of this technique are suitable mineral constitution, culture containing native micro-flora and bio- indicator plants. The SBT comprises soil, formulated granular filter media and some selected cultured plants. It involves a mixture of physical and biological process for processing of waste water and it derives its fundamentals principle from the functioning of a terrestrial ecosystem.

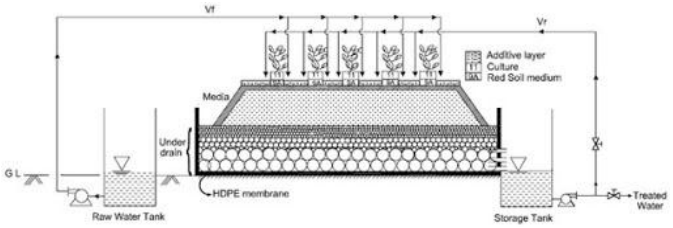

Fig -1 Layout of SBT

The above figure shows the overall layout of the SBT. The construction and operation is sort of easy and straightforward as that of conventional system. There's no chemicals needed for treatment, because all the process from sedimentation to treated effluent are done ecologically. Therefore, the operational and maintenance cost is goes down up to large extent.

The conventional sewage treatment system has lot of different activities than soil biotechnology system. The comparison of technology features of conventional and soil biotechnology system is here.

Table-1: Comparison between conventional and SBT system

Sr. no	Parameter	Conventional System	Soil Biotechnology
1	Treatment process	Process involves chemicals to treat like alum, chlorine, acids, alkalis etc.	No need of any chemical for treatment
2	Odor and nuisance	Due to ammonia and aerosols generated from sedimentation	No possibilities, control is achieved via natural additives

		tanks and sludge	and plantation of aromatic plants
3	Process loss	15 – 20 percent of water is lost in the process since the water is held within the sludge generated during the process apart from surface loss.	Water loss is only due to evapo-transpiration loss from the filter surface. More than 90% recovery is seen.
4	Sludge produced	Chemical and biological sludge is produced as waste by product which needs further handling like dewatering and drying for disposal	No sludge is produced. Bio-mineral fertilizer is produced as useful byproduct.
5	Energy	In this process is based on aqueous phase therefore mechanical aeration is required which is highly energy intensive.	Aeration is achieved by natural aeration, no external energy required, highly energy consumptive
6	Byproduct	No useful byproduct is produce.	Biomass, flowers, bio-fertilizer apart from fish compatible treated water is produced.

2. METHODOLOGY

The general methodology adapted is summarized below.
The samples are collected from various points in college campus i.e from hostels, canteen, mess, college and Architecture College etc. It is important to review the characteristics of waste water to design any kind of treatment facility. The treatment process their duration, efficiency all other factors are depends on the characteristics of an equivalent. After the calculation of observations of various tests performed the results are analyzed with MPCB (Maharashtra pollution Control Board) and CPCB (Central Pollution control Boards) boards. Based on the test results the treatment process is set and therefore the treatment units are designed accordingly.
The treatment process is shortly summarized below.

2.1 Treatment Process

The following figure will give better idea about treatment process.

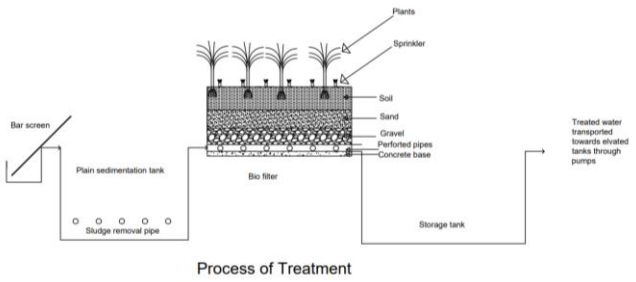

Fig - 2 Process of Treatment

The process can be run in batch mode also as in continuous mode. In above figure, the waste water is firstly come at the screening chamber through a collection pipe. The intake of screening chamber is fitted with coarse screen referred to as bar screen which removes the floating matter and suspended matter sized more than 2cm. Afterwards the mechanical coarse screen removes the fine impurities which wasn't screened through bar screen. The sewage is then transferred towards the sedimentation tank. The detention period is of 4hrs. During this the suspended particles and the other impurities get settled down. This process is done without adding any chemicals into it therefore it is plain sedimentation. The sludge produced is collected and treated for fertilizer production. Then after sedimentation the water is transferred towards the biotechnology filter through pump. To achieve the natural aeration the water is sprinkled over the plants and soil media over the filter with hydraulic loading typically about 0.04-0.06 $m^3/m^2/h$. Now here biological action of bacteria and microorganisms takes place. The water is filtered through this media and picked up in storage tanks near the filter.

The overall duration for operation of treatment process is 4-6 hrs. The filter bed is then kept in rest for the rested time before the next cycle. In Soil Biotechnology system, problem of clogging is get overcome by propagating soil ecology in place, alternate wetting and drying cycles. During drying cycle, this clogging layer develops cracks due to respiration; so alternate wetting and drying is required for efficient performance.

Factors affecting treatment process of SBT

1. Seasonal variation: Reduction of nutrient concentrations during a filter is mainly by biotic, temperature-dependent activity. The losses within the treatment process are mainly evapotranspiration and water taken for growth of plants. Therefore the losses are more in summer season than winter.
2. Plantation: Plantation is a crucial tool for functioning of biological activities. It is oxygen supplying tool for the

treatment. Because of photosynthesis plants supply the oxygen to bacteria or earthworm present within the soil.
3. Bacteria and worms: Earthworm body works a bio-filter which widens the microbial metabolism by increasing their population. It also grinds, aerate, crush, degrade the chemicals and act as biological stimulator.

3. EXPERIMENTAL ANALYSIS

Samples of row waste water were collected in July 2019 and tested. In the present study, tests conducted are pH, turbidity, BOD, DO, solids etc. Conducted tests were performed as per the standard procedures according to IS procedures.

Direct measurement of pH of waste water effluent may vary dramatically due to change in temperature, water flow and any substance present in water. Therefore for the accurate measurement of the pH value of waste water, the accurate value of temperature is additionally required. IS recommends standard pH meter, a durable pH electrode, an ATC (automatic temperature compensation) probe, a stirrer with stir bar, 100-mL graduated cylinder, 100-mL beaker, deionized water and buffers. The pH electrode will be exposed to chemical contaminates and particulates; recommend a double junction electrode.

The presence of suspended particles in the sample is the turbidity. It is caused due to dissolved impurities in water. Its presence is expressed in parts per million of pure water. This can be found out by the aid of various instruments such as Nephelometric turbidimeter, Jackson's turbidimeter, Turbidity rod, Baylie's turbidimeter, etc. In present study the instrument used is Nephelometric Turbidimeter. It indicates the presence of turbidity in NTU (Nephelometric Turbidity Unit).

Biochemical Oxygen Demand (BOD)

The Biochemical oxygen demand of sewage is that the quantity of oxygen required for the biochemical oxidation of the decomposable matter at specified temperature within the specified time. During natural decomposition, the life activities of organism are stimulated by high temperatures and decreased at low temperatures. Therefore, the temperature and time during B.O.D. tests are testified.

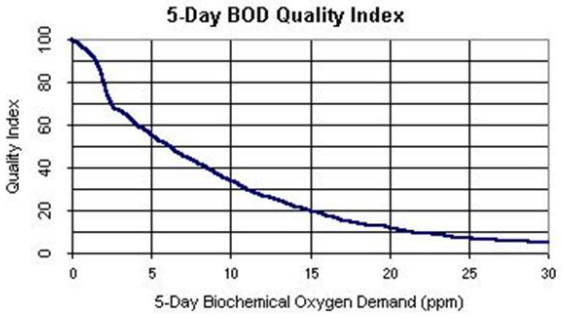

Fig - 3 BOD Graph

It are often seen that within 5 days period, about 60 to 70% biochemical oxidation is completed. Within 20 days period it is about 80 to 100 % completed. As biochemical oxidation is a slow process it take an infinite time for completion. Providing larger period for B.O.D determination is not convenient therefore 5 days period is adopted for B.O.D test. 20c temperature is employed as an average value for slow moving streams in temperate climate and can be easily duplicated in an incubator the rate or biochemical reaction increase with temperature and B.O.D values determined at different temperature will be different. The use of BOD test is (1) to determine the quantity of oxygen that will be required to stabilize the organic matter present, (2) to determine the size of treatment facility & (3) to measure the efficiency of plant.

Dissolved oxygen (DO) levels in environmental water depend on the physiochemical and biochemical activities in water body and it's a crucial useful in pollution and waste treatment process control. Two methods are commonly wont to determine DO concentration: (1) The iodometric method which is a titration-based method and depends on oxidizing property of DO and (2) The membrane electrode procedure, which works supported the rate of diffusion of molecular oxygen across a membrane.

The term "solids" is usually used when pertaining to any material suspended or dissolved in wastewater which will be physically isolated either through filtration or through evaporation. The analysis of this features a great importance because the planning of the filter is depends thereon. Solids may affect water or effluent quality adversely in a number of ways. Waters with high dissolved solids generally are of inferior palatability and should induce an unfavorable physiological reaction in the transient consumer. For these reasons, a limit of 500 mg total solids/l is desirable for treated effluent of waste water. The total solids comprises of two sorts of solids that are suspended solids and dissolved solids.

4. RESULTS & DISSCUSIONS

After analysis the test results are compared with the CPCB board. The results were observed are covered in following table.

Table -2 Test results

Test	Before treatment	CPCB recommendations	Remark
pH	6.7	6-9	No Treatment required
Turbidity	27.8 NTU	35 NTU	No Treatment required
DO	2.4 mg/l	5 mg/l	Treatment required
BOD	133 mg/l	50 mg/l	Treatment required
Total Solids	1000 mg/l	500 mg/l	Treatment required

After the analysis of test results the following discussion were made that are suitable treatment units to be made for the proper treatment. The units of designed treatment facility consists screening chamber, plain sedimentation tank, soil biotechnology filter (soil scape filter) with attached storage tanks.

4.1 Design

1] Design of screening chamber

- The inlet of screening chamber is provided with bar screen of size 1.5m x 1.5m
- Then after mechanical fine screen with conveyer belt setup.
- Therefore the size of screening chamber according to setup is 2m x 2m x 2.5m

2] Design of Sedimentation tank

Designing for total maximum designed capacity = 1 MLD

Quantity of water to be treated during an assumed detention period of 6 hours

$= (1 \times 10^6 / 24) \times 6 = 250{,}000$ lit $= 250$ cu.m

Hence, the capacity of the tank required (V) = 250 cu.m

- Assuming depth = 4 m (with free board)
- Assuming Velocity of Flow = 0.03 m/sec

Therefore,

Length (L) = velocity x detention period

= 0.03 x 6 x 60

L =10m

Now,

Area = Volume / L = 250/10 = 25 m^2

Therefore,

Width = Area / Depth = 25 / 4 = 6.25

Therefore size of sedimentation Tank

= 10m x 6.24m x 4m

3] Design of Soil Biotechnology filter

Total Waste water treated through Filter = 2,50,000 lit
Filtration rate lit/day/ m^2 = 9600 lit/day/ m^2

Now,

Total Surface Area of Filter = Total Waste water/ Filtration rate lit/day/ m^2

= 2,50,000 / 9600 = 26.04 m^2

Now, Size of Filter

A = L X B

Assuming L= 1.5 B

26.04 = 1.5 B X B

B = 4.16 m

L = 1.5 X 4.16 = 6.24 m

Size of Bio Filter= 6.24m x 4.16m x 3m

4] Design of Storage Tank

Total Waste water = 250,000 lit

Evapotranspiration losses =2%
Moisture content of soil =18%
Total filtered water = 80% of Total filtered water
= 80/100 x 250,000
= 200,000 lit

Volume of Tank = 2, 00,000 / 1000 = 200m^3
Height of Tank = 4 m (with free board)

Area of Tank = Volume of Tank / Height of Tank
= 200/4
Area of Tank = 50 m^2

We construct 2 tanks with length = 6.24m

Area of 1 Tank

= Area / 2 = 50 / 2 = 25 m^2

A= L X B

25= 6.24 X B
B= 4m

Size of Storage = 6.24m X 4m X 4m

Designed Treatment units are,

Screening Chamber – 2m x 2m x 2.5m
Sedimentation tank – 10m x 6.24m x 4m
Filter – 6.24m x 4.16m x 3m
Storage tank - 6.24m X 4m X 4m

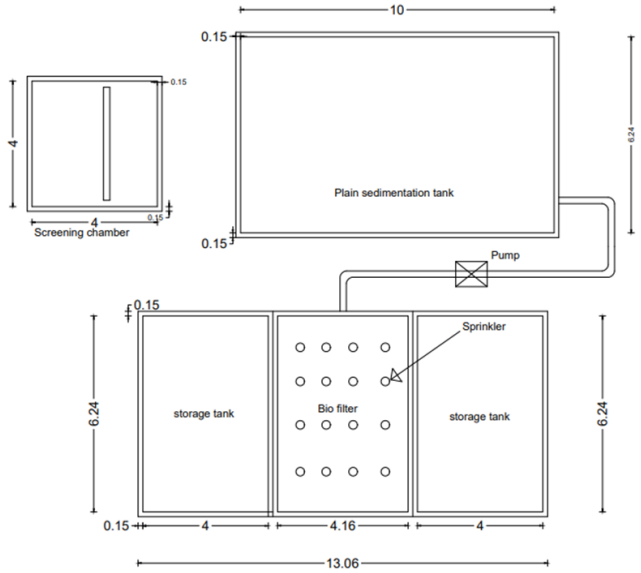

Fig – 4 Plan of whole treatment Facility

5. CONCLUSION

After having study of waste water treatment of waste water from Vishwaniketan's college campus, we carried out different test on waste water, like pH test, turbidity, DO, BOD, TDS, etc. Some of the test results are found above the standard limits which were established or recommended by MPCB and CPCB boards. Our study and design will reduce up to 60 to 65% of total water intake of the campus. And will achieve great economy in water requirement as well as in money. The odour and fly nuisance problems get eliminated in treatment facility due to planted plants on bio-filter. And the sludge from sedimentation tanks will processed and will be useful as a soil fertiliser.

The estimated cost of the Soil Biotechnology Plant (SBT) is Rs. 12, 40,000/-. The operation and maintenance cost is almost 1 to 1.5 lacks per year, which is less as compared to conventional treatment system.

The proposal may be submitted to various government agencies for actual implementation.

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REFERENCES

[1] Yeole U., Pattanaik B. R., and Shankar H. S **"Soil Biotechnology Process Simulation using Computational Fluid Dynamics"**, Department of Chemical Engineering, Indian Institute of Technology Bombay, Powai, Mumbai-400076, India.

[2] A. Kadam, G. Oza, P. Nemade, S. Dutta, H. Shankarn **'Treatment of municipal wastewater using laterite-based constructed soil filter"**, Ecological Engineering 35 (2009) 1051–1061, Department of Chemical Engineering, Indian Institute of Technology, Bombay, Powai, Mumbai 400076, Maharashtra, India.

[3] Joseph D. Rouse **"Development of Environmentally Sustainable Methods for Treatment of Domestic Wastewater and Handling of Sewage Sludge on Yap Island"**, Sustainability 2015, Water and Environmental Research Institute of the Western Pacific, University of Guam.

[4] Dr. B. Pattanaik, Bhawalkar V.S., Shankar H.S. **"Soil Biotechnology for Solid Waste Treatment and Utilization"**, Life Link Technology, 4th world congress on Chemical Engg., 23-27, sept.2001, Melbourne, Australia.

[5] M. Chandrashekhar, and G. Das **"Integrated Water Conservation and Protection Scheme for Rural Location"**, 3rd International Conference on Civil, Biological and Environmental Engineering (CBEE-2016) Feb. 4-5, 2016 Bali (Indonesia).

[6] Danielle Lella Bartolone, **"Culture as Sustainability: The case study of Govardhan Ecovillage and Vedic culture in India"**, City University of New York (CUNY)

CUNY Academic Works School of Arts & Sciences Theses, 2-1-2019.

[7] Ali Hadi Ghawi **"Study on the Development of Household Wastewater Treatment Unit"**, University of Al-Qadisiyah, College of Engineering, Department of Civil Engineering, Iraq., Volume 19, Issue 2, March 2018

[8] Andreas N. A., and Shane A. S., (2015) **"Wastewater Treatment and Reuse: Past, Present, and Future."** Deptartment of Chemical & Environmental Engineering, University of Arizona, Water 2015, 7, 4887-4895; doi:10.3390/w7094887.

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