Domestic Wastewater Treatment by Root Zone Technology using Macrophytes

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Abstract—This project examines Root Zone Technology by using macrophytes, which is a low-cost and environmentally friendly method of wastewater treatment. To effectively treat domestic and industrial effluents, the root zone treatment and macrophytes treatment system uses a natural method. The wetlands bed will be divided into number of zones: soil layer, sand layer, coal layer and aggregate layer. Root zone plants (Colocasia esculenta) planted on the top layer and then treated with floating macrophytes (Pistia stratiotes/Spirodela and Lemma). When wastewater passes through the top and intermediate layers, all suspended solids become trapped in the pores of soil and sand, and the remaining solids are removed by bacteria. After passing through filter bed water is allow to store in another chamber where water is treated with floating macrophytes which utilizes dissolve and suspended nutrients and helps to reduce concentration of pollution of waste water. The effluent characteristics such as pH, color, odor, BOD, COD, TDS, TSS, Nitrogen, and Phosphate determined. The result shows a reduction in parameters because of the longer detention periods, the removal rate is increasing. The goal of this project is to determine which wastewater treatment method is the most cost-effective in comparison to traditional wastewater treatment methods. The conventional method is unsuitable for rural areas due to its high cost. One of the alternative wastewater treatment technologies is the Root Zone technology combine with macrophytes. This Treatment process is simple to use, requires little installation, and requires little maintenance. It is also less expensive than traditional treatment systems. To reap the benefits of this technology and ensure long-term development, it must be fully utilized in developing countries such as India.

Keywords: Wastewater Treatment, Root Zone Technology, Macrophytes

I. INTRODUCTION

Water is the basic source of life. The vast oceans contain 93\% of the total amount of water 4 \% is underground water, 2 \% is stored in the form of icebergs and ice caps, and less than 1 \% is available as freshwater. Environmental protection has received a lot of attention in recent years as a result of globalisation (Climate Change report, 2002). The major water bodies around the world are polluted by the discharge of domestic sewage and industrial wastewater. Water treatment technology is both effective and eco-friendly. Growing population, industrialization, and urbanization are the primary sources of pollution in India. The improper disposal of waste is now a major environmental issue. As economic development has increased, so has water pollution. Most of the Municipal waste is discharged directly into the river without being treated. In urban areas, wastewater treatment plants are available, but in rural areas, sewage drains are directly connected to water bodies.

Root zone technology with aquatic and floating Macrophytes is certain to be a beneficial treatment and alternative treatment technology for wastewater treatment. Root zone technology is a technique for purifying waste as it flows through a man-made wetland area. Some of the physical, chemical and biogeochemical processes that remove pollutants include sedimentation, absorption and nitrification, and uptake by wetland plants. These systems use wetland plants, Macrophytes, soils, and associated microorganisms to remove contaminants and impurities from wastewater. These plants are essential parts of the wastewater treatment process. The larger aquatic plants growing in wetlands are usually called aquatic macrophytes. These include aquatic vascular plants, aquatic mosses, floating and some larger algae. The presence or absence of aquatic macrophytes is one of the characteristics used to define wetlands, and as such macrophytes are an indispensable component of these ecosystems. As the most important removal processes in constructed treatment wetlands are based on physical and microbial processes, the role of the macrophytes is important for treatment process. There is no need for machinery or electricity, there are no operating costs, low maintenance costs, it improves the landscape, provides a natural habitat for birds, and there are no odor issues. The project uses root zone technology, aquatic macrophytes (Colocasia esculenta) and floating macrophytes (Spirodela/Pistia stratiotes and lamna) for treatment to analyze the wastewater characteristics.

II. LITERATURE REVIEW

The literature review pertaining to survey of root zone technology system by using macrophytes and literature related to pure experimental aspects of wastewater treatment with various methods is presented below

A. Nanda Sahil (2017) has studied on Root Zone waste water Treatment for domestic sewage the wastewater is collected from the septic tank when that overflows is transferred to the plant. On the plant, a pit of essential dimension is made. The clarified sewage from the septic tank is made to pass through the Root Zone pit. The length and breadth of the pit depends on the volume of the wastewater to be treated per day. The pit is lined by sealing with low Density Polypropylene sheets or rolls. If necessary, other types of civil structure can be made into the treatment tank. The pit is filled layer by layer with layered media of adequate porosity.

B. Mane Mahesh et.al. (2017) He has studied on Introduction to Waste Water Treatment by Root Zone Technique. In This study Increasing urbanization
and human activities exploit and affect the quality and quantity of the water resources. This has resulted in pollution of freshwater bodies due to increased generation of domestic waste, sewage, industrial waste etc. This paper reviews the Root Zone Treatment System which are planted filter beds consisting of soil gravel, sand and fine aggregate. This Technique uses a natural way to effectively treat domestic and industrial effluents. RZTS are well known in temperate climates and are easy to operate having less installation, low maintenance, and operational costs and incorporates the self-regulating dynamics of an artificial soil eco-system.

C. Parmar Jigar et.al. (2016)

He has studied on Experimental study on post treatment of dairy wastewater is using hybrid Root Zone technology in this Study give knowledge about dairy waste and the dairy waste and their effective treatment. He had used hybrid reed plant for treatment of Dairy waste. It give from this study confirmed that the Hybrid Root Zone system was highly effective on removing BOD up to 14 mg/L and COD at up to 110 mg/L at 36 hours detention time with a removal efficiency of BOD is 97%, and COD is 92% for dairy wastewater. Reductions in TDS and TSS were not significant. Initially the pH of Dairy waste

D. W. Wang, G. Haberer (2013),

The subfamily of the Lemnoideae belongs to a different order than other monocotyledonous species that have been sequenced and comprises aquatic plants that grow rapidly on the water surface. Here we select Spirodela polyrhiza for whole-genome sequencing. We show that Spirodela has a genome with no signs of recent retro transpositions but signatures of two ancient whole-genome duplications, possibly 95 million years ago (mya), older than those in Arabidopsis and rice. Its genome has only 19,623 predicted protein-coding genes, which is 28% less than the dicotyledonous Arabidopsis thaliana and 50% less than monocotyledonous rice. We propose that at least in part, the neotenous reduction of these aquatic plants is based on readjusted copy numbers of promoters and repressors of the juvenile-to-adult transition. The Spirodela genome, along with its unique biology and physiology, will stimulate new insights into environmental adaptation, ecology, evolution and plant development, and will be instrumental for future bioenergy applications.

III. METHODOLOGY

A. Data Collection

Experimental setup: Pilot scale vertical subsurface flow constructed wetland with and without macrophytes were studied. The experimental setup was assembled using required size pit where an outlet was placed at the other from the bottom using a PVC pipe. The surface of the wetland media was one square meter (1.2*0.9 m²). Macrophyte growing media was prepared in multi layers consist of gravel, sand and garden soil from the bottom respectively, each placed for 10 to 30 cm height. The size of the gravel and sand were nearly in the range of 20-40 mm, 10 – 20 mm, 4.5mm – 10 mm, 1mm- 4.5mm and 0.1 –1 mm respectively. This media was thoroughly washed with deionized water to remove contaminants prior to its usage in the wetland system. Then, the aquatic macrophyte Colocasias esculenta was planted in the growing media with the plant. A tank provided at bottom of outlet was assembled with floating macrophyte. The said macrophyte was acclimatized with the feed water for 4 weeks for its better survival in the new environment. The experiments were conducted under controlled conditions in natural environment exposed to sunlight. Once the macrophyte was acclimatized with the feed water, it was fed with wastewater from the top of the media with the hydraulic retention time (HRT) of 24 hour and in floating macrophyte tank 48 hour. This experiment was conducted continuously.

Water sampling and analysis: A grab sampling technique was used to collect wastewater sample from wastewater storage tanks where they store the wastewater prior to final discharge. Before sampling, wastewater was thoroughly mixed with spade to make sure a homogenous mixture. Samples were collected and analyzed for various physico – chemical parameters such as pH (IS 3025, Part 11), Electric conductivity (EC), Total solids and Total suspended solids (IS 3025, Part 17), Total dissolved solids (IS 3025, Part 16), Biological oxygen demand (BOD) (IS 3025 (Part 44)), Chemical oxygen demand (IS 3025 (Part 58)), nitrate (IS 3025 (Part 34)) and phosphate (IS 3025, Part 31). The TS, TSS and TDS were measured by gravimetric method; BOD by Winkler’s method of titration; COD was determined by oxidation (K2CrO4) and titrimetric method. Phosphate, Nitrate and Sulphate were measured by colorimetric method at spectrophotometer wavelength 840 nm, 420 nm, and 420 nm respectively. The standard analytical methods recommended by APHA (1989) were adapted.

Steps involve during Construction of working model:

1. A Root Zone system model made by constructing a required dimension pit.
2. The unit will be constructed by placing separate layers of Coarse Aggregate, River sand, soil, after arranging the layers the plants will be planted in the unit.
3. A PVC pipe and a tap are included with the inlet unit.
4. Only plain water will be sprinkled during the one-month growth period.
5. The wastewater was then allowed to enter the root zone system, and samples were collected.
6. After collecting sample in another chamber it is treated by floating aquatic macrophytes Pistia stratiotes (water lettuce)/Spirodela and lemma for 24-48 hour.
7. After treating with floating aquatic macrophytes water collected in another chamber where we use for another purpose or we can directly disposed of into the stream/river or can be used for gardening purpose.

IV. RESULT AND DISCUSSION

The wastewater sample collected was characterized for various water quality parameters. The study is being carried out in order to identify alternative sources of waste water treatment systems so that a similar methodology can be effectively implemented as a waste water treatment solution for Domestic and municipal waste water.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Wastewater Sample</th>
<th>After Treatment</th>
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<tbody>
<tr>
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</table>
### Table 3.1: Parameters of wastewater before and after Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Before Treatment (Sample 1)</th>
<th>Sample from first chamber (Sample 2)</th>
<th>Sample from second chamber (Sample 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour (Hazen Unit)</td>
<td>60.0</td>
<td>35.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Odour</td>
<td>Smell</td>
<td>Few Smell</td>
<td>No Smell</td>
</tr>
<tr>
<td>pH at 25°C</td>
<td>6.73</td>
<td>6.78</td>
<td>7.1</td>
</tr>
<tr>
<td>BOD (mg/Lit) 3 Days at 27°C</td>
<td>376</td>
<td>182</td>
<td>97.2</td>
</tr>
<tr>
<td>COD (mg/Lit)</td>
<td>476</td>
<td>204</td>
<td>128</td>
</tr>
<tr>
<td>TDS (mg/Lit)</td>
<td>824</td>
<td>576</td>
<td>443</td>
</tr>
<tr>
<td>TSS (mg/Lit)</td>
<td>203</td>
<td>129</td>
<td>92.3</td>
</tr>
<tr>
<td>Nitrogen (mg/Lit)</td>
<td>53.4</td>
<td>28.9</td>
<td>18.4</td>
</tr>
<tr>
<td>Phosphate (mg/Lit)</td>
<td>32.7</td>
<td>24.7</td>
<td>11.8</td>
</tr>
</tbody>
</table>

**V. CONCLUSION**

Waste water discharged was analyzed to determine its characteristics. Unlike in a rural area the waste water shows variation in concentration according to strength. TSS, BOD, COD, Nitrogen, TDS, Phosphate, pH, Colour particularly show large variations. Domestic Wastewater Treatment by Combination of Root Zone Technology and macrophytes (aquatic and floating) was employed on single house scale to treat the waste water. Based on the experimental results, the following conclusions are made.

1) This study demonstrated that the designed sub-surface Vertical flow constructed wetland system could be effectively used for treatment of the domestic waste water.

2) Regarding the performance achieved, the sub-surface Vertical flow constructed wetland was able to reduce further the level of the main physicochemical pollution parameters. The plants do play an important role in the treatment.

3) The overall experimental results demonstrated the feasibility of applying sub-surface Vertical flow constructed wetland unit to treat domestic waste waters. Thus the root zone treatment can be utilized independently or as an addition to macrophytes treatment for complete treatment of waste water.

Reed bed technology is very efficient method for treating decentralized waste water treatment for domestic waste water. It has been observed that In India BOD removal efficiency in Vertical flow varies from 70-80 %, TSS removals are 50-80 % in most cases, In Pathogen and coliform almost 100% removal can be expected. In Reed bed system water is treated in natural manner and not requires much money, not requirement of much energy, not requirement of complicated set up.

**REFERENCE**


