Analysis and Design of Root Zone Technology Reactor for Waste Water Treatment and Management

Pranit Chavan[1], Chaitanya Chikane[2], and Rushikesh Kanase[3], P.G.Borate[4]. S.S.Jadhav[5]

[1,2,3]Student, Department of Civil Engineering, [4,5]Assistant Professor, Department of Civil Engineering
YTC Satara, Maharashtra

Abstract: Excessive human development activities that exploit and impact water resources are responsible for the depletion of water quality on Earth. The rapid growth of cities has caused an increase in pollution of freshwater sources due to the greater generation of household waste, sewage, industrial waste, etc. This article explores the cost-effective and eco-friendly method of Root Zone Technology for treating wastewater. The root zone treatment system effectively purifies both residential and industrial wastewaters using a natural method. This technology has successfully been in use in different countries including Europe and America. The wetland bed will be divided into three sections: soil layer, sand layer, and aggregate layer. Colacassia trees are going to be planted at the topmost level. As the waste water moves through the upper and middle layers, the soil and sand pores will trap any suspended solids, with the assistance of bacteria in removing the rest of the solids.

Keywords: Root zone Technology, Colocassia Esulenta, Vertical sub surface flow, PH, BOD, COD

1.INTRODUCTION

The root zone focuses on the interconnected relationships among bacteria, wetland plant roots, soil, air, sunlight, and water. Root zone treatment is a designed process that cleans wastewater while it travels through a man-made wetland area. The elimination of pollutants occurs through a variety of physical, chemical, and biogeochemical methods such as sedimentation, absorption, and nitrification, as well as being taken in by wetland plants. Root zone systems are said to be the most appropriate for schools, hospitals, hotels, and smaller communities. The purpose of this study is to examine how well the wetland plants Canna and Alocasia work in treating the wastewater produced. A pilot wetland system was built on the campus premises. Canna and Alocasia plants were cultivated outdoors using clean water. Rows of plants were inserted into the system and exposed to sewage from the dormitories and other buildings on campus. Periodically, samples of raw wastewater and treated wastewater were gathered and analyzed for quality. It is observed that this pilot unit is decreasing the levels of TSS, TDS, BOD, COD by, on average. The root zone system meets tertiary treatment standards without incurring operating costs, requiring minimal maintenance, improving the landscape, creating a habitat for birds, and eliminating any odor issues.

2. LITERATURE REVIEW

2.1 Review On Study Of Application Of Root Zone Technology For Grey Water Treatment (June 2023)
Author: Prof. Atul B. Rupanvar, Mr. Omkar. S. Patil, Mr. Vishwajeet. S. Shekhar, Mr. Pavan.S.Jadhav

This paper reviews the Root Zone Treatment System (RZTS) which are planted filter- beds consisting of soil. This Technology 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 ecosystem

2.2 Waste Water Treatment by using Root Zone Technology: Using Colacassia Plant (June 2020)
Author: Punam G. Meshram, Prof. Ritesh J. Raut, Pratik G. Bokse, Atul W. Rathod

This paper reviews that Root Zone Technology is one of the low cost and eco friendly method to treat the wastewater. Root zone treatment system uses a natural way to effectively treat the domestic and industrial effluents. This technology has been successfully running in several countries like Europe and America. The wetlands bed will be divided into three zones as soil layer, sand layer and aggregate layer respectively.

2.3 Domestic Wastewater Treatment by Root Zone Technology using Macrophytes (2022)
Author: Piyush Pal ,Prof. Jayant Ramteke, Prof. Hira Lilhare

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 Lemna). 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.

2.4 Wastewater reuse in agriculture: Prospects and challenges (November 2023)

Sustainable water recycling and wastewater reuse are urgent nowadays considering water scarcity and increased water consumption through human activities.

2.5 Domestic Wastewater Treatment by Root Zone Technology Option (April 2019)
Author: Poonam Thorat, Sayyad Saniya , Salman Shaikh , Raashida Shaikh and Atul Sonawane

Root Zone Technology is one of the low cost methods to treat wastewater. With the help of this system we can treat the Non-Point sources with best results. To achieve this goal we have to divide the Non-Point sources into constructed channels within the river bank followed by root zone bed or if the Non-Point Sources is coming from natural nallas we can provide this system within its Channel.

3.METHODOLOGY

The Root Zone process works in harmony with natural laws to efficiently cleanse both household and industrial wastewater. The Root Zone includes the living relationships of different bacteria species, the roots of reed plants, soil, air, sunlight, and water. Reed Plants can take in oxygen from the surrounding air and produce a large amount of bacteria. The waste water is oxidized and purified by the same bacteria. Due to the occurrence of various chemical reactions underground, the process acts as a reflection of the self-regulating, purifying processes that can be observed in nature.

3.1 Construction and Working of Reed bed.

1. The unit was built by layering stone chips, sand, and stone dust before planting the plants.
2. Further the growth of plants was monitored.
3. Throughout the one-month growth period, only water without any additives was used for sprinkling.
4. Then wastewater was introduced into the root zone system and samples were gathered.

3.2Water sampling and analysis

1. Samples of water were collected one time from both the inlet chamber and outlet chamber of the wetland unit.
2. The samples were obtained by placing a sterile plastic bottle underneath the inlet or outlet pipe of the constructed wetland.
3. The pH, Total Dissolved Solids, TSS, BOD, and COD of the samples were examined following the Standard Methods for Waste and Wastewater Analysis.

3.3 Measurement of Reed bed.

At a lower level, think about using a 10cm thick layer with aggregate particles that are 40mm in size. After taking into account, the coal layer is 10cm thick. A 2 cm thick layer of coconut fiber lies on top of the coal layer. Middle layer consists of 20cm thickness with aggregate size of 20mm, while top layer has a thickness of 10cm with aggregate size of 10mm, and is made up of river sand and black cotton soil. The aggregate was rinsed with water before being placed in the reactor, just like the sand was rinsed with water before being placed in the reactor. Fill all layers of the reactor at the same time and let it sit for twenty-four hours.

3.4 Action of reeds with waste water.

Initially, the presence of the root zone system allows room for the water to flow. Secondly, the roots bring oxygen into the soil and create conditions that support the growth of aerobic bacteria. These organisms play a crucial role in breaking down various compounds, especially in converting ammonia into nitrate, which is the initial stage of breaking down nitro compounds. Thirdly, nitrification occurs, where the plants absorb nitrogen themselves specific quantity of nutrients extracted from the wastewater. Reed beds can assist in improving water quality standards.

1. Significant reduction in both bacteria and viruses.
2. Lowered levels of biological oxygen demand and decreased amount of suspended solids.
3. Decreasing nitrogen levels and eliminating metals.

(A)

(B)

(C)

(D)

3. RESULTS

The samples were collected from the inlet and outlet and analysed for determination quantity in laboratory of Constrotrait Material Testing and LLP Laboratory Wai, Satara. The various parameters analyzed such as pH, BOD, COD and TSS.

Parameters	**Inlet Parameters**	**Outlet Parameters**	**General Standards**
PH Value	8.41	7.95	6.5 – 8.5
Chemical Oxygen Demand (COD)	264	12	Not Specified
Biochemical Oxygen Demand(BOD) For 3 days @27ºC	91	4	< 30 mg/l
Total Suspended Solids (mg/l)	10.60	58.30	< 100 mg/l
Total Dissolved Solids (mg/l)	725	490	Not Specified

4. CONCLUSION

1. While disposing of waste, it was noted that sewage is beneficial for plants because they thrive during the sewage treatment process.
2. There was a significant reduction in the levels of pH, COD, BOD, and TDS in the outlet water when compared to the turbidity of the inlet water.
3. As a result, we concluded that this approach is successful in decreasing COD, BOD, TDS, and adjusting pH to a level similar to neutral water.

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