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Treatment of Dairy Wastewater by Root Zone Technique using Phragmitis Australis

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***Abstract* - A large amount of water is consumed by dairy industry for their processing of dairy products. Hence there is a need to recover the water from the effluent which was discharged from these industries. One of the natural methods to treat this kind of wastewater is Reed Bed System (or) root zone technique. In this study Phragmitis Australis which is locally known as Nanal was used to treat the wastewater. The experiment was conducted with dairy wastewater collected from the effluent treatment plant of dairy industry. From the experimental study it was found that the Root Zone Technique gives a better quality of treated effluent with considerable percentage of reduction in Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).The other monitoring parameters such as pH, Total Dissolved solids (TDS), Electrical Conductivity (EC) and Turbidity were found well within the permissible limits.**

Keywords: Root Zone Technique, Phragmitis Australis, dairy wastewater, COD, BOD.

1. INTRODUCTION

Increase in population, urbanization and industrial development leads to increase in pollution load to the existing water bodies [3, 12]. India has the largest livestock population in the world. The dairy industry is a well established industry and India is known for "Operation flood" also referred as "White Revolution" [11]. The dairy industry is one of the most important food industry among all the major source of waste water [2]. The amount of freshwater will depend on the process technology of milk processing [7]. It generates between 3.739 and 11.217 million m^3 of waste per year (i.e. 1 to 3 times the volume of milk processed) [2, 1]. Hence treatment of Dairy wastewater is very much essential to protect the environment and ecology [9]. For the treatment of dairy wastewater, conventional treatment plants such as physical, chemical and biological methods are normally used but they cause numerous maintenance problems which are tedious and not cost effective [11]. The root zone i.e. filter plant is a biological filter, where biological treatment of wastewater takes place in a soil volume, which is penetrated by the roots of Phragmites australis. This technology is also called as Root-zone system or Bio-Filter or Reed Bed System or Constructed wetland (CW) system or Treatment wetland system. There is a need to exploit this technology in a developing country like India to its maximum to gain its benefits and for sustainable development [10]. Root zone systems whether natural or constructed, constitute an interface between the aquifer system and terrestrial system that is the source of the pollutants [9]. Reed bed is considered as an effective and reliable secondary and tertiary treatment method where land area is not a major constraint [9]. Root zone techniques / Constructed Wetlands (CW) are getting popularity due to their low cost eco-technology for wastewater treatment and also valuable for low income grouped human settlements that cannot bear the cost of conventional treatment systems [5].

2. MATERIAL USED

An untreated wastewater was collected from a nearby dairy industry. The characteristic of the raw wastewater collected from the dairy industry is shown in Table -1. The pH of the chosen influent wastewater is neutral. Phragmites australis a perrineal grass is chosen for using it in the present study of Root Zone Technique. Phragmites australis grows down their roots as underground runners which can spread up to 5 m per year. Phragmites australis, commonly known as the Common Reed, is currently widely used in the remediation of wastewater and various types of grey water through the use of constructed wetlands. This plant will grow in freely drained soil to water to a depth of 1m. The soil in a root zone treatment plant provides a stable surface area for microbial attachment, a solid substrate for plant growth. This helps in the purification of the wastewater by way of physical and chemical processes. Soil plays an effective role in removing suspended solids, pathogenic bacteria and viruses by filtration and sorption [4].

3. EXPERIMENTAL SET UP

A laboratory scale experimental set up was designed to treat the dairy wastewater in a plastic tub. An inlet tank of capacity 10 liters was mounted above the plastic tub (a lab scale confined root zone technique) to have a gravity flow. This inlet tank house an outlet through which the wastewater is allowed to flow into the plastic tub. A valve is fixed to regulate the flow of wastewater to the plastic tub. The type of plastic tub is rectangular in shape. The plastic tub chosen has the length of 0.6m, width of 0.4m and depth of 0.3m. The slope of the plastic tub is

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maintained as 1 in 8m. The filter media is taken as the mixture of pebbles and coarse aggregate. The coarse aggregate of 12 mm size with 10cm thickness was placed on either side wall of the tub. The soil used for the growth of plant was taken as sandy soil with a depth of 25cm. The effluent was drained from the bottom of the plastic tub at regular intervals of four days. The bottom of tub is provided with holes for draining the wastewater. A container is placed under the bin for collection of treated effluent. The schematic representation of the experimental setup is shown in Chart-1.

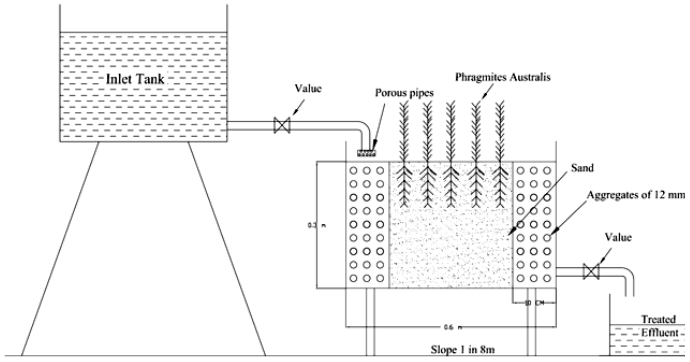

Chart-1: Schematic representation of Root Zone Techniques for treatment of Dairy wastewater

4. METHODOLOGY

The wastewater was collected from the nearby dairy industry and it was filled in the inlet tank. The wastewater was introduced at a rate of 2 liters per day into the plastic tub where the process of absorption by plants, sedimentation and filtration takes place [8]. The amount of filtration of the treated effluent in the plastic tub was very much meager after four days of absorption by Phragmites australis. It was decided to stop the experimentation of collecting the treated effluent after four days. Then the other samples of different concentration were introduced again into the tub to study the effluent characteristics. A total of six samples with different concentration were studied so as to cover the entire varying loading rate of wastewater into the treatment plant generated from the chosen dairy industry using RZT. The experiment was carried out for a period of 24 days to understand the efficiency of the Root zone technique using Phragmites australis (Nanal).

The treated effluent which is collected from the bottom of the plastic tub were tested for different monitoring parameters such as pH, Total Dissolved Solids (TDS) , Electrical Conductivity (EC), Biochemical Oxygen Demand (BOD),Chemical Oxygen Demand (COD), Turbidity and alkalinity.

Table -1: Characteristics of Raw Dairy Industry Wastewater

Characteristics	Values (mg/l)
BOD	280-310
COD	690-750
Turbidity	26-30
pH	6.23-7.1
Hardness	414-435
Alkalinity	503-580
Total Dissolved solids	1098-1125
Electrical conductivity	1570-1660

5. RESULTS AND DISCUSSION:

The treated dairy wastewater using root zone technique by using Phragmites australis has the following inferences at the end of 4 days for each sample are as follows:

1. For a maximum influent BOD concentration of 310 mg/l, there was a greater reduction in the treated effluent with 94 mg/l. The treated effluent has BOD of 85 mg/l for the minimum influent BOD concentration of 280 mg/l as shown in Chart-2.
2. A reduction in COD concentration at the outlet of the RZT for a maximum influent COD concentration as shown in Chart-3 was observed to be 86 mg/l. Similarly for a minimum influent COD concentration of 690 mg/l the treated effluent by RZT was found to be 83 mg/l.
3. The turbidity of the treated effluent was reduced to the range of 2 to 4 NTU as shown in Chart-4 for maximum and minimum influent value (26 to 30 NTU).
4. Hardness of the treated effluent vary from 216 to 243 mg/l for Maximum and minimum influent values.
5. A considerable decrease in the value of alkalinity was observed for the various influent characteristics. It accounts to 379 to 410 mg/l after passing through the Root Zone.

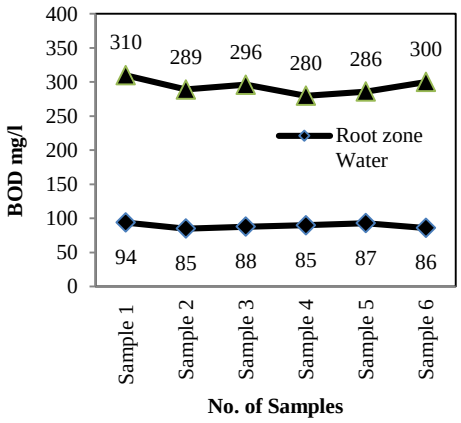

Chart- 2: Effect of Biochemical Oxygen Demand (BOD) for different influent concentration

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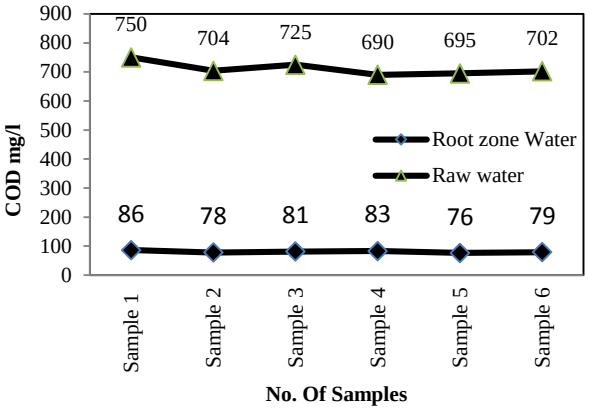

Chart - 3: Effect of Chemical Oxygen Demand (COD) for different influent concentration

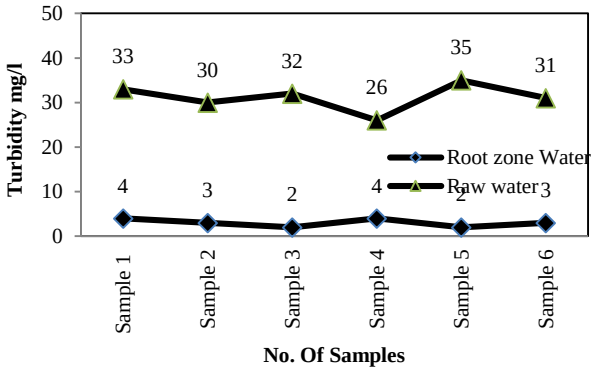

Chart-4: Effect of Turbidity for different influent concentration

6. CONCLUSION

The following conclusions were drawn from the present study:

1. The reduction in BOD effluent concentration was found to be 69 to 71 %. This shows that the organic matter present in the dairy wastewater can be oxidized through the natural Reed Bed system namely Root Zone Technique.
2. Regardless of the higher influent COD concentration there was a considerable higher percentage of reduction in the treated dairy wastewater. It was observed a reduction range of 87 to 89 % was achieved for maximum and minimum influent concentrations. This indicates the chemical used in the process of wastewater are assimilated in the treatment using Phragmites australis by means of Root Zone Technique.
3. A decreasing trend of reduction in the effluent was also observed for the different monitoring parameter such as Turbidity, Alkalinity and hardness for maximum and minimum influent concentration.
4. This shows that even with higher chemical concentration in the influent, the treated effluent by using Root Zone Technique using Phragmites australis was well within the prescribed limits and fulfills the discharge condition as per the regulatory standards.
5. From the above discussion it can be concluded that a root zone treatment plant provides a stable surface area for microbial attachment, a solid substrate for plant growth, and functions directly in the purification of the wastewater by way of physical and chemical processes.
6. Viewing the results the treated effluent shows a greater treatability by the root zone technique for food based industries [1].

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