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Development and Evaluation of Mechanically Aerated Rapid Sand Filter for Waste Water at University Hostel

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***Abstract*— This paper presents the development and evaluation of a mechanically aerated rapid sand filter (MARSF) designed for wastewater treatment in university hostels. The MARSF integrates mechanical aeration to enhance the biological treatment of wastewater, improving the efficiency of rapid sand filtration systems. The study involves the design process, implementation, and performance evaluation of the filter in terms of its efficiency in reducing pollutants and meeting regulatory standards. Results demonstrate the effectiveness of the MARSF in treating hostel wastewater, highlighting its potential for broader applications in similar settings.**

***Keywords*—rapid sand filter, mechanical aeration, sewege treatment**

I. INTRODUCTION

With the linear increasing trend in industrialization and urbanization, there is tremendous increase in the production of industrial effluents and treated sewage waters. This became one of the major important sources of pollution. There are mainly three outlets for its disposal, viz., surface waters, atmosphere and land. Application of sewage sludge, municipal waste water and industrial effluent on land for disposal are being practiced at many places. But, all waste waters cannot be used in all types of soil. Land should not be taken for granted as a neglected waste tank. The qualities of the effluent/sewage water affect the soil productivity. This depends upon the quality of effluent/sewage water, the quantity used and the soil on which it is used. Further, the local climatic conditions also affect the residual pollution in the soil.

II. REVIEW OF LITERATURE

The attempt is made to review the work done on aspects of utilization of sewage water as an irrigation source and its effect on crop production and soil properties.

A. Effect of treated sewage water on yield, nutrient accumulation and quality of crops

The response of a plant to liquid pollutant is an integration of the effects of many factors such as soil type, climate and the nature of the pollutant. Larson et at (1975) stated that industrial liquid wastes could be used safely and effectively with proper precautions to increase soil productivity.

B. Effect of treated sewage water on crop yield

Tiwari et al. (1996) studied the influence of treated sewage water and well water with different fertilizer levels on rice and soil properties. Grain and straw yield of rice increased with the application of all fertilizer levels either with treated sewage water or with tube well water.

Bhatia et al. (2001) studied the effect of sewage application on content and uptake of nutrients, identified the problems associated with sewage use and suggested environmentally safe methods of sewage application Jin agriculture. Application of sewage increased the yield of crops compared to irrigation with fresh water.

Malarvizhi and Rajamannar (2001) reported that the sewage water irrigation significantly increased the yield of green fodder. The interaction effect between 100 kg N with treated sewage water irrigation recorded the highest green fodder yield of 357 t ha^{-1}.

C. Effect of treated sewage water on nutrient accumulation and quality of crops

Gadallah (1994) observed that plants treated with waste water had higher soluble sugars, hydroly sable carbohydrates and soluble protein levels than the control plants, while amino acid content was found variable. Plants grown with waste water had accumulated higher quantity of Fe and Na, and Mn to a lesser extent in their roots whereas Cl, Mg, Ca, P and Zn concentrations were higher in shoots.

Gladis et al (2000) studied the effect of waste water irrigation and N and P fertilizer rates on hydrocyanic acid (HCN) and nitrate (N03) content of fodder sorghum cv. Co.27. The HCN and N03 content were high in waste water irrigated fodder and the highest value was obtained one to cattle shed I wash. Application of N increased, while P decreased these toxic components in fodder with the advancement of crop growth, a decrease was observed in HCN and N03 content.

Malarvizhi and Rajamannar, (2001) reported that the treated sewage water irrigation resulted higher K, Ca, Fe, Mn and Zn content in BN-2 grass A decrease in crude fibre content was

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observed due to the higher implication of N with both the sources of irrigation water because of its involvement In protein synthesis, Chemical analysis for metals in plant parts showed that Cu, Fe end Zn were much higher in plants harvested on treated sewage water sites (Campbell et al, 1683).

Malik et al. (2004) determined the extent of micronutrient (Zn,Cu, Fe and Mn) and heavy metal (Cd, Cr, CO, Ni and Pb) accumulation in some treated sewage water-irrigated soils and crops. They reported that the Pb was not detected in any of the crops. The Cd and Ni concentration was maximum in fodder crops, while Cr and Co were maximum in oilseed crops. The Zn, Cu and Fe were found maximum in vegetables, while a greater concentration of Mn was observed in fodder crops.

Fonseca et al (2005) reported that the secondary treated sewage effluent irrigation water did not affect S, B, Cu, Fe, and manganese Mn content in shoots of properly fertilized plants, but it induced a decline in Zn content of shoot.

D. Effect of treated sewage water on soil properties

Singh and Kansal (1983) reported that the application of municipal waste water increased the accumulation oi available Fe, Mn, Zn, Cu, Pb and Cd in soils. The accumulation was the highest in soils receiving waste water from industrial towns, Azad et al (1986) observed the content of total Cd, Ni and Co in the surface layer of normal soils (i.e. not irrigated with treated sewage water) in the range of 0.53 to 1.05, 18.0 to 30.0 and 11.0 to 21.0 ppm, respectively. Their corresponding values for sewage treated soils were 0.83 to 1.58, 35.0 to 65.0 and 16.0 to 31.0 ppm, respectively.

Azad et al. (1987) confirmed that available N content of top soils irrigated with treated sewage water and tube well water were 87 and 51 ppm, respectively and they decreased with depth; available P content followed a similar trend. Total P and K content of sewage amended soils were 47 and 34 per cent greater, respectively than those of tube well irrigated soils; total P decreased and total K increased with depth. Malik et al.(2004) reported the higher concentration of micronutrients in sewage irrigated soils than the non- irrigated soils. Heavy metal content was rather varied but, their concentrations in the soil samples were found within safe limits.

Janowska (1987) studied forest trees on a sandy soil irrigated with different rates of sewage and well water. Irrigation with treated sewage water (up to 100 mm week-1) favourably affected soil pH, CEC, total N, organic C and % base saturation. Salinization was not found avoided because of rapid leaching. Irrigation with well water also found favorable, however, it was less extensive for soil transformations.

III. MATERIALS AND METHODS

The mechanically aerated rapid sand filter (MARSF) plant is placed in proximity to point of final disposal of sewage water, Care has been taken while locating plant which is the downstream side of the campus i.e. south-west side and sufficiently away from water intake works.

In subject area, the general slope of ground is observed north-east to south-west, if the plant established in south-west, than there may be a problem pollution of general atmosphere by smell and fly nuisance.

A MARSF plant is placed behind the *Vivekananda* boys hostel, JAU campus, Junagadh, Gujarat, India. The raw water from the *Govardhan* Hostel's sump (Sedimentation Tank) is disposed off outside of the campus through 6" *pvc* pipe. For treatment of this waste water, a connection was established with MARSF plant. A T-Connection was established at junction with valve to regulate discharge and bypass if needed. (Figure 1)

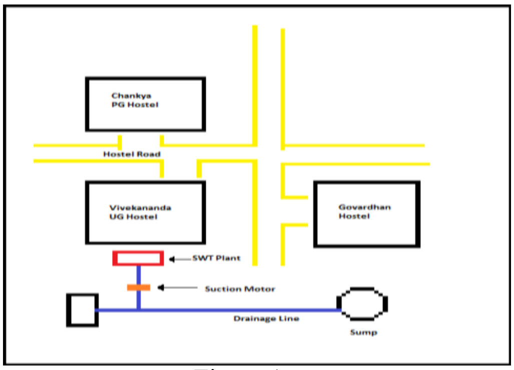

Figure 1

A. MARSF plant layout

The plant consists of iron angle frame (50mmx50mmx3mm) admeasuring 1m × 2.5m x 1m with three storeys, each storey accommodating two parallel PVC pipe of 4 inch diameter filled with sand. The waste water enters in top storey pipe and flow through the sand in spiral pattern and discharged at the bottom storey. Each storey provided with the valve and bypass mechanism for controlling the discharge in each pipe. The total length of sand filled pipe is 12 m.

The discharge from the sand filled pipe is collected in the RCC tank for aeration. The aerator is made up with 5 mm diameter pipe with 1 mm holes at 10 mm spacing; same was placed at the bottom of RCC tank and connected with air compressor.

B. Treatment and sampling

- The 0.5 hp motor pump is used to supply sewage water to MARSF plant, the water flow through the sand filled pipe and same has been collected at different location considering the length of flow i.e. 0 m, 2m, 6m, 10m and 12 m. the collected samples at 12m outlet were aerated for duration of 15 minutes, 30 minutes, 45 minutes and 60 minutes.
- The sample was collected for testing different parameters i.e. pH, EC, BOD, COD, TDS, Ammonical Nitrogen at 0m, 2m, 6m, 10m and 12m with aeration duration of 15 minutes, 30 minutes, 45 minutes annotated as Raw, L2, L6, L10, 12m and L12-15 min, L12-30 min, L12-45 min respectively.

IV. RESULT AND DISCUSSION

This experiment was carried out to determine the changes occurred in the sewage water as it is passes through the different parts of the plant. It can be concluded from the results of these parameters satisfying the FAO quality of irrigation water.

It was observed and concluded that the pH of the water is slightly decreasing as water passes through the sand filled pipes and longer duration of aeration. The results shows that the pH

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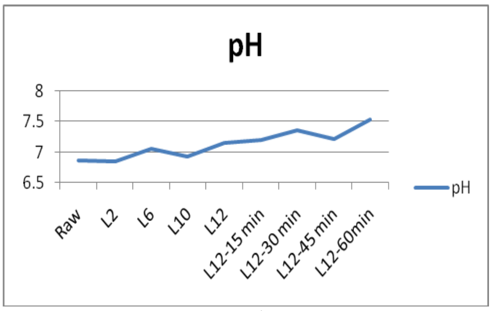
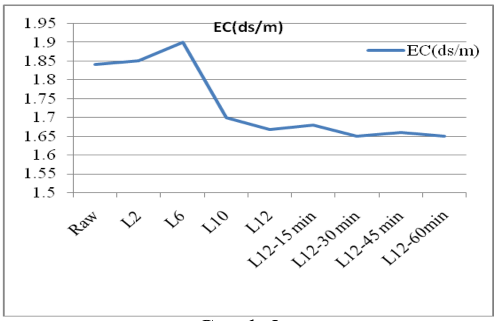
of the water is 7.25 at 12 m pass and shows variation from 7.25 to 7.5 for different level of aeration 15 min. to 45 min. (Graph 1)



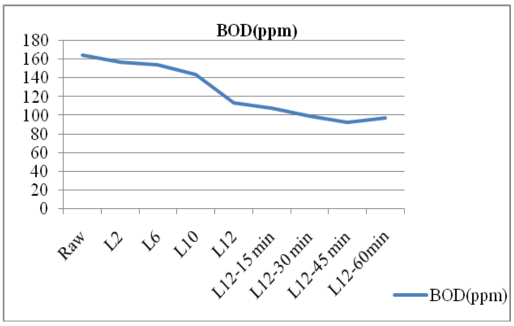
Graph 1

As shown in graph 2, the EC of different samples not seen significant change in the EC of the sewage water (graph 2).



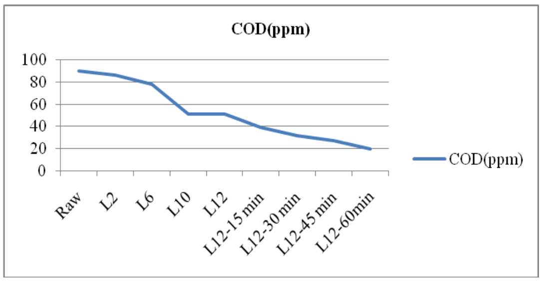
Graph 2

As shown in graph 3, BOD of the samples is continuously decreasing as water passes through the plant. It is decreasing about 40% .



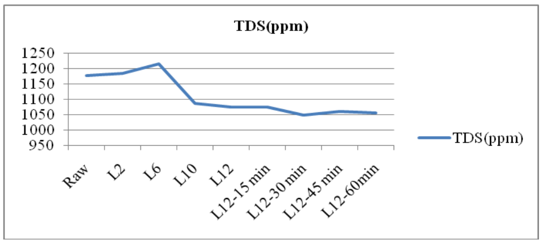
Graph 3

As per the graph 4, the COD content is decreasing from first sample to last sample by 66%.



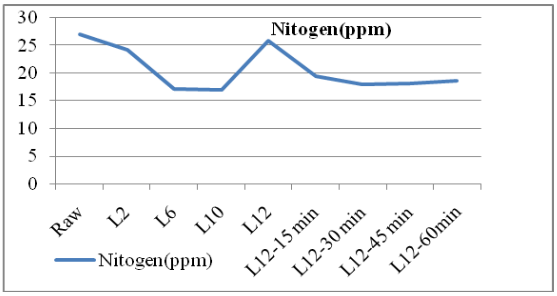
Graph 4

As shown in graph 5, total dissolved solids was not change as waste water passes through plant.



Graph 5

As shown in above graph 6, ammonical content is decreasing from first sample to last sample. Ammonial nitrogen is decreased to 32%.



Graph 6

V. CONCLUSION

This experiment was carried out to determine the changes occurred in the sewage water as it passes from the sewage water treatment plant. It is concluded from the results that the waste water being purified as passes through plant.

The pH of the water is slightly decreased and moving to its neutral value 7.00. There was no significant change observed in the EC of the sewage water at different sample. The BOD is decreased by about 40%. Where the COD is also decreased by around 66%.

It may also be concluded from the result that the TDS content of the sewage samples are not varying more different samples. The Ammonical nitrogen is decreased by 32%.

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