

Bench Scale Treatability Studies of Wastewater by Soil Aquifer Treatment

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ABSTRACT: Soil aquifer treatment (SAT) is a wastewater reclamation and reuse technology that can renovate wastewater effluent to acceptable quality for indirect potable reuse system when coupled with other appropriate wastewater treatment technologies. The development and implementation of cost effective and environmentally sound treatment technologies with low energy are desired to mitigate surface water pollution and provide effective integrated water resources management through water reuse. SAT system is suitable for developing countries seeking for both water resource and water quality managements through surface water and groundwater system. In the present work, bench scale studies were conducted to treat domestic wastewater by soil aquifer treatment system. The variables considered for the experimentation were type of soil and depth of soil. The removal efficiencies of water quality parameters observed pH, Total solids (67.19%), Total dissolved solids (59.28%), Chlorides (57.4%), Chemical oxygen demand (70%) and Total kjeldahl nitrogen (79%). The silty soil with 1.0m depth of soil has shown higher removal efficiencies compared to clayey soil.

KEYWORDS: SAT, Chlorides, pH, COD, Total kjeldahl Nitrogen.

I. INTRODUCTION

Water is one of the world's most valuable resources, yet it is under constant threat due to climate change, explosive population growth, and increasing per capita water consumption, and the draught condition of the world. On the other hand, the volume of wastewater generated is envisaged to increase in the future and exert stress on existing wastewater treatment facilities. These problems have forced various countries and communities to look towards alternative water resource management to meet the growing needs and to be as long term water supplies.

To overcome these problems land treatment of wastewater has emerged as an alternative new technology to the conventional wastewater treatment technologies. In this land treatment of wastewater appropriately pretreated wastewater is allowed to penetrate through the aerated unsaturated soil zone where the soil undergoes purification through unit operation and processes viz adsorption, filtration, chemical processes and biodegradation. Since, both soil and aquifer participate in renovation process, such a land treatment system is called Soil-Aquifer Treatment (SAT) system.[1]In contrast with advanced technologies, SAT has relatively low capital and operation and maintenance costs. Furthermore, it does not require highly trained operators, and generally is well suited for developing countries. On the other hand, the psychological resistance and negative public acceptance of portable reuse of reclaimed wastewater are prevalent and can often be overcome through groundwater recharge [2]. The high purification capacity of the system is a result of unique combination of physical, chemical and biological processes occurring in the soil and aquifer [3].

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Field studies was conducted by Vishwanathan et al[4] to assess the feasibility of soil mass in treating wastewater treated to tertiary level. The wastewater was allowed to infiltrate in the experimental pond for 112 days. The overall loading rate for the entire period was about 0.76 m/day. The results showed removal efficiency of BOD (81%), COD (70%), phosphates (80%) and fecal coliform (100 %) respectively. The study also concluded that the wastewater produced after passing through the soil mass is suitable for unrestricted irrigation and cost of treatment by soil mass is considerably less compare to that of any conventional treatment methods.

Gungor et al [5] conducted Bench –scale soil column experiments to examine the effects of soil type and infiltration condition on the removal efficiencies of wastewater nitrites and nitrates during the biological ripening phase of soil aquifer treatment(SAT) columns. Three 1-m l columns were packed with 3 different agricultural soils having sandy clay loam (SCL), loamy sand (LS) and sandy loam (SL) textures for the experimentation. LS soil operated with 7 days wetting/ 7 days drying cycles showed the highest nitrogen removal performance of 95% .The analysis of the results also concluded that length of wetting period and infiltration rate are the main factors affecting nitrogen removal efficiency of SAT columns. Nagarajappa et al [6] carried out Bench scale column studies to analyse the potential of SAT system in treating three wastewaters i.e low, medium and high strength wastewaters under varied experimental condition viz. soil type, depth of soil mass, initial concentration of pollutants and pH. Based on the analysis of results the conclusions have been drawn. Sat system with silty sand was more efficient in treating wastewater compared to clayey sand. Deepa et al [7] conducted study on treated municipal wastewater to assess the treated wastewater quality performances before and after SAT by using soil columns for short term period. The 7 days of wetting the soil columns results in nitrification of ammonium under aerobic conditions in the soil columns. Due to anaerobic conditions in the soils the decreased removal of nitrite and nitrate after 15th cycles in soil columns C1, C2 and C3 results denitrification. The better removal efficiencies of 97% of Total Suspended Solids, 96% of BOD and 96% of COD were observed in the in soil columns. Due to development of clogging layer at the top soils the infiltration rates varied in the soil columns.

II. METHODOLOGY

Bench scale column studies were carried out with varied experimental conditions to evaluate the performance of SAT system in treating domestic wastewater. Based on reconnaissance survey two different soil samples viz one being from Shamanur village situated at about, 3 km from Davangere city and other being from Industrial area were identified and samples from these sites were collected as per standard procedure given in SP 36 Part(II). The geotechnical properties were analyzed for both soil samples. The domestic wastewater was collected from the drain flowing in Vinoba Nagar located in Davangere city. The initial characteristics of the wastewater were analyzed. Two PVC pipes, each of 5 inches diameter and 1.5 meter length were used as columns. In order to prevent the escape of soil the bottom of each column was plugged with 60 μ mesh inside. The columns were mounted on the stand. Wastewater to be tested was fed into these columns by overhead tank. The ponding depth of 30 cm was maintained above the soil in the column. The treated wastewater samples were collected from the bottom of the column and were analyzed for various parameters.

III. RESULT AND DISCUSSION

A. Soil Characterisation

Soil samples collected from two different sources were analyzed for their geotechnical properties. Based on geotechnical properties the soil was classified as Silty sand (SM) and Clayey sand (SC) respectively.

B. Wastewater Characterisation

To decide line of degree of treatment and disposal of wastewater it is essential to know its composition, quality, and characteristics. The wastewater collected from the source were analyzed for various parameters listed in the table 1

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Table 1. Characteristics of wastewater used for experimentation.

SI NO	Parameters	Values
1	pH	7.6
2	Total Solids, mg/l	945
3	Total Dissolved Solids, mg/l	700
4	Chlorides, mg/l	296
5	COD, mg/l	450
6	TKN, mg/l	8.6

C. Saturation studies on soil:

To evaluate removal efficiency of SAT with respect to time and to find out the optimum efficiency the saturation studies was carried out on soil. Only parameters like Chlorides and COD are done. The results of experimentation are shown in Fig 1 and Fig 2. The optimum removal efficiency of Chlorides (50.67%) and COD (62.5%) was observed at 130 minutes for 0.7m depth of silty soil. Similarly the optimum removal efficiency of Chlorides (57.4%) and COD (70%) was observed at 130 minutes for 1.0 m depth of silty soil.

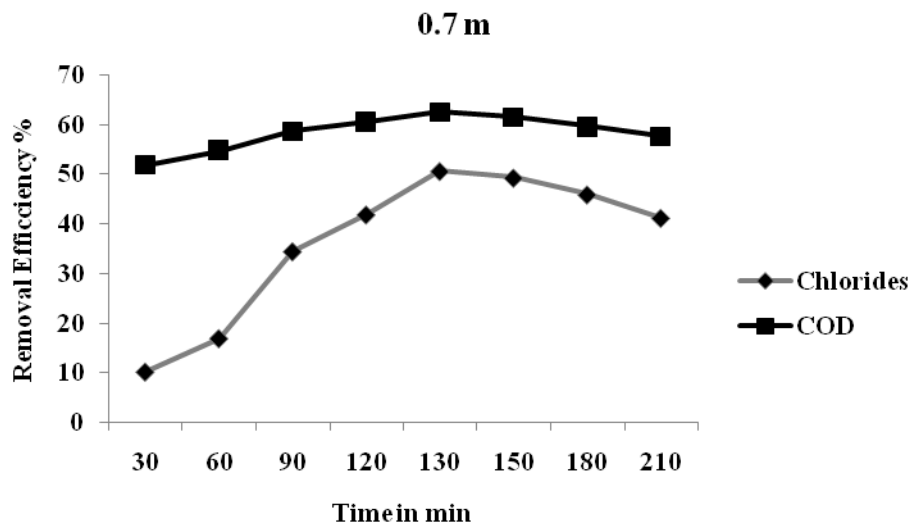


Fig 1: Variation of Experimental Results of Saturation Studies on Silty Soil For 0.7m Depth of Soil

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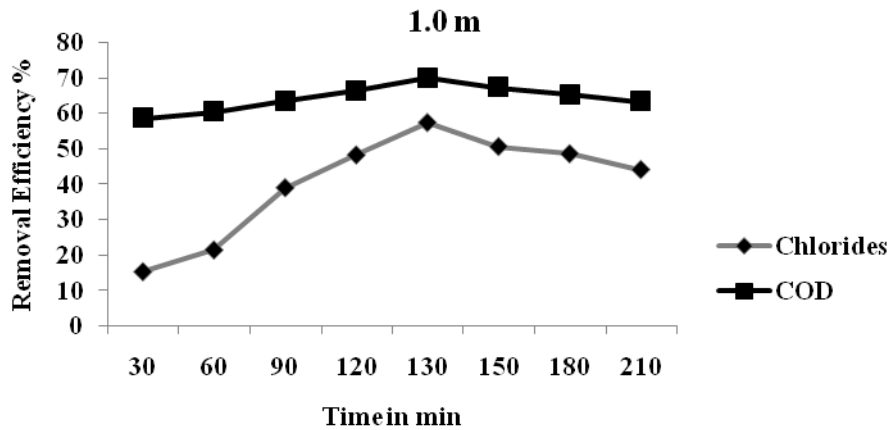


Fig2: Variation of Experimental Results of Saturation Studies on Silty Soil For 1.0 m Depth of Soil

For 0.7m clayey soil depth the optimum removal efficiency was observed at 150 minutes as shown in fig 3. After that the removal efficiency decreases. The optimum removal efficiency obtained was 43.9% and 59.6% respectively for chlorides and COD. Similarly the optimum removal efficiency for 1.0m depth of clayey soil was recorded as 50.67 and 62.5% respectively as shown in fig 4 for chlorides and COD.

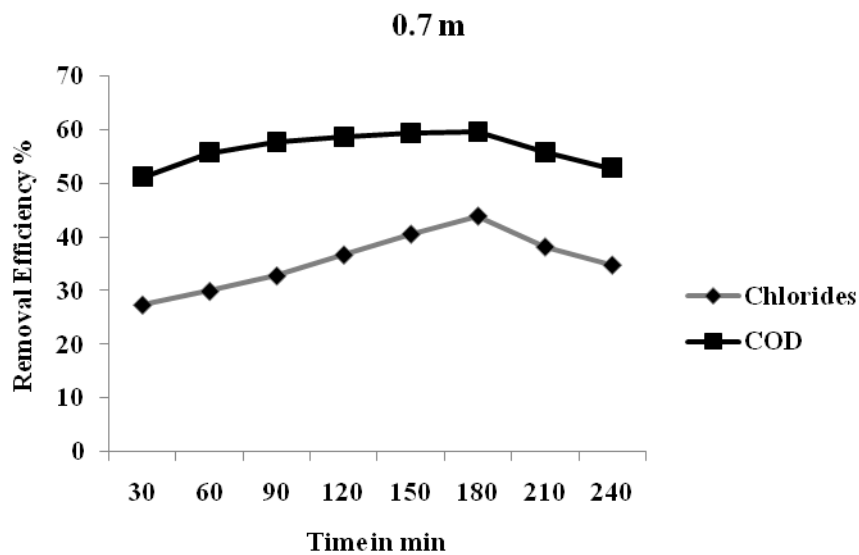


Fig 3: Variation of Experimental Results of Saturation Studies on Clayey soil for 0.7 m Depth of Soil

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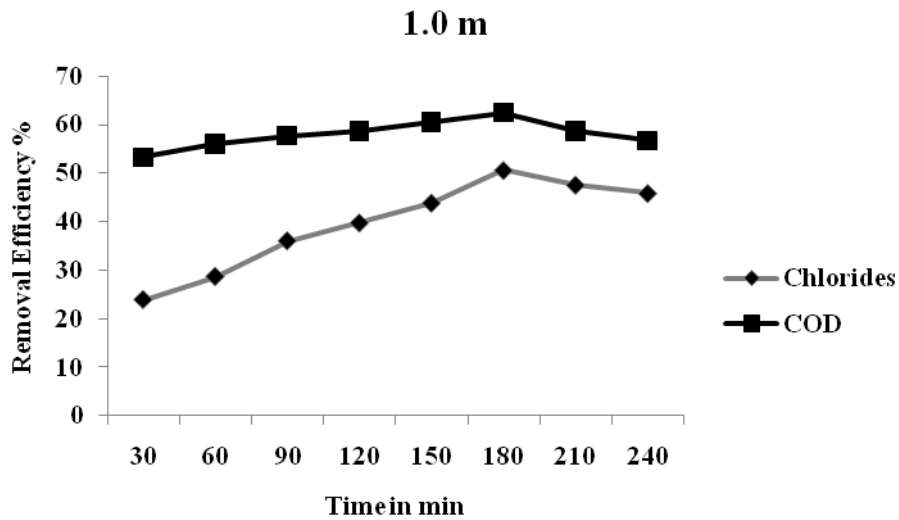


Fig 4: Variation of Experimental Results of Saturation Studies on Clayey soil for 1.0 m Depth of Soil

D. Performance of SAT System for Varying Depth of Soil:

The performance of SAT was carried out with varying depth of soil i.e. 0.7m and 1.0m filled in the columns. The soil acts as a natural filter bed. Thus the various parameters were analyzed and removal efficiency was calculated.

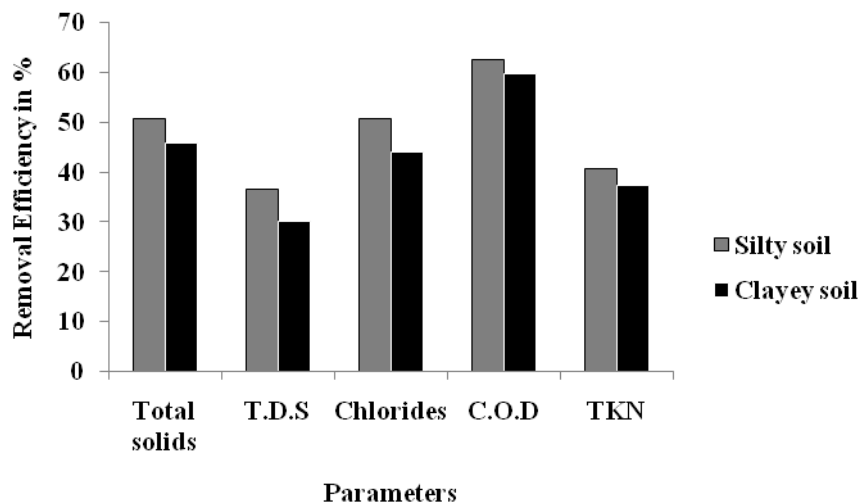


Fig 5 : SAT Removal Efficiencies of all Parameters For 0.7 m Depth of Soil

Further the experiment was carried out to evaluate the removal efficiency of different parameters for both silty soil and clayey soil. Fig 5 and Fig 6 indicates that silty sandy soil with 1.0m depth of soil shows maximum removal efficiency

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compared to clayey sandy soil. Within the practical limitations the removal efficiency were found to be better in silty sandy soil compared to clayey sandy soil in treating domestic wastewater.

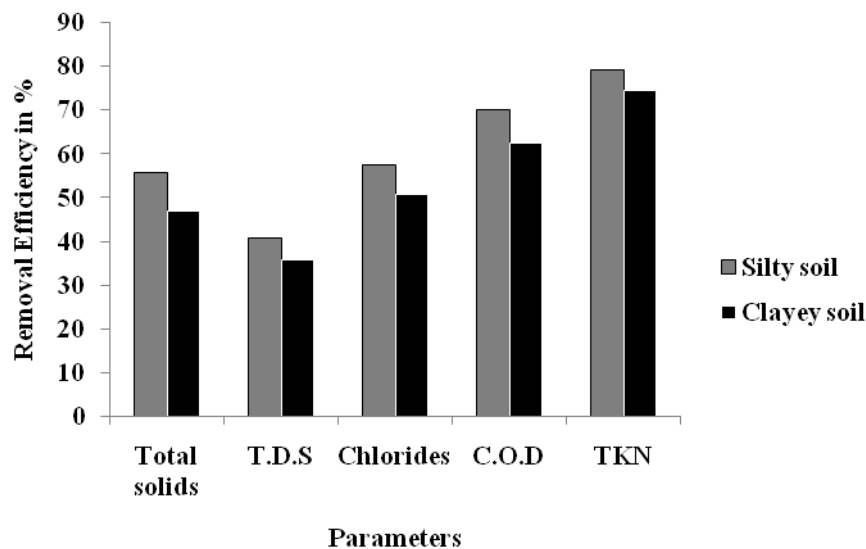


Fig 6 : SAT Removal Efficiencies of all Parameters For 1.0 m Depth of Soil

IV. CONCLUSIONS

The experimental results shows that silty sandy soil shows maximum removal efficiency compare to clayey sandy soil. The removal efficiency increases with increase in the depth of soil. Hence it concluded that SAT with 1.0 m depth of soil is more efficient in treating domestic wastewater compared to SAT with 0.7m depth of soil. The use of geopurification system i.e SAT is effective in treating domestic wastewater.

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