

Investigative Study on the Treatment of Leachate by SAT in Conjunction with Adsorbents

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ABSTRACT:The aim of this study is to evaluate the leachate characteristics using soil aquifer treatment. Clayey sand soil was used for the study. Bagasse and activated carbon were used as adsorbents. Soil column was used. In this study the comparison of removal efficiencies of parameters for only soil, soil with bagasse and soil with activated carbon were investigated. The results showed that soil with activated carbon is effective in removing EC, COD, TDS, TSS, Chlorides, and Turbidity by 71.08 %, 72.83%, 78.97 %, 84 %, 81.21 %, 85.18 % respectively.

KEYWORDS:MSW Leachate, soil aquifer treatment, adsorption.

I. INTRODUCTION

Solid waste generation has been increased all over the world because of population explosion, increased urbanization and industrialization in developing countries. Per capita per day waste generation from domestic purposes is 350 grams, hence proper disposal of municipal solid waste is necessary [1]. The quantity of waste generated in a given area and the characteristics of such waste not only depends on the living standard and life style of the human beings, but also depends on the type of the area's natural resources and their abundance [2].

There are many problems associated with solid waste management. We can achieve the effective management only when we appreciate the waste disposal problems whether it may be liquid or solid. If there is any negligence in the waste management it may lead to many environmental problems such as health hazards, groundwater contamination etc [3].

The land disposal is the most widely used and oldest method for ultimate disposal of solid waste. Sanitary landfill is an engineered and carefully planned facility for disposal of solid waste [4]. The good technique which is still in use for the disposal of Municipal Solid Waste (MSW) is landfilling, as it is very easy to dispose any solid waste material. These landfills are identified as a major threat to the groundwater resources. The wide use of landfilling technique may impact on groundwater contamination. Landfills create many environmental problems for example, landfill leachate and its impact on groundwater [5].

One of the most important drawbacks of sanitary landfilling is leachate formation. Landfill leachates are dangerous aqueous fluids produced from rainwater infiltration through the solid waste. This landfill leachate produced from landfills has a large content of concentrated toxic and organic pollutants, which is very dangerous to the surrounding environment [5]. Leachate treatment before it discharges to surrounding environment is necessary, as it may cause harmful impact on surrounding ecosystem and groundwater [6].

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The leachate treatment methods can be classified as conventional and advanced technologies. Biological and physico-chemical methods come under conventional treatment. Biological methods include, aerobic and anaerobic systems, rotating biological contactors, aerobic activated sludge process, etc. Physico-chemical methods include chemical oxidation, activated carbon adsorption, chemical precipitation, coagulation-flocculation, membrane filtration, ion exchange, etc. Multi-biological process, physicochemical process and physicochemical-biological processes are comes under advanced treatment methods [7]. "Soil aquifer treatment (SAT) is a wastewater reuse phenomenon where the renovation of effluents of wastewater to levels of drinking water takes place. SAT removes viruses and total nitrogen (TN) very effectively [8].

The leachate contaminates the ambient environment when it infiltrates through the soil layers. Soil has the capacity to minimize the leachate movement toward the ground water. The capacity of the soil to remove pollutants from infiltrated leachate through the soil is a function of soil physical, chemical and biological process and soil nature. The top layer of soil has considerable effects than the bottom layers. The top soil usually contains large amount of organic matter than lower one [9].

Hamid Sarkheil et al. [10] conducted study on "Oil by-Product Removal from Aqueous Solution using Sugarcane Bagasse as Absorbent". The effectiveness of sugarcane bagasse as adsorbent was studied in this research in order to remove the oil spills from wastewater. The results indicated that about 20g oil by-product was removed by 1 g of sugarcane bagasse. **Shabiimam M. A. et al. [11]** conducted study on "Adsorption of O-Cresol in Landfill Leachate using Activated Carbon". In this study commercial activated carbon was used as adsorbent to remove o-cresol from aqueous solutions. The results showed that up to 95% of o-cresol was removed from wastewater by activated carbon adsorption within 10 minutes. **K. Deepa et al. [12]** conducted study on Soil Aquifer Treatment (SAT) to evaluate the Water Quality Performance using Municipal Treated Wastewater of Chennai City, India". Certain water quality parameters like pH, TSS, BOD, Nitrates and Nitrites were checked before and after SAT to see the performance. The quality of effluent is improved once it passed through the soil column consisting various layers of soil and also the output quality differs depends on the soil type and their performance. **A. Akber et al. [13]** conducted study to assess the implementation of Soil Aquifer Treatment technology in Quality improvement of tertiary treated wastewater in Kuwait. Soil columns of six numbers were taken with different soil types for the treatment of tertiary treated wastewater. The results indicated that the removal of suspended solids, COD, BOD₅, PO₄, NO₃, NH₃, coliform, total bacteria and E. Coli by 90 %, 90 %, 99 %, 99.6 %, 99 %, 99%, 100 %, 100 % and 100% respectively. And with time the loading rates for all the columns reduced and stabilized between 0.5 and 0.7 m/d.

II. METHODOLOGY

A. Source of Leachate and Collection

The leachate sample was collected from Avargolla place; a solid waste dumping site which is located in the northern part of Davangere and at a distance of about 15 km. Pit based dumping system is used in Avargolla for solid waste management. Grab sampling method was carried out for sampling of leachate. The leachate sample was collected in a clean bottle from the passage where the leachate was stored and was taken to laboratory for analysis of characteristics of leachate and then used for experimentation.

B. Preparation of Soil sample

Clayey sand soil was used for experimentation. For the experimentation, only the variable parameter is a flow rate, which was maintained until the experiment was completed. To maintain different flow rates in the soil, soil make into less dense and filled into the soil columns at different density for set of experimentation. Firstly around 20kg of soil was taken. Some quantity of water was added to soil. Then the soil was filled into the column in four layers with little compaction to each layer. Fresh soil was filled for each predetermined experimental condition.

C. Adsorbents used

- Bagasse
- Activated carbon

The bagasse was collected from nearby juice center and the activated carbon was collected from commercial shop.

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Preparation of adsorbents:

Bagasse was treated as per the procedure given by Kamal Rana et al., (2014). The bagasse was collected from nearby juice center. It was washed with distilled water to remove dust particles and was dried under sunlight until all the moisture content get evaporated. Then it was ground to a fine powder in a grinder. The adsorbent activation was done by treating bagasse with 0.1N sulphuric acid and was dried under laboratory temperature for one day. Again it was washed with distilled water to remove the free acid and was dried under laboratory temperature to remove the moisture. Then adsorbent was passed through 425 micron mesh size and sieved adsorbent is used for experimentation.

Commercially available activated carbon was used for the study as adsorbent.

C. Experimentation

To investigate the performance of soils alone and in conjunction with adsorbents the experiments were conducted under varied experimental conditions. The experimental set up contains the column with accessories. Circular pipemade up of transparent fibre pipe of diameter 10 inches and 2 feet height was used as column and the column was fixed on the stand. Filter cloth with 50holes/cm² supported on steel mesh with 5mm holes were provided at the bottom of column to withstand the weight of soil. A funnel was provided at the end of the column for leachate collection. The prepared soil sample was filled in the column and the leachate to be treated was fed into the column. Flow rates were varied by maintaining different ponding depth. Flow rates maintained were 70,120 and 170 ml/min. 10% of Adsorbents by weight of soil were positioned at bottom of the column. For each flow rates, three effluent samples were collected. The effluent samples were then analysed for physical and chemical parameters as per standard methods.

D. Leachate Analysis

The MSW leachate used before experimentation and after passing through the soil column were analyzed for the various parameters like COD, Chlorides, EC, TDS, TSS and Turbidity as per standard methods.

III. RESULT AND ANALYSIS

A. Influent Leachate Characteristics Analysis

The leachate sample was taken to the laboratory for characteristic study. The Table 1. Demonstrates the initial characteristics of leachate sample before it fed to the soil column. From the table it concluded that almost all the parameters of leachate are of exceed range and it was acidic in nature.

Table 1. Characteristics of leachate

PARAMETERS	RANGE
pH	2.77-2.83
Conductivity ($\mu\text{S}/\text{cm}$)	10010-16600
COD (mg/l)	58890-60000
Chlorides (mg/l)	44180-45000
TDS (mg/L)	8300-9540
TSS (mg/l)	3575-4500
Turbidity (NTU)	8010-9450

B. Classification of soil

The soil sample used for experimentation was collected from UBDT Campus near Mechanical Department, Davangere. The soil was analyzed and classified in the laboratory to determine the geotechnical properties of soil according to IS classification. From Sieve analysis it was observed that soil contains 26.5, 50.3 and 23.2 % gravel, sand, silt and clay respectively. Further C_u and C_c values were found to be 2.54 and 0.96 respectively from sieve analysis. Soil contains 9.2 and 14 % of silt and clay respectively which were found out by Hydrometer analysis. Also soil shows C and ϕ values of 0.23 kg/m² and 30° respectively. 1.90 gm/cc and 13.24 % were the in place density and OMC values. Further

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33.4, 19.04 and 14.36 % of liquid limit, plastic limit and plasticity index respectively were observed. Based on these results, the soil was classified as clayey sand soil.

C. Analysis of column studies

Soil Column studies were carried out under varied conditions of experimentation such as flow rate, soil with and without adsorbents as discussed in methodology. These results are described in this chapter. The Figures 1 to 6 also represents the analysis of results of experimentation for soil and in conjunction with two adsorbents.

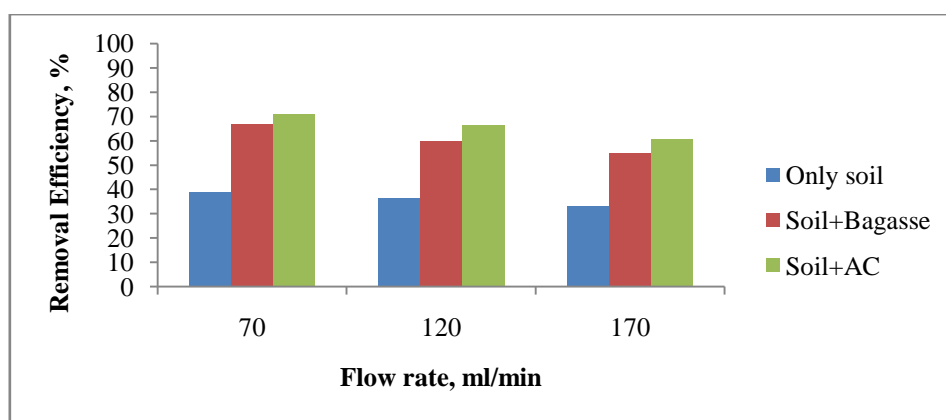


Fig. 1. Effect of flow rate on removal efficiency of EC

Figure 1. shows effect of flow rate on removal efficiency of conductivity. Minimum efficiency was observed for soil treated alone is of 39.05%. Maximum removal efficiency was observed when soil was treated in conjunction with adsorbents and the values were found to be 66.74% and 71.08% for soil with bagasse and soil with activated carbon respectively. Efficiency goes on decreasing as the flow rate increases.

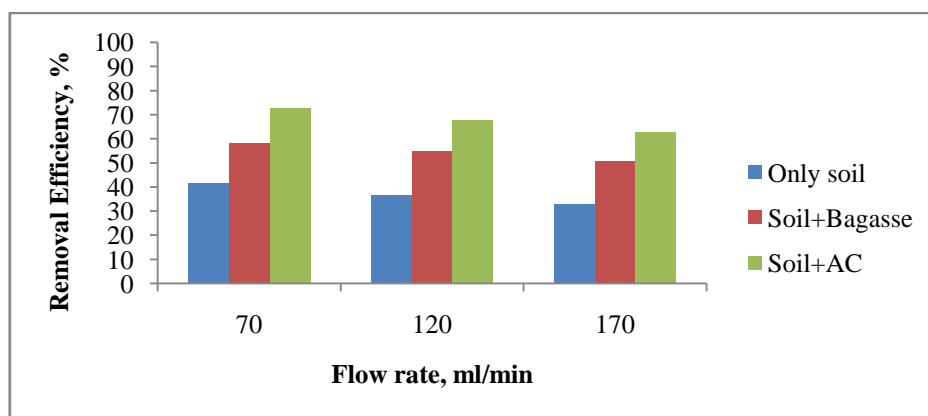


Fig. 2. Effect of flow rate on removal efficiency of COD

Figure 2. shows effect of flow rate on removal efficiency of COD. Minimum efficiency was observed for soil without adsorbents and is of 41.66%. Maximum removal efficiency was observed at a flow rate of 70 ml/min when soil was treated in conjunction with adsorbents and the values were found to be 58.18% and 72.83% for soil with bagasse and soil with activated carbon respectively.

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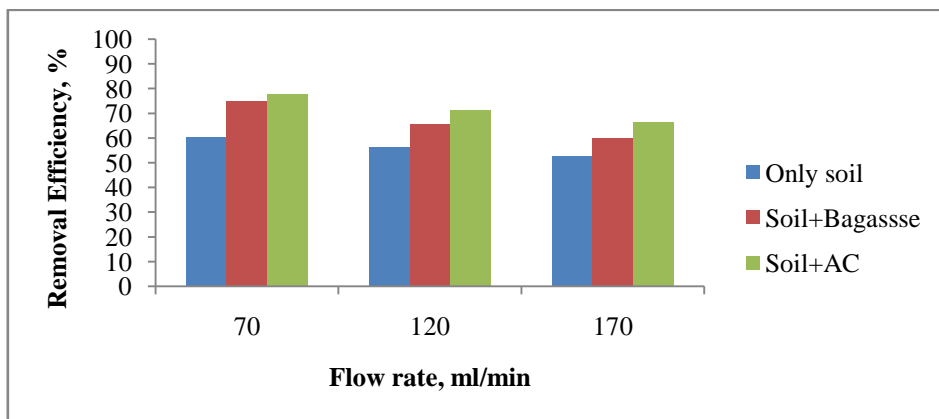


Fig. 3. Effect of flow rate on removal efficiency of Chlorides

Similarly same trend was observed from figure 3 for removal of chlorides also. Maximum efficiency was observed for soil with adsorbents and the values were 74.88% and 77.81% for soil with bagasse and soil with activated carbon respectively.

From figure 4, it was observed that soil with activated carbon exhibited higher TDS removal efficiency rather than soil with bagasse and only soil at 70 ml/min flow rate and the value was found to be 78.97%. Similarly 70.48% and 57.33% efficiencies observed for soil with bagasse and soil mass alone respectively.

From figure 5. Maximum TSS removal efficiency was observed for soil with activated carbon and the value was found to be 84% at 70 ml/min flow rate. 80.13% and 83.48% were the efficiencies observed for soil with bagasse and soil mass alone respectively.

From figure 6. it was observed that soil with activated carbon has shown maximum turbidity removal efficiency rather than soil with bagasse and soil mass alone. The values were found to be 85.18%, 79.7% and 73.65% respectively at 70 ml/min flow rate.

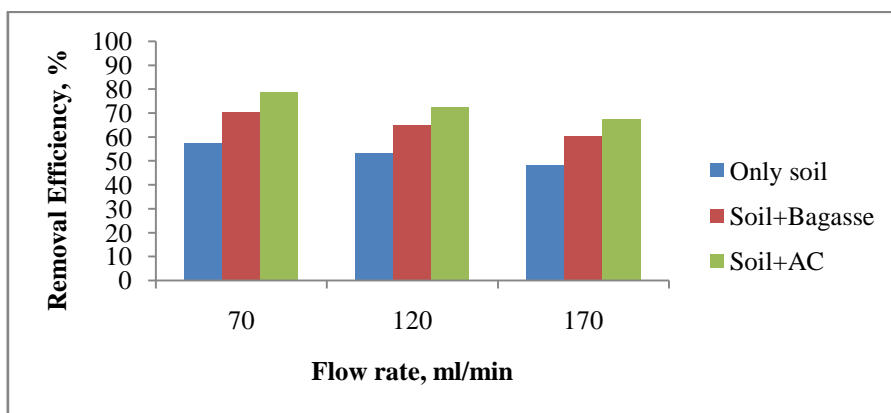


Fig. 4. Effect of flow rate on removal efficiency of TDS

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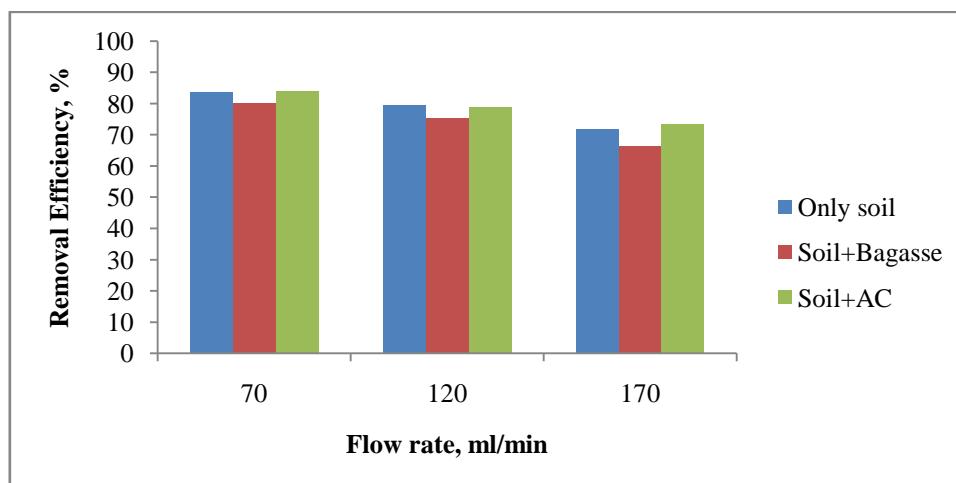


Fig.5 Effect of flow rate on removal efficiency of TSS

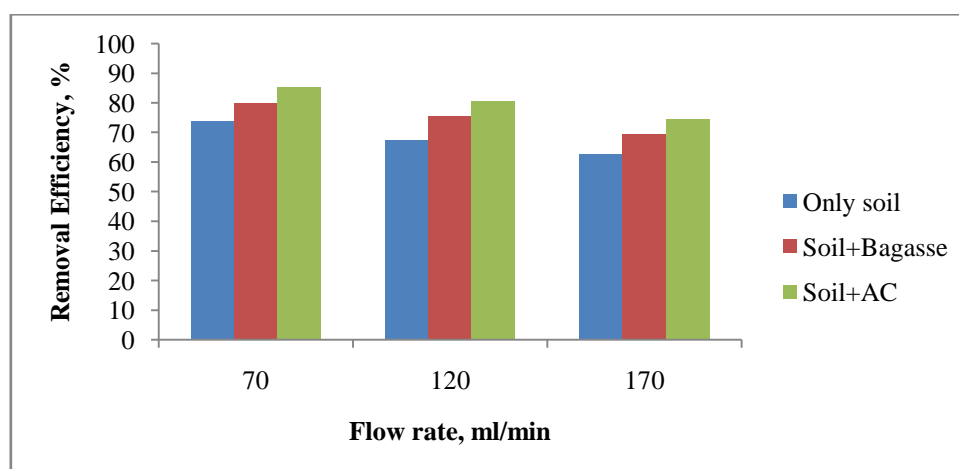


Fig.6 Effect of flow rate on removal efficiency of Turbidity

IV. CONCLUSION

Leachate can be effectively treated using soil in conjunction with activated carbon than soil in conjunction with bagasse and soil mass alone. Hence the removal potential scale will be soil+activated carbon > soil+bagasse > only soil. Flow rate is inversely proportional to removal efficiency of various parameters. At minimum flow rate, maximum removal efficiency was observed under all experimental conditions. Therefore optimum flow rate was found to be 70 ml/min. Soil without adsorbent has shown higher efficiency for TSS removal compare to other parameters and the lowest efficiency was recorded for EC. Soil in conjunction with bagasse has shown higher efficiency for TSS removal compare to other parameters and the lowest efficiency was recorded for COD. Soil in conjunction with activated carbon has shown higher efficiency for turbidity removal compare to other parameters and the lowest efficiency was recorded for EC.

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REFERENCES

- [1] Asha Sivan, Latha P, "Treatment of Mature Landfill Leachate from Vilappilsala by Combined Chemical and Biological Process", International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol. 2, Issue 9, September 2013.
- [2] United Nations Environment Programme, (2005), "Solid Waste Management", Volume.1.
- [3] DigantaGoswami, Bibeka Nanda Choudhury, "Chemical Characteristics of Leachate Contaminated Lateritic Soil", International Journal of Innovative Research in Science, Engg& Technology, Vol.2, Issue-4, 2013.
- [4] Nathanson J.A (2004) "Basic environmental technology- water supply, waste management, and pollution control".
- [5] Adnan Aish, ThaerAbushbak and Mohamed El-Nakhala, "Investigation of the Fate of MSW Leachate in Different Soil Types using Soil Column Method", Journal of Environment and Earth Science, Vol.4, No.4, 2014.
- [6] Sameer Kumar, DhruvKatoria and Gaurav Singh, "Leachate Treatment Technologies", International Journal of Environmental Engineering and Management, ISSN 2231-1319, Volume 4, Number 5 (2013), pp. 439-444.
- [7] Motling Sanjay, DuttaAmit, and Mukherjee S.N, "Applications of Adsorption Process for Treatment of Landfill Leachate", Journal of Environmental Research & Development. Vol.8, No.2, 2013.
- [8] Gary Amy and JorgDrewes, "Soil Aquifer Treatment (SAT) as a Natural and Sustainable Wastewater Reclamation/Reuse Technology: Fate of Wastewater Effluent Organic Matter (EfOM) and Trace Organic Compounds".
- [9] Mohamed Amin El-Nakhala, "Soil Column Investigation on the Impact of Municipal Solid Waste Leachate on Groundwater", Institute of Water & Environment (IWE), 2012.
- [10] Hamid Sarkheil, JavadTavakoli, Reza Behnood, "Oil by-Product Removal from Aqueous Solution using Sugarcane Bagasse as Absorbent", International Journal of Emerging Science and Engineering (IJESE), Volume-2, Issue-9, July 2014, pp.48-52.
- [11] Shabiimam M. A. and Anil Kumar Dikshit, "Adsorption of O-Cresol in Landfill Leachate using Activated Carbon", International Journal of Environmental Science and Development, Vol. 3, No. 2, 2012.
- [12] K. Deepa and M. Krishnaveni, "Water Quality Performance Of Soil Aquifer Treatment (SAT) Using Municipal Treated Wastewater of Chennai City, India", Journal of Environmental Hydrology, Vol.20, Jan 2012.
- [13] A. Akber, E. Al-Awadi and T. Rashid, "Assessment of The Use of Soil Aquifer Treatment (SAT) Technology in Improving the Quality of Tertiary Treated Wastewater in Kuwait", Emirates Journal for Engineering Research, 8 (2), 2003, pp.25-31.