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REMOVAL OF HEAVY METALS FROM LEACHATE BY SOIL AQUIFER TREATMENT IN CONJUNCTION WITH AND WITHOUT SAW DUST

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ABSTRACT

The soil aquifer treatment (SAT) is one of the effective method in the removal of heavy metals from leachate. In this study gravelly soil was used alone and in conjunction with saw dust and groundnut Shell as an adsorbent. The removal efficiencies of three heavy metals namely Arsenic, Cadmium and Nickel were observed. The discharge or flow rate of leachate through soil column has direct influence on the removal of heavy metals. Lower flow rate showed higher removal efficiencies of heavy metals. Higher removal efficiencies were observed in the gravelly soil in conjunction with groundnut shell than gravelly alone and in conjunction with saw dust.

Keywords: *leachate, heavy metal, flow rate, removal efficiency, saw dust, groundnut shell*

INTRODUCTION

Land filling is the most widespread and prevalent technique in the disposal of municipal solid waste (MSW) [1]. One of the critical factors in the municipal solid waste land filling is generation of leachate, and it creates the need to characterize the leachate quality and to ensure leachate management and its treatment to minimize the potentiality of adverse impacts [2]. Leachate is wastewater coming out from the landfill when moisture enters landfill in the form of rain and leaches the organic, inorganic contaminates and heavy metals from the solid waste [3]. The presence of heavy metals and hazardous organic contaminants in landfill leachate are the indicators of the hazardous waste disposal in MSW [4]. Generated leachate from landfill is likely to contaminate groundwater and nearby surface water and also causes the contamination of nearby soil strata and the finally leads to the bioaccumulation of heavy metals in the living organisms [5]. Percolation of leachate through the soil depends on the soil texture, soil porosity, surface area, particle size and permeability and soil plays an important role to minimize the amount of contaminants reaches the groundwater. In the Soil Aquifer Treatment (SAT), soil can attenuate the heavy metals and other contaminants in leachate by cation exchange, adsorption, biodegradation, precipitation and filtration

[6]. Thus in this study an attempt has been made to evaluate the performance of SAT on the removal efficiency of heavy metals and other parameters of leachate.

MATERIALS AND METHODOLOGY

Collection of Leachate

Landfill leachate was collected from the Avaragolla landfill site near Davanagere city. The characteristics of the leachate were analyzed and also for heavy metal by atomic absorption spectrophotometer for arsenic, cadmium and nickel. The Table 1 shows the influent characteristics of leachate.

Addition of Heavy metals to the Leachate

The analysis for leachate characteristics has shown that the absence of arsenic and presence of cadmium and nickel in lesser quantity. Hence for the experimental purpose the heavy metals were externally added to the collected leachate. Arsenic of 0.2 mg, 2.5 mg of cadmium and 2.0 mg of nickel were added in the form of Arsenic trioxide, Cadmium sulphate and Ammonium nickel sulphate.

Preparation of Sawdust Adsorbent

The adsorbent was collected from the nearby local saw mill and dried for one week under sunlight. It was sieved through 250 micron sieve and passed fraction was collected. Then washed by distilled water to remove soil particles. Washed and dried saw dust was treated with HCL thereby increases the active surfaces of adsorbent. The treated adsorbent was again washed with distilled water to remove excess acid contents.

Preparation of Groundnut Shell Adsorbent

The groundnut shells were collected from the agricultural area and dried under sunlight for 2-3 days. It was washed with distilled water to remove dirt and dust particles and once again dried under sunlight. The dried and cleaned groundnut shells were crushed into powder and taken 250 micron passed fraction were taken and it was treated with 1N HNO_3 and kept in oven for 2-3 hours at 80^0C. It washed with distilled water to remove extra acids if any and dried in oven.

Soil Mass used

Gravelly soil was used in the SAT method for the removal of heavy metals and other parameters of leachate. The core sample of soil was collected from the Sarathi village near Harihara, Davanagere district and the geotechnical properties of the soil were determined. Sieve analysis and Hydrometer analysis were used to classify the soils and the soil was found to be gravelly soil and other geotechnical properties like field density, plastic limit, and liquid limit were also determined.

Experimental Setup

The study was carried out was using a soil column to investigate the removal of heavy metals from leachate using gravelly soil in conjunction with and without adsorbent. The column was made up of circular transparent fiber pipe having a diameter of 30.48cm and height of the column was 60.1cm, and the steel funnel was provided for the easy flow of the effluent. The filter cloth of 50 holes per cm^2 was placed between the soil mass and a steel mesh of 5mm holes, to prevent the escape of fine soil particles along with the effluent from soil masses. The soli column setup is shown in the figure 1.

Experimentation

Soil of 20 kg was weighed accurately and filled into the column by layers in mixing with water equivalent to field moisture content and leachate was passed. The effluents were collected to analyze the removal efficiencies of pollutants at a fixed flow rates. The adsorbents were placed at the bottom of the soil about 10% of the depth of the soil. The flow rates of 50, 100, 150 ml were fixed by maintaining the different ponding depth.

Fig 1: Soil Column Setup

RESULTS AND DISCUSSIONS

The results and analyses were conducted to evaluate the performance in the removal efficiency of gravelly soil alone and in conjunction with saw dust under different experimental variables considered and the inferences were drawn based on the results and analysis. Table 1 shows influent characteristics of leachate. Along with heavy metals, other parameters like pH, COD, Turbidity, and Total dissolved solids, Total suspended solids, Chlorides, Colour and Turbidity also were considered in the analysis of experimental work.

The gravelly soil showed maximum removal efficiency of 65.4% was found for cadmium among three heavy metals at the flow rate 50 ml/min and the corresponding value for arsenic and nickel was found to be 61.5% and 27.8% at the same flow rate. The maximum pH variation was found to be 5.10 at the flow rate of 50 ml/min. The maximum removal efficiencies of turbidity, TDS, TSS, COD, Chloride, Colour, EC were found to be 68.35, 38.29, 58.9, 46.5, 59.4, 23.72 and 39.34 respectively. The table 2 shows the variation in leachate characteristics in gravelly soil without adsorbent.

The gravelly soil in conjunction with saw dust exhibited maximum removal efficiency of cadmium and arsenic was found to be 77.51% and 77.1% at the flow rate of 50 ml/min and at the same flow rate corresponding value of nickel 50.6%. At the flow rate 50 ml/min, the maximum pH variation of 5.44 was found. At the flow rate 50 ml/min, the maximum removal efficiencies of 84.87, 77.82, 76.8, 78.19, 72.62, 65.68 and 71.12% were observed for turbidity, TDS, TSS, COD, chloride, colour and EC respectively. The table 3 shows variation in leachate characteristics in gravelly soil conjunction with saw dust.

The gravelly soil in conjunction with groundnut shell showed maximum removal efficiencies for nickel, arsenic and cadmium were found to be 78.5, 79 and 80.16% respectively. The maximum pH variation at the flow rate 50 ml/min was found to be 6.07. The maximum removal efficiencies of 89.75, 81.59, 83.55, 85.46, 81.04, 85.59 and 71.1% were found for turbidity, TDS, TSS, COD, chloride, colour and EC respectively. The table 4 shows variation in leachate characteristics in gravelly soil conjunction with groundnut shell.

Table 1: Influent Characteristics of Leachate

Sample No.	*pH*	*EC*	*COD mg/l*	*Chloride, mg/l*	*TDS, mg/l*	*TSS, mg/l*	*Turbidity Mg/l*	*Colour Pt-Co*
1	2.76	10131	60000	44292	8500	4290	8012	38529
2	2.73	13402	60000	42581	9541	5701	3214	21011
3	2.82	10011	59782	45000	8300	3574	8131	21912
4	2.68	10703	58000	43000	9872	4923	2486	23551
5	2.78	16601	58893	44181	9115	4498	9452	21934

Table 2: Variation in Leachate Characteristics in Gravelly Soil without Adsorbent

Sr. No.	***Parameters***	***Characteristics***				***Removal Efficiency (%) at flow rates, ml/min***		
		Influent	***Effluent Characteristics at flow rates, ml/min***					
			50	100	150	50	100	150
1	Nickel, mg/l	2.0	1.445	1.521	1.691	27.8	23.9	15.5
2	Arsenic, mg/l	0.2	0.077	0.102	0.156	61.5	49.1	22.1
3	Cadmium, mg/l	2.5	0.864	0.902	1.186	65.4	63.93	52.6
4	pH	2.76	5.10	5.08	4.92	-	-	-
5	Turbidity, NTU	8012	2535	3825	4215	68.35	52.2	47.3
6	TDS, mg/l	8500	5245.3	5470.6	5836.9	38.29	35.64	31.33
7	TSS, mg/l	4290	1763.4	2066	2420	58.9	51	43.7
8	COD, mg/l	60000	32120	35281	39819	46.5	41.2	33.63
9	Chloride, mg/l	44292	17991	19110	21681	59.4	56.9	51.04
10	Colour, mg/l	38529	29390	31131	32549	23.72	19.20	15.52
11	EC, µS	10131	6144	6560	6799	39.34	35.24	32.9

Table 3: Variation in Leachate Characteristics in Gravelly Soil Conjunction with Saw dust

Sr. No.	***Parameters***	***Characteristics***				***Removal Efficiency (%) at flow rates, ml/min***		
		Influent	***Effluent Characteristics at flow rates, ml/min***					
			50	100	150	50	100	150
1	Nickel, mg/l	2.0	0.986	1.072	46.4	50.6	46.5	43.5
2	Arsenic, mg/l	0.2	0.046	0.075	0.113	77.1	62.4	43.6
3	Cadmium, mg/l	2.5	0562	0.623	0.692	77.51	75.1	72.33
4	pH	2.82	5.44	4.96	4.94	-	-	-
5	Turbidity, NTU	8131	1876	1972	1989	84.87	80.99	79.72
6	TDS, mg/l	8300	1841	2461	3167	77.82	70.34	61.84
7	TSS, mg/l	3574	826	945	1250	76.8	73.6	65.03
8	COD, mg/l	59782	13036	16320	18036	78.19	72.69	69.82
9	Chloride, mg/l	45000	12320	13571	15980	72.62	69.82	64.48
10	Colour, mg/l	21912	7520	9580	10436	65.68	56.27	52.37
11	EC	10011	2890	3246	3425	71.12	67.57	65.78

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Table 4: Variation in Leachate Characteristics in Gravelly Soil Conjunction with Groundnut Shell

Sr. No.	***Parameters***	***Characteristics***				***Removal Efficiency (%) at flow rates, ml/min***		
		Influent	***Effluent Characteristics at flow rates, ml/min***					
			50	100	150	50	100	150
1	Nickel, mg/l	2.0	0.432	0.496	0.512	78.5	75.2	74.3
2	Arsenic, mg/l	0.2	0.042	0.052	0.055	79	74	72.5
3	Cadmium, mg/l	2.5	0.496	0.562	0.632	80.16	77.52	74.72
4	pH	2.78	6.07	6.1	5.6	-	-	-
5	Turbidity, NTU	9452	968	1489	1935	89.75	84.24	79.52
6	TDS, mg/l	9115	1678	1872	2195	81.59	79.46	75.92
7	TSS, mg/l	4498	740	946	1190	83.55	78.97	73.55
8	COD, mg/l	58893	8560	10936	12126	85.46	81.42	79.40
9	Chloride, mg/l	44181	8378	9915	11862	81.04	77.55	73.15
10	Colour, mg/l	21934	3160	4120	4964	85.59	81.21	77.36
11	EC	16601	4378	4865	5215	71.1	68.4	64.5

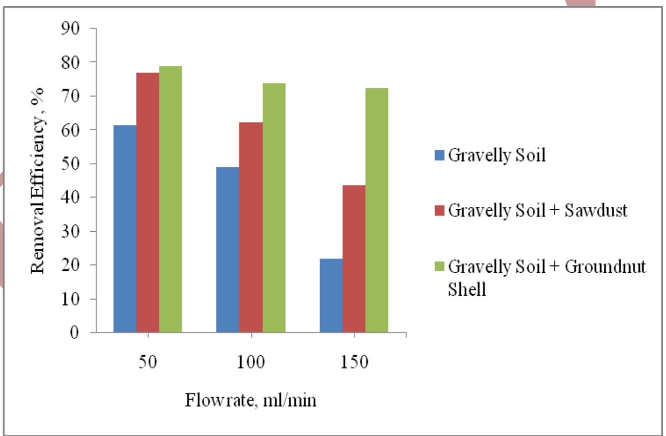

Fig 2: Removal Effiviency of Arsenic in Gravelly Soil Conjunction with and without Sawdust

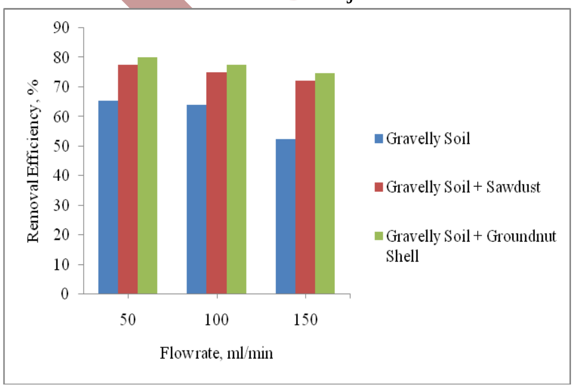

Fig 3: Removal Efficiency of Cadmium in Gravelly Soil with and without Sawdust

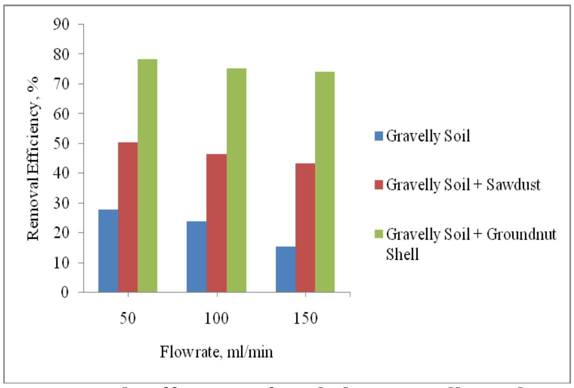

Fig 4: Removal Efficency of Nickel in Gravelly Soil with and without Sawdust

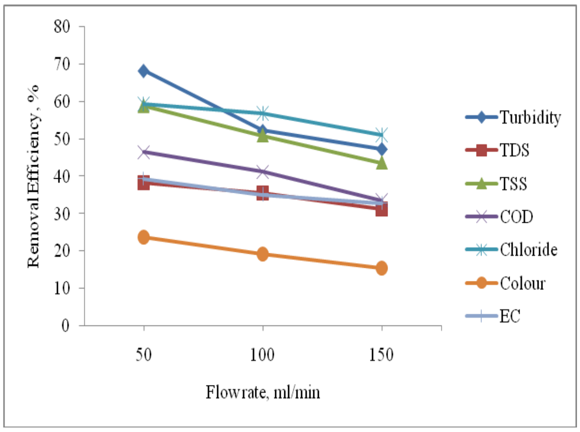

Fig 5: Variations of Leachate Characteristics in Gravelly Soil

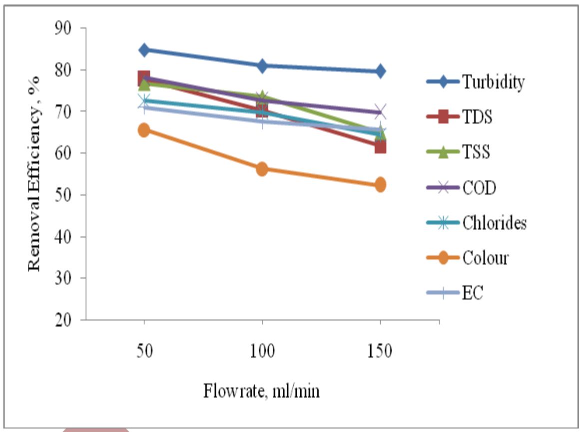

Fig 6: Variation of Leachate Characteristics in Gravelly Soil in Conjunction with Sawdust

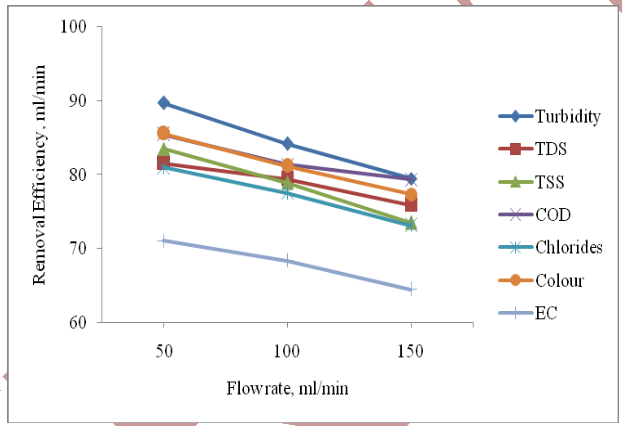

Fig 7: Variation of Leachate Characteristics in Conjunction Groundnut shell

CONCLUSIONS

Based on the results and analysis, it is concluded that the removal efficiencies of leachate characteristics are inversely proportional to the flow rate of effluent in SAT. The flow rate has direct influence on the removal efficiency of effluent characteristics of the leachate.

Gravelly soil alone exhibited poor results in the removal efficiencies of heavy metals and other parameters. The gravelly soil in conjunction with groundnut shell showed higher removal efficiencies compared to gravelly soil in conjunction with sawdust. Among three heavy metals considered, cadmium was removed at higher removal efficiencies in all experimental conditions than the arsenic and nickel. Maximum pH variations were observed in the gravelly soil in conjunction with groundnut shell.

The maximum removal efficiencies of turbidity, TDS, TSS, COD, chloride, colour and EC was found in gravelly soil conjunction with groundnut shell than the gravelly soil alone used and gravelly soil in conjunction with saw dust.

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