Utilization Of Natural Red Earth, Bentonite, Zeolite And Bottom Ash As Liner Material For Removal Of Pollutant For Landfill Leachate

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Abstract: In India a large amount of solid waste is disposed. Landfill liners are constructed in the place before dumping the waste. A large amount of leachate is produced from the solid waste. Usually geosynthetic liners and clayey soils are used as materials for liners. In this study, low cost materials like natural red earth and bottom ash are used. Bentonite has a self – healing properties and low permeability. It can also be used as a absorbent and used in treatment plants. Zeolite is said to have an open frame structure where it can trap the heavy metals in them. Natural red earth is clayey type of soil that is abundantly available in the environment and very stable in all environmental conditions. Bottom fly ash is a by-product that is formed in coal induced power plant and other cement industries. It has the property to purify the pollutants and for the purpose of treatment. The pollutant removal efficiency using these materials is investigated in the temporary glass setup. Leachate quality was determined and heavy metal content, chemical oxygen demand(COD), organic matter, pH and other properties in the leachate sample is measured before and after treatment. The result showed that these materials were effective in pollutant removal.

Keywords: Bentonite, Bottom ash, Landfill leachate, landfill liner, Natural red earth, Removal efficiency, Zeolite.

1. INTRODUCTION

Landfill leachate is a highly toxic liquid that is found in the sanitary landfill. It is a liquid that leaches out from the solid waste that is dumped in a certain area. The composition of the landfill leachate depends on the age of the landfill and the type of waste it contains. It usually contains heavy metals, organic matters which can be either in dissolved or suspended from. Landfill leachate is generated due to precipitation or the moisture content present in the solid waste. This water leached out from the solid waste further percolates into the water and joins the soil layers. This water is a contaminated and a highly hazardous liquid termed as leachate. This highly contaminated liquid leads to rise of fungi, growth of bacteria during the decomposition process, thus during this stage temperature rises and pH of the water also changes. The composition and the concentration of the pollutants depends on the age, type of the solid waste in the landfill. Landfill leachate has an adverse effect on both quality of the groundwater and the soil composition. The risk of the contamination of the groundwater, soil and even the surface water depends upon the pollutants that are present in the leachate. If the leachate when not treated properly can directly enter the soil thus groundwater. The pathogenic microorganisms and high concentration of ammonia and other heavy metals can change the initial characteristics of the groundwater too. Leachate can also effect the aquatic life when it enters into water reservoirs and have acute or chronic impacts. Thus it can also effect the human life while depending on the underground water sources. A landfill liner is intended to be a low permeable barrier which is laid down under an sanitary landfill before dumping solid waste. It is used to prevent the further contamination of groundwater through the percolation of the leachate until the worst scenario due to failure and landfill liner. Nowadays the composite liners are used in the landfill sites. Geosynthetic clay liner is one of the most important and widely used liner. It is made up of sodium bentonite, geotextile, high density polyethylene which can minimize the penetration of the leachate through their barriers.

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2 MATERIALS AND METHODOLOGY

Natural red earth are the locally available soils, like red earth are used for construction of liners for water and waste retention facilities. The natural red earth was purchased from a local agricultural service firm from Bangalore.
Bentonite has the property of adsorbing relatively large amount of molecules. It also has the property of swelling due to which it is used as liner material as it is a useful sealant, having a self-healing property, and low permeability. It is used to line the base of landfills to prevent the contamination of leachate. Bentonite was purchased from a local firm near R T Nagar, Bangalore. Zeolite has an open cage like structure that can trap the heavy metals. It is a stable and can resist any environmental conditions without change in their properties. Zeolite has an ability to accommodate active metal species in them. Zeolite for the experiment was ordered from a dealer through Indiamart. Bottom ash is micron – sized, glassy powder residue as a result of coal combustion in power plants, cement industries. It is usually used in purification of waste industrial water and other treatment process. Bottom ash required for the project was obtained from a RCC mix plant. Leachate sample was collected from the study area located at Bellahalli landfill site. Sample was collected in a sample container and was then placed in refrigerator at -4ºC. Later the sample was given for testing to determine the concentration of the heavy metals present in the landfill leachate. The initial concentration of the leachate is tested to know its composition. A glass apparatus with a mesh attached to the bottom is

prepared for conducting the experiment.

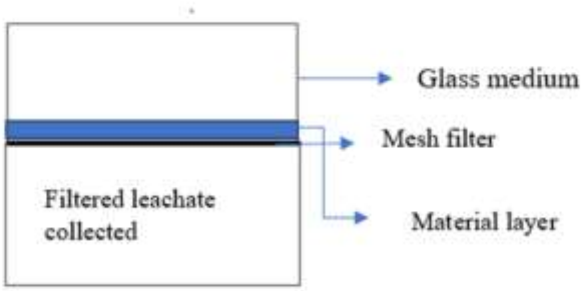


Fig.1 *The experimental setup outline.*

Step 1: The individual removal efficiency of materials namely zeolite, natural red earth, bottom ash are to be found. Thus the leachate is poured into these single layer and tested for the composition of heavy metals.

Step 2: A single layer with equal amount of each materials (Zeolite + Natural red earth + Bottom ash) is prepared and the leachate is passed through this layer. The percentage removal is calculated from the obtained initial and final values of the concentration of heavy metals present.

Step 3 : Bentonite is a clayey material that makes the layer impermeable. So based on literature review about 25% of the bentonite along with 75% of zeolite, Natural red earth, Bottom ash in Set E, F. G respectively is set to conduct the test to know its efficiency.

TABLE. 1
Different setup to conduct the experiment.

Setup	Material Components
Set A	Zeolite
Set B	Natural Red Earth
Set C	Bottom Ash
Set D	Zeolite + Red Soil + Bottom Ash
Set E	Bentonite + Zeolite
Set F	Bentonite + Natural Red Earth
Set G	Bentonite + Bottom Ash

3 RESULTS AND DISCUSSION

The leachate is tested to know the composition and concentration of the pollutants present in it. The heavy metal components, chemical oxygen demand, organic matter and other pollutant concentration if found.

TABLE.2
Initial concentration of pollutants in the leachate.

Sl. No	Parameters	Unit	Results
1	Lead as Pb	mg/L	2735
2	Zinc as Zn	mg/L	0.199
3	Total Chromium as Cr	mg/L	0.107
4	Nickel as Ni	mg/L	0.125
6	Cadmium as Cd	mg/L	BDL
7	Chemical Oxygen Demand	mg/L	4400.0
8	Total Ammonia	mg/L	237.25
10	Manganese as Mn	mg/L	1.41
11	Iron as Fe	mg/L	5.642
12	Potassium as K	mg/L	2735
13	Sodium	mg/L	2300
15	Cobalt	mg/L	BDL

*Below detectable limit

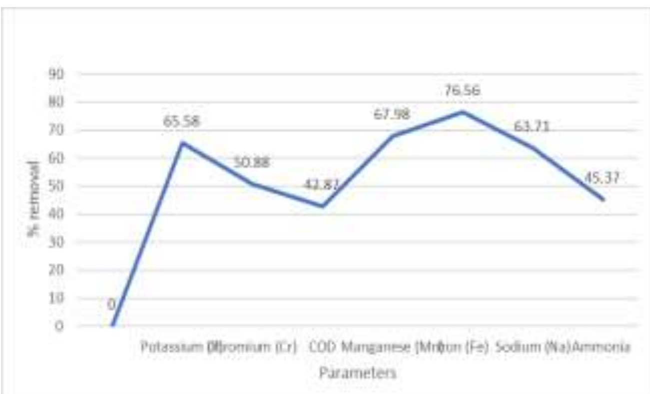
The report obtained after testing the initial leachate concentration was compared with standard requirements and the limit of heavy metals present. The removal efficiency of the heavy metals from the leachate was calculated. The removal efficiency for each material was found out. Each material was considered as different setup. The leachate is passed through the each setup and later collected down at the bottom. The leachate sample is then again tested for the parameters to know the removal efficiency of the heavy metals from the leachate. Once the final concentration of the filtered leachate sample is known. Then the next step is to find out the percentage of removal of the same. This gives us the removal efficiency.

TABLE. 3:
Final concentration of the heavy metals.

SL. No	Parameters	Set A (mg/L)	Set B (mg/L)	Set C (mg/L)	Set D (mg/L)	Set E (mg/L)	Set F (mg/L)	Set G (mg/L)
1	Potassium (K)	941.4	1487.57	416.82	337.78	442.8	939.48	91.08
2	Chromium (Cr)	0.053	0.065	0.020	0.019	0.027	0.052	0.009
3	COD	2513.7	2874.08	1892	1525.04	885.72	1814.5	511.72
4	Manganese (Mn)	102.71	154.68	18.29	13.89	19.06	99.34	1.29
5	Iron (Fe)	1.37	2.58	0.202	0.125	0.624	1.818	0.013
6	Sodium (Na)	834.67	1407.83	569.25	451.72	564.7	1095.9	337.41
7	Ammonia	129.61	152.24	96.33	76.181	47.22	92.58	20.88

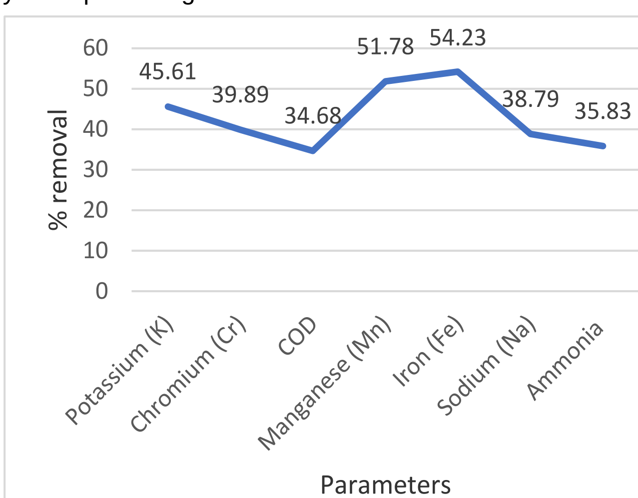
TABLE. 4:
Removal efficiency of heavy metals from different setup.

SL. No	Parameters	Set A (%)	Set B (%)	Set C (%)	Set D (%)	Set E (%)	Set F (%)	Set G (%)
1	Potassium (K)	65.58	45.61	84.76	87.65	83.81	65.65	95.67
2	Chromium (Cr)	50.88	39.89	81.45	82.85	74.95	51.78	92.45
3	COD	42.87	34.68	57	65.34	79.87	58.76	88.37
4	Manganese (Mn)	67.98	51.78	94.3	95.67	94.06	69.03	99.6
5	Iron (Fe)	76.56	54.23	96.5	97.8	88.95	67.79	99.8
6	Sodium (Na)	63.71	38.79	75.25	80.36	75.45	52.35	85.33
7	Ammonia	45.37	35.83	59.4	67.89	80.1	60.98	91.2



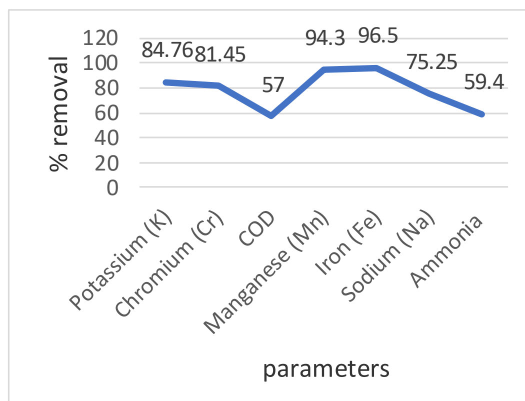
Graph.1: *Removal efficiency in Setup A.*

The above graph represents the efficiency of zeolite in removing the above parameters. It has an efficiency about 76.56% in removal of iron content from the leachate sample. A very least percentage of COD can be reduced.



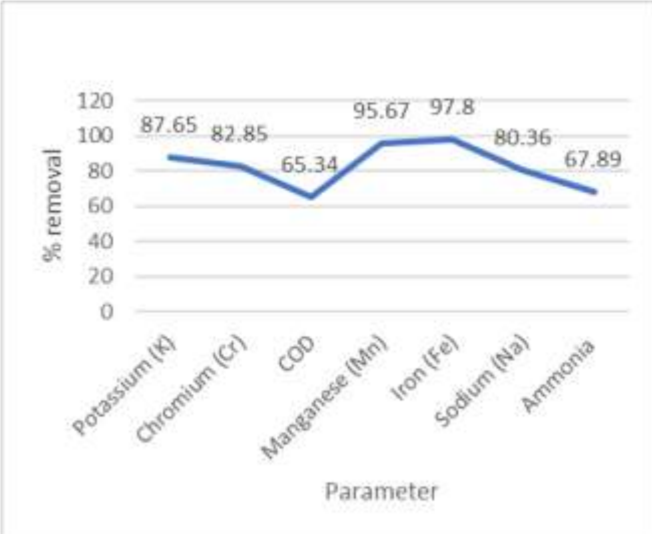
Graph.2: *Removal efficiency in Setup B.*

The Graph.2 represents the efficiency of removal of the selected parameters by the use of natural red earth is plotted. It shows that the removal efficiency is very less for all the parameters in this particular materials. Where the highest percentage removal is iron i.e., 54.23%.



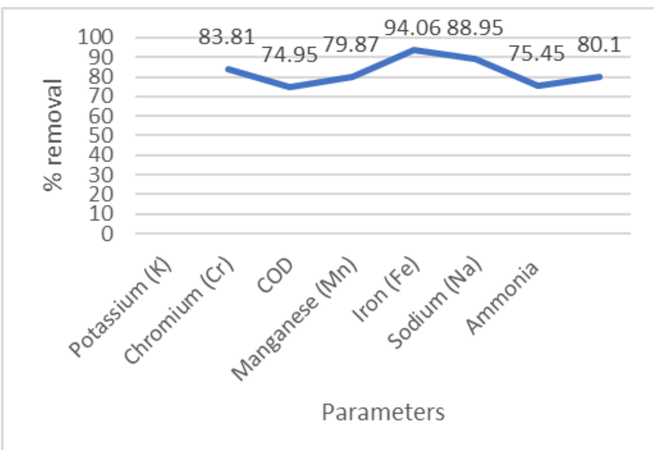
Graph.3*: Removal efficiency in Setup C.*

The Graph.3 represents the parameters along the x-axis and % removal of the respective parameters in the Set C which is Bottom Ash. Bottom Ash as an individual material is found to be very effective in removing the manganese and iron at 94.3% and 96.5% respectively.



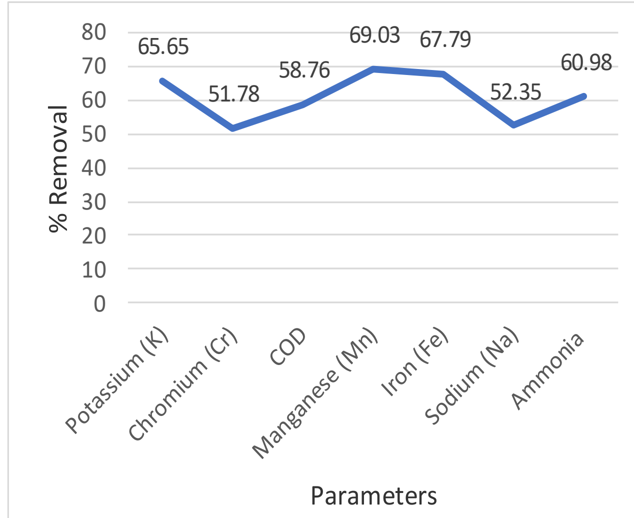
Graph.4: *Removal efficiency in Setup D.*

This above graph represents the efficiency of removal of the selected parameters in the Set D (Zeolite + Natural Red Earth + Bottom ash). It is found likely to be efficient in removing the manganese and iron at good percentage. The least removal efficiency for COD i.e., 65.34% is found in this setup.



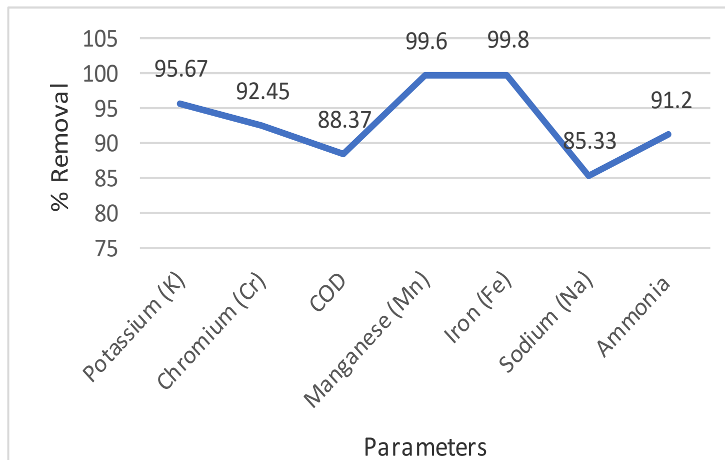
Graph.5 *:The removal efficiency in Setup E.*

The Graph.5 plotted shows the removal efficiency of the zeolite material with 25% of bentonite. This shows that the % removal of the selected parameters were high compared to the Set A where only zeolite was used.



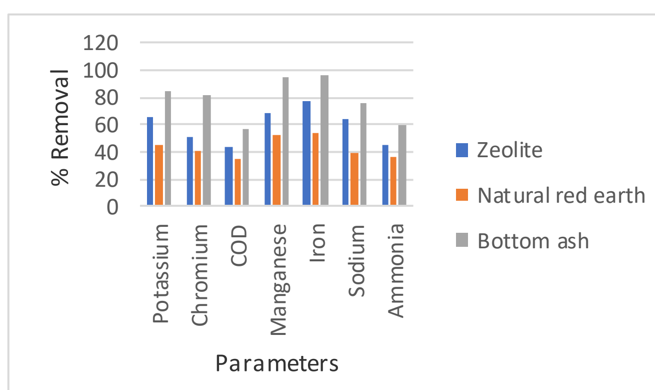
Graph.6*: Removal efficiency in Setup F.*

The Graph 6 represents the efficiency of the setup where Natural red earth along with bentonite. The results are more efficient than natural red earth alone used.



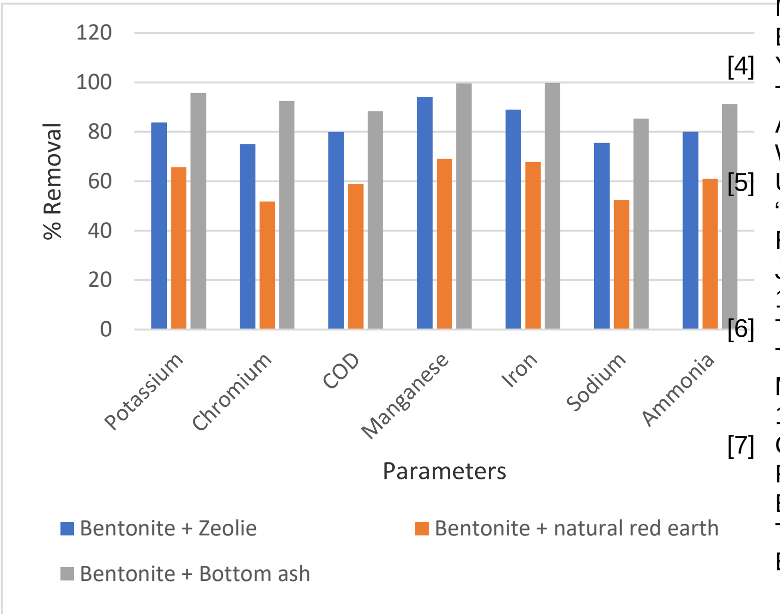
Graph.7*: Removal efficiency in Setup G*

Bottom ash along with 25% of bentonite becomes the most efficient set in removing the parameters selected above. The percentage removal of potassium, chromium, manganese, iron and ammonia is found to be above 90%.



Graph. 8: *Comparison percentage removal of individual materials.*

Zeolite, Natural red earth and Bottom ash are tested to know the individual efficiency of each material in removing the selected parameters. The above Graph.8 is a comparison of the efficiency of each material in removal. The graph shows clearly that the bottom ash is much more effective when compared to other materials.



***Graph.9**: Comparison of the removal efficiency of materials added with certain amount of bentonite.*

The three individual low cost liner material selected added with 25% of bentonite is used in the Setup E,F and G. The Setup G with 25% of bentonite and 75% of bottom ash has high efficiency when compared to any other setup. The removal percentage for most of the parameter is above 90%. Thus makes it as an efficient liner material.

4 CONCLUSION

Leachate have a high impact on groundwater over a period of time. A potential liner is constructed so that there is less pollutants migrating into the groundwater. However the conventional synthetic liner may be a failure due to insufficient capacity of the materials used. The initial concentration of the leachate sample shows that treatment is required to meet the ISO standards. The removal efficiency of the selected pollutants and the parameters are tested after passing the leachate sample through seven different setup. Bottom ash as an individual material is most efficient in removing the pollutants and treating the leachate. Bottom ash with 25% of bentonite increases the efficiency. Bottom ash is one of the waste by product form coal induced industries, cement industries. This method of using bottom ash can also help as the disposal method of the waste from these factories. Thus it is very economically available materials that can be used as the liner material.

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