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Leachate Treatment Using Clay/Stone Filters

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ABSTRACT
Leachate from sanitary landfill from Agbor in Ika South Local Government Area of Delta State, Nigeria was analysed using its physiochemical characteristics. Cation exchange capacity percolation rate studies and mineralogical analysis of clays collected from Amai and Otorho in Ukwuani Local Government Area of Delta State were coded AM and OT, using x-ray diffrctometer were tested on the leachate (Raw and after treatment). The clays were mixed in ratio 1:4 (pebbles:clay) using one and three flow through columns. Clays showed the presence of kaolin, quartz, illite and mixed layer. Raw samples have BOD 80.60 - 210.00 mg/dm^3 COD 842.00 - 933.20 mg/dm^3, NH_3^+-N 0.80 - 11.20 mg/dm^3, TSS 61.20 - 70.20 mg/dm^3, TDS 510.00- 734.00 mg/dm^3, Ca 0.01- 16.00 mg/dm^3 and Salinity 0.90 - 2.10%, percolation rate studies 2.94 x 10^{-7} – 3.76 x 10^{-7}, cation exchange capacity 4-9 cmol/kg. The values were above WHO and NESREA standards, but after treatment, BOD values were 3.00 – 6.20 mg/dm3, COD 15.00 – 18.00 mg/dm^3, $NH3^+$ - N 0.32 – 0.42 COD 15.00 – 18.00 mg/dm^3, TSS 10.10 – 22.50 mg/dm^3, Ca 10 - 12 mg/dm^3, Salinity 0.08 – 0.31 %. This shows that clay/stone filters are efficient, low cost purifying system and environmentally friendly, they fall within acceptable limits.

Keyword: Leachate, column, x-ray diffractometer, clay, percolation rate.

INTRODUCTION

Leachate is defined as the liquid which drains from landfill due to rain, snow and natural moisture, percolating through the waste.[1] In this process, soluble organic and heavy metals which are leached are found in it. As population grows, the need for individual and government to provide for the social and economic need of its teaming population through mechanized farming, inustries, food becomes imperative. These have resulted in an uncontrollable waste generation of various quantity ranging from biodegradable to non-biodegradable, hazardous to non-hazardous[2] Open dumps were mostly adopted in which solid waste were hazardously disposed. The landfill method is a way of reclaiming land or land raising. It is not environmentally friendly and expensive.[3, 4]

In landfilling, solid waste undergoes physico-chemical and biological changes, digestion of the organic fraction of the waste in combination with percolating rainwater producing a highly contaminated liquid called leachate.[5] It is the most important point source of organic groundwater contaminant. Leachate can be categorized as a liquid waste that contains high Chemical Oxygen Demand (COD), high ammonia, etc.[6]

Landfill leachate becomes an issue as a waste water source since it may cause serious pollution to ecosystem. In order to reach environment friendly criteria, for landfill leachate, one must bring these values to an acceptable discharge limit.[7] Hence, landfill leachate must be collected and treated. Many treatment methods have been adopted to treat sewage such as biological methods, membrane process[7], advance oxidation[8]techniques.[9]These methods have drawbacks as decreasing efficacies and high cost. The aim of this paper is to determine some inorganic and organic contaminants in leachate and to use adoption to remove ions dissolved in leachate and treat with clay/stone fitters which can be recharge and disposed off. The method is simple to operate, low cost, efficient and locally available material for landfill leachate treatment.

Materials and Methods

Study Area

Agbor, the administrative headquarter of Ika South Local Government Area is located in the Northern part of the Niger Delta South Central of Nigeria. It lies within the coordinates of latitudes $06^0 05^1$N to $06^0 16^1$N and longitudes $06^0 07^1$E and $06^0 12^1$E. The principal relief features of the area are undulating rugged sedimentary terrain characterised by mainly sand and minor clay with steep slope toward Orogodo River. The mean annual rainfall ranges between 2540 – 3500 m and the temperature varies between 28 ^{0}C – 38 ^{0}Caround March and 23 – 33 ^{0}Caround August. The major occupations of the people are farming, trading and commercial driving. It is an area of industrialization now having foam and paint manufacturing industries. The landfill is about 10 ft above sea level.

The clays were gotten from Otorho (OT) and Amai (AM) in Ukwuani Local Government Area of Delta State, Nigeria using shovel and hammer. The clays were air- dried, and pulverized in a porcelain motar and sieve through a 2 mm (10 mesh) stainless sieve. The air-dried <2 mm samples were stored in a polyethene bags and properly labeled for subsequent analysis.

Small pebble stones were carefully obtained from River Ethiope at Abraka, carefully washed, dried and stored in polythene bags. Suitable amount of leachate were collected at different times in 20 litres clean plastic containers.

Columns made of plastic with height 100 cm and diameter 10 cm were set up. Glass wool was carefully packed to a depth of 2 cm at its base and carefully mixed quantities of clay and pebbles in ratio 1:4 were carefully loaded into the column to 70 cm mark to allow for clay swelling. This was loaded with leachate as shown in Figure 1.

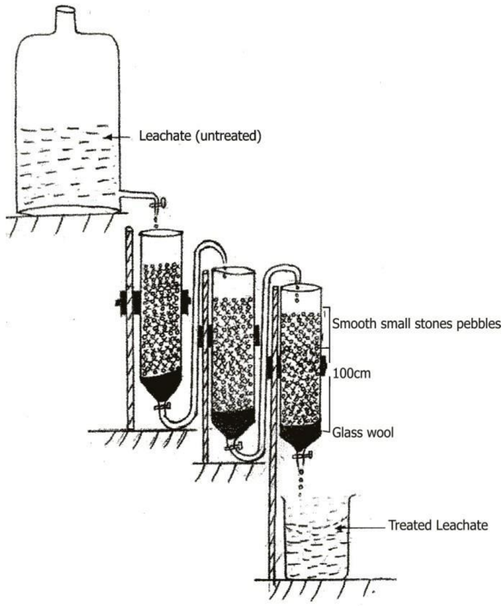

Fig1: Three flow through columns

This was used for the percolation rate studies.[10] Raw and treated effluents were collected and analyzed for various pollution characteristics according to standard methods.[11]

Mineralogical Analysis was done using 2.0 g of sample mixed with sodium based coagulant and the X-ray diffractometer crossed matched the peaks bringing out the mineral constituents using XSPEX version 5. 62. Cation Exchange Capacity was done using [12], all analysis, preservation and holdings were done using standard methods.[11]

pH was done on site by electrometric method using HACH pH meter after standardizing with 4.0 and 9.0 buffers at same temperature. Total Suspended Solids (TSS) were determined using photometer methods with HACH DR 2010. Total Dissolved Solids (TDS) was carried out using conductivity method. Biochemical Oxygen Demand (BOD) was done using Alkali-Azide modification method, Chemical Oxygen Demand (COD) by closed Reflux-Titrimetric Method. Ammonium -Nitrogen by Direct Nesslerization method using HACH DR 5000 UV-Spectrometer and salinity was carried out by electrical conductivity method using cension-5 conductivity meter.[13] Metal ion determination was done using Atomic Absorption spectrophotometer GBS scientific and Na and K were determined by flame photometer Bulk scientific 6 as described by standard methods.

Results and Discussions

The mineral composition showed that the clay types used were kaolin (58.15) for OT and 43.14 for AM and were the predominant type. Chloride was found only in AM clay type and are known for their ability to swell and absorb pollutants and have high cation exchange capacity as shown in Table 1 below.

Table 1: Mineralogical Analysis of Clays (%)

Minerals	OT	AM
Saponite	Nil	Nil
Montrimonllonite	Nil	Nil
Chlorite	Nil	4.30
Illite	10.08	12.13
Interstatified	Nil	Nil
Kaolinite	58.15	43.14
Quartz	27.52	34.20
Hematite	4.25	6.23

The cation exchange capacity falls within the range of kaolin clay 3 – 10 (cmol/kg). AM has 9 (cmol/kg) and OT (cmol/kg). The higher the cation exchange, the higher the pollutant removal.

AM has the higher percolation rate of 3.76 x $10^{-7}m^3/s$ and OT 2.94 x 10^{-7}, the presence of illite is responsible for the relatively longer residence time (percolation rate) of AM clay which has swelling capacity.

The higher the swelling rate of any clay type when soaked in water, the lower the permeability and the higher the residence time of solvent in it and the better the pollutant removal[14].

Table 2: Results of Geochemical Analysis of clay (%) of oxides

Metal oxide (%)	AM	OT
SiO_2	73.10	72.29
Al_2O_3	13.62	7.82
Fe_2O_3	11.23	17.08
MgO	0.18	0.20
CaO	0.31	0.28
NaO_2	1.01	0.01
K_2O	0.49	1.94
TiO_2	0.03	0.31
P_2O_5	0.02	0.04
MnO	0.01	0.03

Table 2 shows the two clay types to be siliceous 73.10% for AM and 72.29 for OT, with AM having 13.62 Al_2O_3 more aluminosilicate than OT having 7.82 of Al_2O_3. Fe_2O_3 was a major impurity found in them.

Table 3: Results of Treatment of Leachate (Mean Values).

Characteristics	Units	Raw sample	AM	OT	WHO	SON/ NESREA
Temperature	O^0C	28.00-29.10	7.00	8.00	27	N.A
pH		7.10-7.70	6.00	6.80	7.2	7.5
TSS	mg/dm^3	61.20-70.20	10.10	25.60	N.A	300
TDS	mg/dm^3	210.00-510.00	21.20	22.50	500	200
BOD	mg/dm^3	80.00- 210.00	5.00	6.20	6.00	5.00
COD	mg/dm^3	842.00-933.00	15.00	18.00	15.00	15.00
NH_4-N	mg/dm^3	0.08-11.20	0.32	0.42	-	-
Salinity	$^0/_{00}$	0.90-3.10	0.31	0.08	Nil	Nil
Pb	mg/dm^3	0.21-0.28	0.02	0.04	0.01	0.01
Cu	mg/dm^3	0.08-0.09	0.03	0.05	1.00	1.00
Cd	mg/dm^3	<0.001	ND	ND	0.003	0.003
Na	mg/dm^3	180-195	105	124	N.A	N.A

Ca	mg/dm^3	0.01 - 16	10	12	750	750

WHO- World Health Organization.[15]
SON - Standard Organization of Nigeria[16]
NESREA - National Environmental Standards and Regulations Enforcement Agency.[17]

The pH became slightly acidic because of carbonaceous materials making the pH to be within narrow range in agreement with [18]. The total dissolved solids from greatly reduced. This was due to the smooth surface of clay which does not allow free flow of liquid. This helped the removal of solids as shown Table 3 above.

The Biochemical and Chemical Oxygen Demand values of a body of water indicates its level of pollution.[18] for BOD, these values were from the cationic or anionic organic pollutants. After treatment, they were greatly reduced. This can be explained by the exchangeable and adsorptive sites on the clay minerals. COD values were also greatly reduced but more for AM clay because when chlorite groups are present in addition to kaolin, the clays perform better[19] in pollutant removal. Salinity which is the amount of dissolved salts in water was also greatly reduced. Cation exchange capacity is fundamental in clay structure because the nature of the exchangeable ion influences the physical properties of the material.[14]

Many of the metals in leachate are in the form of species in which they are complexed to both inorganic as Cl^- and SO_4^{2-} and organic ligands. The high surface area of clays have placed them amongst colloidal particles as metal sobents.[20]

From the pollution characteristics studied, the raw values were above the set standards stated above, after treatment with the clays, they were within these standards. TDS was 5.00 – 6.20 mg/dm^3 BOD 5.00 – 6.20 mg/dm^3, COD 15.00 – 18.00 mg/dm^3, NH_3 –N 0.32 – 0.42 mg/dm^3, salinity 0.08 – 0.31%₀ , Pb 0.02 – 0.08, Cu 0.03 – 0.05, Cadmium not detected and Ca 10 – 12 mg/dm^3. There was remarkable improvement in the water quality when compared with WHO, SON and NESREA standards as shown in Table 3.

Conclusion

The overall performance of clays showed that clays have high potential for leachate treatment, to avoid contamination of surface and groundwater. The technique is simple, low energy consuming and environmentally friendly using locally sourced material (clay).

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