World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-13, Issue-1, July 2022 Pages 01-13

The Environmental Impact of Thermal Desorption Unit on the Physicochemical Composition of Leachate: A Case Study of Beneku, Ndokwa East, Delta State, Nigeria

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***Abstract*— The study is on the environmental impact of thermal desorption unit on the physicochemical composition of leachate in Beneku in Ndokwa East Local Government Area, Delta state. Leachates samples were collected from 6 trenches dug into the dumpsites at 1.5m depth. 2-liter plastic containers were used to collect the leachates. Prior to collection, the containers were rinsed with the samples in order to acclimatize to the sample environment. In order to avoid chemical and biological changes that have the potential to change the natural homogeneity of the samples, the sample for heavy metals analysis were preserved by adding 1ml of conc. HNO3 while 2ml Concentrated H2SO4 was added to samples for COD analysis. The average pH values of the leachate for the wet season was 7.4, while in the dry season it was 6.0. With the pH values varying from 6 to 7.4,which is within the limit of the FMEnv of 6.0 – 9.0, it is a representative of a growing pH from young to old leachate. The electrical conductivity for both the wet and dry seasons are 6119.14 µs/cm and 6206.49 µs/cm respectively, which far exceeded the FMENV standard of 125.00 µs/cm. The BOD average values for the wet and dry seasons are 7.30 mg/l and 7.50 mg/l respectively while the average values of COD were 13.78 mg/l and 14.22 mg/l respectively for the wet and dry seasons. The mean ratio 7.30/13.78 is 0.53 for the wet season and that for the dry season wich is 7.50/14.22 is also 0.53. This figure (0.53) shows that the organic matter in the leachates is readily biodegradable, and has a high organic strength which can be attributed to fact that the study site is active or open, being fed with waste on a continuous basis, which possibly contains organic matter that undergoes biodegradation continually. From the results of the study, the average values of Iron are 249.54 mg/l and 258.88 for the wet and dry seasons respectively and are over the FMEnv limit of 0.05 mg/l, Manganese had 2.89 mg/l and 2.66 mg/l for the wet and dry seasons respectively are were also above the FMEnv limit of 0.05 mg/l, Cadmium concentrations in the leachate were 0.57 mg/l and 0.69 mg/l for the wet and dry seasons respectively and they were above the FMEnv limit of 0.01 mg/l, Chromium recorded an average of 4.36 mg/l and 6.95 mg/l for the wet and dry seasons respectively and were above the FMEnv limit of 0.20 mg/l. Nickel had an average values of 0008 mg/l and 0.006 mg/l and are below the FMEnv limit of 0.01 mg/l, Lead recorded an average of 0.33 mg/l and 0.48 mg/l for the wet and dry seasons respectively and are above the FMEnv limit of 0.05 mg/l. The use of thermal desorption unit as treatment method for contaminated solids has proved to be effective as shown in this study as most of the parameters tested in the leachate were well below the Federal Ministry of Environment set limits.**

***Index Terms*— Thermal Desorption Unit, Contaminated, Soil, Leachate.**

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I. Introduction

Despite the evolution of landfill technology from open, uncontrolled dumps to highly engineered facilities designed to eliminate or minimize potential adverse impacts of the waste on the surrounding environment, generation of contaminated leachate remains an inevitable consequence of the practice of waste disposal in landfills [1]. The subsequent migration of leachate away from landfill boundaries and the release to the adjacent environment is a serious environmental pollution concern and a threat to public health and safety at both old and new facilities. Ground water pollution is by far the most significant concern arising from leachate migration. Soluble organic and inorganic compounds are encountered in the waste at emplacement or are formed as a result of chemical and biological processes within the landfill. Leachate formation creates a non-uniform and intermittent percolation of moisture through the waste mass, which results in the removal of these soluble compounds from the waste and their dissolution and suspension in the leachate

A conventional treatment method for soil is incineration, a costly but efficient ex-situ treatment regarding high removal in which PFASs are destroyed by combusting the contaminated soil ([2]. Fluorotelomer-based acrylic polymer waste and PFAS-contaminated sewage sludge have been reported to degrade PFASs successfully at 725˚C [3] –[6], although others have found that complete degradation of PFASs requires temperatures of 900–1100˚C [1], [5] [6],. Another viable thermal treatment method for contaminated solids is thermal desorption ([7] Kuppusamy, 2017), where the solid is heated ex- situ or in situ [2], and the vaporized contaminants partition to the air phase, from which they can be removed by air filters [8]. The technique is considered to be less energy-demanding than incineration, can achieve high removal [2], and is generally applicable for organic contaminants [9]. Thermal desorption has previously been shown to successfully remove persistent soil organic pollutants such as polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) at 500˚C [10], and PFAS thermal desorption from the soil phase has been observed at 350˚C after 10 days [11]. While thermal desorption is a fast, reliable way to remediate contaminated soil, the ability of the soil to function after treatment is unknown. Several past research works in reclamation attempt often ignore the impacts of thermal treatments on the remediated soil, hence, a comprehensive examination of the magnitude of the effects of soil heating and their implications on soil function and soil properties is needed. Connecting the effects of thermal remediation to soil function is vital in the subsequent reclamation process. In this study, the impact of physicochemical composition of leachate from thermal desorption unit on the environment in Beneku and environment in Ndokwa East was evaluated using six sampling locations for both the rainy and dry seasons.

II. MATERIALS AND METHODS

The samples were immediately transferred to ice chest and transported to the laboratory for analysis. In-situ parameters such as pH, total dissolved solids and electrical conductivity were measured using Hanna hand held pH and conductivity/TDS meter. All the parameters were measured according to the standard method for the examination of water and wastewater by APHA, 2005. pH was determined by glass electrode method with a standard calibrated pH. Dissolved solids, and conductivity were measured in situ. An Atomic Absorption Spectrophotometer was used for metals analyses after samples were digested, using concentrated trioxonitrate (V) and the volume made up to 50ml with deionized water. BOD was computed from dissolved oxygen (DO) – determined by Azide modification of Winkler's method. Open reflux method utilising potassium tetra-oxo chromate (VI) in boiling concentrated tetra-oxosulphate (VI) solution in the presence of silver catalyst was used to determine COD. Phosphate, chloride and sulphate were analysed by colorimetry using molybdovanadate method.

III. RESULTS AND DISCUSSIONS

A. *Presentation of Results*

Leachate is the term for the liquid pollution that seeps through a landfill's waste pile when it rains or snows. The concentration of the physicochemical composition of the leachate are shown in Table 1 and discussed in the following subsections.

pH: The pH values obtained in the study ranges between 6.54 and 8.58 with an average of 7.4 in the wet season and between 6.32 and 8.21and an average of 6.0 in the dry season (Table 1and **Figure 1**). In both season the average values are within the 6.0-9.0 range of FMEnv limit.

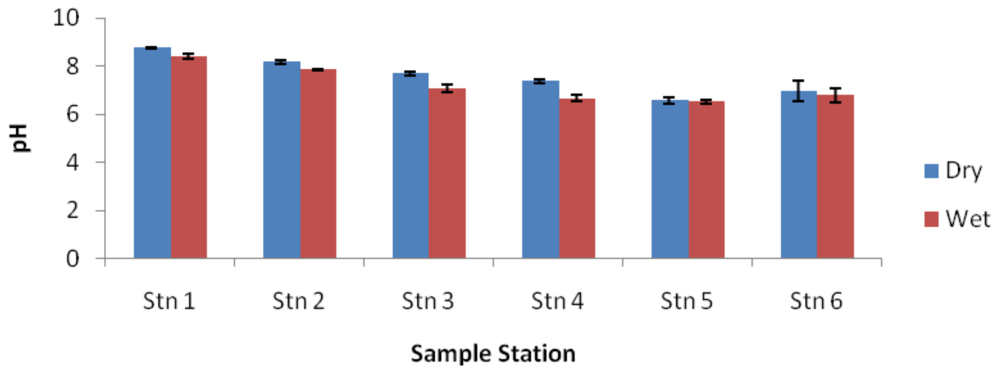

Fig. 1: Concentration of pH for the Wet and Dry Seasons

Dissolved Oxygen (DO): In the wet season, the values ranges from 3.13 mg/l to 5.13mg/l with an average value of 4.36 mg/l, while in the dry season the values range from 3.21 mg/l to 5.31 mg/l with an average of 4.48 mg/l. The average values for both seasons are below the FMEnv limit of 5.00 (Table 1 and Figure 2)

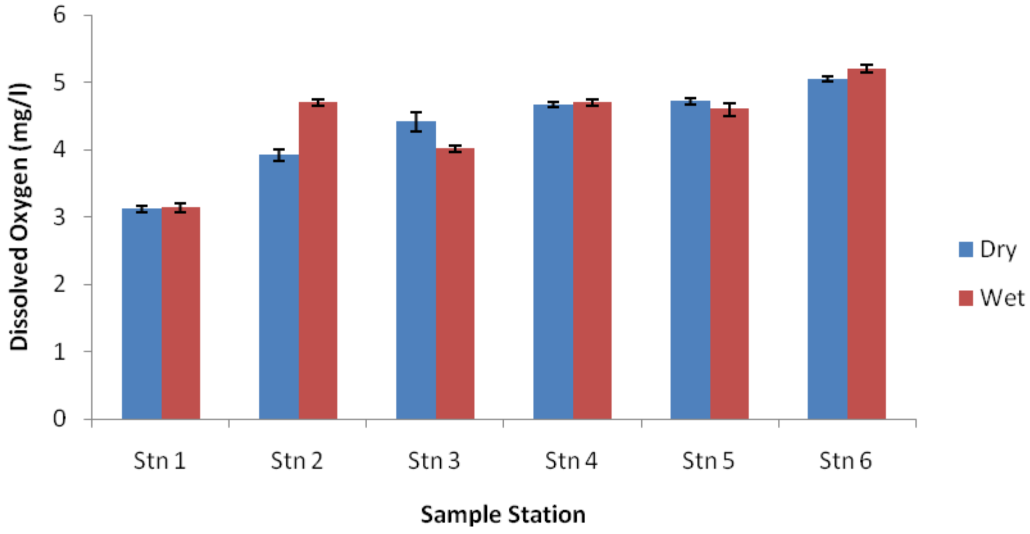

Fig. 2: Concentration of Dissolved Oxygen for the Wet and Dry Seasons

Electrical Conductivity: Electrical Conductivity is the ability of a solution to permit the flow of electrical current. It varies with the number and type of ions in the solution. The conductivity in effluent is proportional to the concentration of dissolved solids, mostly inorganic salts. The higher the salinity of water the higher the conductivity value. The E. Conductivity had value range of 5343.83 to 7013.33 with an average of 6119.14 in the wet season and value range of 6010.43 to 7012.23 with an average of 6206.49 in the dry season. The average values for both seasons are well above the FMEnv standard of 125.00 (Table 1 and Figure 3).

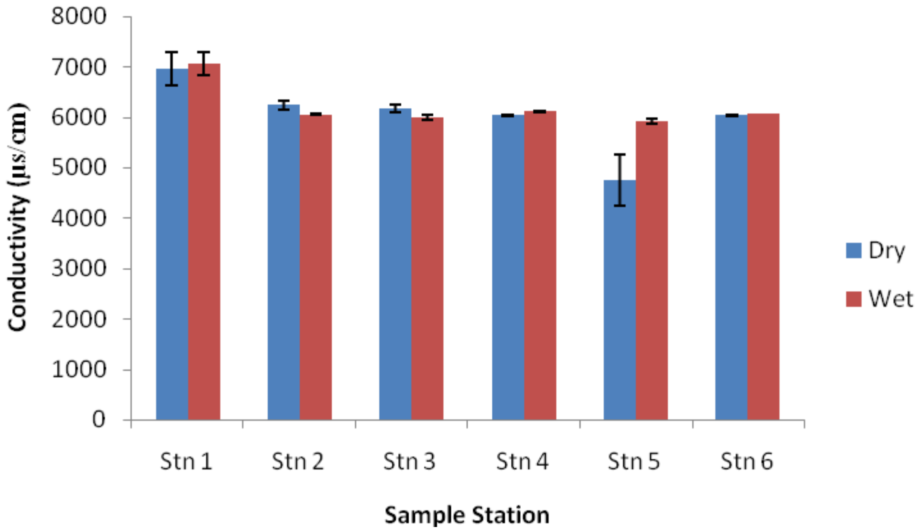

Fig 3: Concentration of Conductivity for the Wet and Dry Seasons

TABLE 1: CHARACTERISTICS OF LEACHATE FOR THE WET AND DRY SEASONS

Parameters	Sample Stations							
	Stn 1	Stn 2	Stn 3	Stn 4	Stn5	Stn 6	Range	FEPA Standard
Ph (Wet)	8.58±0.07	8.01±0.06	7.38±0.12	7.01±0.13	6.54±0.07	6.88±0.25	7.4	
Ph (Dry)	7.45±0.05	7.05±0.08	6.32±0.02	8.21±0.03	7.24±0.09	7.35±0.16	6.0	
Dissolve Oxygen (mg/l) (Wet)	3.13±0.04	4.31±0.13	4.21±0.09	4.69±0.03	4.66±0.05	5.13±0.04	4.36	5.0
Dissolve Oxygen (mg/l) (Dry)	3.21±0.06	4.60±0.17	4.71±0.11	4.81±0.07	4.22±0.03	5.31±0.06	4.48	
E. Conductivity (Wet)	7013.33±192.21	6146.75±46.45	6078.75±53.60	6077.17±11.75	5343.83±302.22	6055.00±10.11	6119.14	125.00
E. Conductivity (Dry)	7012.23±191.11	6105.55±45.35	6045.64±25.40	6020.06±10.56	6010.43±342.24	6045.00±10.11	6206.49	
Total Dissolve Solids (mg/l) (Wet)	3717.25±101.86	3252.58±22.71	3221.83±28.40	3220.58±6.49	3574.67±353.57	3209.17±5.37	3366.01	500
Total Dissolve Solids (Dry)	3750.35±111.95	3012.44±12.51	3015.63±17.30	3310.34±8.17	3304.28±234.16	3249.14±6.48	3273.70	
Salinity (mg/l) (Wet)	2907.08±46.10	2313.33±20.29	1913.94±231.20	2256.83±4.80	2407.58±116.57	2246.58±3.77	2340.89	
Salinity (mg/l) (Dry)	2703.02±37.20	2215.24±10.17	1512.54±123.30	2316.76±6.40	2304.32±106.27	2259.52±1.46	2218.57	
Alkalinity (mg/l) (Wet)	3.18±0.06	2.99±0.11	2.34±0.07	1.91±0.10	1.61±0.07	1.42±0.04	2.24	4.50
Alkalinity (mg/l) (Dry)	3.03±0.02	2.54±0.01	2.54±0.09	2.01±0.18	1.82±0.09	1.53±0.07	2.25	
Oil &Grease (mg/l) (Wet)	187.05±11.20	98.98±13.50	66.15±6.34	33.83±3.48	32.08±3.95	24.19±0.82	73.71	
Oil &Grease (mg/l) (Dry)	196.08±14.10	154.25±10.30	124.17±3.14	62.53±1.72	53.18±2.75	35.25±0.72	104.24	
Nitrate (mg/l) (Wet)	16.47±1.73	12.12±1.18	10.93±1.00	9.52±0.94	9.46±0.54	7.39±0.44	10.98	20.0
Nitrate (mg/l) (Dry)	18.25±1.43	14.92±1.46	12.43±1.08	12.82±0.83	11.27±0.18	6.27±0.12	12.66	
Sulphate (mg/l)	125.76±0.25	115.22±2.36	101.89±4.18	82.53±5.31	55.95±5.65	45.45±5.44	87.8	100.00

(Wet)								
Sulphate (mg/l) (Dry)	122.26±0.22	102.35±0.18	98.63±2.04	89.33±2.71	65.75±6.75	47.25±4.89	87.60	
Biological Oxygen Demands (mg/l) (Wet)	9.53±0.06	7.12±0.18	7.26±0.24	6.58±0.06	6.54±0.08	6.79±0.03	7.30	30.00
Biological Oxygen Demands (mg/l) (Dry)	9.41±0.02	6.02±0.13	9.13±0.01	6.93±0.08	6.85±0.09	6.68±0.02	7.50	
Chemical Oxygen Demands (mg/l) (Wet)	18.07±0.26	14.20±0.54	14.14±0.76	12.02±0.27	12.16±0.32	12.09±0.29	13.78	75.00
Chemical Oxygen Demands (mg/l) (Dry)	18.74±0.27	12.08±0.13	17.12±0.78	13.12±0.29	13.18±0.34	11.08±0.16	14.22	
Iron (mg/l) (Wet)	263.68±14.14	239.15±11.54	228.55±8.29	231.71±6.70	227.28±6.02	306.72±13.43	249.52	0.05
Iron (mg/l) (Dry)	252.17±12.18	242.17±10.64	221.35±6.15	221.14±6.12	220.12±5.05	396.32±16.3	258.88	
Manganese (mg/l) (Wet)	3.06±0.17	2.77±0.13	2.65±0.10	2.68±0.08	2.63±0.07	3.55±0.16	2.89	0.05
Manganese (mg/l) (Dry)	2.09±0.12	2.65±0.11	2.42±0.07	2.42±0.03	2.52±0.04	3.84±0.18	2.66	
Cadmium (mg/l) (Wet)	0.73±0.04	0.66±0.05	0.56±0.05	0.49±0.06	0.49±0.06	0.48±0.05	0.57	0.01
Cadmium (mg/l) (Dry)	0.84±0.06	0.82±0.07	0.72±0.07	0.63±0.07	0.53±0.07	0.57±0.08	0.69	
Chromium (mg/l) (Wet)	5.97±0.68	5.22±0.67	4.48±0.58	3.62±0.48	3.05±0.56	3.80±0.86	4.36	0.20
Chromium (mg/l) (Dry)	6.82±0.76	8.61±0.82	7.24±0.71	6.51±0.72	6.13±0.627	6.40±0.92	6.95	
Nickel (mg/l) (Wet)	0.011±0.007	0.009±0.006	0.009±0.005	0.008±0.004	0.007±0.004	0.006±0.003	0.008	0.01
Nickel (mg/l) (Dry)	0.002±0.003	0.005±0.004	0.002±0.003	0.012±0.005	0.012±0.005	0.002±0.004	0.006	
Vanadium (mg/l) (Wet)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001	

Vanadium (mg/l) (Dry)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001	
Lead (mg/l) (Wet)	0.15±0.10	0.13±0.08	0.45±0.14	0.43±0.14	0.42±0.14	0.41±0.14	0.33	0.05
Lead (mg/l) (Dry)	0.00±0.00	0.00±0.00	0.69±0.16	0.72±0.17	0.72±0.17	0.72±0.17	0.48	
Copper (mg/l) (Wet)	2.88±0.02	2.47±0.09	1.94±0.14	1.60±0.15	0.75±0.06	0.55±0.06	1.70	5.00
Copper (mg/l) (Dry)	2.77±0.01	2.24±0.06	1.02±0.02	1.74±0.16	0.43±0.03	0.32±0.03	1.42	
Zinc (mg/l) (Wet)	4.03±0.29	3.68±.29	3.68±0.36	3.08±0.26	2.83±0.25	2.59±0.25	3.32	6.00 – 9.00
Zinc (mg/l) (Dry)	5.14±0.32	4.54±.32	5.72±0.43	5.04±0.27	3.42±0.32	5.32±0.53	4.86	
Barium (mg/l) (Wet)	5.70±0.70	4.89±0.60	4.46±0.56	4.60±0.56	4.18±0.44	3.68±0.48	4.59	
Barium (mg/l) (Dry)	7.45±0.78	6.76±0.80	6.55±0.58	6.73±0.67	6.82±0.57	5.57±0.49	6.65	
Mercury (mg/l) (Wet)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001	
Mercury (mg/l) (Dry)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001	

Total Dissolved Solid (TDS): Total Dissolved Solid (TDS) is the differences between the total solids (TS) and the suspended solids (SS). The result of the total dissolved solid (TDS) for the wet season ranges from 3220.58 to 3717.75 with an average of 3366.01 while the results for the dry season range from3304.28 to 3750.35 with an average of 3273.70 (Table 1 and **Figure 4)**.

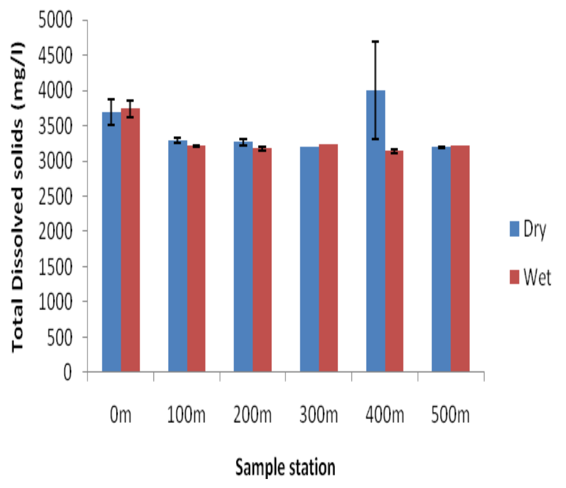

Fig. 4: Concentration of Total Dissolved Solids for the Wet and Dry Seasons

Salinity: Salinity is the total of all non-carbonate salts dissolved in liquids, usually expressed in parts per thousand (1 ppt = 1000 mg/L). The salinity level of the leachate sampled ranged between 1913.94mg/l and 2907.08mg/l with an average of 2340.89 in the wet season and ranges from1512.54 to 2703.02 with an average of 2218.57 in the dry season (Table 1 and Figure 5).

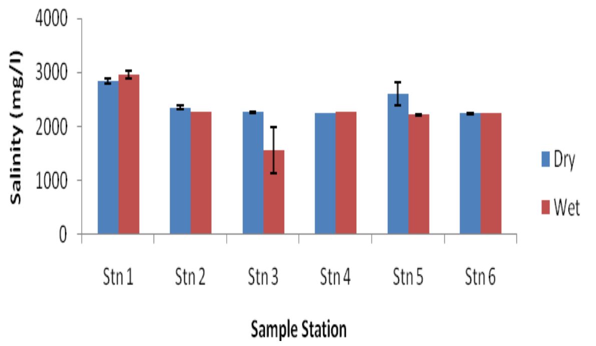

Fig 5: Concentration of Salinity for the Wet and Dry Seasons

Alkalinity: This is the buffering capacity of a liquid body; a measure of the ability of the water body to neutralize acids and bases and thus maintain a fairly stable pH level". Alkalinity is not a chemical in water, but, rather, it is a property of liquid that is dependent on the presence of certain chemicals in the liquid, such as bicarbonates, carbonates, and hydroxides. The value of alkalinity of the leachate obtained during the study for the wet season ranged from 1.42mg/l to 3.18mg/l with an average of 2.24 mg/l and from 1.53 mg/l to 3.03 mg/l with an average of 2.25 mg/l in the dry season. The average for both season are below the FMEnv limit of 4.50 (Table 1 and Figure 6)

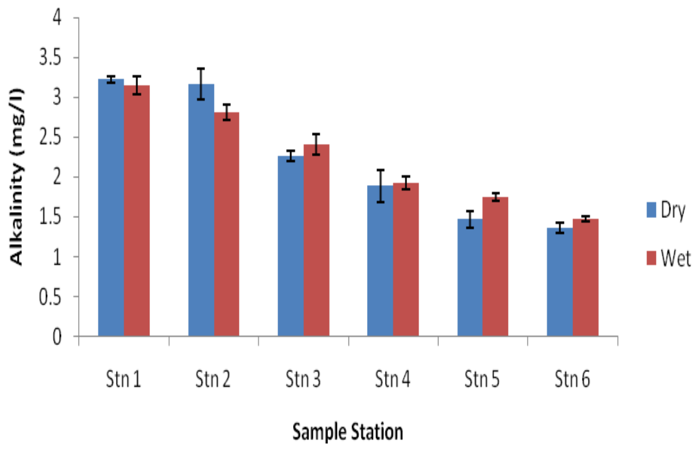

Fig 6: Concentration of Alkalinity for the Wet and Dry Seasons

Nitrate: Nitrates (NO_3-) in the soil are converted into the potent greenhouse gas nitrous oxide (N_2O), during a process called denitrification. Nitrate is water soluble so can leach out of soils and pollute watercourses. In the wet season, nitrate concentration in the leachate samples ranged from 7.39 to 16.47mg/l with an average of 10.98 mg/l and in the dry season it ranges from 6.27 mg/l to 18.25 mg/l with an average of 12.66 mg/l. Averages for both seasons are below the FMEvn limit of 20.0 mg/l (Table 1 and Figure 7)

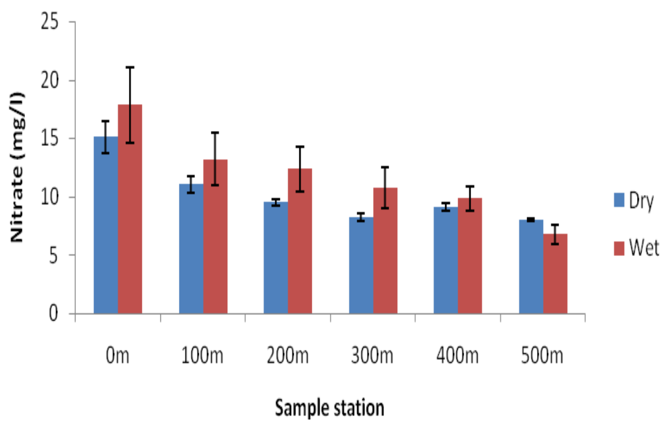

Fig 7: Concentration of Nitrate for the Wet and Dry Seasons

Sulphate: The amount of sulphate in the leachate for the wet season ranges from 45.45 mg/l to 125.76 mg/l with an average of 87.7 mg/l and in the dry season; it ranges from 47.25 mg/l to 122.26 mg/l with an average of 87.60 mg/l. The averages of both seasons are below the FMEnv limit of 100.00 mg/l (Table 1)

Biochemical Oxygen Demand (BOD): Biochemical oxygen demand (BOD) represents the amount of oxygen consumed by bacteria and other microorganisms while they decompose organic matter under aerobic (oxygen is present) conditions at a specified temperature. The decay of organic matter in leachate is measured as biochemical or chemical oxygen demand. BOD level in the leachate samples in the wet season ranges from 6.t54 mg/l to 9.53 mg/l with an average of 7.30 mg/l and in the dry season the values range from 6.02

mg/l to 9.41 mg/l with an average of 7.50 mg/l. The averages of both seasons fell below the FMEnv limit of 30.00 mg/l (Table 1 and Figure 8).

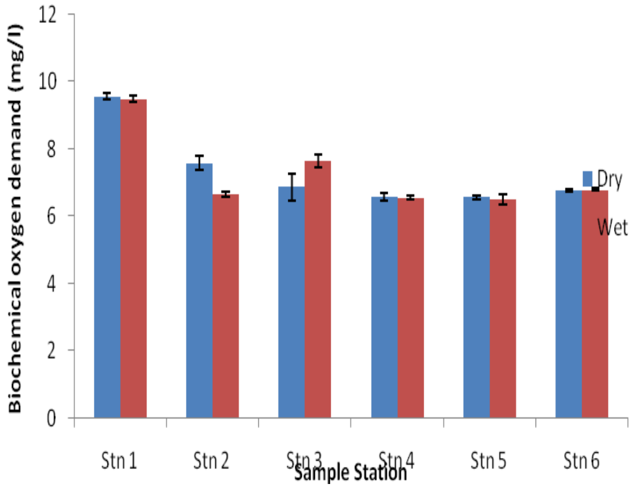

Fig 8: Concentration of Biochemical Oxygen Demand for the Wet and Dry Seasons

Chemical Oxygen Demand (COD): In the wet season, the concentration of COD in the leachate ranges from 12.02 mg/l to 18.07 mg/l with an average of 13.78 mg/l. While in the dry season, it ranges from 11.08 mg/l to 18.74 mg/l with an average of 14.22 mg/l. The averages of both seasons fell below the FMEvn limit of 75.00 mg/l (Table 1 and Figure 9).

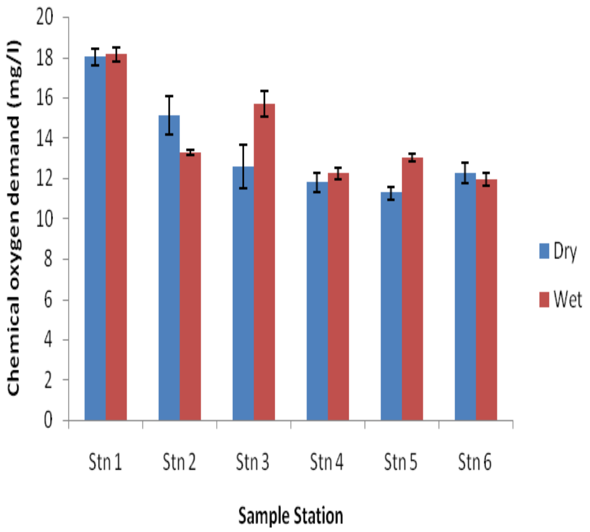

Fig 9: Concentration of Chemical Oxygen Demand for the Wet and Dry Seasons

Iron (Fe): The concentration of Iron in the leachate in the wet season ranges from 228.55 mg/l to 306.72 mg/l with an average of 249.52 mg/l while in the dry season, the values range from 220.12 mg/l to 396.22 mg/l with an average of 258.88 mg/l. Average values for both seasons far exceeded the FMEnv limit of 0.05 mg/l (Table 1 and Figure 10).

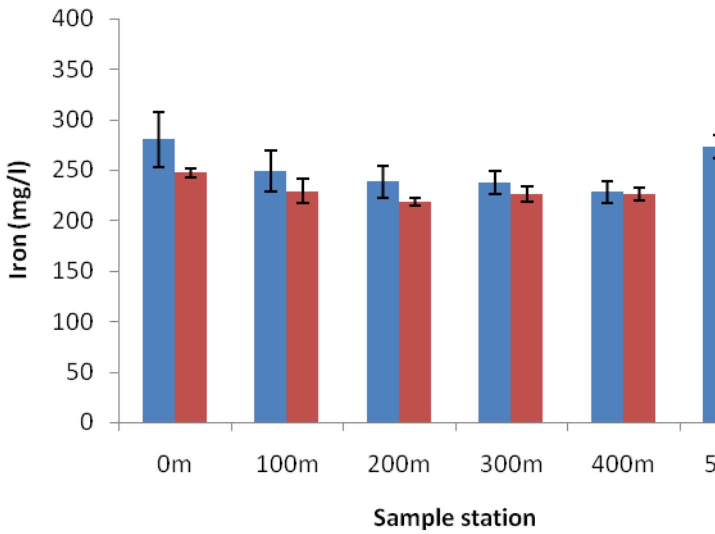

Fig 10: Concentration of Iron for the Wet and Dry Seasons

Manganese (Mn): The concentration of Manganese in the leachate in the wet season ranges from 2.65 mg/l to 3.55 mg/l with an average of 2.89 mg/l while in the dry season, the values range from 2.09 mg/l to 3.84 mg/l with an average of 2.66 mg/l. Average values for both seasons exceeded the FMEnv limit of 0.05 mg/l (Table 1 and Figure 11).

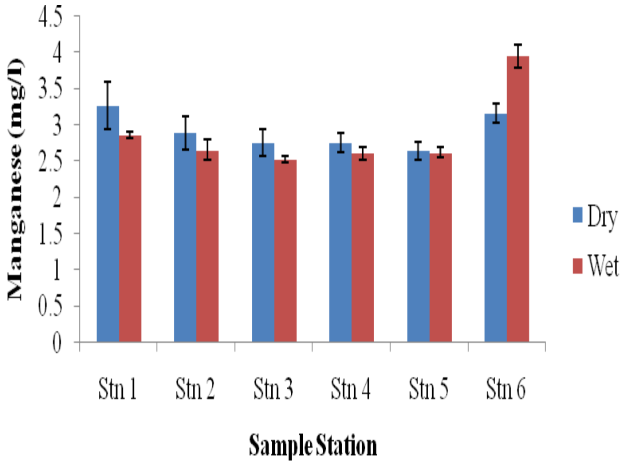

Fig 11: Concentration of Manganese for the Wet and Dry Seasons

Cadbium (Cd): The concentration of Cadbium (Cd) in the leachate in the wet season ranges from 0.48mg/l to 0.73 mg/l with an average of 0.57 mg/l while in the dry season, the values range from 0.53mg/l to 0.84mg/l with an average of 0.69 mg/l. Average values for both seasons exceeded the FMEnv limit of 0.01 mg/l (Table 1 and Figure 4.12).

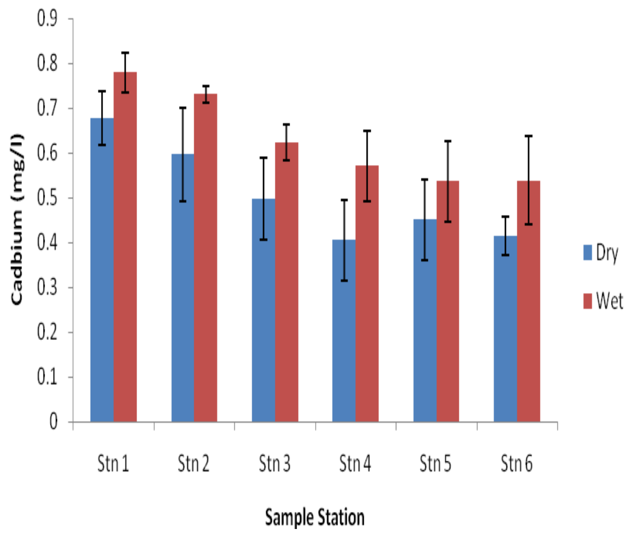

Fig 12: Concentration of Cadbium for the Wet and Dry Seasons

Chromium: The concentration of Chromiun in the leachate in the wet season ranges from 3.05mg/l to 5.97 mg/l with an average of 4.36 mg/l while in the dry season, the values range from 6.13mg/l to 6.82mg/l with an average of 6.95 mg/l. Average values for both seasons exceeded the FMEnv limit of 0.20 mg/l (Table 1 and Figure 13).

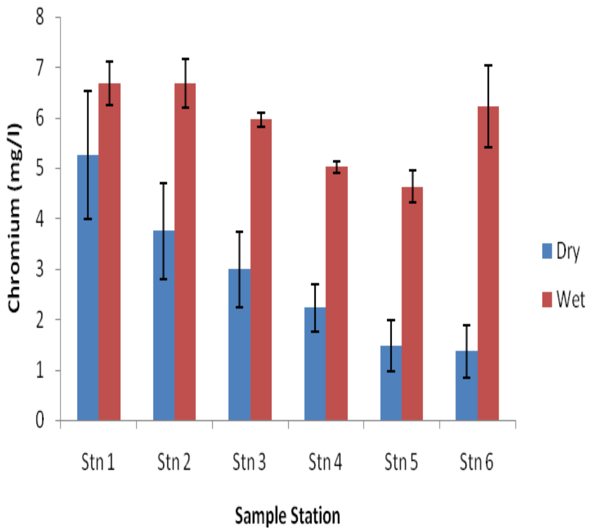

Fig. 13: Concentration of Chromium for the Wet and Dry Seasons

Nickel: The concentration of Chromiun in the leachate in the wet season ranges from 0.006mg/l to 0.011mg/l with an average of 0.008mg/l while in the dry season, the values range from 0.002mg/l to 0.012mg/l with an average of 0.006mg/l. Average values for both seasons exceeded the FMEnv limit of 0.01 mg/l (Table1 and Figure 14).

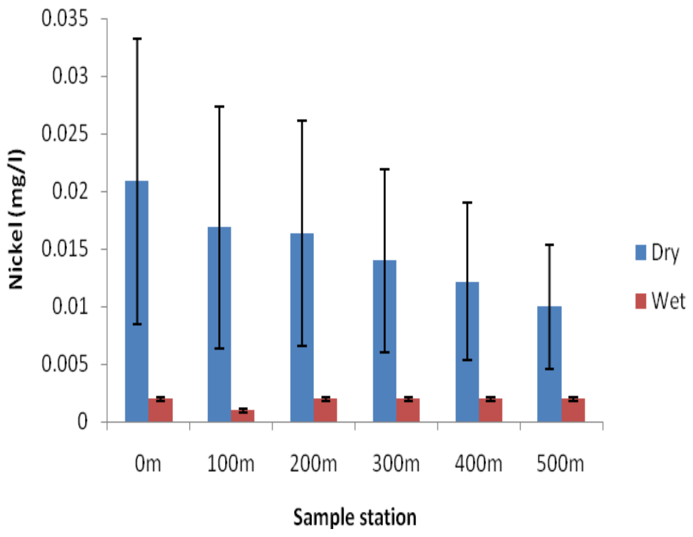

Fig. 14: Concentration of Nickel for the Wet and Dry Seasons

Vanadium: The concentration of Vanadium in the leachate in the wet season ranges from 0.001mg/l across all the sample points same for the dry season with an average of 0.001mg/l for both season (Table 1 and Figure 15).

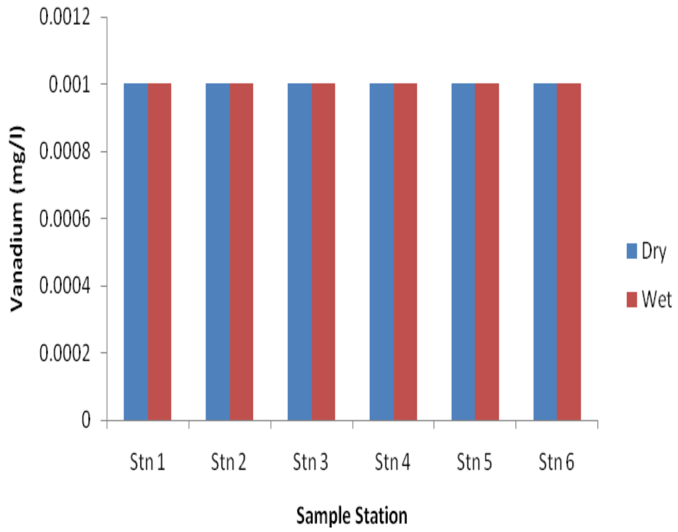

Fig 15: Concentration of Vanadium for the Wet and Dry Seasons

Lead: The concentration of Lead in the leachate in the wet season ranges from 0.13mg/l to 0.45mg/l with an average of 0.33mg/l while in the dry season, the values range from 0.00mg/l to 0.72mg/l with an average of 0.48mg/l. Average values for both seasons exceeded the FMEnv limit of 0.05 mg/l (Table 1 and Figure 16).

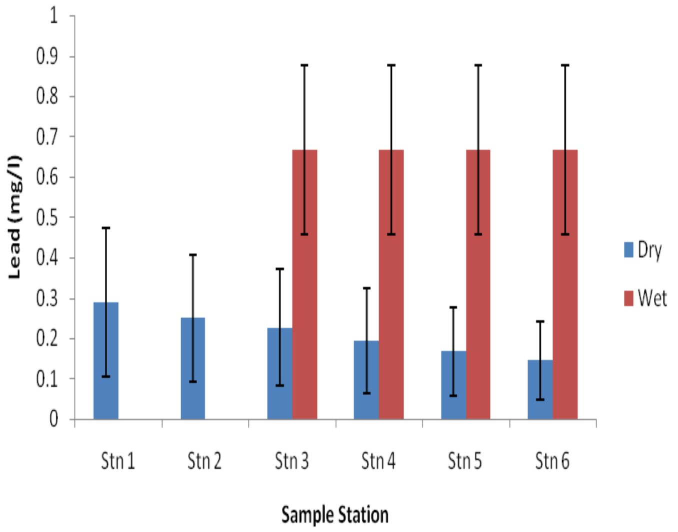

Fig. 16: Concentration of Lead for the Wet and Dry Seasons

Copper (Cu): The concentration of Copper (Cu) in the leachate in the wet season ranges from 0.55mg/l to 2.88mg/l with an average of 1.70mg/l while in the dry season, the values range from 0.32mg/l to 2.77mg/l with an average of 1.42mg/l. Average values for both seasons are below the FMEnv limit of 5.0 mg/l (Table 1 and Figure 17).

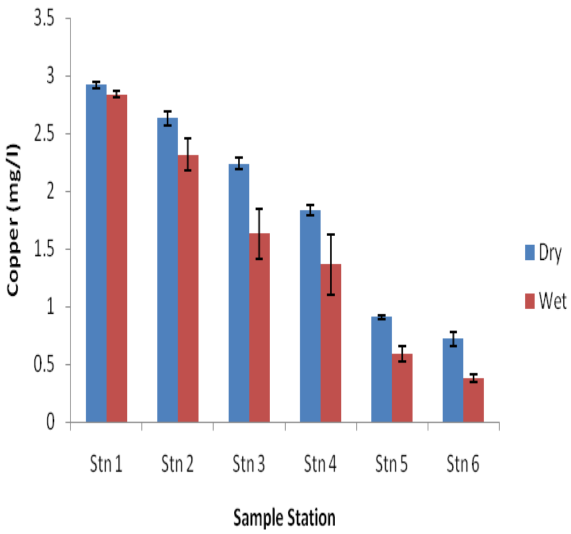

Fig. 17: Concentration of Copper for the Wet and Dry Seasons

Zinc (Zn): The concentration of Zinc (Zn) in the leachate in the wet season ranges from 2.59mg/l to 4.03mg/l with an average of 3.32mg/l while in the dry season, the values range from 3.42mg/l to 5.72mg/l with an average of 4.86mg/l. Average values for both seasons are below the FMEnv range of 6.00 mg/l to 9.00 mg/l (Table 1 and Figure 18).

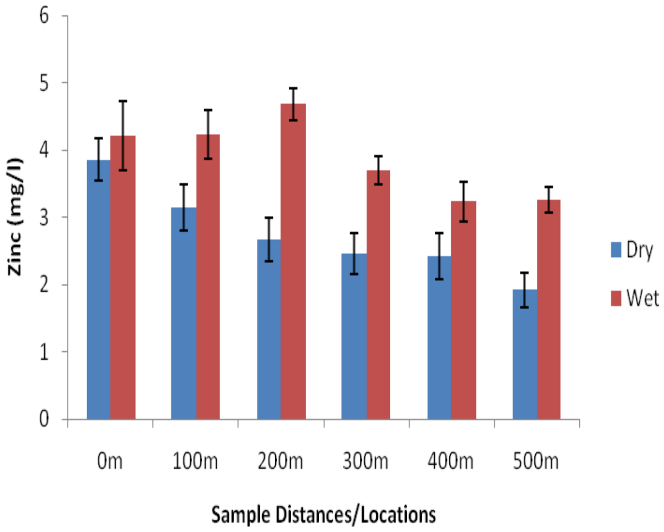

Fig 18: Concentration of Zinc for the Wet and Dry Seasons

Barium: The concentration of Barium in the leachate in the wet season ranges from 3.68mg/l to 5.70mg/l with an average of 4.59mg/l while in the dry season, the values range from 5.57mg/l to 7.45mg/l with an average of 6.65mg/l (Table 1 and **Figure 19).**

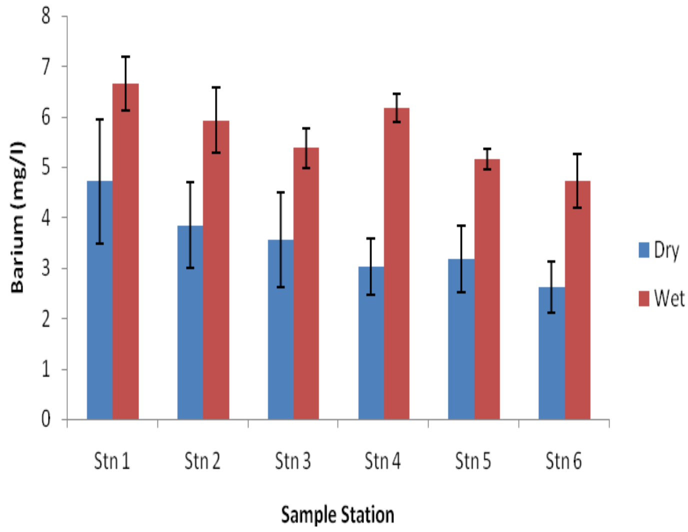

Fig 19: Concentration of Barium for the Wet and Dry Seasons

Mercury: The concentration of Mercury in the leachate is 0.001 across all the sampling points for both seasons (Table 1 and Figure 20).

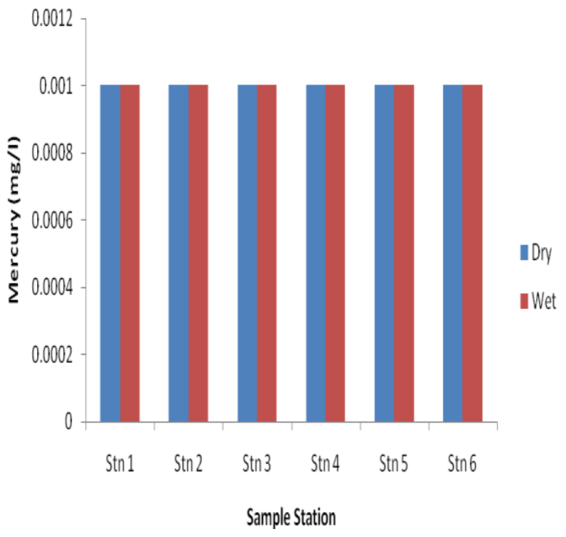

Fig 20: Concentration of Mercury for the Wet and Dry Seasons

B. Discussion of Results

Leachates are generally found to have pH between 4.5 and 9 [12]. The pH of young leachates is less than 6.5 while old landfill leachates has pH higher than 7.5 [13]. Stabilized leachates shows fairly constant pH with little variations and it may range between 7.5 and 9. The average pH values of the leachate for the wet season was 7.4, while in the dry season it was 6.0. With the pH values varying from 6 to 7.4,which is within the limit of the FMEnv of 6.0 – 9.0, it is a representative of a growing pH from young to old leachate according to [13]. [14] reported that the pH of leachates increased with time due to the decrease of the concentration of the partially ionized free volatile fatty acids. The values of pH recorded in the study suggest that the leachate is tending towards a steady state as observed by[15] and [16], reported a range of pH of 7.3 - 8.8 that is slightly higher than the rage recorded in this study but at variance with values of 3.96 – 5.01 recorded by [17].

The electrical conductivity for both the wet and dry seasons are 6119.14 µs/cm and 6206.49 µs/cm respectively, which far exceeded the FMENV standard of 125.00 µs/cm. The high value of electrical conductivity in this study is indicative of the presence of inorganic material in the samples. Conductivity is a measure of water's capability to pass electrical flow and is directly related to the concentration of ions, which come from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonate compounds. The more ions that are present, the higher the conductivity of water. Likewise, the fewer ions that are in the water, the less conductive it is. This means, the leachates from this site contains lots of inorganic material. This is indicative of a high degree of pollution.

TDS comprises mainly of inorganic and dissolved organics. The amount of TDS reflects the extent of mineralization and a higher TDS concentration can change the physical and chemical characteristics of the receiving water ([18], [19]. The average values of TDS of the study area for the wet season was 3366.01 mg/l, while that for the dry season was 3273.70 mg/l. The leachates can be said to have undergone more mineralization process because of the high values obtained and have a very high tendency to change the physical and chemical characteristics of the receiving water body. The values vary significantly from those reported by [17] who reported ranges of 581 to 1,960 mg/L. The average values for both seasons are greater than the FMENV standard of 500mg/L.

The BOD average values for the wet and dry seasons are 7.30 mg/l and 7.50 mg/l respectively while the average values of COD were 13.78 mg/l and 14.22 mg/l respectively for the wet and dry seasons. The values were in contrast to the values reported by [17] who reported ranges of 798 to 1,396 mg/L and 946 to 1,942 mg/L for BOD and COD respectively. However, [20] in their study reported much lesser ranges of 1.24 – 5.95 mg/l for BOD5 and 3.10 – 14.87 mg/l for COD. In the initial acidogenic biodegradation stage, the leachate is characterized by high BOD and COD ([21]. For stabilized leachates, COD generally ranges between 5,000 - 20,000 mg/L ([22]. The mean values of the BOD of the leachate for both seasons are lesser than FMEnv standard of 30.00 mg/l while those for COD also exceeded the FMENV of 75mg/l. The BOD and COD values indicate the presence of a high amount of putrescible organic matter in the dumpsite.

The strength of Organics in leachates are characterized by different levels of biodegradability. Generally, the organic strength describes the degree of biodegradation and gives information on the age of a dumpsite. A decline in BOD concentrations can be attributed to a combination of reduction in organic contaminants available for leaching and the increased biodegradation of organic compounds [23]. A constant decrease in COD is also expected as degradation of organic matter continues [24]. The organic strength is given by: *BOD/COD ratio;* [25], [26]. The biodegradability of the leachates will also vary with time. Checking the BOD/COD ratio can monitor changes in the biodegradability of the leachates. Ratios in the range from 0.4 to 0.6 are taken as an indication that the organic matter in the leachates is readily biodegradable.

For a young landfill, the BOD/COD ratio may be in the range of 0.4 to 0.6 or higher, whereas the ratio in old or matured dumpsites may be in the range of 0.05 to 0.2 suggesting that the organic matter in the leachates is not readily biodegradable. The mean ratio 7.30/13.78 is 0.53 for the wet season and that for the dry season which is 7.50/14.22 is also 0.53. This figure (0.53) shows that the organic matter in the leachates is readily biodegradable, and has a high organic strength which can be attributed to fact that the study site is active or open, being fed with waste on a continuous basis, which possibly contains organic matter that undergoes biodegradation continually. During the methanogenic phase, the organic strength of the leachates is reduced by methanogenic bacteria such as methanogenic archaea and the concentration of volatile fatty acids also reduces which results in a ratio of BOD/COD less than 0.1 ([25]- [28]. The calculated ratio of 0.53 suggests high organic strength for the leachate and this ratio is similar to those obtained by previous researchers ([20],[29], [30], [31]. Sulphate had an average value of 87.7 mg/l and 87.60 mg/l for the wet and dry seasons respectively, which are below the FMEnv limit of 100.00 mg/l.

From the results of the study, the average values of Iron are 249.54 mg/l and 258.88 for the wet and dry seasons respectively and are over the FMEnv limit of 0.05 mg/l, Manganese had 2.89 mg/l and 2.66 mg/l for the wet and dry seasons respectively are were also above the FMEnv limit of 0.05 mg/l, Cadmium concentrations in the leachate were 0.57 mg/l and 0.69 mg/l for the wet and dry seasons respectively and they were above the FMEnv limit of 0.01 mg/l, Chromium recorded an average of 4.36 mg/l and 6.95 mg/l for the wet and dry seasons respectively and were above the FMEnv limit of 0.20 mg/l. Nickel had an average values of 0008 mg/l and 0.006 mg/l and are below the FMEnv limit of 0.01 mg/l, Lead recorded an average of 0.33 mg/l and 0.48 mg/l for the wet and dry seasons respectively and are above the FMEnv limit of 0.05 mg/l, Copper had 1.70 mg/l and 1.42 mg/l for the wet and dry seasons respectively and were below the FMEnv limit of 50 mg/l. Zinc with average values of 3.32 mg/l and 4.86 mg/l for the wet and dry seasons respectively were not within the range of 6 - 9 mg/l limit of FMEnv. Concentration of heavy metals in a landfill is generally higher at earlier stages because of higher metal solubility as a result of low pH caused by production of organic acids [12]. As a result of increased pH at later stages, a decrease in heavy metal solubility occurs resulting in rapid decrease in concentration of heavy metals except lead because lead is known to produce very heavy complex with humic acids [27]. This support the likelihood of decrease in the concentration of heavy metals in the leachate analysed. However, the solubility and mobility of metals may increase in the presence of natural and synthetic complexing ligands such as humic substances ([21]. The presence complexing ligands in the leachate analysed will increase the concentration of heavy metals. Though there were variations; some of the heavy metals fell below FMENV while some others exceeded it.

IV. CONCLUSION

The use of thermal desorption unit as treatment method for contaminated solids has proved to be effective as shown in this study as most of the parameters tested in the leachate were well below the Federal Ministry of Environment set limits except for Electrical conductivity, Total dissolve solid, Iron, Manganese, Cadmium, Chromium and Lead that had deviation from the set limit. It can be concluded that there is a significant heavy metals concentration in the leachates that can pollute the environment.

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