*Arid Zone Journal of Engineering, Technology and Environment, February, 2017; Vol. 13 (1): 140-148*
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*Print ISSN: 1596-2490, Electronic ISSN: 2545-5818, www.azojete.com.ng*

# CHARACTERIZATION OF LEACHATE CONTAMINANTS FROM WASTE DUMPSITES IN MAIDUGURI, BORNO STATE

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**Abstract**
This study characterized and analysed the constituents of the leachates from four uncontrolled and unlined waste dumpsites in Maiduguri, North eastern Nigeria. The leachate samples were carefully collected from waste dumpsites without any conventional collection equipment and transferred to the laboratory for analysis. The ionic concentration, *p*H, electrical conductivity (EC), and total dissolved solids (TDS) were determined using a conductivity meter, potassium and sodium by photometer; chlorine and calcium by titration method, BOD was computed from dissolved oxygen as determined by Winkler's method and the UNICAM 969 Atomic Absorption Spectrophotometer was used to measure the cation and anion concentrations. The *p*H and TDS values ranged between 8.19 to 11.32, and 208 to 7460 mg/l respectively indicating a reduction in the palatability of groundwater below the waste dumpsites due to the presence of large amount of anions and cations. The analysis has so far indicated that the concentration of Fe ion was highest followed by that Pb, Zn, Cr, Mn and Cu ions respectively. This is attributed to the presence of large iron-base materials such as metallic construction materials, fluorescents lamps, electrical appliances, paint products, batteries and wood preservatives. To avert the health-related hazards as a consequence of groundwater contamination by leachates, it is imperative for the Borno State Environmental Protection Agency (BOSEPA) to urgently address waste management practices. This could be achieved by employing the environmental engineering principles of waste management as panacea to the threat posed by leachate and other groundwater contaminants in the study area.

**Keywords:** characterization, leachate, waste dumpsites, landfills, Maiduguri

## 1. Introduction

In most under developed countries such as Nigeria, uncontrolled, unscientific and poorly managed dumpsite for municipal Solid Waste (MSW) in open lands without any pre-treatment could culminate to adverse environmental hazard, that constitute aesthetic nuisance for the population (Remesh *et al*., 2009; Ramaiah *et al*., 2014; De *et al*., 2016). Waste dumpsites, from time immemorial have been identified as major threat to the quality of groundwater resources due to the gradual release of its initial interstitial water moving through the waste deposit (USEPA, 1984; Fatta *et al*., 1999; Afolabi, 2015). However, due to rainwater percolation through the waste dumps, the decomposition of such wastes results into chemical, biochemical and microbiological reactions of the organic materials within the soil mass, and gradual infiltration of its initial interstitial water moving through the waste deposit in form of leachate without any hindrance (Goswanmi and Sarma, 2007; Sunil *et al*., 2008; Afsar *et al*., 2015; De *et al*., 2016). The leachate appear as key vector of many diseases due to its intrinsic ability to mobilize and transport groundwater contaminants through the underlying soils (Elkadiri *et al*., 2005; Hester and Harrison, 2005; Iqbal *et al.,* 2015). The mechanisms involved in the generation of leachate are very complex and are of a biological and physico-chemical nature (Kulikowska *et al.*, 2008). The constituents of the leachate from the emplaced contaminated waste dumps may consist of large amounts of soluble salts, biodegraded organic products, compounds of sulphide, ammonia, nitrogen and other toxicant, thus leachate is a major source of concern to dwellers in the vicinity of any waste dumping site (Renou *et al*., 2008; Aziz *et al*., 2009; Foul *et al.*, 2009; Oni, 2010). Environmental impact due to landfills probably poses the most severe risk of polluting groundwater as a result of absence of engineering principles in the construction of the landfills (Afsar *et al*., 2015). Landfills have been accepted as the most economical and environmentally friendly way for the disposal of solid waste compared to other waste disposal methods such as composting, incineration and gasification (Zainol *et al*., 2012). This study presents an over view of characterization and analysis of the leachate composition obtained from Maiduguri, and suggest the concept of modern landfills designed to circumvent the migration of leachate and other chemicals that may pose the risk of groundwater pollution.

## 2. Materials and Methods

### 2.1Site Description

Leachate samples were collected from four out of the several dump collection centres in Maiduguri metropolis. The four centres included Ajiganaram dumpsite (AGD), Bulabulin dumpsite (BBD), Gwange dumpsite (GGD) and Monday market dumpsite (MMD). The wastes dumps are normally evacuated after a period of two to three months, for final disposal at one the six designated waste dumpsites situated along Baga, Bama, Damboa, Dikwa, Jos and Old Maiduguri roads. Most of these waste collection centres have been in use for over two decades.

The Ajiganaram dumpsite (AGD) is considered as one of the oldest waste dumpsite located at lat 11$^{o}$49’52 34’’N and long13$^{o}$09’26 27’’ which is close to the Maiduguri city centre. It’s a vast land area with no defined space for waste dumping and it has no leachate collection system.

Bulabulin dumpsite (BBD) is also an old waste dumpsite located at lat 11$^{o}$49’52 34’’N and long 13$^{o}$09’26.27’’ with neither defined space for waste dumping nor leachate collection system.

Gwange dumpsite (GGD) is indeed another old waste dumpsite which is located at lat 11$^{o}$49’52 34’’N and long13$^{o}$09’26 27’’ is close to a seasonal river with no definite space for dumping of waste.

Monday market dumpsite (MMD) is located at lat 11$^{o}$49’55 86’’N and long13$^{o}$9’14 71’’. This is closer to river Ngadda, a seasonal river that passes through so many areas of Maiduguri metropolis. The heap of waste started piling for over two decades and had no defined space for waste dumping or leachate collection system. Figures 1 to 4 show the nature of the four waste dumping collection centres covered in this study.

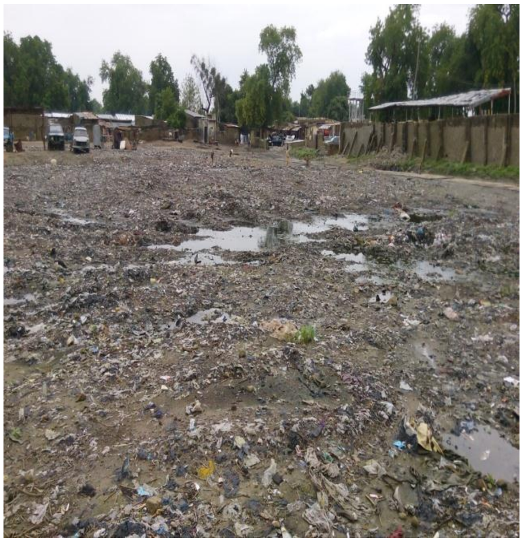

Figure 1: Ajaganaram Dump Site

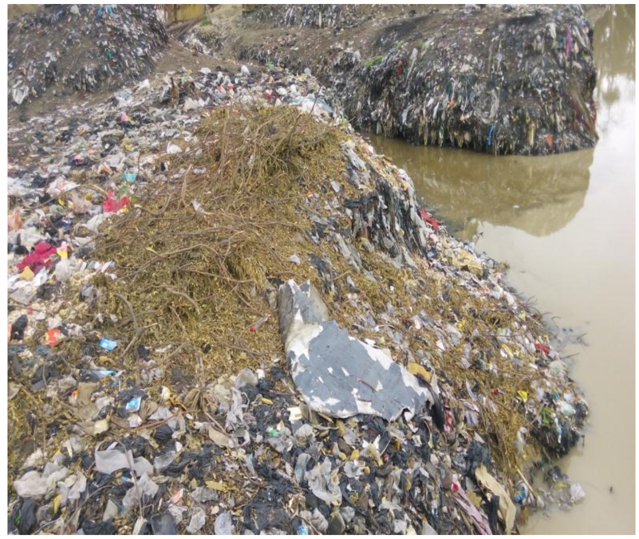

Figure 2: Bulabulin Dump Site

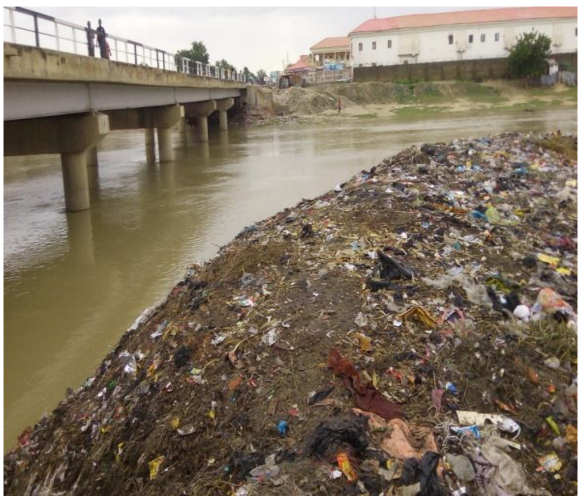

Figure 3: Gwange Dumpsite

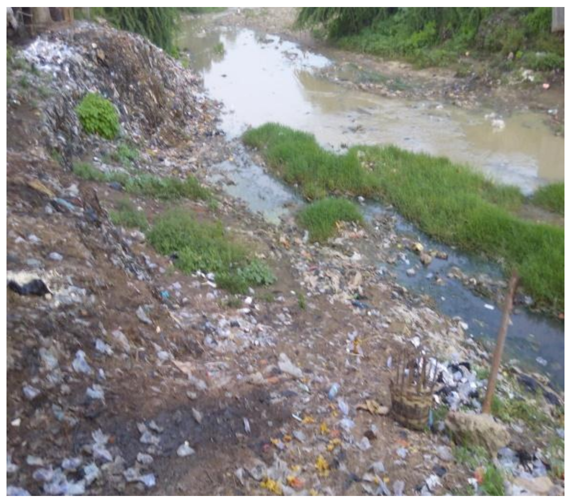

Figure 4: Monday Market Dumpsite

**2.2 Leachate collection and sampling**

Leachate samples were collected from the four designated waste collection centres, which are non-engineered, non sanitary open dump heaps that have no bottom liner or leachate collection equipment. The leachate was collected using a system of plastic pipes connected to a plastic container placed at the base of the waste dump. The leachate then flows by gravity in to the plastic container. Three samples were collected per dumpsite and then bulked to form composite sample per dumpsite. The weighted linear sum aggregate function was used to sum up the behaviour of all the leachate pollutant variables obtained..The samples are thus transported to the laboratory for analysis. The ionic concentration, electrical conductivity, and total dissolved solids were measured with the aid of conductivity meter, potassium and sodium by photometer; chlorine and calcium by titration method, BOD was computed from dissolved oxygen as determined by Winkler's method of the American Public Health Association (APHA) (1998) as suggested by Ramiah et al., (2014). Ca and $Cl^-$ were analyzed by titrimetric methods. $SO_4^{2-}$ was analyzed by using UV-VIS spectrophotometer. The UNICAM 969 Atomic Absorption Spectrophotometer was used to measure the cat ion concentration such as Cu, Fe and Pb.

## Results and Discussion

The results obtained from the physico-chemical analyses of the leachate samples from the different dumpsites are presented in Table 1.

Table 1: Physico-chemical parameters of leachate

| Parameters | Designated dumpsite Locations | | | |
|---|---|---|---|---|
| | AGD | BBD | GGD | MMD |
| pH | 11.32 | 8.19 | 8.55 | 8.54 |
| EC (µs/cm) | 1445 | 1690 | 475 | 1811 |
| TDS (mg/l) | 7460 | 936 | 208 | 898 |
| DO (mg/l) | 3.21 | 10.0 | 15.0 | 7.0 |
| BOD (mg/l) | 17.00 | 12.0 | 3.0 | 14.0 |
| Cl (mg/l) | 12.50 | 14.6 | 2.2 | 15.6 |
| $SO_4$ (mg/l) | 83.00 | 28.0 | 5.0 | 13.0 |
| Ca (mg/l) | 0.25 | 156.0 | 80.0 | 124.0 |
| Cu (mg/l) | 0.24 | 0.17 | 0.02 | 0.09 |
| Fe (mg/l) | 0.42 | 0.44 | 0.34 | 1.47 |
| Pb (mg/l) | 3.0 | 0.94 | 3.0 | 1.2 |
| Zn (mg/l) | 0.96 | 0.10 | 0.08 | 0.48 |
| Na (mg/l) | 0.46 | 358.8 | 100.3 | 331.2 |
| Mn (mg/l) | 0.01 | 0.15 | 0.58 | 0.11 |
| K (mg/l) | 0.40 | 1.1 | 1.7 | 1.2 |
| Cr (mg/l) | 0.62 | 0.10 | 0.10 | 0.12 |
| Odour | Objectionable | Objectionable | Objectionable | Objectionable |
| Appearance | Cloudy | Cloudy | Cloudy | Cloudy |

### 3.1 *p*H and TDS

The ionic concentration (*p*H) value ranged between 8.19 and 11.32. High value of *p*H for the leachate samples indicates a certain phase of decomposition of wastes is in progress that is characterized by the production of volatile fatty acids and carbon dioxide (Kjeldsen *et al*., 2002). The *p*H value below 6.5 is normally considered to be from young landfill, which is probably less than 5 years; while matured or stabilized landfill with over ten years has *p*H ranging from 7.5 and 9 as observed by (Oweis and Khera, 1998). Total Dissolved Solid (TDS) ranged between 208 and 7460mg/l, and this high level of TDS may be responsible for reduction in the palatability of underlying groundwater due to the presence of inorganic materials in the samples as observed by (Gupta and Rani, 2014). In the same vein, high level of TDS in leachate may be associated with the presence of large amount of anions and cations indicating presence of inorganic materials (Munir et al., 2014).

### 3.2 Biochemical Oxygen Demand

The BOD in the present research varies between 3.0 and 17.0 mg/l. This is far below the results suggested by Zainol et al., (2012) who suggested that the BOD in MSW leachate varied from 2000 to 30, 000 mg/l for new landfill and 100 to 200mg/l for matured landfills. High BOD is known to be an indication of high organic matter in leachate, and has greater clogging impact (Oweis and Khera, 1998).

### 3.3 Heavy metals contents

Large concentrations of heavy metals were found from the leachate samples (Table 1). The result show that iron concentration was highest, followed by lead, zinc, chromium, manganese and copper. An earlier research conducted by Aziz *et al*. (2004) confirmed that iron appears in a landfill due to the presence of iron-based waste materials, especially metal construction materials, colour compounds and electrical appliances. The high concentrations of Lead in the leachates is in concordance with the findings of Munir *et al*. (2014) that municipal solid wastes contain fluorescents lamps, paint products, refused batteries and metallic items. Also, presence of chromium may probably have originated from automobile exhaust emission, paint products and wood preservatives.

High quantities of other parameters such as $Ca^{2+}$ are important for total hardness of water, but compounds of $SO_4^{2-}$ are dangerous, and could result to diarrhoea in children and causes dehydration (Mor et al., 2006). However, the values of *p*H, EC, TDS, DO, lead, iron and Manganese were higher than the maximum limit specified by Federal Environmental Protection Agency and World Health Organization (Ojaowo *et al*., 2012; Gupta and Rani, 2014). The mean *p*H value of 9.6 was greater than the maximum limit specified by both FEPA and WHO World Health Organization. On the other hand, the values of Biochemical Oxygen Demand, Sulphate, Chloride, Calcium, Zinc, Sodium, Copper and Potassium were considerably lower than the maximum limit specified by FEPA and WHO as shown in Table 2.

This result implies that MSW are neither treated nor sorted and contain heavy metals and other water contaminants. Heavy metals are causes of many diseases and sources of groung as well as surface water contamination. The Borno state government through the Borno State Environmental Protection Agency (BOSEPA) should put more emphasis on improving the concept of solid waste management practice which should include sorting of wastes, use of standard approved engineering principles in construction of modern landfill and scientifically proven MSW treatments to cut-off the menace of ground and surface water contaminations.

Table 2: Comparison of the average concentration of Leachate with the maximum limit specified by FEPA and WHO

| Parameters | Average measured concentration | FEPA Standard (Ojoawo *et al*., 2012) | WHO Maximum limit (Gupta and Rani, 2014) |
|---|---|---|---|
| pH | 9.15 | 5.00 | 9.2 |
| EC ( µs/cm) | 1355 | 125.00 | - |
| TDS (mg/l) | 2376 | 500.00 | 1500.00 |
| DO (mg/l) | 8.80 | 5.00 | - |
| BOD (mg/l) | 11.5 | 30.00 | - |
| Cl (mg/l) | 11.23 | 100.00 | 600.00 |
| $SO_4$ (mg/l) | 32.25 | 100.00 | 400.00 |
| Ca (mg/l) | 90.06 | 50.00 | 200.00 |
| Cu (mg/l) | 0.13 | 5.00 | - |
| Fe (mg/l) | 0.67 | 0.05 | 0.3 |
| Pb (mg/l) | 2.04 | 0.05 | - |
| Zn (mg/l) | 0.41 | 6.00 – 9.00 | 5.00 |
| Na (mg/l) | 197.69 | 0.50 | 200.00 |
| Mn (mg/l) | 0.21 | 0.05 | - |
| K (mg/l) | 1.1 | 100.00 | 200.00 |

## 4. Conclusion

The following conclusions were drawn from the study:

1. The *p*H and BOD values of the collected leachates in Maiduguri ranged from 8.19 to 11.32 and 3 to 17 mg/l respectively, which connote that the MSW leachate Maiduguri could be a stabilized.
2. The TDS values ranged between 208 and 7460mg/l, indicating that they have the potential of reducing the palatability of groundwater underlying them due to the presence of large amount of inorganic materials, anions and cations discovered in the leachate samples.

The heavy metals in the leachate samples obtained from the laboratory analysis showed that the concentration of Fe was the highest followed by Pb, Zn, Cr, Mn and Cu in that order.

3. The values of pH, EC, TDS, DO, Pb, Fe and Mn were no doubt higher than the maximum limit specified by FEPA and WHO. While the values of BOD, $SO_4$, Cl, $Ca^{2+}$, Zn, Na, Cu and K were considerably lower than the standard maximum limit by FEPA and WHO.
4. The BOSEPA should put more emphasis on improving the concept of solid waste management practice to include sorting of wastes, use of modern standard engineering principles in construction of modern landfill and scientifically proven MSW treatments.

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