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Assessment of Municipal Solid Waste Leachate on Soil and Water Bodies at Ilokun Dumpsite in Ado Ekiti, Nigeria

A.O. Akinro[1], and O .A. Oni[2]
[1]*Department of Civil Engineering, Rufus Giwa Polytechnic, Owo, Ondo State*
[2]*Department of Civil Engineering, Ekiti State University, Ado Ekiti, Nigeria*
(E-mail of the corresponding author: onilayi@gmail.com)

ABSTRACT
The impact of the leachate produced at Ilokun waste dumpsite in Ado Ekiti on the immediate environment was undertaken in this study. Samples of soil and water systems in the vicinity of the dumpsite were analysed. The analysis of the leachate showed heavily polluted leached water. The surface water was found to be fairly polluted while the groundwater was relatively unpolluted, probably due to natural attenuation within the soil strata above the groundwater. Comparison of the heavy metals in the soil with Dutch target limits showed a highly polluted soil that should be remediated. Immediate stoppage of refuse dumping and installation of deep perimeter fence are recommended to minimise the consequence of the unabated refuse dumping to the environment.

Keywords*: leachate, soil, water, pollution, refuse dumpsite.*

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I. INTRODUCTION

Surface water and groundwater form the natural water bodies available to mankind. While considerable attention is often paid to surface water owing to its visual presence, less is paid to groundwater probably owing to the saying “out of sight and out of mind”. Of the global quantity of available freshwater, more than 98% is groundwater; stored in earth pores and fractures of rock strata. Groundwater is an important source for industry and agriculture uses as well as sustaining rivers experiencing low flows. Groundwater is not only used for water supply or river regulated purposes, it also naturally feeds surface waters through springs and passages into rivers. It also supports wetlands and their ecosystems. A reduction in either quality or quantity of the discharging groundwater can significantly influence surface water quality and the attainment of water quality standards. Surface water and groundwater are therefore intimately linked in the water cycle, with many common issues, the protection of which quality, therefore, are of paramount importance.

Solid waste management has been the focus of considerable environmental attention in recent times as communities worldwide have recognized the hazards that it poses [1]. Significant among the hazards is the environmental pollution. Pollution is anything that makes the environment foul, unclean, dirty; any physical, social activities of living organizations that alters the environment in undesirable ways [2]. Environmental pollution is a process by which obnoxious substances are introduced into the environment such that the quality of such environment becomes degraded. It releases matter or energy into the environment that causes undesirable impacts on the health of living beings. For decades, landfilling has been favoured as a method of waste disposal for a number of reasons, often because it is probably the cheapest available method owing to the availability of natural voids and man-made voids from mineral extraction. Landfilling of municipal solid waste (MSW) is a common practice in many countries of the world and its dependency arose from huge investment outlay for treatment and disposal alternatives [3, 4]. One of the greatest concerns on the impacts of an existing or a proposed landfill is the groundwater pollution caused by landfill leachate [5-7]. Leachate composition varies and depends on the age of the landfill and the type of wastes contained. The organic strength of landfill leachate can be 20 to 100 times greater than the strength of raw sewage, making this "landfill liquor" a potentially potent polluter of soil and water [8]. In open dumps, the leached water will drain to surface water and percolates into groundwater in the aquifer system. The chemical quality of leachate varies as a function of a number of factors, including the quantity produced, the original nature of the buried waste materials, and the various chemical and biochemical reactions that may occur as the waste materials decompose. Even small amounts of landfill leachate can pollute large amounts of groundwater, rendering it unusable for domestic and many other purposes. Municipal solid waste contains a variety of potentially significant chemical constituents and pathogenic organisms that could adversely affect public health, groundwater quality, and the environment within the area of influence of the landfill. Several authors [9-17] have acknowledged the pollution of groundwater sources by leachate from landfills and dumpsites. Those chemical constituents include regulated hazardous chemicals such as heavy metals and chlorinated solvents; conventional pollutants, chemicals that cause taste and odors such as H_2S, Fe, Mn, Cl, and ammonia. These pollutants cause severe damage o water sources and impair the use of groundwater for domestic water supply [18, 19]. It is thus imperative to determine the extent of pollution caused by unregulated refuse dumps, which are scattered especially in the developing countries in order to take necessary action. This study therefore assessed the impact of municipal solid waste leachate on soil and water bodies in the vicinity of Ilokun dumpsite in Ado Ekiti, Nigeria.

II. STUDY AREA

The study took place at an open waste dumpsite located at Ilokun in Ado-Ekiti, the capital city of Ekiti State, Nigeria. The dumpsite is operated by Ekiti State Waste Management Board (EKSWMB). The city is located at about 48 kilometres north of Akure, about 344 kilometres north of Lagos (Nigeria) and about 750 kilometres south west of Abuja, the Federal Capital Territory (FCT). It serves as a Local Government Headquarter in one of the sixteen Local Government Areas in Ekiti State. The city has a tropical humid climate with two distinct seasons; a relatively dry season from November to March and a rainy season from April to October. The average annual rainfall ranges between 1405 mm and 2400 mm of which the rainy season accounts for 90% while the month of April marks the beginning of rainfall. The city falls mainly in the deciduous forest. The temperature fluctuates throughout the year. Relative humidity is high during the rainy season and falls in the dry season. Ado-Ekiti is underlain by Precambrian basement complex rocks which yields low lying residual hills and rocks. Generally, the terrain is undulating and the characteristics nature of the rocks give rise to fertile clayed and loamy soils. The soils are marked by differentiation of horizon and abundance of area falls within the rain forest belt of Nigeria. However, the natural forest has been cleared and converted to various land useful such as farming, residential, recreational and commercial. The projected population of the city for 2020 is put at 484,152 using 2006 census [20] at a growth rate of 3.14%. This development will no doubt have some consequences on the way waste is managed in the city.

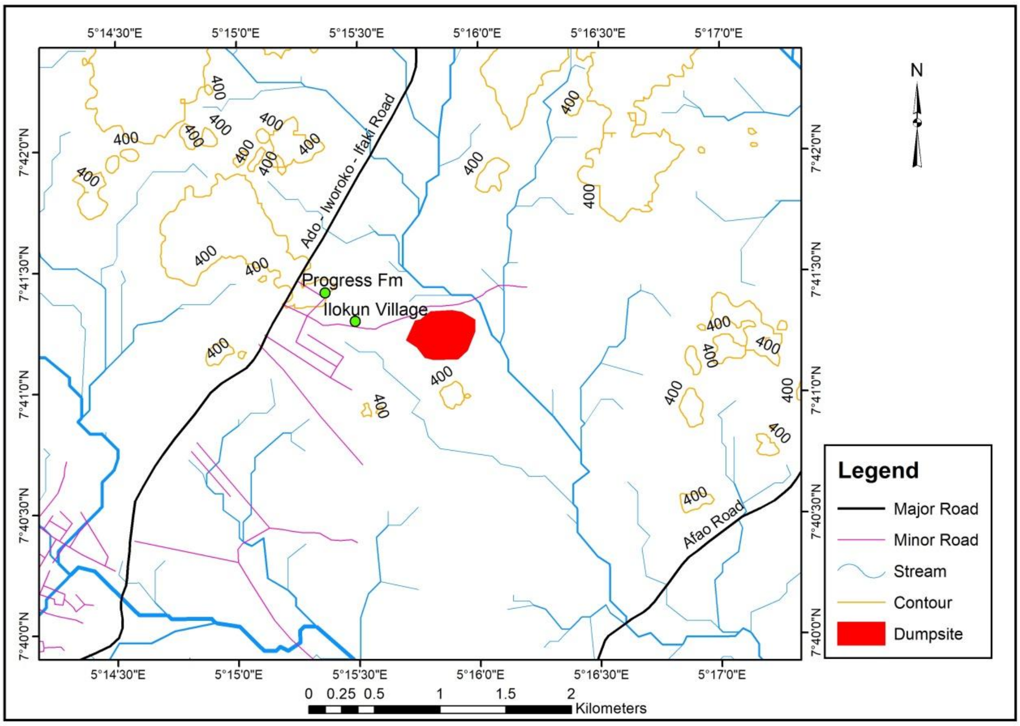

Figure 1: Map of Ilokun Dumpsite, Ado Ekiti.

III. MATERIALS AND METHODS

Water analyses: Three existing 6" diameter boreholes and five hand-dug wells with the average depth of 40 metres in the basement formation located within the distance of 50, 80, and 100 m radially away from the centre of the dumpsite were used as the sampling points for groundwater quality testing. The wells were carefully selected to avoid public wells where contamination of sampled water caused by the containers used to draw water may occur. For each groundwater sample, 15l of water was collected in 600 ml sterilised polyethylene bottles, stored at the temperature of 4°C and analysed. The analyses covered physical, chemical, and bacteriological parameters of the water samples from each borehole and the wells. Water samples were also obtained from the adjacent Ilokun River. The qualitative analyses were carried out at the water laboratories of the Civil Engineering Departments of Afe Babalola University and the Federal Polytechnic, both in Ado Ekiti, The physical parameters tested included: odour, taste, colour, turbidity and temperature. Chemical parameters analysed were pH, dissolved oxygen (DO), total dissolved solids (TDS), total hardness (TH), total iron, nitrate, nitrite, chloride, calcium and heavy metals such as copper, zinc, and lead. The pH was determined using a Meter Toledo pH meter by direct measurement, analog mercury thermometer was used for temperature measurements, and a Hach 2100A turbidimeter was used for turbidity determination. The samples were also analysed in the water laboratories for total dissolved solids, total hardness, iron, nitrate (NO_3), nitrite (NO_2), calcium, and chloride using standard methods for the examination of water [21]. The concentrations of heavy metals such as copper, zinc, and lead in the water samples were determined with flame atomic absorption spectrophotometer. All the results were compared with the World Health Organization [22] and the Nigerian Standard for Drinking Water Quality [23] values.

Soil sampling and analysis: The soil samples were collected from the dumpsite. The soil samples were taken at depths 0.4 m, 0.8 m, and 1.2 cm, respectively per sampling point. They were collected at five different locations that were at a distance of 10 m from each another. Samples were air dried, sieved using a 2 mm mesh, and stored in sampling bags for analysis. The constituents of heavy metals such as Cd, Zn, Cu, Cr, Pb, Ni, and As were determined in the laboratory using standard procedures by [24]. Average value per sampling point was determined.

Leachate sampling: Leachate samples were collected from randomly selected drains at the landfill site in accordance with American Public Health Association (APHA) Standard 1060A3 (APHA, 2005). Leachate samples were collected in clean polyethylene terephthalate (PET) sample bottles, rinsed three times with raw leachate before sample collection. Approximately, 55 litres of composite leachate was collected and analysed before and after treatment to determine percentage reduction in physical and chemical characteristics. To avoid chemical and biological changes which may have the potential to change the natural homogeneity of the samples, sample for heavy metals analysis was preserved by adding 1ml of concentrated HNO_3 while 2 ml concentrated H_2SO_4 was added to samples for COD analysis. The samples were immediately transferred to ice chest and transported to the laboratory for analysis. All the parameters were measured according to the standard method for the examination of water and wastewater by APHA (2005).

IV. RESULTS

The physicochemical analysis of leachate samples obtained from the site is shown in Table 1. Comparison of the values of physicochemical parameters of the leachate at the dumpsite with that of WHO (2011) and NSDWQ (2007) shows that the leached water from emplaced waste at the dumpsite is highly polluted. More importantly, the high concentration of the heavy metals in the leachate is of great concern as high content of lead would result in death of human and aquatic lives. In order to prevent grave consequences of the unabated refuse placement at the site, urgent stoppage of refuse dumping and immediate containment of the site is required. In the same vein, comparison of the values of physicochemical parameters of the surface water in the vicinity of the refuse dumpsite to that of WHO (2011) and NSDWQ (2007) shows that the river is contaminated (Figure 2). This is quite understandable as the leachate formed within the refuse dump will be transported through the runoff of precipitation as the dumpsite slopes downwards to the river. However, the impact of the leachate runoff into the river will be reduced owing to dilute and dispersion that will take in the river. The extent of this phenomenon will depend on the volume of water in the river at the time of transport of the leached contaminant into it. Contrarily, values of physicochemical parameters of the groundwater in the environment of the refuse dumpsite (Figure 3) appear to be within limits specified by WHO (2011) and NSDWQ (2007). This is best explained through the process of natural attenuation that would have taken place before percolating water reaches the groundwater. The soil (earth) would have served as a filter, as the percolating water would have been strained through the torturous path in the pore structure of the soil. The majority of the pollutants would have been adsorbed to the soil grains or got clogged in the pores. The organic content would have been digested by the microorganisms in the percolating water in the soil. The results of the physicochemical tests of the well samples indicate that there is no fault in the overlying soil on the groundwater at the site. Otherwise, the percolating leachate would have been transported though the fault to the groundwater.

Table 1: Physicochemical Analyses of Leachate Samples

S/No	Parameters	Unit	LEACHATE SAMPLES A	B	C	NSDWQ (2007)	WHO (2011)
1	Appearance	U	Dark Yellowish	Deep Brownish	Light Yellowish	Clear	Clear
2	Colour	H.U	35.00	> 70.00	25.00	5 -15	5-15
3	E. Conductivity	υS/cm	19,300	1000	6,300	1,000	1000
4	Turbidity	NTU	49.00	605	41.00	5.00 –15.00	5-15
5	TDS	Mg/l	717.00	903.00	581.00	500	500
6	TSS	Mg/l	33.00	347.00	41.00		
7	Total Solid	Mg/l	750.00	1250.00	622.00		
8	pH Value	-	7.10	8.8	6.2	6.5- 8.5	
9	Total Alkalinity	Mg/l	341.60	265.00	146.40	250	250
10	Chloride Cl^{-2}	Mg/l	737.36	1,460	460.10	150.00	100
11	Magnesium Hardness Mg^{2+}	Mg/l	158.00	321.00	165.00	50.00	50
12	Calcium Hardness(Ca^{2+})	Mg/l	160.00	86.00	140.00	50.00	50
13	T. Hardness	Mg/l	318.00	407.00	305.00		
14	Cadium	Mg/l	0.06	0.12	0.02	0.003	
15	Lead	Mg/l	0.68	0.45	0.34	0.01	
16	Nickel	Mg/l	0.44	0.81	1.10	0.02	
17	Zinc	Mg/l	9.90	1.04	1.87	3.0	
18	Copper	Mg/l	3.20	2.80	1.89	1.0	
19	Manganese	Mg/l	0.01	0.08	0.22	0.2	
20	Iron	Mg/l	11.62	9.89	13.40	0.3	
21	Potassium	Mg/l	0.06	N.D	0.08		

Table 2: Physicochemical Analysis of River Sample

S/No	Parameters	Unit	A	NSDWQ (2007)	WHO (2011))
1	Appearance	U	Faint Yellowish	Clear	Clear
2	Colour	H.U	15.00	5 -15	5-15
3	E. Conductivity	υS/cm	2,400	1,000	1000
4	Turbidity	NTU	23.00	5.00 –15.00	5-15
5	TDS	Mg/l	313.00	500	500
6	TSS	Mg/l	29.00		
7	Total Solid	Mg/l	342.00		
8	pH Value	-	6.3	6.5- 8.5	
9	Total Alkalinity	Mg/l	61.00	250	250
10	Chloride Cl^{-2}	Mg/l	368.68	150.00	100
11	Magnesium Hardness Mg^{2+}	Mg/l	130.00	50.00	50
12	Calcium Hardness(Ca^{2+})	Mg/l	80.00	50.00	50
13	T. Hardness	Mg/l	210.00		

Table 3: Physicochemical Analyses of Well Water Samples

S/No	Parameters	Unit	Water Samples A	B	C	NSDWQ (2007)	WHO (2011)
1	Appearance	U	Clear	Clear	Clear	Clear	Clear
2	Colour	H.U	3.00	2.10	1.8	5 -15	5-15
3	E. Conductivity	υS/cm	7,200	436	240	1,000	1000
4	Turbidity	NTU	2.00	1.3	2.7	5.00 –15.00	5-15
5	TDS	Mg/l	61.00	434	145	500	500
6	TSS	Mg/l	4.00	25	17		
7	Total Solid	Mg/l	65.00	459	162		
8	pH Value	-	6.0	6.9	6.6	6.5- 8.5	
9	Total Alkalinity	Mg/l	61.00	120	158	250	250
10	Chloride Cl^{-2}	Mg/l	88.80	34	72.7	150.00	100
11	Magnesium Hardness Mg^{2+}	Mg/l	35.00	37.4	29.5	50.00	50
12	Calcium Hardness(Ca^{2+})	Mg/l	15.00	22	40	50.00	50
13	T. Hardness	Mg/l	50.00	59.4	69.5		

The values of the heavy metals in the soil at the dumpsite are shown in Table 4. The values of target and intervention values as proposed by the Dutch government [25] are shown in parallel to the test values for comparison. Currently, there is no universally-accepted guideline on soils; however, the Dutch Standard is commonly used. It could be observed in Table 4 that the concentration of the heavy metals in the soil is far above the target values required by the Dutch Standard. More importantly, the values are greater than the values in which urgent intervention is required, as in soil contamination cases. The content of the heavy metals in the soil is caused by the high concentration of such in the leachate. As the leachate infiltrates and percolates in the soil, the heavy metals are retain in the soil mass, especially in the uppermost part of the soil layer, as explained above. In general, it is therefore apparent that urgent intervention is required for soil remediation of the dumpsite.

Table 4: Heavy Metals in the Soil at the Dumpsite

Parameters	SA (mg/kg)	SB (mg/kg)	SC (mg/kg)	SD (mg/kg)	SE (mg/kg)	Dutch Pollutant Values	
						Target (mg/kg)	Intervention Value (mg/kg)
Cd	37102	38622	45442	ND	41909	0.8	12
Zn	479	1254	171	702	274	140	720
Cu	640	1045	231	941	481	36	190
Cr	384	312	381	ND	1264	100	380
Pb	401	325	711	1211	823	85	530
Ni	609	2514	2429	1198	450	35	210
As	615	1098	ND	1131	75	29	55

SA Soil Sample A
SB Soil Sample B
SC Soil Sample C
SD Soil Sample D
SE Soil Sample E

V. CONCLUSION

The unabated dumping of refuse at Ilokun dumpsite by EKSWMB has resulted in the formation of highly concentrated leachate, which has been transported into the immediate environment. This has resulted in the pollution of the immediate soil and the river close to the dumpsite. The soil at the dumpsite is the most polluted as it requires urgent intervention owing to the high content of heavy metals, which are dangerous to animal and plant lives in the vicinity of the dumpsite. Immediate stoppage of refuse dumping and installation of deep perimeter fence is recommended to minimise the consequence of the unabated refuse dumping.

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