International Journal of Science, Environment and Technology, Vol. 3, No 3, 2014, 1004 – 1015

ISSN 2278-3687 (O)

IMPACT ASSESSMENT OF DUMPSITES ON QUALITY OF NEAR-BY SOIL AND UNDERGROUND WATER: A CASE STUDY OF AN ABANDONED AND A FUNCTIONAL DUMPSITE IN LAGOS, NIGERIA

***Temilola Oluseyi, Oluwatoyin Adetunde and Emmanuel Amadi**
Analytical/Environmental Chemistry Research Group, Department of Chemistry,
University of Lagos, Nigeria
E-mail: toluseyi@unilag.edu.ng (**Corresponding Author*)

Abstract: Comparative assessment of the impact of a functional and an abandoned waste dump site on the quality of neighbouring groundwater was carried out at in Lagos Nigeria. The levels of some physico - chemical, microbial and heavy metals of two soil samples obtained from the dumpsites and nine hand-dug wells at different proximities to the dumpsites were accessed. pH, Conductivity, Total solids, Total dissolved solids, Dissolved oxygen, Biochemical oxygen demand, Chloride, Acidity, Alkalinity, Hardness, Phosphate, Nitrate, Sulphate, copper, cadmium, chromium, iron, lead and zinc, Total heterotrophic bacteria, Total heterotrophic fungi and Total coliform, were determined in the water samples while pH, Total organic carbon and some potentially toxic metals were determined in the soil samples.

Mean concentration of the physico-chemical parameters except sulphate and phosphate were found to be greater at wells near the functional dumpsite at Olusosun. However all the parameters determined were within World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) permissible limits. Metals in the water sample were within WHO and NSDWQ permissible limit except for Lead in both dumpsites with mean concentration of 0.069 ± 0.075mg/l for wells near Oke-Afa dumpsite and 0.17 ± 0.086mg/l for wells near Olusosun dumpsite. The soil samples in both dumpsites show a considerable level of pollution as all the metal determined exceeded the specified WHO limit. The comparative analysis of the abandoned dumpsite with the active dumpsite reveals no significant difference in the concentration of soil and water parameters measured.

Keywords: Dumpsites, Groundwater, Pollution, Soil, Water quality.

1. Introduction

The sustenance of life depend greatly on water therefore the demand for potable water increases continually in line with world population growth. Recently, many African cities have undergone unprecedented growth in population through migration from rural areas which has led to the growth of cities into sprawling “mega-cities” with large areas of unplanned sub-standard housing with few services. The unplanned expansion of such cities leads to a serious pollution threat to the groundwater supplies as lack of organized domestic

*Received Apr 25, 2014 * Published June 2, 2014 * www.ijset.net*

waste disposal and uncontrolled industrial and commercial activity add to the pollution threat (UNEP, 2002). This has been a major problem in developing countries as provision of drinking water has become expensive and difficult. Many communities in Nigeria depend on ground water supply for domestic purposes. The main source of potable water in many of these cities is groundwater, commonly from shallow hand-dug wells and deeper water supply boreholes. In Nigeria, like many other developing countries, open dumping has been the only management option of solid waste disposal. In previous years management system has been based on collection and dumping out of the city boundaries in conformity with the concept of “out of sight out of mind” (Arukwe et al, 2012). But in recent times in a mega-city like Lagos, the siting and development of residential quarters near waste sites are common due to shortage of building land to cope with the increasing rate of migration and consequent population explosion (Ikem et al., 2002).

Dumpsites have been identified as one of the major threats to groundwater resources receiving a mixture of municipal, commercial and mixed industrial wastes. The depressions into which solid wastes are often dumped include valleys and excavations. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designed waste disposal facilities (Amadi et al., 2012). Uncontrolled dumpsite and waste dumpsites threaten the ground-water supply as movement of leachates from dumpsites through the soil and the aquifers pose a risk to the environment and human health. Waste placed in dumpsites or open dumps are subjected to either groundwater underflow or infiltration from precipitation (Mor et al., 2006). The presence and potential exposures of the community to groundwater contaminants may contribute to the predilection of human health impacts, from simple poisoning to cancer, heart diseases and teratogenic abnormalities (Su, 2008).

Release of pollutants through leachates from both functional and abandoned dumpsites pose a high risk to nearby soil and groundwater if not adequately managed (Ikem et al., 2002). Leachates percolating into the groundwater is a mixture of highly complex contaminants such as potentially toxic metals e.g. lead, mercury, cadmium, chromium etc ; persistent organic pollutants (POPs) e.g. dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers PBDEs etc; inorganic compounds, such as ammonium, sulphates, chlorides as well as bacterial contamination – total coliform and feacal coliform (Mor et al., 2006; Longe and Balogun, 2010; Oyeku and Eludoyin, 2010; Agrawa et al., 2011 and Galarpe and Parilla, 2012) Considering these concerns, possible impact to surrounding environment brought by dumpsites is inevitable.

Despite the enormous resources and efforts that have been committed to waste management, refuse collection and disposal remains a major problem in Lagos state. Lagos is the most populous city in Nigeria even though it has a small land mass; hence enormous pressure is put on the environment due to huge amounts of solid waste generated in the state. The residents make a heavy demand on resources and, at the same time, generate large quantities of solid waste. Approximately 4 million tonnes of municipal solid waste (MSW) and 0.5 million tonnes of untreated industrial wastes is generated annually in the city (Kofoworola, 2007 and Ugwuh, 2009). Environmental problems in Lagos are compounded by its high water table, swampy nature and intensive rainfall (Lawson, 2011). Generally, wastes are not treated; they are transferred to the several dumpsite sites in the State where they are openly burnt. The overwhelming environmental significance and impact of leachates on soil and nearby groundwater and surface water has become a great concern because of its serious threat to the quality of life of human beings that depend hugely on water to sustain their livelihood.

Like most developing countries of the world, waste land filling continues to be the main and most common method of disposal of municipal solid wastes (MSW) in Lagos. For the purpose of this research, soil samples and groundwater from two land fill sites (an abandoned land fill and a functional land fill) are accessed for the level of soil pollution and groundwater contamination through leachates percolation from the dumpsites. The aim of this project is to compare the effect of a functional and non-functional dumpsite on soil and groundwater properties in order to establish the level of environmental pollution emanating from the dumpsites.

2. Materials and Method

2.1 Study area

The functional dumpsite at Olusosun is located between 6°23'N 2°42'E and 6°41'N 3°42'E. It is the largest of all the dumpsites in Lagos area and has received more than 50% of the total refuse in Lagos area since 1989. The size is about 42.7 hectares and has a residual life span of 20yrs. The depth of hand dug well in the region varies from 3.81m to 30.37m above the mean sea level. Most of the hand dug well were neither lined nor had properly constructed base or covers. Some were simply covered with planks and rusted metal sheets. The geology of the area is generally characterized by coastal plain sands which form the low lying gentle sloping upland and coastal deposits forming extensive red earths, and loose poorly sorted sands that are mixed with an abundance of clays. The dumpsite is surrounded by residential houses, industries, a gasoline station, a motor park and an automobile repair workshop.

Oke-Afa dumpsite is an abandoned land fill and is located in Isolo LGA of the state. The dumpsite is located between 6^{o}31'N3^{o}18'E and 6^{o}31'N3^{o}19'E. It was one of the few dumpsite used in the 1980s and early 1990s before it was abandoned. Sited almost opposite the dumpsite is the Isolo General Hospital, also a few meters away is the Oke-Afa Isolo Housing Estate. Beside and around the dumpsite are residential houses, as well as the Oke-Afa canal, that flows into the Lagos lagoon.

2.2 Sample collection

Top soil (0-15cm) samples were collected from four different points in a quadrant from each of the dumpsites.. Samples were scooped with plastic spoon and transferred into polythene bags, after which they were transported to the laboratory for analysis. The four samples were mixed together to form a composite sample. Soil samples were spread in petri dishes and dried in oven at 105^{o}C for 4 hours. The dried soil was grinded and passed through an aluminum sieve with 2mm mesh. Soil samples < 2mm were later stored in polythene bags prior to analysis.

Water samples were collected from 6 hand dug wells, 3 samples from each dumpsite at different proximities (between 150 and 840 meters) to the dumpsites. The wells sampled were functional, active, located away from toilets, have not undergone any chemical treatment and were continuously used for drinking and domestic purposes. Samples were obtained using same material normally used by the householders to draw water from each well. Water samples were collected in 1L plastic bottles and stored in the refrigerator prior to analysis using the standard procedure (APHA, 2005).

2.3 Analysis of soil samples

Digestion of soil samples was done using aqua regia and heavy metal contents of each digest were determined by an Atomic Absorption Spectrometer (Perkin-Elmer Aanalyst 200). Soil pH was determined in $CaCl_2$ solutions using a Mettler Toledo Seven Easy pH Meter. Total Organic Carbon was determined by the Walkley-Black Titrimetric Method.

2.4 Analysis of water samples

The physical, chemical and bacteriological parameters were determined in each water sample. The pH of the samples was determined electrometrically using a Mettler Toledo

Seven Easy pH Meter. Electrical Conductivity (EC) was determined using a conductivity meter. Total solids (TS), Total dissolved solids (TDS) and Total suspended solids (TSS) solids were determined gravimetrically. The acidity, alkalinity, dissolved oxygen (DO), biological oxygen demand (BOD) were determined by titrimetric method. Nitrates, phosphates and sulphates were determined by UV spectrophotometry (APHA, 2005). Potentially toxic metal concentration was determined by acid digestion using nitric acid and further analysed with Perkin Elmer A Analyst 200 Flame Atomic Absorption Spectrometer.

Total Coliform (TC) was determined using Membrane filter method. Total heterotrophic bacteria (THB) and total Heterotrophic fungi (THF) in each sample were determined by plating out 0.1ml of 10^{-1} and 10^{-2} dilutions series of water sample on nutrient agar plate for total heterotrophic bacteria and on potato dextrose agar plate for total heterotrophic fungi respectively. For bacteria analysis, two replicates were made and incubated aerobically at $37^{\circ}C \pm 2^{\circ}C$ for 24 - 48hrs, for fungi analysis, two replicates were also incubated aerobically at $22^{\circ}C$ - $28^{\circ}C$ for 5 - 7 days. At the end of incubation, the colonies that developed were screened, counted and identified based in their morphological and biochemical properties (APHA, 2005).

3. Result and Discussion

Study of pollution of soil and ground water at a functional dumpsite and an abandoned dumpsite were carried out to at different proximate distances from both sites.

Soil analysis

The result of the analysis of the surrounding soil is shown in Table 1. The functional dump site (Olusosun) was found to have a higher total organic carbon of 12.2% compared to the abandoned dumpsite (Oke Afa) which had a total organic content of 11.8%. This clearly shows more decomposition of organic constituents in the abandoned dumpsite than in the current dumpsite. The levels of chromium, copper, iron and lead were higher in Olusosun dumpsite compared to the Oke Afa dumpsite, which is an indication of gross pollution of the soil in the neighbourhood of the two dumpsites. Using the person correlation, there was no significant difference in the analysis of the soil samples from the two dumpsites.

Table 1: Result of soil analysis from the two dumpsites

	pH	% Total Organic Carbon	Copper, mg/g,	Cadmium, mg/g	Chromium, mg/g	Iron, mg/g	Lead, mg/g	Zinc, mg/g
Oke Afa	8.0	11.8	307.3	13.9	12.1	542.2	ND	113.7
Olusosun	7.9	12.2	404.8	13.2	16.2	565.2	0.9	110.3

Ground water analysis

Summary of results of the studied parameters in the ground water at different distances from the two dumpsites is shown in Table 2. All the water samples were found to be slightly acidic with the pH values for the water samples at Oke Afa ranging from 6.2 to 6.5 while that of Olusosun ranged from 5.1 to 7.0. In the two sites the farther the well was from the dumpsite the higher the pH which is an indication of the extent of pollution from the dumpsites. For electrical conductively (EC), the highest value was obtained at the closest site with the value of 1094 $\mu S\ cm^{-1}$ and the lowest value of 201 $\mu S\ cm^{-1}$ was obtained at the farthest site to the Olusosun dumpsite. Similar trend was observed at the wells close to Oke Afa dumpsite with an exception of the well at 350m from the dumpsite with a high value of 1147 $\mu S\ cm^{-1}$ as against 404 $\mu S\ cm^{-1}$ and 182$\mu S\ cm^{-1}$ values of the 150m and 575m wells respectively. However the pH and electrical conductivity values were found to be within the range of their respective World Health Organization (WHO) and Nigeria Standard for Drinking water quality (NSDWQ) standard values with the exception of two water samples which were above the guidelines for potable water. Previous research on the groundwater in Lagos had shown similar trend in the acidic nature of Lagos groundwater (Longe and Enekwechi, 2007; Longe and Balogun, 2010 and Oyeku and Eludoyin, 2010). The acidic nature of Lagos groundwater is characteristic of the coastal groundwater whose pH is as a result of its hydro geological setting (Longe et al., 1987).

Table 2: Physico chemical parameters in groundwater located close to the two dumpsites

	Distance from dumpsite (m)	GPS Location	pH	EC µs/cm	T S mg/l	TDS mg/l	DO mg/l	BOD mg/l	Acidity mg/l	Alkalinity mg/l	Hardness mg/l	PO_4^{3-} mg/l	NO^{3-} mg/l	SO_4^{2-} mg/l	Cl^-, mg/l
Oke Afa	150	N06^{0}31'52.6" E03^{0}18'58.6"	6.2	404	310	284	3.22	89.1	7.28	35.6	93.6	0.22	0.05	0.02	38.4
	350	N06^{0}31'48.3" E03^{0}19'09.9"	6.2	1147	840	736	5.45	45.2	9.1	44.4	126	0.12	ND	0.08	128.2
	575	N06^{0}32'12.7" E03^{0}18'51.6"	6.5	182	210	124	6.67	75.4	2.73	18.8	37.8	0.16	0.07	0.02	19.7
Olusosun	150	N06^{0}35'28.4" E03^{0}22'27.5"	5.1	1094	660	567	4.85	74.8	4.55	133.5	165.6	1.88	1.07	0.09	270.9
	350	N06^{0}35'19.7" E03^{0}22'26.4"	6.8	533	430	373	5.04	57.3	17.29	0	45	0.24	0.11	0.02	24.6
	575	N06^{0}35'15.0" E03^{0}2220.6"	7.0	201	220	139	8.47	40.5	1.82	26.7	41.4	0.18	0.04	0.03	72.9
Standard		WHO	6.5-8.5	1000	1000	1000	NS	NS	NS	NS	NS	NS	50	400	250
		NSDWQ	6.5 – 8.5	1000	NS	500	7.5	NS	NS	NS	150	5	50	500	250

Key: GPS = Global Positioning system, WHO=World Health Organization, EC=Electrical conductivity, NS= Not specified NSDWQ= Nigeria Standard for Drinking water quality, TDS = Total dissolved solids, DO = Dissolved oxygen, BOD =biological oxygen demand

In Olusosun dumpsite, the concentrations of Total solids (TS) and Total Dissolved Solids (TDS) decreases as the ground water is farther from the dumpsites. This trend was not observed at the Oke Afa dumpsite with the well at 350meters from the dumpsite veering off the trend and having the highest levels of TDS and TS. It was found to be higher than all the other two wells at 150m and 575m from the dumpsite. This could be as a result of pollution from another source apart from the dumpsite. This sample also had the highest values for electrical conductivity which was higher than the WHO level for potable water.

The Dissolved Oxygen (DO) which is one of the most important parameter in determining water quality was found to increase as the distance of the well from the dumpsite increased. This trend the trend clearly shows a decrease in pollution as distance from the dumpsite increased. The values for the well water DO ranged from 3.22mgL^{-1} to 8.4mgL^{-1}. All the water samples expect one at Olusosun dumpsite had acceptable DO value for potable water. Concentrations of phosphates, nitrates, sulphates and chlorides in all the groundwater samples were low and found within the specified WHO and NSDQW standards for drinking water quality, though higher level were observed at the functional dumpsite at Olusosun.

Potentially toxic metals in the water samples were analysed and the result shown in Table 3. There was no clear trend in the way the values varied from well to well. However it was observed that Zn, Cr, Cu, and Cd were lower that the regulatory limit. Only iron and zinc were found to exceed the regulatory limit for some wells. These might be due to other environmental factors like soil type or activities occurring close to the wells.

Table 3: Potentially toxic metals in Groundwater at the dumpsites

Name of Dumpsite	Distance from dumpsite (m)	GPS Location	Copper, mg/l	Cadmium, mg/l	Chromiu mmg/l	Iron, mg/l	Lead, mg/l	Zinc, mg/l
Oke Afa	150	N06^{0}31'52.6" E03^{0}18'58.6"	0.019	0.002	ND	0.007	0.008	0.023
	350	N06^{0}31'48.3" E03^{0}19'09.9"	0.002	0.007	ND	0.449	0.033	0.036
	575	N06^{0}32'12.7" E03^{0}18'51.6"	0.013	0.001	ND	0.448	0.056	0.012
Olusosun	150	N06^{0}35'28.4" E03^{0}22'27.5"	0.009	0.016	ND	0.269	0.093	0.015

	350	N06^{0}35'19.7" E03^{0}22'26.4"	0.023	0.005	0.005	0.282	0.295	0.988
	575	N06^{0}35'15.0" E03^{0}2220.6"	0.017	0.001	ND	0.324	0.166	0.018
Standard		WHO	0.5	0.005		0.3	0.01	3
		NSDWQ	1	0.003	0.05	0.3	0.01	3

Total Coliform (TC), Total heterotrophic bacteria (THB) and total Heterotrophic fungi (THF) in each sample were determined and the values are shown in Table 4**.** These coliforms, bacteria and fungi are known to be pathogenic and opportunistic and their presence indicates poor quality of water. The wells closet to the dumpsite had the highest TC, THB and THF values. These values all exceeded the WHO and NSDWQ values. These values show the effect of the dumpsite on the well. The THB and THF values from well close to Olusosun dumpsite (the currently functional dumpsite) had higher values compare to the abandoned dump site of Oke Afa. TC count in well closest to Olusosun dumpsite had values higher than that closest of Oke Afa but the other wells at 350m and 575m to Olusosun dumpsite had 0Cfu/ml compared the 10fu/ml and $1.20x10^2$ Cfu/ml of 350m and 575m well of Oke Afa respectively . These values of TC, THC and TBC for all the wells studied were all higher than the values of the control which was not within the WHO and NSDWQ limit. High incidence of faecal coliforms in these areas was indicative of increasing pollution of the groundwater by organic contaminants at the dumpsites.

Table 4: Microbial count in groundwater located close to waste dumpsite at Oke Afa and Olusosun

	Distance from dumpsite (m)	GPS Location	THB, Cfu/ml	THF, Cfu/ml	TC, Cfu/ml
Oke Afa	150	N06^{0}31'52.6" E03^{0}18'58.6"	$1.21x10^5$	$14.0x10^3$	$1.10x10^2$
	350	N06^{0}31'48.3" E03^{0}19'09.9"	$1.10x10^5$	$10.0x10^3$	10
	575	N06^{0}32'12.7" E03^{0}18'51.6"	$1.10x10^5$	$11.0x10^3$	$1.20x10^2$
Olusosun	150	N06^{0}35'28.4"	$3.14x10^5$	$15.0x10^3$	$1.30x10^2$

		E03^{0}22'27.5"			
	350	N06^{0}35'19.7" E03^{0}22'26.4"	$2.30x10^5$	$7.0x10^3$	0
	575	N06^{0}35'15.0" E03^{0}2220.6"	$1.5x10^5$	$13.0x10^3$	0
Standard		WHO	$1.1\ x10^2$		0
		NSDWQ			10

Microbial isolates identified in the well water samples are as shown Table 5. More isolates were identified in the wells close to the functional dumpsite, at Olusosun as against the abandoned dump site at Oke Afa.

Table 5: Microbial Isolates in Groundwater Located Close to Waste Dumpsite at Oke Afa and Olusosun

	Distance from dumpsite (m)	*Bacillus spp*	*E coli spp*	*Aspergillus niger spp*	*Aspergillus flavus spp*	*Trichoclerma spp*	*Lactobacillus spp*	*Aspergillus wentii spp*	*Penicillium spp*	*Fusarium spp*	*Staphylococcus spp*
Oke- Afa	150	+	+	+	+	+	-	-	-	-	-
	350	+	-	+	-	-	+	-	-	-	-
	575	+	+	-	+	-	+	+	-	-	-
Olusosun	150	+	+	+	+	-	+	-	+	-	-
	350	+	-	+	-	-	+	-	+	+	-
	575	+	-	+	+	-	-	-	-	+	+

Key: **+** = Present - = Absent spp = Species

4. Conclusion

Analysis has been carried out on groundwater and soil samples at various distances to both a functional and abandoned dumpsite. The values show that the wells studied had values of many parameters within limit of WHO and NSDWQ. However the values for microbial parameters exceeded the regulatory limit or were just on the mark. Hence measures should be put in place to provide alternative water supplies as the water supply are not fit for domestic use. The wells close to the current dumpsite had higher microbial counts compared to the well close to the abandoned dumpsite.

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