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ASSESSING POTENTIAL CONTAMINANTS IN GROUNDWATER IN A TYPICAL OPEN REFUSE DUMPSITE IN ENEKA, OBIO/AKPOR, RIVERS STATE, NIGERIA

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ABSTRACT

This study assesses the potential contaminants in a refuse dump. Standard sampling and analytical methods were followed. The results revealed that the groundwater is generally acidic with pH values varying between 4.01 to 6.01 in the boreholes around the dumpsite and basic in the boreholes away from the dumpsite. The mean pH value of 4.6 recorded in the dumpsite area is below the stipulated World Health Organization (WHO) pH tolerance range of 7 to 8.5 for potable water. The total dissolved solids (TDS) values obtained in groundwater varied from 601.5mg/l to 622.5mg/l and a significant attenuation of TDS concentrations in all wells could be observed down gradient of the waste dumpsite. The measured values of sulphate and nitrate in groundwater were below the WHO – stipulated value for each of the anion for potable water. The measured values of iron and lead in the groundwater samples were above WHO tolerance levels for drinking water in the boreholes around the dumpsite. The biochemical oxygen demand (BOD) measured values fell above the WHO tolerance levels of 0mg/l for potable water. The high level of BOD is indicative of pollution. The physico-chemical parameters of the groundwater samples from the waste dumpsite are below WHO tolerance limit of potability. The local groundwater flow direction is southeast in the two waste dumpsites. It is recommended that regular monitoring of the quality of water be carried out.

Key words: Groundwater Quality, Contaminants, Boreholes, Dumpsites, Eneka, Rivers State

INTRODUCTION

The study area (Eneka town) is located along Eneka-Igwuruta and Eneka - Rukpokwu roads in Obio/Akpor Local Government Area of Rivers State (Fig.1) covering an area of 1,200 and 2,800.04 square meters. The site is located between latitudes 4^o53^lN and 4^o54^lN and longitudes 7^o0^lE and 7^o2^lE. The area depicts flat topography with a mean elevation of 28 meters above mean sea level characterizes the area. It is also characterized by alternate wet and dry seasons (Iloeje, 1992), with a total annual rainfall of about 240cm; relative humidity of over 90% and mean annual temperature of 27°C (Udom and Esu, 2004).The dump sites are full to capacity with waste therefore dumping has been suspended.The waste dump is composed of mainly organic and inorganic municipal waste materials which are already degrading.

Geologically, the area under study is a typical Niger Delta environment of which sedimentary basin has been subdivided into three stratigraphic units, namely, the Benin, Agbada and Akata Formations in order of increasing age (Short and Stauble, 1967). The Benin Formation is predominantly sandy with little shale which may represent back swamp deposits. The formation has thickness ranging from 0-2100m (Etu-Efeotor, 1981). The Agbada Formation consists of alternating deltaic(fluvial, intertidal and fluvio-marine) sands and shales while the Akata Formation consists of low density high pressure deep marine shales (Etu-Efeotor, 1981).

The area is basically underlain by the Benin Formation, classified as coastal plain sands (Reyment, 1965). It consists of massive, highly porous and permeable freshwater bearing sands with minor clay intercalations (Fig. 1). The formation is generally water-bearing and hence it is the main source of potable groundwater in the area (Etu-Efeotor, 1981; Udom&Nwankwoala, 2011a; Nwankwoala&Udom, 2011b). The aquifers are recharged mainly by rainfall and nearby drainages. Aquifer conditions from nearby boreholes around the waste dumpsite exist at depth of 25m to 40m below the water table.

Waste disposal dumps are common phenomena especially in industrial and highly populated cities where dumps are generated in tons on a daily basis and thus becomes a more important and efficient way of maintaining a clean environment in urban settings (Ayolabi*et al*., 2013). The challenges in solid waste dumping, handling and management, all pose great threats to the environment. In most cases, dumpsites were originally located from urban areas, but increasing expansion due to ever-increasing population and urbanization have resulted in the development of land adjacent to dumps as either public buildings or residential houses. Humans are therefore exposed to a range of environmental hazards but particularly percolation of polluted leachate into the shallow aquifers which is the main source of drinking water in developing countries.

A number of factors can affect the quality of groundwater reservoir, such as contamination from surface pollution or toxic industrial wastes. These pollutants pose common environmental problems that have created the need to find suitable methods for monitoring the extent of such environmental damage (Berstone and Dahlin, 1996). Studying leachate at landfills is usually done using either geophysical methods or geochemical analysis of groundwater. Most cases, combination of geophysical and geochemical methods are used either to enhance resolution and effectiveness or to complement one another.

Abu-zeid,*et al* (2003) did a case study of the Marozzo Canal (NE Italy) through an integrated approach including geochemical analyses and geophysical investigations, aimed at characterizing the chemical composition of leachate and at highlighting the extent and magnitude of the plume in terms of spatial distribution.

This study aims at assessing the potential contaminants in groundwater in a typical open refuse dumpsite in the study area due to the large population of the area depending on groundwater as the source of fresh water. These boreholes are located in and around the dumpsites. Therefore, assessing the groundwater quality for its suitability for potability becomes necessary in the study area.

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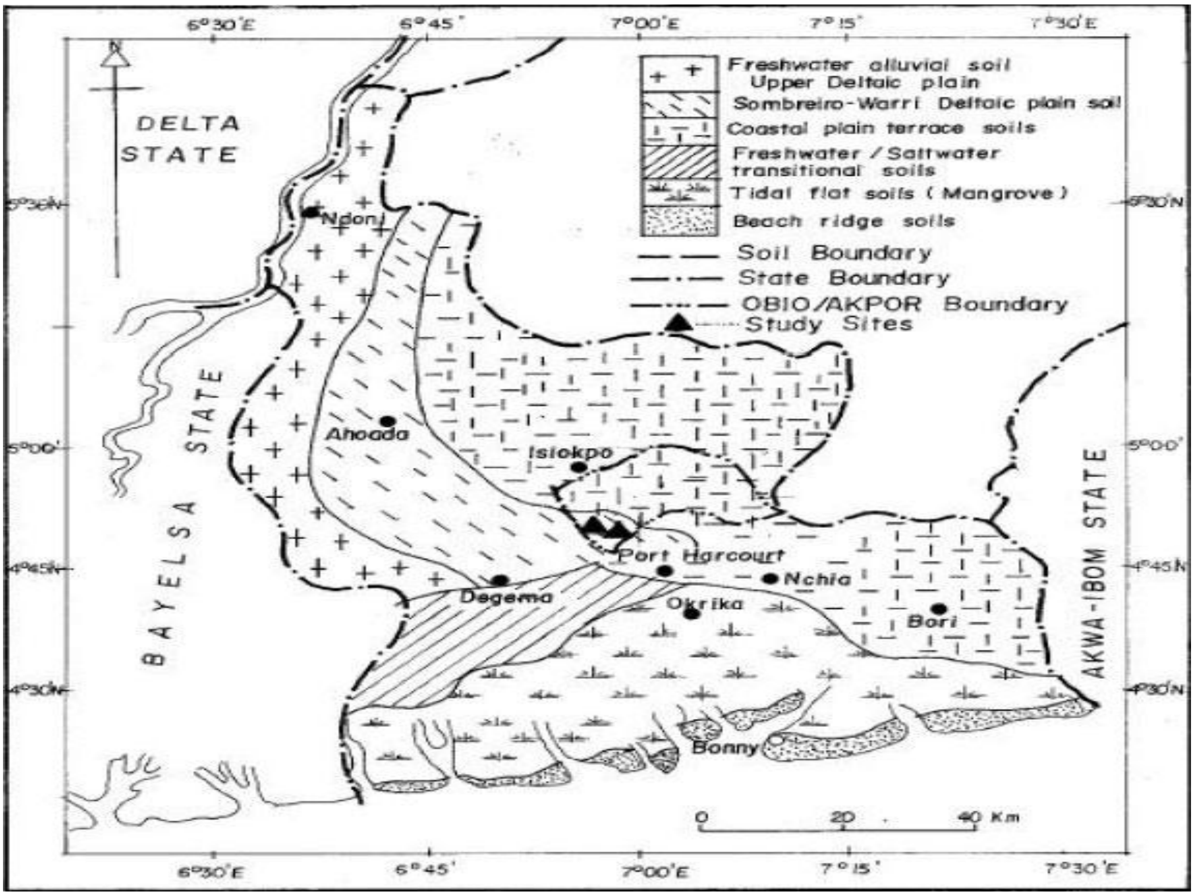

Fig.1: Geological Map of the Study Area

MATERIALS AND METHODS

For a comprehensive study, the physico-chemical analyses of water samples of wells around the dump sites were carried out. Four (4) groundwater samples were collected from wells located around each of the waste dumpsites. For all samples, conductivity, total dissolved solid, total suspended solids, pH, Cl^-, NO_3^-, SO_4^{2-}, biochemical oxygen demand (BOD), Na^+, Fe^{2+}, Cu^{2+}, Pb, and Zn were determined in the laboratory.

The conductivity and total dissolved solids was determined using conductivity/TDS meter(INOLAB Conductivity Meter Level 1). The pH was determined using pH meter(HANNA HI 222 microprocessor), the NO_3^-, SO_4^{2-}, BOD and total suspended solid were determined using portable data logging DR 2800 Spectrophotometer. The chloride content was determined by titration and Na^+, Fe^{2+}, Cu^{2+}, Pb and Zn were determined by Atomic Absorption Spectrometer (AAS – A Analyst 100). The analyses were carried out in Nigeria Agip Oil Company (NAOC) industrial laboratory, Port Harcourt, Nigeria.In dump site 1, three existing boreholes with average depth of 35m were located within the distance of 30m, 90m and 200m radially from the center of the dumpsites and a well which is 2000m from the center of dump site 2.

RESULTS

Physico-Chemical Properties

Table 1: Analytical Results of Borehole Water Samples in Location 1

PARAMETER	SAMPLES			
	W1	W2	W3	WHO(2006)
Distance from Dumpsite (m)	30	90	200	NS
Colour	Not Clear	Not Clear	Moderate	Clear
Odour	Odour	Odour	Odour	Odourless
Ph	4.5	5.6	6.3	6.5-8.5
Conductivity (µs/cm)	964	875	706	500
TDS (mg/l)	709	669	589	500
TSS (mg/l)	8	6	5	5
BOD (mg/l)	6.15	3.02	1.22	NS
Chloride (mg/l)	145	134	120	250
Sulphate (mg/l)	14.2	13.9	14.12	250
Nitrate (mg/l)	10.5	9.2	8.9	50
Sodium (mg/l)	9.22	10	7.05	NS
Iron (mg/l)	1.77	0.43	0.32	0.3
Copper (mg/l)	0.32	0.26	0.18	1.5
Zinc (mg/l)	0.09	BDL	BDL	1.5

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Table 2: Analytical Results of Borehole Water Samples in Location 2

PARAMETER	SAMPLES				
	W1	W2	W3	W4	WHO(2006)
Distance from Dump sites (m)	30	90	200	200	NS
Colour	Not Clear	Not Clear	Moderate	Clear	Clear
Odour	Odour	Odour	Odour	Odourless	Odourless
pH	4.9	4.7	5.3	7.4	6.5-8.5
Conductivity (µS/cm)	998	906	852	509	500
TDS (mg/l)	666	623	601	510	1000
TSS (mg/l)	7	6	5	2	5
BOD (mg/l)	5.15	3.11	1.63	0.09	NS
Chloride (mg/l)	133	123	110	98	250
Sulphate (mg/l)	15.2	13.61	14.4	14.01	250
Nitrate (mg/l)	9.5	9.51	9.9	7.7	50
Sodium (mg/l)	9.66	9.07	7.11	6.04	NS
Iron (mg/l)	1.69	0.46	0.4	0.20	0.3
Copper (mg/l)	0.14	0.11	0.11	0.03	1.5
Zinc (mg/l)	0.09	BDL	BDL	BDL	1.5

N/B: NS = Not Stated; BDL = Below Detection Limit

The physico-chemical parameters tested for are stated in Tables 1 and 2. The results and comparison of sample parameters with the World Health Organization (WHO) are presented in Table 3.The presence of colour in virtually all the wells analyzed with the exception of W4 in dump site 2 which serves as the control was an indication of pollution and confirmed infiltration of leachates into the wells (Akinbile*et al*, 2011). The presence of colour violates the definition of potability of water. Potable water must be colourless, odourless and tasteless and fit for consumption. All the wells in the two dump sites have conductivities greater than 600mg/l but W4 of dump site 2 which is the control well has 501mg/l. The value of greater than 600mg/l is poor and an indication of pollution, in accordance to WHO standard (>1000mg/l, unacceptable). The high values of conductivity indicate that there are mobile ions in the water which must have come from the dumpsite. The mobile ions came from the leachates which usually contain biological and chemical constituents.

Organic matter decomposing under aerobic conditions produces carbon dioxide which reacts with the leaching water to form carbonic acid; $CO_2 + H_2O \rightarrow H_2CO_3$ (Ugwu and Nwosu, 2009). This in turn acts upon metals in the refuse and other calcareous material in the soils resulting in increasing hardness and conductivity of contaminated water.

The pH range of wells in the two dump sites is acidic (4.5 – 6.03). This falls outside the WHO permissible range of 6.5 – 8.5 and confirmed the acidic nature of the wells. Metals such as zinc damaged battery cells and improperly disposed used cans of aerosol and other disinfectants deposited in the dumpsite as waste, after exposure to air and water may have found their ways to the well-water levels through seepage to give it the toxic acidic nature it currently has. The acidity was decreasing eastward of the dump site.

The concentration of chloride in groundwater ranged from 145mg/l to 120mg/l and 133mg/l to 110mg/l of the borehole within dumpsite 1 and 2, respectively. There is a definite attenuation pattern observed in wells down gradient of the waste dumpsites from 145mg/l to 120mg/l and 133mg/l to 110mg/l. Chloride is a good measure of the extent of dispersion of leachates in groundwater. The current observed chloride concentration in the groundwater samples are below the WHO background levels.

Nitrates, the most oxidized form of nitrogen compounds is commonly present in surface and groundwater because it is the end product of the aerobic decomposition of nitrogenous matter. Nitrates had their values greater than 8mg/l for boreholes within the dumpsites, showing appreciable presence of pollutants in all the water samples within the dumpsite. The nitrates may have its way to the water table from the dumpsite which may contain manure from livestock and animal wastes.

The values of the TDS shows that the water samples from the boreholes are contaminated. The total dissolved solids (TDS) which ranged from 589.5mg/l to 702.5mg/l are an indication of pollution.The metals tested in the water samples from the wells as shown in the table indicates the presence of toxic wastes perhaps from disposed off battery cells, aerosol cans and other materials with certain degrees of toxicity.

From W4, all physico-chemical parameters tested as shown in Table 2 are within the permissible limits of WHO (2006) standards. The W4 sample is the control which is about 2000metres from the waste dumpsite.

Groundwater Flow Direction

From Table 3, three existing boreholes were chosen in the study area within the dumpsites for the determination of groundwater flow direction.The water table of the boreholes from the ground surface were measured and indicated in Fig.2. Equipotential points were determined. The direction of flow is always perpendicular to the equipotential lines, the flow direction in the area is southeast of the dumpsite (Fig. 2).

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Table 3: Well data for groundwater flow direction

	WELL 1	WELL 2	WELL 3
Ground elevation (m)	24.8	24.5	25
Static Water level (m)	8.4	8.2	8.9
Hydraulic head (m)	16.4	16.3	16.1

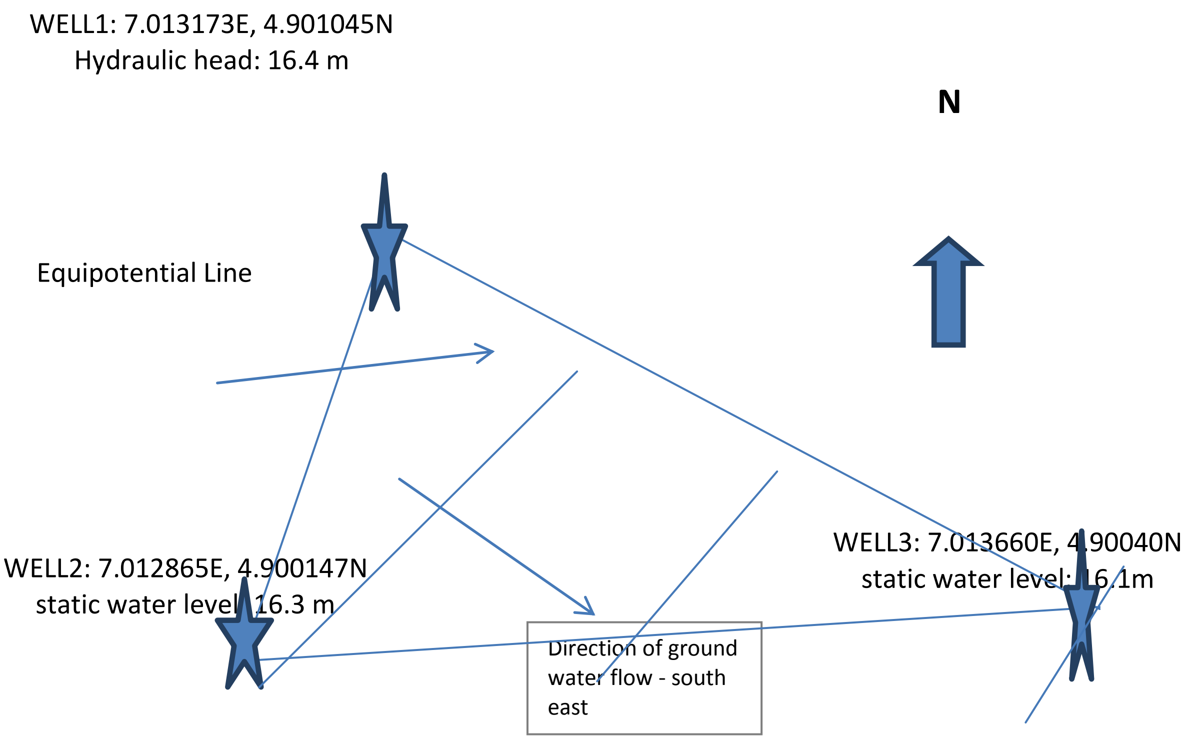

Fig 2: Determination of groundwater flow direction

Determination of Hydraulic Gradient
Distances: WELL1 to WELL2: 80m, WELL2 to WELL3: 166m, WELL3 to WELL1 : 170m
Hydraulic Gradient
16.4m – 16.1m = 0.3m/170m
=0.00176

The groundwater is generally acidic around the dumpsite and asignificant attenuation of TDS concentrations in all wells could be observed down gradient of the waste dumpsite.The measured values of sulphate and nitrate in groundwater were below the WHO – stipulated value for each of the anion for potable water. Except for ions, heavy metals in natural or contaminated groundwater almost invariably occur at concentrations below 1mg/l (Longe&Enekwachi, 2007). The measured values of iron and lead in the groundwater samples were above WHO tolerance levels for drinking water in the boreholes around the dumpsite. These make the iron and lead an important groundwater quality issue.

The BOD measured values fell well above the WHO (2004) tolerance levels of *0* mg/l for potable water. The high level of BOD is indicative of pollution.The physico-chemical parameters of the groundwater samples from the waste dumpsite are below WHO tolerance limit of potability.The local groundwater flow direction is southeast in the two waste dumpsites. Regular monitoring of the dumpsite to ascertain the quality of water is very necessary.

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