Investigation Of Physico-Chemical Characteristics Of Shallow Aquifer Around Dumpsites: A Case Study Of Kajola, Agbowo Dumpsites, At Ibadan, Oyo State, South Western Nigeria.

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Abstract

Management of solid waste and related environmental impacts presents a challenge to both developing and developed countries. This study is to investigate the physico-chemical properties of shallow aquifer around dumpsites in Kajola, Agbowo at Ibadan. Water samples were obtained from nine randomly selected shallow aquifers around the dumpsite in January (dry season) and May (wet season). The leachate samples were also collected which was used as control. From these samples, pH and conductivity were determined using a pH-conductivity meter, while the concentrations of the heavy metals Fe, Pb and Cu were determined using atomic absorption spectrophotometer (AAS). Most of the groundwater samples are generally acidic for the dry season with mean pH value of 7.01 which is below the world health organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ guidelines for potable water). Water samples from sample W3 has the highest level of DO (4.8mg/L in dry season and 4.2mg/L in wet season).During the rainy season the content of Nitrite shoot up to 1.65mg/L, high level of nitrite is discovered in well W3 showing 0.495mg/L of nitrite exceeding the permissible limit of NSQDW and WHO of 0.2mg/L. The average temperature is 29.4°C for both seasons, while well W8 during dry season has the highest temperature. The effect of excess nitrite is that it causes cyanosis, and asphyxia (blue-baby syndrome) in infants. The result of this study clearly shows a polluted environment and groundwater quality.

Keywords: Leachate, shallow aquifer, groundwater.

Introduction

The discovery of pollution in groundwater sources by leachate from open dumps and landfills have been recognized for a long time. In 2006, Clark described landfill practices as the disposal of solid wastes by infilling depressions on land. The depressions into which solid wastes are often dumped include valleys, abandoned quarry sites or sometimes a selected portion within the residential and commercial areas in many urban settlements where the capacity to collect, process, dispose of, or re-use solid waste in a cost-efficient, safe manner is often limited by available technological and managerial capacities. The amount of waste generated is directly linked to the increasing population, increasing wealth and resource use. The most widely used method for disposal of municipal solid waste is landfilling, accounting for up to 95% of the total waste collected worldwide. Landfilling is also generally the most economical method of disposing of municipal solid waste. However, there are a number of environmental drawbacks associated with landfills which have aroused social and environmental attention in recent decades. Amongst the drawbacks, disposal of solid waste in landfills constitutes a considerable source of groundwater pollution. After waste is disposed off at landfills, it undergoes a number of physical, chemical and microbiological changes. Leachate is generated when water percolates through the waste layers (Kjeldsen *et al.* 2002). When the amount of rainfall is greater than the evaporation rate, the leachate level in the landfill increases. Leachate from a landfill can continue to pose a groundwater contamination problem for many years after the closure of the landfill.

In most developing countries such as Nigeria, several tons of garbage is left uncollected on the streets each day, acting as a feeding ground for pests that spread disease, clogging drains and creating a myriad of related health and infrastructural problems. The practice of landfill system as a method of waste disposal in many developing countries is usually far from recommended standards (Adewole, 2009). A standardized landfill system involves carefully selected location, and are usually constructed and maintained by means of engineering techniques, ensuring minimized pollution of air, water and soil and risks to man and animals. Landfilling involves 'placing' wastes in lined pit or a mound (sanitary landfills) with appropriate means of leachate and landfill gas control. In most cases however, 'landfill' in developing countries' context is usually an unlined shallow pit, Zurbrugg et al. (2003) referred to it as 'dumps' which receive solid wastes in a more or less uncontrolled manner, making a very uneconomical use of the available space and that which allows free access to waste pickers, animals and flies, and often produce unpleasant and hazardous smoke from slow-burning fires.

Study Location

Ibadan the capital city of Oyo State is located approximately on Latitude 7^o 22' N and Longitude 3^o 58'E of the Greenwich Meridian. Nevertheless, the expanse of land normally referred to as the metropolitan area lies in the portion lying between Latitudes 7^o 15' and 7^o 30' North of the Equator; and Longitudes 3^o 45'' and 4^o 00' East of the Greenwich Meridian Fig 1. Dumping of refuse started in Kajola, Agbowo in Ibadan back in the early 80's after a quarry site was abandoned by road construction contractors. Their departure left behind a valley in the midst of the community without any useful contribution. The community decided to be filling the valley with waste in general not considering the environmental, health and its hazardous effect. Today, the valley is filled up and it has over flown to the surrounding houses of occupants who are very close to the location causing a major effect on the community in terms of clean environment, safe water, air pollution etc.

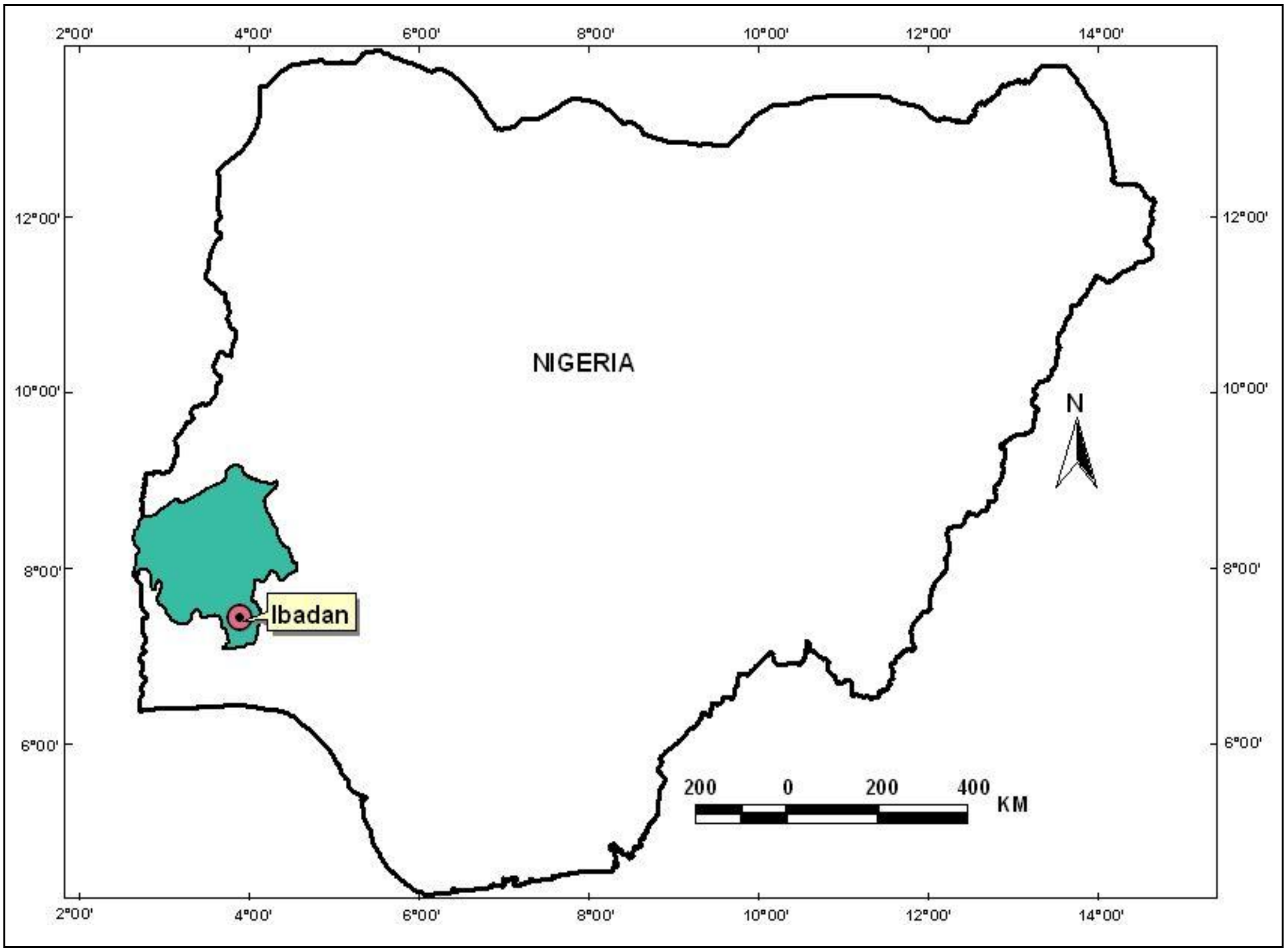

Figure 1: Map of NigeriaShowing Oyo State and Location of Ibadan

Materials and Methods

Sampling Sites: The samples were collected from nine shallow aquifers (hand dug wells) around the dumpsite; the leachate collected from the dumpsite (L) is used as the control for the other samples from the nine selected shallow aquifers. Details of the sampling points are in Table 1, the locations of the groundwater points were obtained with a hand held Global Positioning System (GPS, Germin 72 model) with position accuracy of less than 10 m. The choice of the sampling stations considered location of the dump site, accessibility and proximity to residential areas and the topography of the study area. Unstable parameters such as pH, temperature and conductivity were measured insitu at the point of sample collection; a thermometer was used to determine the temperature of the samples while pH211 microprocessor pH meter was used to measure the pH of the samples. The other water samples were analyzed for iron (Fe), zinc (Zn) and copper (Cu);

Solute properties that have generated concerns in water development, globally (WHO, 2006), especially in terms of their toxicity. While Cu, Fe, Cr, Mg, Ca and Zn were determined with the aid of the Atomic Absorption Spectrophotometer (AAS).

In addition, Autoclave Analog Pressure Autoclave was used to sterilize the culture media prepared for cultivation of microbes for determining bacterial count and coliform count. This laboratory equipment is used to provide uniform temperature within the chambers up to and including the sterilizing temperature up to 121°C at 1 atm pressure.

Table 1: Samples location and elevation

SAMPLE NUMBER	LOCATION	ELEVATION
Leachate (L)	N07°26.990' E003°55.173'	219m
W1	N07°26.937' E003°55.188'	221m
W2	N07°26.951' E003°55.126'	222m
W3	N07°26.950' E003°55.108'	212m
W4	N07°27.009' E003°55.131'	220m
W5	N07°27.033' E003°55.182'	210m
W6	N07°27.041' E003°55.201'	209m
W7	N07°26.995' E003°55.149'	203m
W8	N07°27.064' E003°55.184'	203m
W9	N07°27.037' E003°55.166'	202m

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Table 2: Physicochemical Parameters of samples of water collected in Kajola, Agbowo in Dry Season.

PARAMETERS	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Temperature	31.9	29.4	31	29.8	29	29.4	29.5	29.6	29.9	29
Colour	200	5	50	15	5	10	5	30	15	40
Turbidity (NTU)	212	2.71	10.2	22.6	3.1	8.62	2.25	6.3	14.5	2.81
pH Value	7.4	6.2	6.8	7.4	6.8	6.9	6.8	7	7.4	7.8
Dissolved Oxygen mg/L	5.2	5.4	4.9	4	4.8	4.5	4.1	4.1	4.6	5
Conductivity (µs/cm)	1928	924	1120	906	1500	522	1112	910	902	1100
Total Solids mg/L	1850	250	178	220	210	162.5	158.3	157.1	149.5	200.5
Total Dissolved solid	1150	106	80	103	96.9	90	90.4	84	83.4	120.3
Total Suspended solid	700	144	98	118	113.1	72.5	67.9	73.1	66.1	80.2
Acidity	Nil	0.8	0.2	0.1	0.1	0.1	0.3	0.1	0.2	0.2
Total Hardness	214	100	218	228	338	311	280	340	225	186
Calcium hardness	32.7	21.6	42.4	59.2	80	81	82.4	72	58.2	42.4
Magnesium hardness	19.52	11.22	27.32	19.52	33.67	26.8	18.06	39.04	25.62	14.52
Chloride	171.5	112	156.5	141	200	192	189.5	157	186	93.5
Nitrate	0.8	3.7	18	4.4	8	22	6	3.6	5	7
Sulphate	150	36	70	65	98	72	45	100	75	59
Phosphate	7.2	0.96	0.88	0.65	0.49	0.48	0.33	0.82	0.68	0.16

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Table 3: Concentration of Heavy metals on samples of water collected in Kajola, Agbowo in Dry Season.

HEAVY METALS	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Iron	0.1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chromium	Nil	0.02	0.05	0.05	0.06	0.45	0.06	0.05	0.02	0.06
Copper	Nil	0.04	0.07	Nil	Nil	0.07	0.09	0.12	0.16	0.09
Manganese	0.482	Nil	0.1	Nil	0.087	Nil	Nil	0.04	Nil	0.025

Table 4: Bacteriological analysis on samples of water collected in Kajola, Agbowo in Dry Season.

BACTERIOLOGICAL	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Bacteria Count/100ml	80	10	50	20	25	20	15	50	20	35
E.Coli (Coliform 24hrs)	180+	50	180+	45	20	180+	50	180+	80	80

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Table 5: Physicochemical Parameters of samples of water collected in Kajola, Agbowo in Wet Season.

PARAMETERS	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Temperature	29.4	29.3	29.2	29.4	29.5	29.4	29.4	29.4	29.5	29.3
pH Value	8.24	6.33	7.1	7.75	7.15	7.06	6.92	7.38	7.67	7.45
Dissolved Oxygen mg/L	4.8	4.5	4.1	3.6	4.2	3.9	3.7	3.4	4.05	4.1
Conductivity (µs/cm)	2011	1081	1618	1057	1931	1521	877	1456	1076	1205
Colour	180	5	10	20	5	5	10	10	10	10
Turbidity (NTU)	118	0.24	5.89	15.4	0.95	2.48	3.85	2.2	7.25	3.92
Total Solids mg/L	1586	685.7	825	771.4	1002.5	1001.5	1325	813.5	625	721.4
Total Dissolved solid	1008	481	437	469	346	475	395	469	491	321
Total Suspended solid	578	204.7	388	302.4	656.5	526.5	930	344.5	134	778
Acidity	Nil	0.5	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Total Hardness	228	120	197	195	332	212	214	266	203	304
Calcium hardness	108	64	96	94	138	108	105	50	66	78
Magnesium hardness	120	56	101	101	194	110	109	216	137	150
Chloride	430	203	290	270	203	255	268	305	265	212
Nitrate	1.3	6.8	25	9.1	20	15.3	10.8	3.5	12	9.6
Nitrite	1.65	0.033	0.066	0.495	0.198	0.456	0.099	0.066	0.066	0.035
Sulphate	95	15	28	12	10	15	14	11	9	12
Phosphate	6.2	0.22	0.79	0.13	0.49	0.32	0.2	0.6	0.43	0.16

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Table 6: Concentration of Heavy metals on samples of water collected in Kajola, Agbowo in Wet Season.

HEAVY METALS	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Iron	0.1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Chromium	Nil	0.01	0.04	0.05	0.06	0.05	0.05	0.04	0.02	0.05
Copper	Nil	0.08	0.08	Nil	Nil	0.08	0.09	0.12	0.12	0.09
Manganese	0.335	Nil	0.079	Nil	0.027	Nil	Nil	0.029	Nil	Nil

Table 7: Bacteriological analysis on samples of water collected in Kajola, Agbowo for Wet Season.

BACTERIOLOGICAL	L	W1	W2	W3	W4	W5	W6	W7	W8	W9
Bacteria Count/100ml	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
E.Coli (Coliform 24hrs)	>160	>160	>160	>160	>160	>160	>160	>160	>160	>160

Results and Discussion

The average temperature is 29.4°C for both seasons, while well W8 during dry season has the highest temperature. The pH results from Tables 2 and 5 indicate anaerobic or methanogenic fermentation stage of leachate. The stage is usually characterized with production of volatile fatty acid (VFAs) and high partial pressure of carbon dioxide with a pH range of 6 to 8 (Kjeidsen et al, 2002). Most of the groundwater samples are generally acidic for the dry season with mean pH value of 7.01 which is below the world health organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ guidelines for potable water). Water samples from well W4 has the highest level of DO (4.8mg/L in dry season and 4.2mg/L in wet season).This value indicates a very high level of dissolved oxygen in groundwater which is below the leachate level values. It could be inferred from this observation that there is direct contamination of the aquifer by the leachate outflow. The composition of leachate varies from one part of the landfill to another thus have different pollutional effects on the environment (Tricy, 2002). The pollutional level therefore depends on its sources (sewage, detergents, industrial effluents and agricultural drainage) and volume. Traces of high turbidity shows in wells W2,W3,W5,W7 and W8 for both seasons and average leachate content of 165NTU.This values are higher than the WHO standard of 5NTU (World Health Organisation, 2006). Nitrate reduces to nitrite which can oxidize haemoglobin (Hb) to methaeglobin (metHb), thereby inhibiting the transportation of oxygen around the body (Alsabahi et al, 2009). Concentration of Total dissolved oxygen (TDS) and sulphate in groundwater sample are low and found within the specified WHO and NSDQW standards for drinking water(Table 2 and Table 5). High level of sulphate could lead to dehydration and diarrhea and children are more sensitive to it than adults. Appreciable concentration of chromium were found in Wells W4 and W9 (0.06 and 0.07mg/L) during dry season (Table 3) and in W5(0.06mg/L) during the wet season (Table 6). These values are above the WHO and NSDWQ stipulated value of 0.05mg/L of chromium in drinking water quality. Heavy dose of chromium salts even though are rapidly eliminated from human body could corrode the intestinal tract (WHO, 2004). Traces of Chlorine residue could not be found in all the groundwater samples and leachate for both seasons. The results of bacterial count for dry season ranges from 10 to 50cfu/mL and with leachate content of 80fcu/mL. The results shows an Indication of faecal contamination of some wells in the study area. E-coli were seen in all the sampled groundwater and Leachate (Tables 4 and 7). The presence of E-coli in the groundwater is a big threat to the community because it causes Urinary tract infections, bacteraemia, meningitis, diarrhea, (one of the main cause of morbidity and mortality among children), acute renal failure and haemolytic anaemia.

Conclusion

The assessment of the groundwater quality of the shallow aquifers with respect to the general water parameters, heavy metals and micro biological determination of the water content revealed that the leachate from Kajola dumpsite within the community posed a big treat on the health issue of people living in the community. The study has also provided some relevant baseline information for accessing the public health risks, which could arise from the intake of groundwater from Kajola area,Agbowo,Ibadan.It is therefore recommended that the dumpsite condition be improved to minimize the effects on the environment or that it be relocated to another area, outside the residential area.

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