International Journal of Current Research in Applied Chemistry & Chemical Engineering
Vol. 3, Issue 2 - 2019

ASSESSMENT OF THE IMPACT OF DUMPSITES ON GROUND WATER QUALITY IN OSOGBO METROPOLIS, NIGERIA

AKINRINLOLA OLUMIDE[*], OCHONMA CHARLES[*], AKINRINLOLA RAPHAEL[**], OMOGUNSOYE ADEKOJUSOLA[***], OLABODE AJAYI[*]

ABSTRACT

The contamination of the quality of groundwater resulting from the infiltration of leachates from dumpsites have been a great concern in recent years. Consequently, this research is focused on investigating the impact of leachates from dumpsites on ground water quality by the determination of the physico-chemical properties and heavy metal contents of two well-water samples near two dumpsite and a control site in osogbo metropolis, Nigeria. The result of physico-chemical parameters are: temperature (26.1-26.3 ^{o}C) , pH (6.95-8.95), conductivity (150.3-1207 µS/cm), Dissolved Oxygen (DO) (5.68-7.26 mg/L), Total Dissolved Solids (TDS) (170.51-608.2 mg/L), Total Hardness (TH) (33.43-120.28 mg/L), Nitrate (1.08-7.05 mg/L) , Sulphate (12.15-39.06 mg/L), Phosphate (0.8-1.33 mg/L), Biochemical Oxygen Demand (BOD) (1.34-3.46 mg/L), Ca (25.65-72.34 mg/L) and Mg (7.78-29.28 mg/L). The result of heavy metal concentration (mg/L) are: Cu (0.75-0.93), Zn (0.90-2.25), Pb (0.01-0.03), Cr (0.05-0.12), Co (0.01-0.04), Mn (0.07-0.20), Fe (0.85-2.72), Ni (0.006-0.37), Cd (0.003-0.02). The result showed some level of infiltration of leachates from dumpsite into the water. However, many anlaysed parameters were below the permissible limit of WHO and Nigerian Standard for Drinking Water Quality (NSDWQ) with the exception of Pb, Cd, pH and TDS. Furthermore, the findings revealed the effect of variation of season on the quantity of measured parameters. Therefore, the study suggests the implementation of a well-designed leachate collection system to avert the continual contamination of underground water.

KEYWORDS: Dumpsite, Ground-Water, Physico-Chemical Properties, Heavy Metals.

INTRODUCTION

The increased anthropogenic activities of man resulting from industrialization and urbanization has led to generation of all kinds of waste. According to Raju [1], solid waste are classified into six categories namely domestic, agricultural, municipal, industrial, hazardous and residential waste.

[*]Department of Chemistry, Federal University of Technology, Akure, Nigeria.
[**]Department of Biochemistry, Adekunle Ajasin University, Akungba-Akoko, Nigeria.
[***]Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
Correspondence E-mail Id: editor@eurekajournals.com

 ISSN: 2581-5385

These wastes are sorted out either by incineration, composting, source reduction, recycling or by landfills. The oldest and commonest method of waste disposal in developing nation is landfill [2].

Landfill is a system of waste disposal that is constructed to discard solid waste by burial in lands as a means of ameliorating the contamination of surrounding environment. Nevertheless, landfill operations in developing nations is different from a well-dugged hole in the ground used in developing nations. The inability of most cities of developing countries to reduce, re-use, recycle or recover solid waste has led to indiscriminate dumping of solid waste in old quarries, excavated sites, valleys, selected land portions etc[3].

The environmental pollution attendant upon the operation of open dump have sparked myriad of research [4-5]. One of the negative effects associated with the dumpsite is the introduction of leachates into the immediate environment and the pollution of landmass and aquatic bodies [6-7]. The composition of solid waste being infiltrated into the surrounding environment is highly toxic in nature. As a consequence, the flora and fauna is being altered and ultimately the overall wellbeing of the individual living in that environment is seriously impaired.

Underground water is highly valuable and widely used for various domestic, commercial, and industrial purposes. The indispensable nature of groundwater to human existence and the proness to contamination has engendered a lot of studies. One of the common pollutant of groundwater is leachate from dumpsite [8]. The infiltration of leachate from dumpsites and contaminants from sediments is highly detrimental to groundwater if not well managed [9].

Odukoya et al. [10] observed that leachates from dumpsites are major sources of heavy metal pollutant. Ebong et al. [11] showed that the impacts of landfill on groundwater has being a situation of concern in the past. Some researchers revealed that leachate are the major sorces of groundwater with close proximity to landfills [5, 12, 13, 14].

Several researches has been carried out to investigate the impact of landfills on groundwater quality across the states of Nigeria. But, no research has assessed the effect of dumpsites on the quality of groundwater in Akilapa and Oleyo dumpsite in Osun state. Hence, the aim of the study is to investigate the impact of dumpsite and degree of pollution of groundwater quality close to Akilapa and Oleyo dumpsite in Osogbo, Osun state, Nigeria.

DESCRIPTION OF STUDY AREA

The study areas are Oleyo dumpsite, Akilapa dumpsite and the control site (Fig. 1). They are all located along Olorunda Local Government Area of Osun state, Osogbo, Nigeria. Akilapa dumpsite lies between Latitude N07° 31.966' and Longitude E005° 45.480'; Oleyo dumpsite lies between Latitude N07° 31.860' and Longitude E005° 45.483' and the control site lies between Latitude N07° 29.168' and Longitude E005° 44.146'. The control site is 8km from Akilapa and 10km from Oleyo dumpsite respectively. These areas are in the surburb of Osogbo Metropolis; Osogbo as a capital of Osun state has rapidly increase in polpulation to about 154, 694 people in accordance with the 2006 census report.

 ISSN: 2581-5385

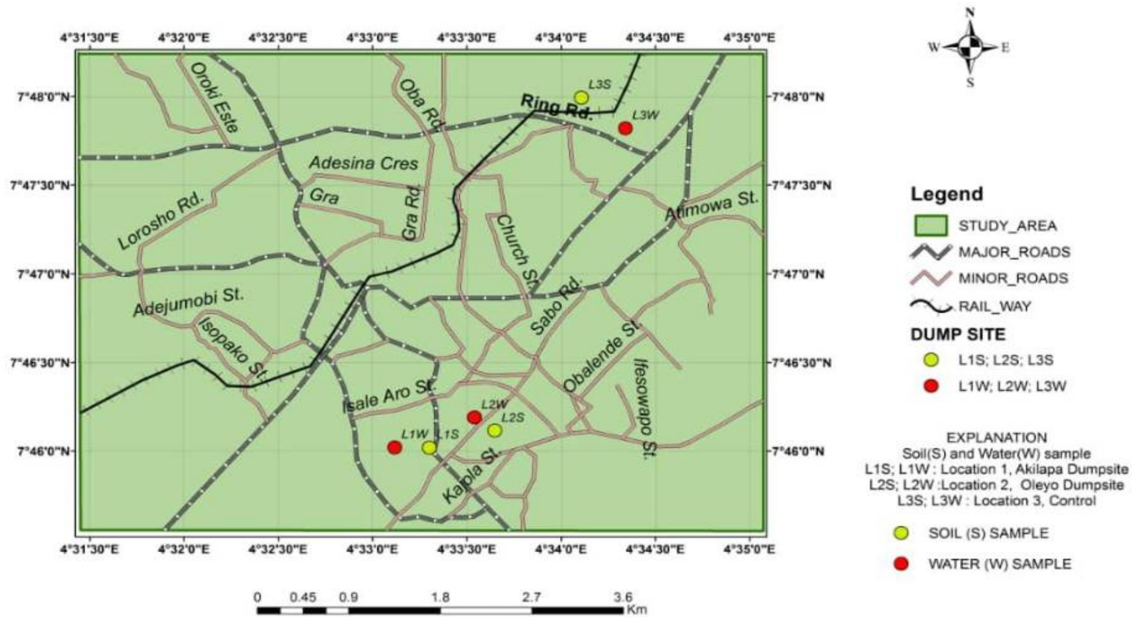

Figure 1.Location Map of the Study Area

MATERIALS AND METHODS

COLLECTION OF WATER SAMPLES

The water from the nearby well at Akilapa and Oleyo dumpsite as well as control sites were sampled for analysis. The well nearby Akilapa dumpsite is 100m away with average depth of 20m. The well nearby Oleyo dumpsite is 120m away with average depth of 25m. The well water for the control site was sampled at a distance of about 8km away from Akilapa and 10km from Oleyo dumpsite respectively.One litre(1L) polyvinyl chloride(PVC) plastic container was used to collect the water sample at each sample points for heavy metal analysis. Another 1L PVC plastic container was used to collect water samples for the determination of physico-chemical properties. A 250ml amber bottle was used for the collection of water samples for biochemical oxygen demand (BOD) determination.

DETERMINATION OF PHYSICAL PARAMETERS

The physical properties such as pH, color, odour, temperature nd electrical conductivity were determined in situ. All analysis was carried out by standard method of water analysis [15, 16].

DETERMINATION OF PHYSICOCHEMICAL PROPERTIES

Physicochemical parameters such as Ca, Mg, Total Dissolved Solid (TDS), Dissolved Oxygen (DO), Sulphate, Phosphate, Nitrate, Total Hardness (TH), Biochemical Oxygen Demand (BOD) were all analyzed for the various water samples. The physicochemical proportion of water samples were determined according to the standard analytical method [16, 17].

HEAVY METAL ANALYSIS

Heavy metals such as Cu, Cd, Cr, Pb, Mn, Zn, Mn, Co and Fe were analyzed in all the water sample. The heavy metals was determined using atomic absorption spectrophotometer.

RESULT AND DISCUSSION

DETERMINATION OF PHYSICAL PARAMETERS

Table 1 revealed the results of the physical parameters (colour, odour, temperature, and Electrical Conductivity (EC)) of all the water samples. The water samples collected from W1and W2 indicated the presence of colour with the exception of water samples from W3. The colouration of the water sample with close

 ISSN: 2581-5385

proximity to the well suggests the infiltration of leachates from dumpsite into the well [18-19]. The temperature of the water samples ranged between 26.10-26.30^oC. Afolayan et al. [20]. reported similar value of temperature ranging between 24.8-26.7^oC for groundwater sample close to a landfill in Lagos state, Nigeria. Also, the odour of all the water sample is unobjectionable. The EC of all the water samples which is the measure of the ability of water to conduct electricity ranged between 150.30-1,321.10 µS/cm for the wet and dry seasons. The value is similar to the values reported by [21].. The EC of water samples in W_1 and W_2 is higher in wet season than the dry season with the exception of W_3 which is higher in dry season than wet season. Hence, the result showed that seasonal variation affect the electrical conductivity of water samples.

Table 1.Physical characteristics of the well-water samples

Samples	Season	Colour	Odour	Temperature (^oC)	EC(µS/cm)
W1	Dry	Not Clear	Odourless	26.20	905.00
	Wet	Not Clear	Odourless	26.00	1207.00
W2	Dry	Not Clear	Odourless	26.30	843
	Wet	Not Clear	Odourless	26.20	1321.10
W3	Dry	Clear	Odourless	26.00	339.00
	Wet	Clear	Odourless	26.10	150.30

W1: water from Akilapa dumpsite, W2: water from Oleyo dumpsite, W3: water from the control site

DETERMINATION OF PHYSICO-CHEMICAL PROPERTIES

Table 2 revealed the results of the physicochemical analysis carried out on the water samples. The results were compared with the World Health Organization (WHO) and NSDWQ (Nigeria Standard for Drinking Water Quality). The pH value of the water sample ranged between 6.95-8.95. These values fall within the standard values of WHO & NSDWQ with the exception of the W_2 during the dry season. Hence, W_2 is not suitable for drinking. The pH values from this research agrees with the findings of Afolayan et al. [20]. The pH of the water samples in dry season is comparably higher than that of the wet season. At low pH, water becomes corrosive as well as at an highly alkaline pH [22].

The value for TH in water samples are all lower than the standard value (150mg/l $CaCO_3$) of WHO & NSDWQ with value ranging between 33.43-120.28mg/l $CaCO_3$. Afolayan et al.[20] obtained a similar value (122-126mg/l) for ground water. The TH value for W_1 and W_2 is reasonably higher than W_3. This might be attributed to the infiltration of Ca & Mg ion from dumpsites into the well. Also, seasonal variation significantly affect the value of TH in all the water samples. Higher water hardness prevent water from forming easy lathering with soap.

The TDS ranged between 170.51- 608mg/l which is above the stanadard values. The relatively higher value of W1 and W2 compared to W3 is an indication that the dumpsite has greatly affected the TDS level of the well water. These are not agreeable with the values (18- 342mg/l) reported by [22]. Also, TDS is relatively higher in wet season compared to dry season. This might be due to the corrosion of organic matter into well water.

The Ca and Mg value of the water samples varies between 25.65- 72.34mg/l & 7.78-29.28mg/l respectively. The Ca and Mg are below the standard values of WHO and NSDWQ. The Ca and Mg ions for W3 is lower compared to W1 and W2. This might be attributable to the leaching of Ca & Mg ions from the dumpsite. These values are significantly lower compared to the value

 ISSN: 2581-5385

reported by [23]. The Ca and Mg concentration is higher in wet season compared to dry season. Higher magnesium content can result into clogging of water pipes.

The concentration of Phosphate (PO_4^{3-}) in the water samples is below detectable limit during the wet and dry season with the exception of W1 with 0.8 mg/L and 1.33 mg/L during the dry and wet season respectively. The PO_4^{3-} content of W1 is far below the standard value of 250 mg/L. This result revealed that the PO_4^{3-} of the dumpsites are very low. This value is agreeable with that reported by [23].

The concentration of NO_3^- in the water samples ranges 1.08-7.05 mg/L. The NO_3^- content of W1 and W2 is relatively higher than W3. This is an indication that the water samples in W1 and W2 has been affected by the dumpsite, however, all the values are below the standard value (50 mg/L). These values is lower than those reported by ChidanandPatil et al. [24] which ranges between 19-35 mg/L. The discrepancy may be attributed to variance in the composition of the dumpsites. Also, the concentration of Nitrates differs for both both wet and dry seasons. Nitrate is the end product of the aerobic decomposition of organic nitrogenous matter; hence, it is commonly found in underground waters [25].

The concentration of SO_4^{2-} in the samples ranges 12.15 mg/L-39.06 mg/L and this is far below the standard values (250/100 mg/L). The SO_4^{2-} content of W1 and W2 is relatively higher than W3. This is an indication that the water samples in W1 and W2 has been affected by the dumpsites. Oyelami et al. [26] reported a similar value for the concentration of sulphate ion in ground water samples. High sulphate content may cause gastro-intenstinal irritation in the presence of magnesium or sodium [27].

Table 2.Chemical composition of the well-water samples in comparison with the WHO/NSDWQ Standard

Parameters	Seasons	W1	W2	W3	WHO/NSDWQ
pH	Dry	8.22	8.95	7.40	6.5-8.5
	Wet	7.60	8.21	6.95	
Ca (mg/L Ca^{2+})	Dry	67.33	60.92	25.65	75
	Wet	72.34	69.28	26.46	
Mg (mg/L Mg^{2+})	Dry	24.81	26.75	7.78	30
	Wet	28.25	29.28	11.29	
TH (mg/L $CaCO_3$)	Dry	92.14	87.67	33.43	150
	Wet	120.28	115.42	42.50	
TDS (mg/L)	Dry	553.40	506.60	170.51	500
	Wet	608.20	580.14	180.21	
Nitrate (mg/L)	Dry	7.05	4.27	2.57	50
	Wet	5.60	3.01	1.08	
Phosphate (mg/L)	Dry	0.80	BDL	BDL	250
	Wet	1.33	BDL	BDL	
Sulphate (mg/L)	Dry	20.47	39.06	15.62	250/100
	Wet	15.60	28.20	12.15	
DO (mg/L)	Dry	5.68	6.18	6.40	N/S
	Wet	6.82	7.26	6.53	
BOD (mg/L)	Dry	3.15	3.46	1.60	N/S
	Wet	2.26	2.82	1.34	

 ISSN: 2581-5385

The Dissolved Oxygen (DO) of the water samples ranges between 5.68-7.26 mg/L. The closeness between the values of well waters in the dumpsites and control site is an indication of absence of oxygen depletion by pollutants. These values are agreeable with that reported by Afolayan et al. [20] for dissolved oxygen. It was also observed that seasonal variation affected the DO of the water samples. Dissolved Oxygen is an important parameter in the control of water quality.

The Biochemical Oxygen Demand (BOD) of the water samples varies between 1.34-3.15 mg/L. The BOD is lower that that reported by Raju [1] (9.2-10.4 mg/L). The BOD value was affected by seasonal variation.

DETERMINATION OF HEAVY METALS (mg/L)

Table 3 showed the heavy metal concentartions of the water samples. The concentration of Cu ranges between 0.58-0.93 mg/L and are below the permissible limit of 1.0 mg/L. These values agree with the findings of [21].The concentration of Cu is relatively high in wet season compared to dry season. At high concentration, Cu will impart taste and precipitation in groundwater [28].

Cd (0.003-0.02 mg/L) and Cr (0.05-0.12 mg/L) are present in the water samples below permissible limit with the exception of W2 and W3 and W2 for Cd and Cr respectively. The result is an indication that higher concentration of Cd and Cr might not be attributed to the presence of dumpsite due to high level of Cr in the well water of the control site. Hence, the water in this area are not safe for drinking because at high concentration, Cd and Cr impart toxicity on water samples. Afolayan et al. [20] reported similar values (0.0006-0.0013 mg/L) for Cr

Zn (0.90-2.25 mg/L) and Mn (0.07-0.20 mg/L) are present in the water samples below the permissible limits. Christopher and Mohds [29] reported similar values Zn concentration (0.3-3.0 mg/L) in ground water samples. At high concentration, Mn will impart colour on groundwater.

Table 3.Concentration of Heavy metals in the well-water samples (mg/L)

Metals	Seasons	W1	W2	W3	WHO/NSDWQ
Cu	Dry	0.93	0.58	0.75	1.0
	Wet	0.99	0.64	0.78	
Cd	Dry	0.02	0.01	0.02	0.005
	Wet	0.008	0.004	0.003	
Cr	Dry	0.06	0.07	0.05	0.05
	Wet	0.12	0.32	0.05	
Co	Dry	BDL	0.01	0.01	
	Wet	BDL	0.04	0.03	
Mn	Dry	0.20	0.18	0.19	0.2
	Wet	0.08	0.07	0.20	
Fe	Dry	1.98	0.85	2.50	0.50
	Wet	2.37	1.30	2.72	
Ni	Dry	0.30	0.10	0.62	
	Wet	0.37	0.14	0.006	
Pb	Dry	BDL	0.02	0.01	0.01
	Wet	0.01	0.03	0.01	
Zn	Dry	1.65	0.90	1.20	3.00
	Wet	2.25	1.70	1.26	

 ISSN: 2581-5385

Fe (0.85-2.72 mg/L) and Pb (0.01-0.03 mg/L) are present in the samples above permissible limit with the exception of water samples in W1 and W3 for Pb^{2+} ion. These values are agreeable with the findings of [1] reported for Fe content. Higher concentration of Fe can result into the colouration of groundwater [30]. High concentration of Pb makes groundwater toxic and unsafe for drinking.Co (0.01-0.04 mg/L) and Ni (0.006-0.37 mg/L) are present in the water samples with the exception of W1 which was below detectable limit for Co.

CONCLUSION

The research showed that the composition of waste materials in the dumpsite has systematically infiltrated into the groundwater over time. The result of the investigation revealed a high concentration of all the parameters for the well waters closed to the dumpsites as compared with the control site. In spite of this, vitually all the parameters with the exception of few are below the standard values of World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) [31-32]. However, some heavy metals (Pb and Cd) with high toxicity are present above permissible limit. Hence, the well waters with close proximity to the landfills are not safe for drinking but can be used for domestic and industrial purposes. Also, the colouration of the well water closed to the landfill are attributable to the closeness of an abbatoir. Furthermore, seasonal variation also affect the quantity of parameters in the water samples. Therefore, the study suggests the application of a well-designed leachate collection system to avert the continual contamination of underground water.

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