Original Research Article

Impact of Solid Waste Dumpsite on Groundwater Quality in the Neighbouring Communities

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Authors Contributions:
The work was carried out in collaboration among all authors, Author OPO wrote the first draft and protocol. Author AOV collected the data in the field and analyzed the samplings. Author MKCS designed the study and supervised the data collection and critically evaluated. AOC critically went through the data collection and reviewed the manuscript, reviewed the data. All authors read and approved the final manuscript.

Abstract: Leachate seepages into groundwater aquifer from solid waste dumpsites is likely to release toxic pollutants in groundwater which are hazardous to human health and local ecosystem. A study was conducted on the Physico-chemical parameters of dumpsite leachate and surrounding groundwater from Awotan Solid Waste Dumpsite, in Ibadan, Oyo State. The study was aimed at assessing the impact of the leachate from the dumpsite. The physicochemical analyses of the water samples were carried by standard analytical methods. The results obtained were compared with the WHO (World Health Organization) permissible limit of those parameters in drinking water. The Physico-chemical values obtained for the dumpsite leachate were generally higher than those of groundwater samples, suggesting that a source of contamination could be from the dumpsite leachate. The pH of groundwater samples ranged between 5.03 to 6.94, indicating that the groundwater was acidic. Results of Physico-chemical parameters of dumpsite leachate for Cl^-, NO_3^-, TH, Alk, BOD, COD exceeded the WHO limits for drinking water. The BOD and COD of dumpsite leachate and groundwater samples exceeded the WHO limits and hence not safe for drinking. The concentration of Cl^- and TH in the groundwater closer to the dumpsite were higher than WHO permissible limits for drinking water. Also, concentrations of the analyzed parameters decreased with increasing distance from the dumpsite, thus implicating leachate seepage from the dumpsite into the groundwater. It is therefore recommended that dumpsites be located away from the human settlements to avoid drinking water contamination and local ecosystem & biodiversity degradation.

Keywords: Groundwater contamination, leachate, water quality, Awotan Dumpsite.

1.0 Introduction

Groundwater pollution is often caused by anthropogenic activities. In areas where population growth and human use of land is high, groundwater quality is especially threatened. Virtually all activities where chemicals or wastes may be discharged into an environment indiscriminately can contaminate groundwater. In developing countries like Nigeria, open dump system of waste is very common and recognized as major damage to groundwater resources (Abdus-Salam *et al*, 2011, Beyode *et al*,2012, Ekeocha *et al,* 2012 and Charles *et al*,2013). The Municipal Solid Waste (MSW) generated are intentionally or accidentally dumped on open dumps untreated (Chatherjee, 2010). The solid wastes deposited on the open dumps often contain residential, municipal, commercial, industrial and agricultural wastes which degrade and are leached out by rainwater and humid weather conditions. The leachate contains organic and inorganic chemicals, heavy metals as well as pathogens that pollute the underground water (Ikem *et al,* 2002). The leachate follow defined topography from recharge areas to discharge areas. Soils that are porous and permeable tend to transmit water and certain contaminants with relative ease to an aquifer below ground level. Contamination of groundwater often result in poor drinking water quality, degraded surface water systems, high clean -up cost, high cost for alternative water supplies and potential health problems such as diarrhea, cholera and dysentery arising from the pollution potential of the leachate that originated from such open dumpsites (Mor*et al*, 2006, Oyediran and Adeyemi, 2011; Omole and Alakinde, 2013; Moruff, 2014).

Population growth, urbanization and industrialization influence the degree and volume of solid waste generation in Ibadan city (Ayininuola and Muibi, 2008). Ibadan is ranked the third-largest city based on population with about 2.9 million people in the year 2011 and an annual increase of over 100,000 inhabitants at 4.59% growth rate (United Nations – Habitat 2014). Interestingly, more wastes are produced as the city grows. Solid waste disposal facilities in Ibadan are open dumpsites that are not regulated.

In this study, groundwater around Awotan dumpsite was investigated to determine the effect of leachate from the dumpsite on groundwater quality and the environment (local ecosystem & biodiversity). The spatial distribution of leachate and its impact on groundwater quality were also assessed. Leachate samples from the investigated dumpsite, groundwater samples around the dumpsite and control sample were collected and analyzed for various Physico-chemical parameters that were compared with WHO standards for drinking water.

2.0 Literature Review

According to Nagarajan et al., (2012) the concentrations of Cl^-, NO_3^-, SO_4^{2-}, NH_4^+ were found to be in considerable levels in the groundwater samples particularly near to the landfill sites, likely indicating that groundwater quality is being significantly affected by leachate percolation in Erode City India.
Ogwueleka, T. (2009) found that the solid waste density ranged from 280 to 370 kg/m and the waste generation rates ranged from 0.44 to 0.66 kg/capita/day in Nigeria. They opined that there is a need to train the waste personnel to manage solid waste issues: formulate the policy for community-based programme, waste reduction and recycling project; preparation of legislation.
In South Africa Ololade et al., (2019) investigated the influence of landfill leachate on the surrounding soil and water quality of the Northern landfill in Bloemfontein and the implication on water and food security. Based on the findings they concluded that most of the parameters analysed were above the permissible limit of SANS241, WHO for drinking water, and DWAF specification for irrigation, an indication that the groundwater was unfit for drinking, domestic, and irrigation purposes.

3.0 Study Objectives

In this study, groundwater around Awotan dumpsite was investigated to determine the effect of leachate from the dumpsite on groundwater quality and the environment.

4.0 Materials and Method

4.1 Study Area- Salient Features

The Awotan Solid Waste Dumpsite is situated in Ido-Local Government (LGA) of Ibadan City (Figure 1). GPS coordinate are 07’ 27 719’ – 07’ 27 811 North and 003’ 51 003-003’ 50 599 East. Awotan dumpsite in Akinyele LGA is one of the four major dumpsites in Ibadan. Others are Lapite, Ajakanga and Aba Eku dump sites located in Oluyole, Ona-ara and Ido local government areas respectively. The four dumpsites are practically maintained by the Oyo State Government through the Oyo State Waste Management Authority (OYOWMA). According to OYOWMA, Aba-Eku is the oldest dumpsite established in 1985 while the largest dumpsite is Awotan with an area of 20 hectares. Awotan Solid Waste Dumpsite (ASWD) was formed in1998 to receive solid waste generated in Ibadan. Going by the records of OYOWMA of 2015 data annual waste deposited in Awotan dumpsite was 95,775 metric tons. The dumpsite is characterized by a preponderance of houseflies, mosquitoes, odour and smoke that constitute a health risk. The tipping of waste and monthly fumigation of the dumpsite by Oyo State Waste Management Authority (OYOWMA) has not significantly helped in controlling odour and houseflies. The dumpsite is not a sanitary landfill site and does not possess all the technical requirements, essentially required for solid waste management. A mixed fleet of heavy transport from different parts of the city bring waste to the dumpsite in an irregular manner (Figure 2). Un-segregated waste is dumped and it is the rag pickers who sometimes rummage and separate the garbage. They generally collect glass material, plastic and metals and sell the items to the recycling units. Solids waste disposed into the dumpsite comprises of domestic, industrial and agricultural components. The biodegradable components undergo decomposition due to the activities of bacteria and fungi and lecheting of contaminants into groundwater. Contaminants from the dumpsite can leach into the groundwater due to rainfall and in humid environments. The location map and solid waste dumping practices are shown in figure 1 & 2 respectively, as below;

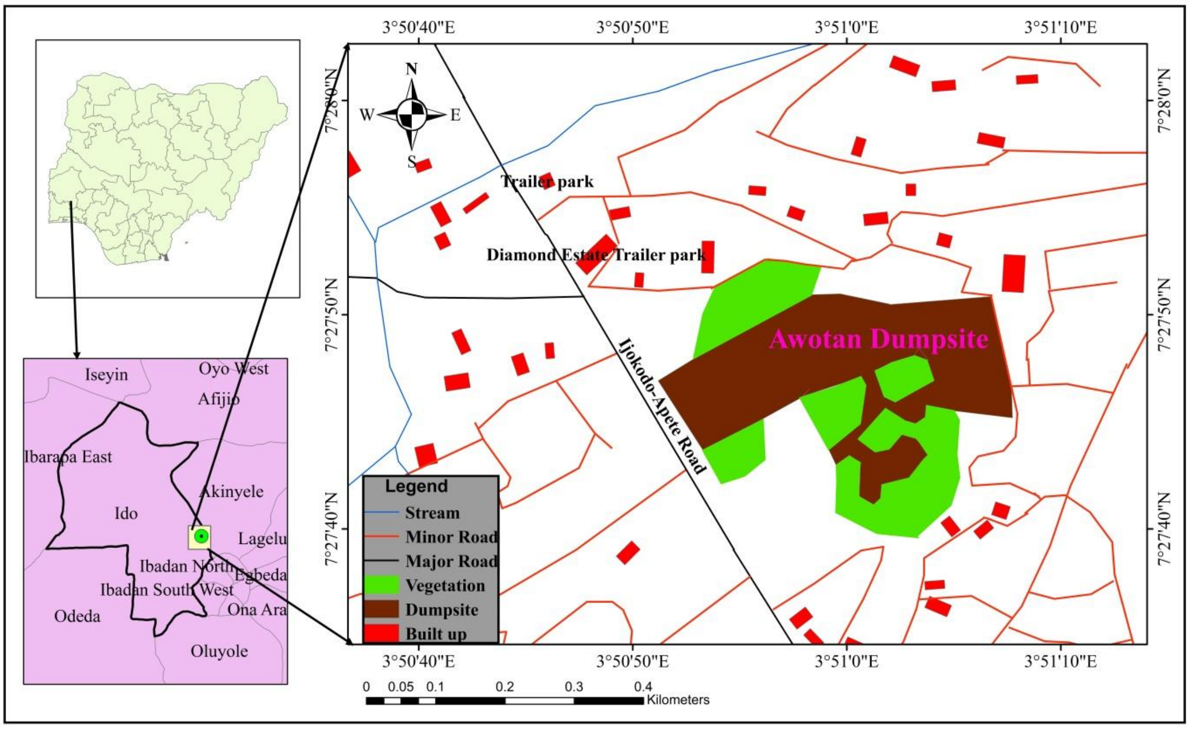

Figure 1: Map of Ibadan showing Awotan Solid Waste Dumpsite

Figure 2 : Indiscriminate Dumping of Waste within and Outside Awotan Dumpsite

4.2 Preparation of Sampling Containers

Two-litre plastic bottles meant for collecting the samples were thoroughly washed with a non-ionic detergent, rinsed with tap water and then soaked in 10% HNO_3 for 48 hours before sampling for analyses to get rid of all possible dirt and contaminants. Furthermore, the containers were rinsed with distilled water and also rinsed thrice at the site with water sampled. All glassware was washed with a non-ionic detergent, rinsed with tap water, soaked in 10% HNO_3 for 48 hours and finally rinsed with distilled water to rule out trace metal contamination.

4.3 Samples Collection

4.3.1 Leachate Samples

Leachate was discovered from different sites of the dumpsite. Samples were collected from the different locations in other to capture all the properties of leachate under study. A clean plastic bowl was used to collect the leachate and poured into the sampling container which had been sterilized. The sample was well labelled A and taken to the laboratory.

4.3.2 Groundwater Sampling

Water samples were collected from different wells in the community around Awotan dumpsite. The groundwater samples B, C, D and E were taken at 200m, 1km, 2.5km and 4km from the dumpsite respectively. The control sample was collected at 4km from the dumpsite. The collection of groundwater samples was influenced by the availability of wells or boreholes. All samples were carefully labelled. The samples were preserved at 4^oC and thereafter taken to the laboratory for analysis. In all the cases listed above, test samples were collected during the wet season when the activities of leachates will be readily feasible at the dumpsite.

4.4 Sample Analysis

The collected samples were analyzed for Physico-chemical parameters and heavy metals. The physical-chemicals parameters include pH, Total Dissolved Solids (TDS) Electrical Conductivity (EC), Total Hardness (TH), Alkalinity (Alk), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Nitrate (NO_3^-), Chloride (Cl^-), Total Hardness, Alkalinity (AlK), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), while the minerals include ferrous ion (Fe^{2+}), Sodium ion (Na^+) and Magnesium ion (Mg^{2+}). The physicochemical parameters of the water samples were carried out following the standard analytical methods (APHA 1995). The values from each parameter obtained were compared with their WHO (World Health Organization) permissible concentrations for those parameters for drinking water.

5.0 Results and Discussion

5.1 Results

Physico-chemical characteristics of leachate and water samples collected from dumpsites are shown in table-1 & 2 below;

Table 1: Physico-chemical characteristics of leachate at the dumpsite

Physical Parameter	A	WHO standards
pH	6.74	6.6-8.5
TDS (mg/L)	62.8	500
EC (µs/cm)	96.4	1000
Chemical parameters		
NO_3^- (mg/L)	173.35	<50
Cl^- (mg/L)	2439.24	250
TH (mg/L)	2000	100-150
AL (mg/L)	880	120
BOD (mg/L)	4626.67	2.5
COD (mg/L)	11566.70	2.5
Minerals		
Fe^{2+} (mg/L)	2.24	0.3
Mg^{2+}) (mg/L)	6.78	40
Na^+ (mg/L)	198.67	<200

A = Source (Dumpsite Leachate)

Table 2: Physico-chemical characteristics of groundwater samples

Physical Parameter	B	C	D	E	WHO standards
Ph	**6.94**	**5.54**	**5.62**	**5.03**	**6.5-8.5**
TDS (mg/L)	**1.98**	**7.91**	**10.09**	**1.67**	**500**
EC (µs/cm)	**3.30**	**13.25**	**16.77**	**2.66**	**1000**
Chemical parameters					
NO_3^- (mg/L)	**6.53**	**55.11**	**8.52**	**7.71**	**<50**
Cl^- (mg/L)	**253.92**	**405.00**	**5.99**	**31.99**	**250**
TH (mg/L)	**364**	**480**	**148**	**64**	**100-150**
AL (mg/L)	**92.00**	**28.00**	**60.00**	**25.00**	**120**
BOD (mg/L)	**325.00**	**162.50**	**132.50**	**105.00**	**2.5**
COD (mg/L)	**812.50**	**406.25**	**331.25**	**262.50**	**2.5**
Minerals					
Fe^{2+} (mg/L)	**BDL**	**BDL**	**BDL**	**BDL**	**0.3**
Mg^{2+}) (mg/L)	**BDL**	**BDL**	**BDL**	**BDL**	**40**
Na^+ (mg/L)	**167.42**	**89.30**	**58.02**	**58.02**	**<200**

BDL = Below Detectable Limit
B = Groundwater 200 meter from the source
C = Groundwater 1 kilometre from source
D = Groundwater 2.5 kilometre from source
E = Groundwater 4 kilometre from source and it serves as the control

5.1.1 Correlation of Coefficient

The correlation between Physico-chemical parameters are shown in table 3, below;

Table 3: Two-tailed correlation coefficient between the physicochemical parameters of water

	pH	TDS mgL	ECμ scm	NO3 mgL	Clmg L	TH mgL	Alk mgL	BOD mgL	COD mgL	Fem gL	Mg mgL	Nam gL
Ph	1											
TDSmgL	.484	1										
ECμscm	.481	1.000**	1									
NO3mgL	.442	.965**	.965**	1								
ClmgL	.562	.978**	.976**	.982**	1							
THmgL	.596	.973**	.972**	.981**	.998**	1						
AlkmgL	.575	.986**	.984**	.945*	.985**	.978**	1					
BODmgL	.554	.987**	.984**	.955*	.989**	.982**	.999**	1				
CODmgL	.554	.987**	.984**	.955*	.989**	.982**	.999**	1.000**	1			
FemgL	.519	.990**	.988**	.958*	.987**	.978**	.997**	.999**	.999**	1		
MgmgL	.519	.990**	.988**	.958*	.987**	.978**	.997**	.999**	.999**	1.000**	1	
NamgL	.931*	.674	.669	.679	.776	.795	.762	.754	.754	.726	.726	1

** Correlation is significant at the 0.01 level (2- tailed)
* Correlation is significant at the 0.05 level (2- tailed)

5.1.2 pH Values

Tables(1 and 2) show the pH of the dumpsite leachate and groundwater samples as well as WHO permissible limits of pH for drinking water. The pH of the dumpsite leachate was 6.74, while the pH of groundwater samples were 6.94, 5.54, 5.62 and 5.03 for locations B, C, D and E respectively.

5.1.3 Total Dissolved Solids (TDS)

The TDS concentrations of the dumpsite leachate and groundwater samples as well as WHO permissible limits for drinking water are shown in Tables 1 and 2. The concentration of the dumpsite leachate was 62.8mg/L while the TDS of groundwater samples ranged between 1.67 to 10.09mg/L.

5.1.4 Electrical Conductivity (EC)

Electrical conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in water (Wetzel, 2001). The EC concentration of the dumpsite leachate 96.4μs/cm, while the EC concentration of groundwater samples ranged between 2.66 and 13.25 μs/cm, Tables 1 and 2.

5.1.5 Nitrate (NO_3^-)

Nitrate concentration of dumpsite leachate was 173.35mg/L Table (1). The Nitrate concentration in groundwater samples for locations B, C, D and E are 6.53mg/L, 55.11mg/L, 8.52mg/L and 7.71mg/L respectively Table (2).

5.1.6 Chloride (Cl^-)

Chlorides are present in both freshwater and saltwater and are important elements of life. Naturally, chloride exists as salts of sodium chloride, potassium chloride and calcium chloride (Napacho and Mangele, 2010). The chloride concentration of the dumpsite leachate was 2439.24mg/L Table 1. The concentrations of chloride in the groundwater samples ranged from 31.99mg/L (4km borehole sample E) to 405.00mg/L (Table 2).

5.1.7 Total Hardness (TH)

Water hardness is the amount of dissolved calcium and magnesium in the water. Hard water is formed when water percolates and has contact with calcium and magnesium carbonates. The total hardness of the dumpsite leachate was 2000mg/L (Table 1). The TH of groundwater samples in locations B, C, D and E were 364mg/L, 480mg/L, 148mg/L and 64mg/L respectively (Table 2).

5.1.8 Alkalinity (Alk)

It is the quantitative capacity of the aqueous solution to stabilize the pH or neutralize an acid, usually from wastewater. The alkalinity concentration of dumpsite leachate was 880mg/L (Table 1). The alkalinity values for the groundwater samples ranged from 25mg/L to 92mg/L, with the 4km borehole water having the lowest value 25mg/L (Table 2).

5.1.9 Biochemical Oxygen Demand (BOD)

It is the amount of dissolved oxygen required by aerobic biological organisms in a body of water to break down organic material present in a given water sample at a certain temperature over a specific period. The high value of BOD (4626.67mg/L) was found in the dumpsite leachate (Table 1). Similarly the BOD concentration in the groundwater samples in locations B, C, D and E were 325,00mg/L, 162.00mg/L, 132.50mg/L and 105mg/L respectively (Table 2).

5.1.10 Chemical Oxygen Demand (COD)

Tables (1 and 2) shows COD of the dumpsite leachate and groundwater samples collected at four (4) dumpsite at different distances from the dumpsite. A high COD value of 11,566.70mg/L recorded in the leachate sample. The concentration of COD in groundwater samples ranged from 262.50mg/L to 812,5mg/L.

5.1.11 Minerals

a. Iron Fe^{2+}

Tables (1-2) shows the concentration of iron in the dumpsite leachate which was 2.24mg/L, while the iron was not detected in all the underground water sampled (Table 2). The concentration of Fe^{2+} in the dumpsite leachate is above WHO standards (0.3mg/L).

b. Magnesium (Mg^{2+})

The concentration of magnesium in dumpsite leachate was 6.78mg/L (Table 1). Magnesium was not contained in the groundwater samples 0.00mg/L (Table 2).

c. Sodium (Na^{+})

The concentration of sodium in the dumpsite leachate was 198.67mg/L (Table 1), while the concentrations of sodium in the groundwater samples ranged between 56.02mg/L and 167.42mg/L.

5.1.12 Correlation analysis

Table 3 displays the result of the correlation analysis of the examined dumpsite leachate and groundwater parameters. When TDS goes up in concentration the waters Na^{+} is likely to increase ($P<0.05$). TDS, on the other hand, will go up ($P<0.01$) and EC, NO_3^-, Cl^-, TH, Alk, BOD and COD, Fe^{2+} and Mg^{2+} will go up at ($P<0.01$). When the water EC rises NO_3^-, C^-, TH, Alk, BOD, COD, Fe^{2+} and Mg^{2+} goes up at ($P<0.01$). The NO_3^- of the water goes up with Cl^- and TH ($P<0.01$) and concentrations go up in the waters, Alk, BOD, COD, Fe^{2+} and Mg^{2+} ($P<0.05$). The Cl^- concentration has a direct positive relationship with TH, Alk, BOD, COD, Fe^{2+} and Mg^{2+} ($P<0.01$). It is also notable that TH increases in the water bodies Alk, BOD, COD, Fe^{2+} and Mg^{2+} also increased ($P<0.01$). Also as Ak increases BOD, COD, Fe^{2+} and Mg^{2+} increase ($P<0.01$). As BOD and COD increase COD, Fe^{2+}, Mg^{2+} increases ($P<0.01$). TDS, EC, NO_3^-, Cl^-, TH, ALK, BOD, COD and Fe^{2+} have strong correlation at ($P \lt 0.01$)

5.2 Discussion

In the present study, the pH value of dumpsite leachate and location B were within the limits of WHO permissible limits for drinking water. However, the pH values in the locations C, D, and E of groundwater were below the WHO permissible limit for drinking water (6.6 – 8.5), indicating that they are acidic and polluted by the dumpsite leachate. The pH of groundwater generally decreased with increasing distance from the dumpsite. The organic acids resulting from decaying vegetation might be responsible for the low pH. The result is similar to what was obtained by Ugwoha and Emete (2015). The ideal pH level for drinking water should be between 6.5 and 8.5. Lawson (2011) reported that the safest pH level of drinking water would be 7 which is the pH level of pure water. Based on this, water from C, D and E are not suitable for drinking. Environmental Protection Agency (EPA) warns that consuming high acidic or alkaline water is harmful. The low pH recorded for groundwater samples in locations C, D and E is of great concern. Low pH water may have a bitter or metallic taste.

The Total Dissolved Solids concentration of the dumpsite leachate and groundwater were below the WHO permissible limit for drinking water (500mg/L). However, the TDS of the dumpsite was higher than the concentration of TDS groundwater samples. This indicates that the groundwater samples may be polluted with the leachate's TDS for groundwater samples. This result is similar to what was observed by Ugwoha and Emete (2015) that despite the high concentration of TDS of the dumpsite leachate, the TDS of concentrations of groundwater samples generally below the standards for drinking water. Thus, the groundwater seems unpolluted with the leachate's TDS. The implication of a very low concentration of TDS in drinking water may give water a fiat taste which may be undesirable to many people, while high TDS concentration does not pose any health hazard. An elevated TDS indicates that the concentration of the dissolved ions may cause the water to be corrosive, salty or brackish taste, result in scale formation and interfere and decrease the efficiency of water heaters.

The values of EC of dumpsite leachate and groundwater samples were below the 1000 µs/cm WHO permissible limits. TDS and EC of water are generally related. The low values of TDS recorded in this study could also be accountable for the low EC results. The Nitrates concentration in the leachate was higher than the WHO permissible limit for drinking water (<50mg/L). On the contrary, the concentrations of NO_3^- in the groundwater samples were generally low and below the WHO standards for drinking water except for the NO_3^- concentration in location C that was moderately high. Generally, nitrate and nitrite concentration had been reported to decrease with the depth of the water (Akinwumi *et al*, 2012). The low NO_3^- of groundwater may not pose any danger to human health. George *et al*, (2010) reported that a high concentration of Nitrate in drinking water is debilitating on human health. Nitrate is a strong oxidizing agent and NO_3^- can react with secondary amines present in the human body, to form nitrosamines. Methemoglobinemia is the main negative effect associated with human exposure to nitrate. Chloride is widely dispersed in nature as salts of sodium chloride and calcium chlorides (Napacho and Manyele, 2010). The source of chloride both in surface and groundwater may originate from both natural and man-made activities which include the use of inorganic fertilizer, landfill, septic tank, effluents, animal feed and industrial effluents (Napacho and Manyele, 2010). The chloride concentration of dumpsite is higher than the permissible standard stated by who for chloride in drinking water is 250mg/L. The chloride concentration in location B and C exceed the WHO limits for drinking water. The chloride concentration in the leachate water sample was significantly higher than that of other tested water samples (Tables 1 and 2). The high chloride concentration in the leachate sample may be due to the discharge of chloride bearing sewage into the dumpsite. Chloride concentration decreased with increasing distance, indicating that the presence of chloride in groundwater can be distributed to leachate migration from dumpsite to the surrounding groundwater. The appreciable lower chloride content obtained in the borehole sample could be as a result of its far distance from the dumpsite and the depth of water. In the controlled intake of water containing sodium chloride at a concentration above 2.5g/litre has been reported to cause hypertension. Chloride concentration above 250mg/L can give rise to detectable taste depending on the associated cations (NSDWQ 2007, WHO 2011). The concentration of TH in the dumpsite leachate and groundwater samples in locations B, C, and D were greater than WHO permissible limits for drinking water, while the TH concentration of groundwater in location E was lower than the WHO permissible limits for drinking water. Hard water high concentration of minerals may have moderate health benefits but it can cause critical problems. Hard water can also cause a problem in washing and cleaning. The high mineral concentration present in hard water prevents the foaming action of soap and detergents. Skin disease such as eczema can be developed as a result of the use of hard water in bathing which makes the skin dry.

The pH value of dumpsite leachate and location B were within the limits of WHO permissible limits for drinking water. However, the pH value in location C, D and E of groundwater were below the WHO permissible limit for drinking water (6.6-8.5), indicating that they are acidic and polluted by the dumpsite leachate. The pH of groundwater generally decreased with increasing distance from the dumpsite. The result is similar to what was obtained by Ugwoha and Emete (2015). The ideal pH level for drinking water should be between 6 to 8.5.

Environmental Protection Agency (EPA) warns that consuming high acidic or alkaline water is harmful. The low pH recorded for groundwater samples in locations C, D, and E is of great concern. Low pH water may have a bitter or metallic taste.

The TDS concentration of the dumpsite leachate and the groundwater samples were below the WHO permissible limit for drinking water (500mg/L). However, the TDS of dumpsite leachate was higher than the concentration of TDS groundwater samples. This indicates that the groundwater samples may not be polluted with leachate's TDS for the groundwater samples. This result is similar to what was observed by Ugwoha and Emete (2015).

The implication of a very low concentration of TDS in drinking water may give water a fiat taste which may be undesirable to many people, while a high TDS concentration does not pose any health hazard. An elevated TDS indicates that the concentration of the dissolved ions may cause the water to be corrosive, salty or brackish taste, result in scale formation and interfere and decrease the efficiency of water heaters.

The values of EC and groundwater samples were below the 1000µs/cm. TDS and EC of water are generally related. The low values of TDS recorded in this study could also be accountable for the low EC results. The electrical conductivity values of most freshwater range from 10-1000Us/cm but may exceed1,000Us/cm especially in polluted waters or water receiving large quantities of land runoff.

The NO_3^- concentration in the leachate was higher than the WHO permissible limit for drinking water (<50mg/L). On the contrary, the concentrations of NO_3^- in the groundwater samples were generally low and below the WHO standards for drinking water except for the NO_3 concentration in location C that was moderately high. The low NO_3 of groundwater may not pose any danger to human health.

George *et al.,* (2010) reported that a high concentration of Nitrate in drinking water is debilitating on human health. Nitrate is a strong oxidizing agent and NO can react with secondary amines present in the human body, to form nitrosamines. Methemoglobinemia is the main negative effect associated with human exposure to nitrate

Chloride is leached from many rocks and enter into the soil and water through weathering. The source of chloride both in surface and groundwater may originate from both neutral and man-made activities which include the use of inorganic fertilizer landfill, septic tank effluents, animal feed and industrial effluents (Napacho and Mangele 2010). The chloride concentration of dumpsite is higher than the permissible standard stated by WHO for chloride in drinking water is 250mg/L. similarly, the Cl^- concentration in location B and C exceed the WHO limits for drinking water. The chloride concentration in the leachate water sample was significantly higher than that of other tested water samples (Tables 1 and 2). The high chloride concentration in the leachate sample may be due to the discharge of chloride bearing sewage into the dumpsite. Chloride concentration decreased with increasing distance, indicating that the presence of chloride in groundwater can be attributed to leachate migration from dumpsite to the surrounding groundwater. The appreciable lower chloride content obtained in the borehole sample could be as a result of its far distance from the dumpsite and the depth of water. In the controlled intake of water containing sodium chloride at a concentration above 2.5g/litre has been reported to cause hypertension. Chloride concentration above 250mg/l can give rise to detectable taste depending on the associated cations.

The concentrations of TH in the dumpsite leachate and groundwater samples in locations B, C and D were greater than WHO permissible limits for drinking water, while the TH concentration in of groundwater in location E was lower than the WHO permissible limits for drinking water. Hard water with a high concentration of minerals may have moderate health benefits but it can cause critical problems. Hard water can also cause a problem in washing and cleaning. The high mineral concentration present in hard water prevents the foaming action of soap and detergents. Skin disease such as eczema can be developed as a result of the use of hard water in bathing which makes the skin dry.

The concentration of dumpsite leachate was above the WHO permissible level (120mg/L); while the values of TH concentration in groundwater samples are below 120mg/L WHO permissible limit of TH for drinking water. The concentration of TH decreased with increasing distance from the dumpsite, which implies that the presence of a concentration of minerals can be attributed to leachate migration from the dumpsite to the surrounding groundwater. Alkalinity can lead to corrosion and can influence chemical and biochemical reactions (George *et. al.*, 2010).

The BOD concentration of dumpsite leachate and groundwater samples were higher than the WHO permissible limits for drinking water. The concentrations of BOD are high in the wells near the dumpsite. When the BOD of water is high the dissolved oxygen concentration will reduce due to the oxygen that is available in the water is been used by the bacteria. Thus the higher the BOD value the greater the amount of organic matter in the water samples. The high BOD in the groundwater samples indicates polluted water by organic matter from the sewage discharged to the dumpsite, hence the water from the groundwater around the dumpsite may not be safe for human consumption. Water with a high concentration of BOD is a common feature of organically pollutants in the water bodies (Ogbogu and Olajide, 2002, Tyokumbur *et al,* 2002, Atobadele *et al,* 2005).

The high values of COD in the dumpsite leachate and groundwater samples indicate high chemically oxidizable organic pollutants in the groundwater which implies that the groundwater may not be safe for drinking (Talsi and Zouboulis, 2002). The COD values of the dumpsite leachate and groundwater were higher than the WHO permissible limits for drinking water. The pollution levels are high in the groundwater wells near the dumpsites an indication that the dumpsite leachate is contributing to the chemically organic contaminant levels of the surrounding groundwater. High levels of COD indicates that there was the decomposition of organic and inorganic compounds in the water that requires high levels of oxygen in the water.

The source of the iron which is the dumpsite leachate may be as a result of metallic components from factories and other industrial wastewater containing ferrous iron is clear and colourless and it is soluble in water. Human bodies require iron to function properly, but iron like many substances is toxic at high doses. Iron in well water has its effect on laundry dishes and water receptacles. The concentration of iron in the groundwater samples that contained (0.00mg/L) may have negative effects on the community that surround the dumpsite. The iron deficit can lead to anaemia, causing tiredness, headaches and loss of concentration. The immune system may also be affected. In young children, this negatively affects mental development, leads to irritability and causes concentration disorder. Young children, pregnant women and women in their period are often treated with iron (II) salts upon iron deficits. High iron concentration is absorbed by haemochromatosis patients, iron is stored in the pancreas, liver and spleen and heart. This may damage these vital organs. However, healthy people are generally not affected by an iron overdose, which is also generally rare. It may occur when one drinks water with iron concentrations over 200ppm.

The magnesium concentration in the dumpsite leachate was lower than the WHO permissible limit for drinking water (40mg/L). The sources of Mg^{2+} in the dumpsite leachate could arise from both natural and anthropogenic sources. Magnesium present in the rock can be washed and subsequently end up in the dumpsite, also effluent discharged fertilizer and cattle feed may end up in the dumpsite. Magnesium and other alkali earth metals, which makes the water to be hard; hence water containing low amounts of magnesium is regarded as soft water.

Magnesium as a dietary mineral for most organisms. Magnesium is important in plant photosynthesis or it is present as a central molecule of chlorophyll. The health effects of magnesium show that it is present in the human body and present in bones, muscles and other tissues. Magnesium is responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. However, a large dosage may cause vomiting and diarrhoea. Magnesium in high doses in medicine and food supplements may cause muscle slackening, nerve problems, depressions and personality.

Despite the high concentration of sodium in dumpsite leachate, the concentration of sodium in the leachate and groundwater samples were below the WHO permissible limits for drinking water as shown in Table (2). The concentration of sodium decreased with increasing distance from the dumpsite, indicating that the presence of Na^+ in the groundwater can be attributed to leachate migration from the dumpsite to the surrounding groundwater. Sodium is a common element that exists in the environment and it is often found in food and drinking water. The human body needs sodium requires sodium to maintain blood pressure, control fluid lev.els for normal nerve-muscle function.

6.0 Conclusion

Generally, contaminations of groundwater are high in the wells near to Awotan Dumpsite. The pH of dumpsite leachate was within the recommended values for of the WHO limits for drinking water, while the pH of the groundwater samples ranges from 5.03-6.94, implying the groundwater in the study area was acidic. Values obtained from the dumpsite leachate for Chloride, Nitrate, Total hardness Alkalinity, Biochemical Oxygen Demand and Chemical Oxygen Demand were above the recommended values World Health Organization (WHO), while the remaining parameters were within. The BOD and COD of groundwater samples did not meet the WHO required standards, implying that the groundwater in the study area was severely contaminated with organics. Similarly, the concentration of Chloride and Total hardness in the locations B and C parameters exceeded the WHO limits, while all other parameters of groundwater samples were within the WHO standards. The groundwater samples, in this study, did not contain minerals such as Iron and Magnesium. The groundwater samples however contained Sodium, in the content below the WHO standard and the concentration decreased with increasing distance from the dumpsite. Na^+ in Awotangroundwater can, therefore, be attributed to leachate migration. Analyzed parameter like TDS, EC, NO_3^-, Cl^-, TH, Alk, BOD, COD and Fe^{2+} showed a strong positive correlation

(P ‹ 0.01) and their relationships may be traced to a common source. It is concluded that the water from dumpsite surroundings in Awotanis not safe for drinking.

Competing Interests

Authors have declared that no competing interest exists,

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