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Assessment of Landfill Induced Ground Water Pollution of Selected Boreholes and Hand-Dug Wells around Ultra-Modern Market Dutse North-West, Nigeria

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Abstract

Despite the robust understanding of groundwater sources' safety, its pollution can lead to serious public health crisis. This study was conducted to assess the water quality of groundwater sources very close to the landfill site around ultra-modern market in Dutse, Nigeria. Systematic random sampling was adopted for collecting six (6) samples; three (3) bore-hole and three (3) hand-dug water samples from different locations around the landfill site. Water samples collected were subsequently assessed for physico-chemical and microbiological analyses. The concentrations of metals and bacteriological contamination coupled with other water quality parameters in some of the sampled locations slightly exceeded the World Health Organisation (WHO) water quality guidelines and Nigeria Standard for Drinking Water Quality (NSDWQ) maximum acceptable limits. Temperature ranged from 27.4 to 30.1^0C coupled with mean pH (8.06), Nitrate (1.051 mg/l), Sulphate (0.2403 mg/l) `Cadmium (0.1833 mg/l), Zinc (0.0695 mg/l), Lead (0.0718 mg/l) and total bacterial counts (9.6×10^1 to 12.2×10^1 cfu/ml). Even though the landfill is improperly sited and designed, the results obtained indicate that all the borehole and hand-dug well water samples were polluted thereby requiring treatment before it can be passed fit for human consumption. However, detailed analysis of groundwater flow direction in the study area is highly required to safeguard the exploration and exploitation of groundwater with a view to forestalling impending public health crisis.
Keywords: Ground-water, hand-dug well, borehole, landfill leachate, pollutants and human health crisis.

Introduction

Water is the most abundant environmental resource on earth but its accessibility is based on quality and quantity, as well as space and time (Annenberg, 2012). It has been established that groundwater plays a vital role for urban and agricultural water supply. Groundwater constitutes a major portion of the earth's water circulatory system known as hydrological cycle and occurs in permeable geologic formation known as aquifers (Afolayan *et al*., 2012). Groundwater is not only abstracted for supply or river regulated purposes, it also naturally feeds surface-waters through springs and passes into rivers and it is often important in supporting wetlands and their ecosystems (Ayoade, 2003). The protection of groundwater quality is of paramount importance.

According to Lehr (2002), incase groundwater gets polluted, it is difficult, if not impossible, to rehabilitate it. This author further submitted that the risk of groundwater pollution is increasing due to indiscriminate disposal of waste materials and the widespread use of potentially environmental polluting chemicals in the industrial and agricultural sectors. The slow rate of groundwater flow and low microbiological activity limit any self-purification (Lenntech, 2011). One of the dreaded consequences of rapid urbanization has been the problem of solid waste management, particularly in terms of environmental nuisance combined with the health hazard and its implications (Adewole, 2009).

Pollution of groundwater can occur in discrete or point sources, one of which landfilling with wastes has been implicated (Tharme, 2003). However, waste management has become an endemic problem that characterizes Nigerian cities (Groundwater Foundation, 2012). Eludoyin and Oyeku (2010) have attributed over reliance on landfilling by most state governments in Nigeria to a lack of capital and appropriate technology for environmentally friendly waste management practices. According to Alloway and Ayres (1997), landfills are not properly engineered and operated to accepted world standards in most cases. Most of the inhabitants of areas around the dumpsites depend either on hand-dug wells or bore-holes which may likely be affected by the generated leachate through waste decomposition from the dumpsites (Afolayan *et al*., 2012). However, the ultra-modern market in Dutse is located just by the side of the main landfill site. It is important to state clearly that the landfill site is poorly engineered and managed as it lacks all the attributes of properly engineered and managed ones obtained in developed countries of the world. This study was therefore conducted to measure and analyze the impact of leachates emanating from the landfill site beside Dutse ultra-modern market on groundwater.

Materials and Method

Study Area

Dutse is the capital city of Jigawa State and equally the headquarters of the 28 local government areas currently available in the state. Dutse is situated at 460 meters elevation above sea level, latitude 11.76° North and longitude 9.34° East (Figure 1). Map (2011) reported that it is a small city that has about 17,129 inhabitants. Arrays of food products are sold in Dutse ultra-modern market.

Water Sampling Techniques

Randomize systematic sampling techniques was employed to select sampling points (water sources; wells and boreholes) that are spatially distributed within the study area. Water samples from three (3) boreholes and three (3) hand dug wells were taken in the study area, and respective geographic positioning system (GPS) was taken for each sampling point and landfill site. Physio-chemical and microbial analyses of the water samples collected from the study area were done using established laboratory techniques and procedures described by APHA (1998).

Statistical Analysis

Multivariate statistical analysis was applied for the physio-chemical parameters utilizing correlation matrix so as to evaluate factors influencing the groundwater chemistry and sources of pollution in the aquifer of the areas.

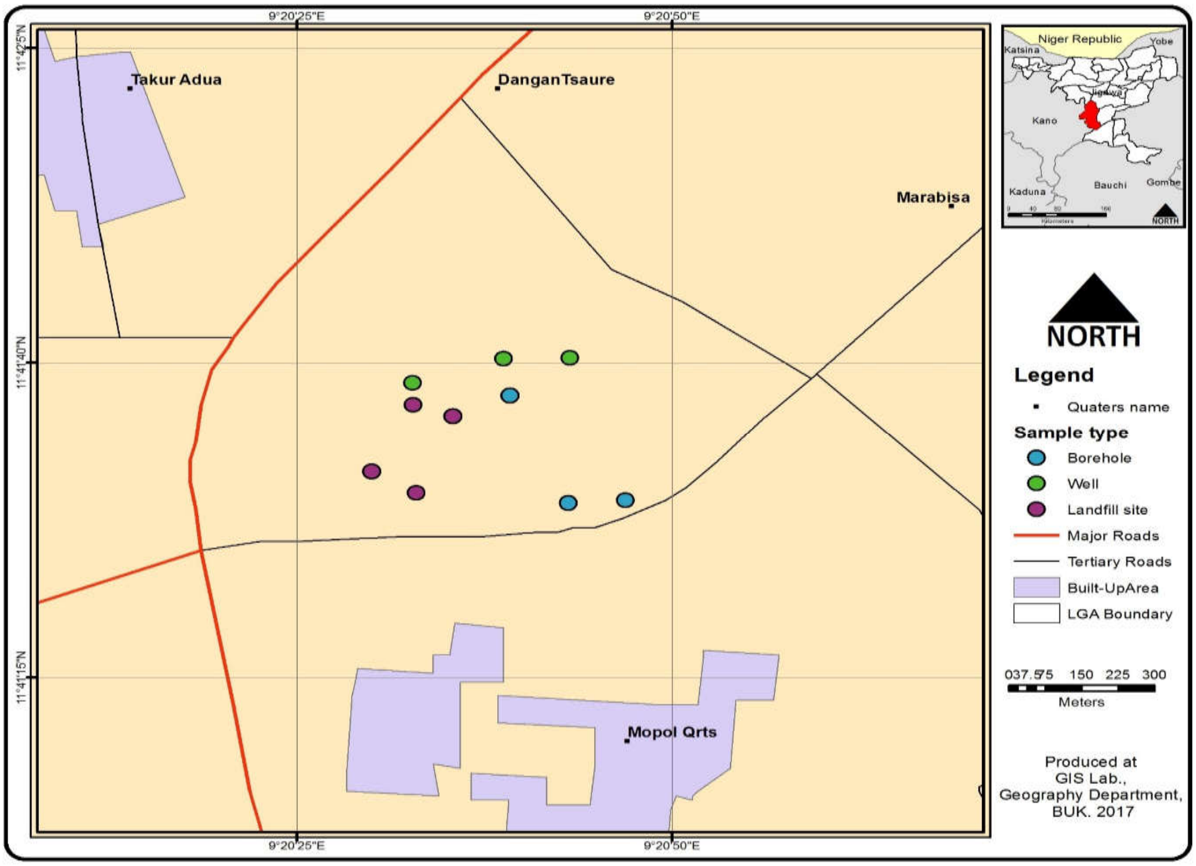

Figure 1: Map of the study area showing the landfill site and water sampling points.

Results and Discussion

Physico-chemical analyses

The physical properties of the sampled groundwater are depicted in (Table 1). It can be seen from Table 1 that in all sample locations, appearance, odour and turbidity fall within the WHO recommended limits. Temperature ranged between 25.4^{0}C - 26.6^{0}C below the standard limit of 35^{0}C -

40^{0}C, indicating the presence of foreign bodies such as active micro-organisms as reported by Akinbile and Yusoff, (2011).

Table1: Physical characteristics of the water samples analyzed and comparison with WHO Standard

Sample	Appearance	Odour	Turbidity	Temperature(^{0}C)
WHO Standard	Colourless	Odourless	5 NTU (mg/l)	35 – 40
B1	Colourless	Odourless	Clear	28.1
B2	Colourless	Odourless	Clear	27.4
B3	Colourless	Odourless	Clear	28.3
W1	Colourless	Mild	Clear	29.1
W2	Colourless	Odourless	Clear	30.1
W3	Colourless	Odourless	Clear	29.3

Legends: B1=Borehole 1, Borehole 2=B2, Borehole 3= B3, Well 1=W1, Well 2=W2, Well 3=W3

Algae were also observed growing in and around most of the hand-dug well sampled. Chemical parameters of whose samples showed a 100% compliance with WHO standards include: Zinc, Sulphates, and Nitrate (Table 2).

Nitrates

Nitrate concentrations in all the groundwater samples during this study were within the WHO guidelines and NSDWQ maximum permissible limits (Table 2). High nitrate levels in water can interfere with the ability of the red blood cells in humans to transport oxygen and can also cause blue baby syndrome, a condition that can be detected especially in infants under six months (Self and Waskom, 2013).

pH

The pH of all the groundwater samples recorded acidic conditions as the borehole and hand-dug well water samples ranged from 7.9 to 8.25 and 7.59 to 8.42 respectively (Table 2). The pH values recorded in this study are contrary to the ones reported by Amoo, Gambo, Adeleye and Amoo (2018) in their assessment of groundwater quality in Sharada industrial area of Kano, North-western Nigeria. These acidity levels recorded in the groundwater of the study area in this current study could be attributed to metal contaminants present in the leachate emanating from the landfill site. However, in this current study, only the water sample sourced from W1 exceeds the recommended limits suggested by WHO (2007); NSDWQ (2007); USEPA (2013).

Table 2: Chemical properties of the sampled water and comparison with standards (WHO/ NSDWQ)

Sample	pH	Cd(mg/L)	Pb (mg/L)	Zn(mg/L)	SO_4 (mg/L)	NO_3 (mg/L)
WHO Standard	6.5 - 8.5	0.003	0.015	1.5	250	10
NSDWQ	6.5 - 8.5	0.003	0.01	3.0	100	50
B1	7.90	0.3	0.043	0.083	1.165	0.701
B2	8.25	0.1	0.086	0.111	0.131	1.401
B3	8.21	0.1	0.043	0.028	0.087	0.701
W1	7.59	0.3	0.043	0.056	0.029	0.701
W2	8.42	0.1	0.130	0.056	0.015	1.401
W3	7.99	0.2	0.086	0.083	0.015	1.401

Note: NSDWQ Values are the maximum permitted levels in the Nigerian Standards for Drinking Water Quality. WHO values are the maximum permitted levels in the WHO Drinking Water Quality Guideline

Lead (Pb)

Lead (Pb) was observed to be above standard limits in all groundwater samples analysed in this study (Table 2). The presence of Pb in all the groundwater samples can be linked with the disposal of Pb rich materials which must have undergone decomposition and subsequent percolation thereby polluting the groundwater sources sampled around the study area. The high Pb levels recorded in this study indicating groundwater pollution is in agreement with the report of Ravi and Prasada (2014) who equally obtained minimum and maximum concentration levels of Pb that varied between 0.012 – 0.153 mg/L in their study. According to Sanborn, *et al*. (2002); Brodkin, *et al*. (2007) excessive exposure to Pb is associated with various neurodevelopmental problems and increased risk of attention-deficit hyperactivity disorder in children. The concentrations of Pb in all the groundwater samples analysed in this current study are sufficient enough to pose any serious health risk to individuals that consume the water, as it all exceeded recommended limits.

Cadmium (Cd)

During this study, Cadmium was also observed to be above WHO and NDSWQ recommended limits in all the water samples (Table 2). This may be due to the disposal of products like paints and plastics which would ultimately form part of landfill leachate that pollutes the groundwater in the study area.

Zinc (Zn)

The concentration levels of Zn in this study fall below the recommended limits set by WHO and NDSWQ (Table 2). Interestingly, these results are in agreement with the concentrations of Zn reported by Amoo *et al.* (2018) in their study involving groundwater quality assessment.

Sulphate (SO_4)

The Sulphate concentrations range in all the groundwater samples; borehole (0.087 to 1.165 mg/l) and hand-dug well (0.015 to 0.029 mg/l) fall within the WHO guidelines and NSDWQ minimum permissible limits (Table 2). However, Bichi and Bello (2013); Kwari (2015) in their respective studies reported higher concentrations of SO_4 when compared with the results obtained in this study.

The results obtained on the concentration and determination of metals in the groundwater samples assessed in this current study is synonymous with the report of the study conducted by Oyeku and Eludoyin (2010), on the possibility of groundwater pollution due to the influence of the landfill dumpsite in Ojota, Lagos state. These authors reported higher concentrations of Fe, Pb and Cd in their study compared to the levels detected in this current study. Remarkably, the current situation in the study area has been reported by many authors (Sunnudo-Wilhelmy and Gill, 1999; Egwari and Aboaba, 2002; Lu, 2004; Afolayan *et al*. 2012) as a result of the siting of groundwater sources in areas where indiscriminate waste disposal is rampant which would inevitably lead to groundwater contamination.

Table 3: Descriptive Statistics of Metal Concentrations in Groundwater Samples

Parameters	Range	Mean	Standard Deviation
Ph	0.83	8.06	0.29651
Cd	0.2	0.1833	0.09832
Pb	0.087	0.0718	0.03544
Zn	0.083	0.0695	0.02889
SO_4	1.15	0.2403	0.45534
NO_3	0.7	1.051	0.383406

Bacteriological Analysis

The bacteriological characteristics of the samples tested are as reported in Table 4. It can be seen in Table 4 that the highest average total count of bacteria detected in all the water samples that were bacteriologically assessed occurs in W3 (12.2.4 x 10^1 CFU/ml), while the lowest average total count recorded can be seen in B3 (9.6 x 10^1 CFU/ml). It can be said that these ground water sources are not potable enough for human as the presence of bacterial counts have negated the zero bacterial count recommended by WHO. However, these results when subjected to statistical analysis revealed that the bacterial counts are not significant ($P > 0.5$). The variance is higher than WHO recommended limit which further confirms bacteriological pollution, not limited to human sources and coming perhaps from the remains of dead animals or even a grave yard near the landfill site.

The results obtained in this study are in concord with the report submitted by Akinbile (2006); Omofonmwan and Esigbe (2009) which concluded that the disposal of faecal materials to the public disposal systems (landfill) end up polluting groundwater sources. Lack of functional sewage systems in most parts of Dutse tends to be responsible for the presence of faecal pollutants in the sampled ground water sources as all waste products get dumped on the landfill site. These results showed that all the six (6) samples do not satisfy the WHO requirements stipulated for the portability of water fit for human consumption. The results obtained in this current study are in accordance with the submissions of Adeyemo *et al.* (2002); Chukwu (2008) regarding groundwater pollution due to leachate emanating from abattoir waste dump-site close to their respective study areas in Ibadan, Oyo state and Minna, Niger state in Nigeria respectively. The WHO and NSDWQ standards of 1 and 10 in 100 CFU/ml for other coliforms respectively, have been surpassed by all the water samples analysed as they all recorded over 1/100 CFU/ml (Table 4).

Table 4: Total bacterial counts in sampled bore-hole and hand-dug well water

Sample	Dilution Factor	Total Count (CFU/ml)	Average Total Count (CFU/ml)
B1	10^{-1}	173×10^{-1}	10.9×10^{2}
	10^{-2}	140×10^{-2}	
	10^{-3}	88×10^{-3}	
	10^{-4}	36×10^{-4}	
B2	10^{-1}	178×10^{-1}	11.0×10^{1}
	10^{-2}	144×10^{-2}	
	10^{-3}	78×10^{-3}	
	10^{-4}	40×10^{-4}	
B3	10^{-1}	166×10^{-1}	9.6×10^{1}
	10^{-2}	128×10^{-2}	
	10^{-3}	62×10^{-3}	
	10^{-4}	30×10^{-4}	
W1	10^{-1}	184×10^{-1}	12.0×10^{1}
	10^{-2}	152×10^{-2}	
	10^{-3}	100×10^{-3}	
	10^{-4}	44×10^{-4}	
W2	10^{-1}	188×10^{-1}	11.4×10^{1}
	10^{-2}	156×10^{-2}	
	10^{-3}	74×10^{-3}	
	10^{-4}	38×10^{-4}	
W3	10^{-1}	190×10^{-1}	12.2×10^{1}
	10^{-2}	154×10^{-2}	
	10^{-3}	100×10^{-3}	
	10^{-4}	44×10^{-4}	

Conclusion

The results obtained from the laboratory analyses of selected groundwater samples around the landfill site indicated that metals, faecal microorganisms and other contaminants from the landfill leachate have impaired the water quality. The concentrations of metals (Fe, Cd, Zn, SO_4 and NO_3) and bacteriological contamination coupled with other water quality parameters in some of the sampling locations slightly exceeded the WHO and NSDWQ acceptable limits.

Recommendations

In other to control groundwater vulnerability to pollution through landfills, there is need for adequate and proper planning, design, construction, and strategic disposal of waste. Un-engineered landfill sites or dumpsites need to be outlawed and provision of modern sanitary landfill sites should be provided to ameliorate and alleviate possible groundwater pollution.

Detailed analysis of hydrogeology and groundwater flow direction in the area is highly required to safeguard the exploration and exploitation of groundwater. Government agencies such as Jigawa State Environmental Protection Agency (JISEPA) and all other relevant stakeholders should engage in more research studies to monitor contaminant levels and plan mitigation strategies with a view to forestalling impending public health crisis that may arise from uncontrolled groundwater pollution. There is equally also a need for public awareness about the specific purpose of which the groundwater in the study area can be used for and incase of domestic use, necessary purification methods should be applied to avert public health crisis.

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