Open Access
Asian Open Waste Management & Technology Journal
Vol. 1, No. 1, November 2015, pp. 1-9
Available online at http://www.astecrp.com/Journals.php

Research article

EFFECT OF SOLID WASTE DISPOSAL ON GROUNDWATER QUALITY IN MAKURDI URBAN AREA OF BENUE STATE, NIGERIA.

Edward Tersee and [1]Ogwuche Jonathan Ali

Department of Geography, Benue State University, Makurdi, Nigeria.

1 Corresponding Author: E-Mail Address: ogwuche.jonathan@yahoo.com

Abstract

Man's unguided development and ineffective waste management, especially in urban centres of Nigeria, as well as other developing countries, results in a degraded urban environment and underground water quality, with impact on human health and livelihoods. This study assessed the effect of solid waste disposal on ground water quality in Makurdi urban area of Benue State, Nigeria. Using water samples collected during the raining and dry seasons from a sample of 20 wells, with 10 each located near waste dump sites and 10 far away from solid waste dump sites (to serve as control), 12 physico-chemical and ion parameters were assessed, and evaluated against the WHO International Standard for drinking water 2011. The results obtained show that PH, sulphate and copper fall within the acceptable limits, while Total Dissolved Solids, nitrate, Total Hardness, sodium, Iron II, manganese and chloride are above the limits. This means that the groundwater there contains salt water and heavy metals with health implications, as water-related diseases constitute 100 percent of the total burden of diseases in the area, as obtained from hospital records. Proximity to waste dumpsite was found to be a major factor in the variation of water quality there. Therefore, for a sustainable utilization and protection of groundwater in the area, this study recommends the adoption of key measures such as identification and mapping of pollution sources, development of vulnerability maps, integrated pollution prevention and control strategies, and establishment of environmental protection zones.

Keywords: Solid waste, groundwater, water quality parameters, waste dumpsites, water-related diseases, water pollution and contamination.

Introduction

Solid waste means so much to so many people, and have been variably defined. To NISP (2003), it means any unavoidable material resulting from an activity which has no immediate economic value and which ought to be disposed of. By extension, Okecha (2000) sees it as a bye-product of process lines or material that may be regarded as, by law, to be disposed of; and further classifies it into three - environmental risk, utility, and physical properties - based on sources.

In urban areas, classes of wastes are generated from the varied industrial, household, economic and other human activities that characterize the urban environment. The extent to which the municipal authorities responsible for waste collection and disposal rise up to match with the rate of generation underlies the effectiveness of waste management system. However, these wastes when indiscriminately disposed, give rise to a number of environmental problems, notably among which is the seepage of waste waters from the dumpsites to water bodies. This would result in water pollution, which Murphy (2012), claims occurs when pollutants are discharged directly into water bodies without adequate treatment to remove harmful compounds. This water pollution affects plants and organisms living in these water bodies, together with their individual species and population, and by extension, the natural biological communities.

In nature, water occurs on the surface and sub-surface, normally called surface and groundwater respectively. Groundwater is the body of water which occupies the earth's mantle, and which forms the sub-surface section of the hydrological cycle (Dictionary of Environmental Science 2010). This ground water occurs in saturated water-bearing strata called the aquifer, with the surface known as the water table (Areola, Mamman, Onweluze, and Omotosho 1999). According to UMCE (2007), groundwater moves slowly from areas of higher elevation to areas of lower elevation. The volume of groundwater in an area changes seasonally and varies from year to year, depending on the amount of precipitation and how water is removed by plants.

Ground water pollution or contamination is many and varied. Pollution by disease-causing micro-organisms occur when human and animal wastes containing virus, bacteria and parasites come in contact with groundwater. Also, chemical pollutants can leach into groundwater from a variety of sources, including hazardous waste dumps, sewage, injection wells, indiscriminate solid waste disposal and percolation of pesticide on land.

Groundwater is assessed through boreholes and hand-dug wells, and is extremely important to most societies. According to USGS (2007), it provides a reliable and simple supply of water for home use, irrigation, and industries where surface water is scarce, such as in deserts. Urban and rural communities have frequently explored hand-dug wells to provide water for individual, household and commercial uses.

The quality of water indicates the chemical, physical, biological and radiological characteristics of water (Nancy 2009). It is a measure of the condition of water relative to the requirement of one or more biotic species and or to human needs or purposes (Johnson *et al* 1997). The most acceptable standard used to access water quality is that which relate to the health of ecosystems, safety of human contact and drinking water. In the setting of standards, agencies make political and technical/scientific decisions about how water will be used (Washington, D.C. 2006).

In the case of natural water bodies, they also make use of some reasonable estimate of pristine conditions, i.e the quality varies in response to environmental conditions. This means that different water users raise different concerns, and therefore sets different standards. Assessment of groundwater pollution potentials is an essential step towards providing better understanding of the actions required to protect effectively its quality against degradation and to ensure sustainable water resources development (Dimitriou *et al* 2008). Researches have shown that groundwater pollution is generally as a function of the interaction between the aquifer vulnerability and the pollution loading (Morris *et al* 2003, WHO 2006). It is against this backdrop that this study is focused on Makurdi urban area where hand-dug wells dominate due to high water table, with its susceptibility to contamination.

Statement of the research problem

In spite of all the efforts of governments (Federal, Benue State and Makurdi Local Government) to ensure a healthy population, maintain a clean environment, and constantly supply portable water in Makurdi (the state capital of Benue State), there exists a plethora of social, environmental and infrastructural (water) problems. A careful observation in the study area seems to indicate incidences and persistence of water-related illnesses, indiscriminate disposal of wastes, and high water demand by the increasing population and socioeconomic activities in the urban area. The fear is that this situation may escalate more during the dry season, when well water is heavily relied on for all households and commercial activities.

Study area

Makurdi, the Benue State capital, is located between latitudes $7^o 35^1$ and $7^o 53^1$N and longitudes $8^0 24^1$ and $8^0 42^1$ E. The urban area is traversed by the River Benue, which divides it into two – Makurdi North and South. (see fig 1). The geology of Makurdi is principally of sedimentary formation with pockets of basement complex. This is made up of sandstones, mudstone, and limestone that influence both surface and groundwater availability. Climatic fluctuations have been a strong influence on the availability of water in the State.

Open Access
Asian Open Waste Management & Technology Journal
Vol. 1, No. 1, November 2015, pp. 1-9
Available online at http://www.astecrp.com/Journals.php

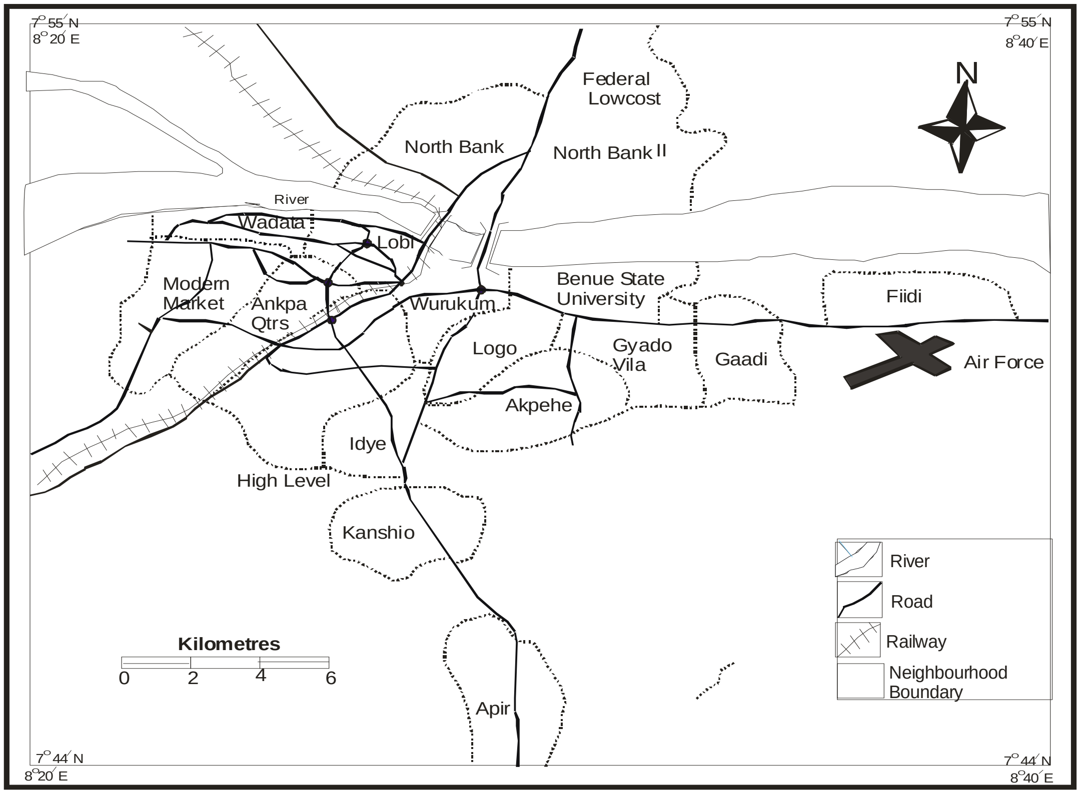

Figure 1: Map of Makurdi Town.

Methods

The research design adopted in this study is the field survey and experimental. In this study, the population of study involved two sets of wells – those close to solid waste dumpsites and those far from the dumpsites. A sample of 10 wells located near solid waste dump sites and 10 located far away were randomly selected. The later served as control.

The field surveys were conducted in the two seasons -wet and dry seasons to obtain the minimum and maximum values of water quality. The first took place between July and August 2014, while the second was undertaken between October and November 2014. In each case water samples were collected from each of the sampled wells and analysed for compositional characteristics, notably physico-chemical and ion parameters of pH, turbidity, Total Dissolved Solids (TDS), Chlorine, Nitrate, Sulphate, Total Hardness, Sodium, Iron II, Manganese, Copper and Calcium. The results are evaluated against the WHO International Standard for drinking water 2011.

Data collected were subjected to two statistical tests. First, is the test of the effect of solid waste on groundwater quality, using Chi-square; and the second is the test of significant difference between water parameters with respect to proximity to solid waste dumpsite using Analysis of Variance (ANOVA).

Open Access
Asian Open Waste Management & Technology Journal
Vol. 1, No. 1, November 2015, pp. 1-9
Available online at http://www.astecrp.com/Journals.php

Results and Discussions

Table 1: Results of the Physio-Chemical Parameters of Water Sample From Well Near and Far Away From Solid Waste Dump Sites in Makurdi Urban Area

Parameters	Proximity	To SWD	Non	Proximity	WHO STD	STATUS
	X (Min)	Y (Max)	X(Min)	Y(Min)		
pH	6.20	7.70	5.53	7.80	6.5 - 8.5	Normal
Turbidity	5.00	28.00	3.00	29.00	5	Above
Total Dissolved Solid	74.75	1221.70	79.00	1506.00	600	Above
Chloride	90	420	41.45	346.00	200.- 250	Above
Nitrate	9.50	81.00	6.64	68.00	50	Above
Sulphate	53.00	390.00	21.00	316.00	500	Normal
Total Hardness	152.00	790.00	26.45	375.00	200	Above
Sodium	27.00	491.00	13.00	368.00	200	Above
Iron II	0.00	2.33	103.00	727.00	0.3	Above
Manganese	0.00	1.15	0.00	2.48	0.4	Above
Copper	0.00	2.09	0.00	1.05	2	Normal

Source: Chemistry Department Lab, Benue State University, 2015.

From the table above, the following parameters ranked normal when compared with WHO 2011 standards – pH, Sulphate, and Copper. The rest were above the limits. There are also variations in the values of the concentrations of well water close to solid waste dumpsites and those not close. These variations were likely caused by a number of factors such as rain water infiltration and dilution effects, the influx of contaminants from natural and anthropogenic activities like percolation of solid waste leachates and other land-uses.

Table 2 shows the Chi-square table for the test of significant difference between the quality of water in wells close to solid waste dumpsites and those far away from dumpsites.

TABLE 2: Chi-square Table.

S/No	Observed (O)	Expected (E)	O – E	$(O – E)^2$
1	6.67	107.69	- 100.72	10144.52
2	525.5	107.69	417.86	174.61
3	12.00	107.69	- 95.69	9156.58
4	212.5	107.69	104.83	10989.33
5	150.0	107.69	42.33	1791.83
6	33.50	107.69	- 74.17	5501.19
7	213.0	107.69	105.33	11094.41
8	34.0	107.69	- 73.69	5430.22
9	103.5	107.69	- 4.17	17.39
10	0.75	107.69	- 106.94	11436.16
11	0.64	107.69	107.05	11459.70
12	0.41	107.69	- 107.28	11491.84
Total		**1292.28**		**88687.63**

x^2 calculated = 88687.63/1292.28 = 68.63

Degrees of freedom = N – 1 = 12 – 1 = 11

Table value = 19.675 at 0.05 level of significance.

Decision: Since the calculated value is greater than the table value, the null hypothesis is rejected and the alternate hypothesis that there is significant relationship between solid waste and ground water quality is accepted.

In an effort to link the likely influence of the leachate from solid waste dumpsites, hospital records of 100 patients resident in Makurdi, at the Federal Medical Centre were randomly selected and 80 of them contained records of patients with water-related illnesses. These illnesses are presented in table 3 below:

Table 3: Water-related Illnesses From Hospital Records

Water-related disease	Frequency	Percentage
Cholera	22	27.5
Typhoid	28	35
Skin disease	4	17.5
Diarrhea	16	20
TOTAL	80	100

Source: Federal Medical Centre, Makurdi, 2015.

From table 3 above, it is observed that water (notably well water) has significant effect on the health of the residents of Makurdi, as 100 percent of the total burden of illnesses the residents suffer from are water-related, with typhoid as the highest (35%). This study shows some significant levels of contamination in different parts of Makurdi metropolis. These constitute health challenges, as residents consume the water containing salt water (from chloride) and heavy metals (from iron II and manganese). This result is corroborated by Adejo *et al* (2007), Ocheri and Mile (2010), and Ocheri, Mile and Obeta (2010) in earlier studies on the quality of water from underground sources such as boreholes and hand dug-wells in Makurdi metropolis.

A further test was carried out to determine if proximity to solid waste dumpsites was a major factor in the variation of underground water quality. The ANOVA result is shown in table 4.

TABLE 4: ANOVA RESULT

S/No	Parameter	F	Sig.	Decision
1	pH	1.00	0.609	Ho is rejected
2	Turbidity	395.351	0.003	Ho is rejected
3	TDS	0.0497	0.749	Ho is accepted
4	Chlorine	0.343	0.814	Ho is accepted
5	Nitrate	3317.9	0.00	Ho is rejected
6	Sulphate	0.679	0.595	Ho is rejected
7	Total hardness	0.131	0.884	Ho is accepted
8	Sodium	0.459	0.764	Ho is accepted
9	Iron II	2095.85	0.00	Ho is rejected
10	Manganese	0.346	0.812	Ho is accepted
11	Copper	0.030	0.971	Ho is accepted
12	Calcium	0.133	0.739	Ho is accepted

From table 4, it is observed that there is a significant difference in the parameters of pH, Turbidity, Nitrate, Sulphate, Iron II, with respect to proximity to the solid waste dumpsites (based on F > sig.). Conversely, there are no significant differences in the parameters of Total Dissolved Solids, Chlorine, Total Hardness, Sodium, Manganese, Copper and Calcium (based in F < sig.).

The study also shows that there is a significant relationship between solid waste and groundwater quality. Of the 12 assessed water quality parameters, only 5 shows no significant differences in the parameters with respect to proximity to solid waste dumpsites, whereas 7 show significant differences. Therefore distance is a major factor in the variation of water quality. This agrees with studies of Elhatip (2003), Efe (2005), Muhammed (2012) and Akotoyinbo (2013). This clearly shows that ground water has ceased to be the purest source of world's liquid fresh water, more so as the natural capacity of soil to remove pollutants is limited and varies from place to place as well as with the activities taking place on the ground surface (land use), intrinsic physical and chemical characteristics of the human activities and animals that release pathogens into the environment (WHO 2006, Buyofaky 2006, Odoma 2006). Also, the type and concentration of natural impurities found in ground water depend on the geological material through which water moves, the quality of ground water that recharges it, and the rate of recharge (Odoma 2006). According to her, other factors that give rise to natural impurities include the soil that ground water filters through under the force of gravity. For instance, fine textured soils like clay, loams or silt, present low risk of groundwater contamination, whereas coarse textured soils like sand, sandy loam and gravel present very high risk. The result of this study agrees with Ifabiyi (2008), who found out that wells downhill from a polluting source (such as a solid waste dumpsite) have a higher risk of contamination compared to wells that are upslope from all polluting sources. Other studies, such as Efe (2005) and Omotoyinbo (2007) discovered that wells closer to polluting sources have a higher risk of contamination compared to wells that are further away.

CONCLUSION AND RECOMMENDATION

Results obtained from this study have shown that the following assessed underground water quality parameters – pH, Sulphate and Copper - fall within the acceptable limits of the World Health Organisation, while Total Dissolved Solids, Nitrate, Total Hardness, Sodium, Iron II, Manganese and Chlorine are above the limits with high concentrations. This means that the water contains salt water (from chloride) and heavy metals (from iron II and manganese), with health implications, as water-related illnesses constitute 100 percent of the total burden of diseases in the area. The study also shows that there is a significant relationship between solid waste and groundwater quality. Distance is a major factor in the variation of water quality. This study, therefore, recommends a ground water management strategy in Makurdi metropolis as an important step towards utilization and protection of groundwater in the area. This can be achieved through the adoption of key measures such as identification and mapping of pollution sources, development of vulnerability maps, integrated pollution prevention and control strategies, and establishment of environmental protection zones.

REFRENCES

[1] Adejo, S. O, Aboho S. Y and Ekele O. A (2007) Water Quality Assessment: A Case Study of the Federal Low cost housing Estate, North Bank, Makurdi, Benue State. The Benue State Valley Journal of Interdisciplinary Studies, Benue State University, Makurdi, Nigeria Vol 6 Pp 10 – 22

[2] Akotoyimbo I. S (2013) Evaluation of GROUNDWATER QUALITY using Quality Indices in parts of Lagos, Nigeria. Journal of Environmental Geography, Vol 6, Issue 1 – 2, Pp 29 – 39

[3] Buyofsky I. A (2006) Relationships Between Groundwater Quality and Landscape Characteristics in the Lamprey Watershed. Unpublished M.Sc. Thesis, University of New Hampshire, United States of America

[4] Dimitriou et al (2008) Ground Water Risk Assessor at a Heavily Industrialized Catchment and the Associated impacts in a Peri-Urban Wetland. Journal of Environmental Management, 88, Pp 526 – 538

[5] Echatip H, Atsin M, Kuseu I and Kavurma M. (2003) Influences of Human Activities and Agriculture on Groundwater Quality. Kayseri-Incesu-Docuzpinar Spings, Center Part of Turkey, Environmental Geography, 4 Pp 490 - 494

[6] Efe S. I (2005) Quality of Water from Hand-dug Wells in Onitsha Metropolitan Areas of Nigeria. The Environmentalist, Vol 25, Pp 5 – 12

[7] Ifabiyi I. P (2008) Department of Hand-dug Wells and Water Chemistry: Examples from Ibadan North East L.G.A, Oyo State, Nigeria. Journal of Social Sciences. Vol 17, Pp 261 – 266

[8] Johnson P, Lambert M, Saw A and Winter-Nelson E (1997) Meaning of Environmental Terms. Journal of Environmental Quality

[9] Morris B. L. et al (2003) Ground Water and its Susceptibility to Degradation: A Global Assessment of the Problem and Option for Management. Early Warning and Assessment Report Series, RS 03 – 3, Kenya UNEP

[10] Muhammed M. M (2012) Assessment by Ground Wet Quality in Low Income High Density Areas of Kaduna Metropolis. Academic Research International. Vol 2, No 1, Pp 183 – 190

[11] Murphy (2012) Environment Risk Management

[12] Nancy (2009) Water Quality: Frequently asked Questions. Florida Brooks National Marine Sanctuary, Key West, Florida.

[13] NISP (2003) Contractor Employer, HSE Training Manual, level 3, ECWEC Ltd, Port-Harcourt, Nigeria.

[14] Ocheri M. I and Mile I (2010) Spatial and Temporal Variation in Groundwater Quality in Makurdi Sedimentary Formation, Nigeria. Journal of Geography, Environment and Place Vol 6, No 1, Pp 141

[15] Ocheri M. I, Mile I and Obata M. C (2010) "Seasonal Variation in Nitrate Level in Hand-dug Wells in Makurdi Metropolis" Pakistan Journal of Nutrition, Vol 9, No, Pp 141 – 146.

[16] Odoma A. L (2013) An Assessment of Underground Water Quality in Lokoja Town, Kogi State. Unpublished M.Sc. Dissertation, Department of Geography, Benue State University, Makurdi, Nigeria.

[17] Omotoyinbo O. S (2007) Determination of the Level of Contamination of Underground Water (hand-dug well) by Organic Waste: A Case Study of Ado-Ekiti, Nigeria. Ethiopian Journal of Education and Sciences, Vol 3, Pp 43 – 50

[18] UMCE (2007) Water Quality of Hand- dug Wells for Drinking

[19] USAS (2007) Science for Changing World: Groundwater Well

[20] Washington D. C (2006) Water Quality Standard

[21] WHO (2006) Guidelines for Drinking Water Quality. WHO Press, Geneva, Switzerland

[22] WHO (2011) Guidelines for Drinking Water Quality, 4th Edition. WHO Press, Geneva, Switzerland