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Assessment Of The Effects Of Solid Waste Disposal On Ground Water Quality In Selected Tubewells And Boreholes In Kano Metropolis North West Nigeria.

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Abstract: *This work assesses the effects of solid waste disposal on ground water quality in selected boreholes and tube wells in Kano metropolis North West Nigeria. The methodology involved the collection of water samples from tube wells and boreholes located within the vicinity of waste dump sites at Sharada, Gyadi-gyadi, Maimalari and hajj camp. Control points were selected 8km away from the dumpsites. Samples collected were analyzed for their physical, chemical and biological properties. The quality parameters varied as follows: Electrical conductivity varied from 126-149 uS/cm , Total Dissolved Solids (TDS) from 410-600 mg/L and Total Suspended Solids (TSS) from 16.4-18.2 mg/L. Temperature varied from 26.0–28.0 ^{0}C, pH varied from 6.40–7.00, and Dissolved Oxygen (DO) varied from 4.80–5.40 mg/L.TSS varied from 11.0–18.2 mg/L. Total coli form counts varied from 0.40–0.80 MPN. The levels of BOD, total coli form counts and most of the mineral constituents exceeded WHO acceptable limits. Percolations and infiltrations from these dumpsites affected the groundwater qualities of the selected boreholes and tube wells. Wastes should be treated before disposal or converted to useful green energy.*

Keywords: *Bore hole, Tube well, Dump site, Ground water, Point, Leachate.*

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I. Introduction

Every human activity generates waste. Waste is defined as some materials discarded after use or as moveable materials that are perceived to be of no further use, (Turk, 1980). Solid waste when mixed with water turns to sewage, which is capable of infiltrating underground water resources by way of leachates and seepages. It may be characterized by volume, physical properties, chemical make-ups and bacteriological organisms.

Many contaminants have been identified in groundwater accessed in different parts of Nigeria (Okoli et al., 2005). Some of these contaminants arise from chemical components resulting from progressive breakdown and leaching of wastes from surface and subsurface origins (Ogbonna *et al*., 2008). Liquid waste can also gain entrance into groundwater receptacles through open dump sites that are not standard landfills (Domerska et al, 2005).

Organic and microbiological constituents of sewage can cause changes in the soil and introduce pathogens into groundwater (UNEP, 2008). Contamination of the soil with untreated sewage is a big problem in Nigeria as these can have a long term effect on groundwater quality. Proper waste disposal has become imperative in most cities of Nigeria.

Recent studies have also revealed that waste dumpsites can transfer significant amounts of toxic and persistent metals into the soil environment (Gurnnadha *et al*., 2011). Eventually these metals are taken up by humans and get incorporated into the food chain (Erah *et al*., 2002). The presence and levels of heavy metals, and other physicochemical constituents in sewage are encouraged by anthropogenic activities like indiscriminate dumping of waste and unprofessional waste treatment processes.

The United Nations Environmental Programme (UNEP, 2006**)** observed that in the past two or three decades, rapid urbanization across Africa has led to the growth of large areas of unplanned sub-standard housing in most cities and those residents of such cities or areas usually resort to groundwater as a source of inexpensive, quality domestic water supply. The study further revealed that the uncontrolled expansion of this kind of housing together with sewage leakage, indiscriminate waste disposal and uncontrolled industrial and commercial activities all led to the increasing pollution and deteriorating quality of groundwater and mounting public health problems. Since this emergent African urban scenario is characteristic of most cities in Nigeria today, there is the need to characterize groundwater quality at locations such as gyadi-gyadi, dala, maimalari and hajj camp of Kano metropolis, where waste dump sites are located. This study assessed the effects of solid waste disposal on ground water quality in selected boreholes and tube wells in Kano metropolis Nigeria.

II. Materials And Methods

Study Area: Gyadi-gyadi, maimalari, dala and hajj camp are all located within Kano metropolis. Kano is the primate city of northern Nigeria. It is located on latitude 12^0 03'N and longitude 8^0 32'E and is 1,549ft above sea level. The climate is essentially Sudan savannah. The temperature is warm to hot throughout the period between November - February. The mean annual rainfall is about 800mm. Only four months (June-September) are actually wet (Turaki, 1982). The waste dump sites receive waste from homes and Refuse management and sanitation board (REMASAB)..

Samples collection: Samples were collected from four (4) monitoring boreholes and four (4) tube wells located within the selected waste disposal sites. Also, one control borehole and tube well samples located about 8 km away from the waste disposal sites were collected. Borehole/tube well water samples were collected according to the method earlier described in 250 ml plastic containers from the eight sampling boreholes and tube wells and were identified as BH1, BH2, BH3, BH4, TW1, TW2, TW3, TW4 and BHC, TWC. Samples for Biological Oxygen Demand (BOD) determination were collected in 250 ml brown (BOD) bottles. Water samples for heavy metals 30 ml plastic containers and fixed with concentrated HNO_3 were further acidified to pH 2 or lower with 1 ml conc. HCl/80g and transported to the laboratory in an ice container. Samples for other physic-chemical properties were collected with 500 ml analytical bottles and taken to the laboratory for analysis.

Water analyses: The Horiba U-10 water quality checker was used to determine pH, water temperature, dissolved oxygen and conductivity. The meter was pre-calibrated with the standard phthalate calibration solution and the desired physicochemical parameter read off the LCD of the meter. Total Dissolved Solids (TDS) was also determined electrometrically with HACH conductivity meter (Model CO150) with an inbuilt automatic TDS and values were read off directly in mg/L from the LCD display screen.

Heavy metal concentrations were determined with the use of Atomic Absorption Spectrophotometer (AAS), (Varian Spectra AA 600) after digestion.

BOD was determined after five days incubation period at 20 +/- 1^0C with same HORIBA U-10 water quality checker.

Calculation:

$$BOD5\ (mg/l) = \frac{D1 - D2}{P}$$

Where, D1 is Dissolved Oxygen (DO) of the dilution sample 15 minutes after preparation. D2 is Dissolved Oxygen (DO) of the dilution sample after incubation period of 5 days and P, decimal fraction of sample used. Serial dilution procedure was employed for cultivation and enumeration of coli form bacteria, in accordance with standard methods. 1.0 ml of water sample was mixed with 9.0 ml of sterile distilled water from where serial dilution was made up to 10-3 dilution. Appropriate volumes of undiluted samples were inoculated into test tubes of suitable liquid medium. All inoculated media were incubated at 37 ^{0}C for 24 hours. Enumeration of total coli form bacteria was carried out by the most probable number (MPN) method.

Data analysis: MS Excel 2007 was used to analyze the data generated from the study. Specifically, comparative analysis was used to establish variation within the samples collected. The results of the analysis were compared with WHO (World health organization) standard for drinking water.

III. Results And Discussion

The levels of the groundwater physicochemical characteristics and mineral constituents measured across the ten sampled points are shown in tables 1, 2, 3 and 4.

Table 1: Results of analysis of the physicochemical characteristics of borehole Samples collected from the selected dump sites.

Parameters	BH 1	BH 2	BH 3	BH 4	BHC	WHO
Temp (^{0}C)	27.00	27.0	27.20	27.0	26.0	NS
pH	6.40	6.60	6.50	6.80	6.9	6.5-8.5
DO (mg/L)	5.20	5.00	5.40	5.30	7.00	7.5
BOD (mg/L)	12.0	12.80	12.40	14.20	21	20-25
EC (µS/cm)	125.0	130.0	124.0	240.0	370.0	150-700
COD (mg/L)	2.10	4.00	3.90	3.20	5.20	NS
TDS (mg/L)	280.0	286.0	282.0	400.0	1340.0	1500
T. coli. (MPN)	0.80	0.50	0.50	0.40	0.90	1
TSS (mg/L)	15.0	15.0	13.4	11.0	25.0	25

BH1-BH4= Monitored boreholes, BHC = Control borehole, NS = Not specified
WHO = World health organization.

Table 2: Results of analysis of the mineral constituents of borehole samples collected from the selected dump sites.

Parameters	BH1	BH2	BH3	BH4	BHC	WHO
SO_4 (mg/L)	360	385	380	370	400	400
NO_3 (mg/L)	0.49	0.42	0.46	0.45	0.49	0.50
PO_4 (mg/L)	7.4	6.6	8.0	7.0	9.8	10.0
Ca (mg/L)	90	86	98	126	200	200
Mg (mg/L)	0.40	0.42	0.45	0.40	0.50	NS
K (mg/L)	5.0	5.0	4.98	4.8	5.0	5.0
Cl (mg/L)	8.0	7.6	7.4	8.0	8.4	‹ 10
CO_3	410	420	415	425	498	500
Fe (mg/L)	2.00	2.10	2.00	2.20	0.98	1.0
Pb (mg/L)	0.003	0.003	0.0025	0.003	0.002	0.002
Ag (mg/L)	0.54	0.53	0.61	0.52	0.480	0.5
Cr (mg/L)	0.06	0.08	0.08	0.06	0.049	0.05
Ni (mg/L)	0.065	0.06	0.078	0.07	0.05	0.05

BH1-BH4= Monitored boreholes, BHC = Control borehole, NS = Not specified
WHO = World health organization.

Table 3: Results of analysis of the physicochemical characteristics of tube well Samples collected from the selected dump sites.

Parameters	TW 1	TW 2	TW 3	TW4	TWC	W
Temp. (^{0}C)	27.00	27.0	28.0	28.0	28.0	NS
pH	6.80	6.50	6.60	7.00	6.90	6.5-8.5
DO (mg/L)	5.00	5.40	4.80	4.80	7.30	7.5
BOD (mg/L)	16.4	16.50	16.40	16.90	23.0	20-25
EC (µS/cm)	129.0	133.0	126.0	149.0	390.0	150-700
COD (mg/L)	3.10	4.20	3.90	3.70	5.20	NS
TDS (mg/L)	410.0	470.0	520.0	600.0	1340.0	1500
T. coli. (MPN)	0.80	0.50	0.40	0.70	1.00	1
TSS (mg/L)	18.0	18.2	17.4	16.4	25.0	25

TW1-TW4= Monitored Tube wells, TWC = Control tube well, NS = Not specified
WHO = World health organization.

Table 4: Results of analysis of the mineral constituents of borehole samples collected from the selected dump sites.

Parameters	TW1	TW2	TW3	TW4	TWC	WHO
$S0_4$ (mg/L)	350	345	330	390	400	400
$N0_3$ (mg/L)	0.47	0.41	0.48	0.45	0.49	0.50
$P0_4$ (mg/L)	8.4	7.6	8.2	7.8	9.8	10.0
Ca (mg/L)	110	96	92	136	200	200
Mg (mg/L)	0.50	0.48	0.46	0.44	0.50	NS
K (mg/L)	4.30	4.60	4.82	4.80	5.0	5.0
Cl (mg/L)	8.2	7.8	7.8	8.3	8.4	‹ 10
$CO_{3\,(mg/L)}$	430	410	425	445	499	500
Fe (mg/L)	0.50	0.70	0.65	0.64	0.98	1.0
Pb (mg/L)	0.003	0.003	0.0025	0.003	0.002	0.002
Ag (mg/L)	0.54	0.53	0.61	0.52	0.480	0.5
Cr (mg/L)	0.06	0.08	0.08	0.06	0.049	0.05
Ni (mg/L)	0.065	0.06	0.078	0.07	0.05	0.05

TW1-TW4= Monitored Tube wells, TWC = Control tube well, NS = Not specified
WHO = World health organization.

Results show differences in the levels of electrical conductivity varied from 126-149 uS/cm , Total Dissolved Solids (TDS) from 410-600 mg/L and Total Suspended Solids (TSS) from 16.4-18.2 mg/L. Temperature varied from 26.0–28.0 ^{0}C, pH varied from 6.40–7.00, and Dissolved Oxygen (DO) varied from 4.80–5.40 mg/L.TSS varied from 11.0–18.2 mg/L. Total coli form counts varied from 0.40–0.80 MPN. Calcium varied from 86-136 mg/L, Sulphate 330-390 mg/L, Nitrate 0.41-0.49 Mg/L, Phosphate 6.6-8.4 Mg/L, Magnesium 0.40-0.50 Mg/L, Potassium 4.3-5.0 mg/L, Chloride 7.8-8.3 mg/L, Bicarbonate 410-445 mg/L , Iron

0.5-2.2mg/L , Lead 0.002-0.003 mg/L, silver 0.52-0.62 mg/L, chromium 0.06-0.08 mg/L and Nickel 0.06-0.78 mg/L. Water pollution is any damage to the quality of water that reduces its fitness for a specific purpose such as drinking, agriculture, laundry etc. Accordingly, Sharaf (2010) stated that even when water is unsuitable for a purpose; it could still be useful for another. Sewage systems are considered one of the biggest source of waste and pollutants discharge to the environment (Jumma et al., 2006). Subsequently, polluted water becomes the main vehicle for the prevalence of some serious diseases to humans. The health crisis in some cities has been exacerbated due to high rates of drinking water contaminated with sewage and high proportion of salt (Jumma, 2006). The wide variation observed in EC, TDS and TSS indicates high levels of both suspended and dissolved solid pollutants (many of which are electrically charged and so constituted conductivity) that infiltrated the groundwater aquifers from the surface, open dump origin. However, the narrow differences observed in the levels of the other contaminants in the aquifers could be related either to longer retention time and the pathway through which the water moves through the soil to the groundwater, or to the relatively trace availability of the pollutant species in the surface sewage source point of pollution.

The high values observed in the levels of contaminants such as BOD, total coli forms, PO, Cu, Fe, TSS, Cr and Ni over the World Health Organization (WHO) regulatory standards reflects high pollution loads from the dumpsites. BOD is the measure of the dissolved oxygen required by microorganisms in the biological oxidation of organic matter. It is a widely used indicator parameter of organic pollution of water and so, indicates the presence of large amounts of organic pollution. The high levels of heavy metals such as Ni, Cr and Fe could portend environmental hazards, as some of these heavy metals are carcinogenic in nature (Akhionbare, 2009). Heavy metals concentrations in gas streams are diverse and also dangerous to health and the environment. For example, Cu affects the kidney, while Ni and Cr affect the skin, bone, or teeth (Akhionbare, 2009).

Fe causes brownish coloration of groundwater, which renders it unfit for drinking. Faecal coliform bacteria can be found in water contaminated by domestic waste or other sources of human and animal wastes. The presence of total coliform over the WHO standard further reveals that the sewage dumpsite infiltrated and percolated groundwater. This could eventually lead to ill health conditions such as inflammation of the bowel wall and poisoning in worst cases, fever, acidity in the blood and effect on kidney as well (Al-Tairah, 20004). High TSS leads to high turbidity and could cause water to harbor pathogenic organisms. This is because colloidal materials provide adsorption site for chemicals that may be harmful to health or cause undesirable taste or odour to drinking water (APHA, 1998). High levels of PO_4^{2-} reflects elevated concentrations of leached organic materials from the sewage dumpsite which can increase the nutrient contents of the groundwater and so, could further alter the aquatic ecosystem by stimulating bacteria activities, and hence, the resultant depletion of DO.

This study also observed marked spatial difference in levels of the pollutants between the impacted and reference boreholes; indicating that the open dumpsite actually contributed significant amounts of the pollutants in the groundwater aquifers. The presence and concentrations of total coliforms in the boreholes corresponded with high BOD levels, and indicate faecal pollution. This form of pollution has been associated with the prevalence of such diseases as dysentery, cholera, salmonellosis, diarrhea, etc (Akhionbare, 2009)..

Temperature in this study meets the WHO (1998) limit for drinking water, though; Adekunle *et al*. (2007) reported a higher value of 29^0C in Abeokuta, Nigeria. Temperature is the most important parameter in aquatic environment, because almost all the physical, chemical and biochemical properties are governed by it (and it directly influences the amount of DO and other gases that are available to aquatic organisms).Temperature also has influence on water treatment and immunological evaluations (John de Zuane, 1997). The observed significant correlation in levels of the pollutants between the impacted and reference boreholes indicates relatedness in the aquifers of the study area sampled. There were wide variations in the levels of electrical conductivity, total dissolved solids and total suspended solids of the groundwater aquifers. The levels of biological oxygen demand, total coliforms counts, phosphate, copper and iron, as well as total suspended solids, chromium and nickel ions in ground waters exceeded the WHO maximum regulatory limits for drinking water. Variations were observed in the levels of the ground water quality between the selected boreholes/tube wells and control boreholes/tube wells. Total suspended solids, temperature and total dissolved solids contributed to the observed differences.

IV. Conclusion

This study revealed that the groundwater quality parameters within the waste disposal sites have been altered, sequel to infiltrations from the waste dump sites. Pollutants types included organic and inorganic, as well as biological species that migrated from the waste dump sites.

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