



Effect of Dumpsites on Underground Water in Wukari Metropolis

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Abstract

This study was conducted to determine the effect of dumpsite on underground water. The study was conducted in Wukari Local Government Area Taraba State. Water samples were collected from three wards namely; Hospital ward, Puje ward, and Avvi ward within Wukari metropolis and were analyzed at the Biological Science Laboratory Federal University Wukari, where the water samples were analysed to determine the physiochemical and bacteriological composition of the samples in order to ascertain the effect of dumpsite on underground water sources (borehole and well). The results showed that well water was significantly high in turbidity and phosphate while borehole water had low values of turbidity and phosphate. Well water was also observed to be significantly high in total dissolved solids acidity, alkalinity, total coliform, sulphate, temperature, while borehole water has significantly low values of total dissolved solids, acidity, alkalinity, total coliform, sulphate, temperature. The results on pH also showed a significant difference between borehole and well water. The study also reveal the presence of various bacterial species, including *Escherichia coli*, *Staphylococcus aureus*, and *Bacillus* spp. The total coliform count showed varying levels of contamination, with some samples exceeding acceptable limits, raising concerns about possible fecal contamination. Biochemical tests confirmed the presence of *Staphylococcus aureus* (found in dumpsite), known for its potential to cause waterborne diseases. *Bacillus subtilis* (found in Water), a bacterium associated with poor sanitary conditions, The bacteriological analysis revealed the presence of *Bacillus subtilis*, *Escherichia coli*, and *Staphylococcus aureus* as the predominant bacterial species in the sampled water. These results have shown that dumpsites have more effect on well water than borehole water hence borehole water is safer for consumption than well water.

Keywords: Dumpsite, Metropolis, Water, Wukari, Underground

Introduction

Municipal wastes management had become a main problem to many environmental protection agencies in Africa, and Nigeria in particular. With the growing human population and lack of effective waste management structures in Nigeria had encouraged indiscriminate disposal of solid wastes along the roadsides and lowlands (Ogbaran & Uguru, 2021). Open dumps as a method of waste disposal are the oldest and most common way of disposing solid wastes in most cities of developing nations (Al Sabahi *et al.*, 2009).

In major cities of Nigeria, the disposal of solid wastes within the last few decades have posed major environmental and public health issues as the majority of open dumpsites which were initially located on the outskirts are now within the heart of the

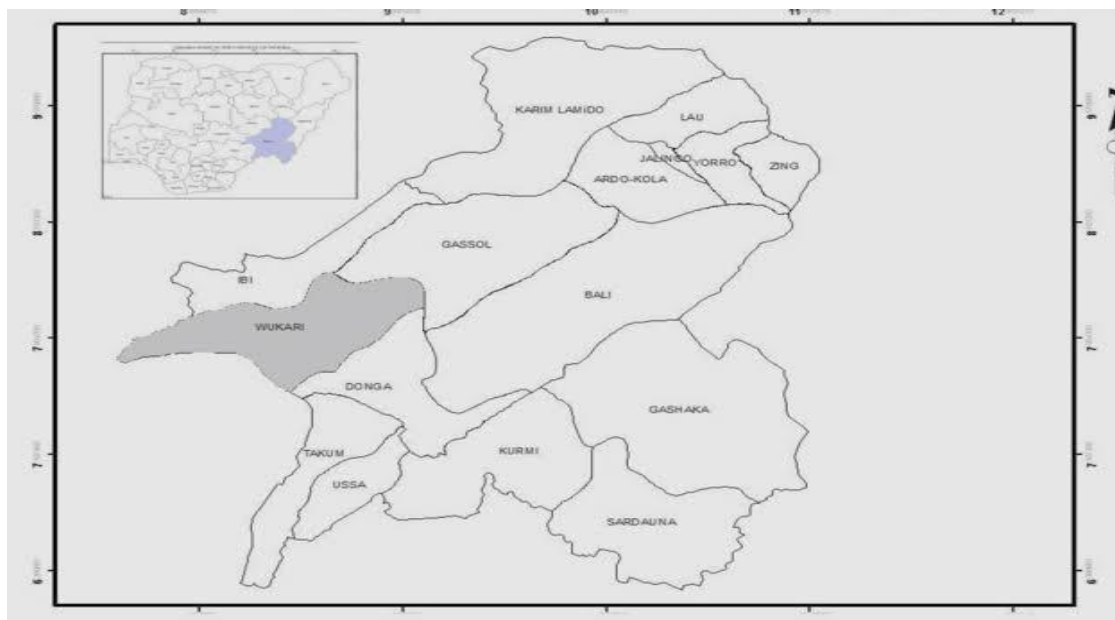
city as a result of urbanization and migration ((Lagos Waste Disposal Board, 2006). Solid waste management is on a downward spiral in Nigeria, with most communities especially within city centers not benefitting from the municipal waste disposal services (Fafioye and John-Dewole, 2013). In some parts of Nigeria, it is common to see refuse being dumped along major roads and highways constituting a nuisance in those locations (Oyeniyi, 2011). This has become an eyesore as major streets have been turned into refuse dumps with ugly mountains of waste causing serious traffic problems.

Materials and Methods

Study Area

This study was carried out in Biology laboratory, Federal University Wukari, Wukari Local Government Area, Taraba State, Nigeria. Wukari is a Local Government Area in Taraba State, Nigeria and is situated at latitude 7.85° North, longitude 9.78° East and 152 meters elevation above the sea level in the northern part of Nigeria.

Fig 1: Map of Taraba State showing Wukari Local Government



Source: Cartography Department of Taraba State land and survey, 2021

Sample Collection

A total of twelve (12) water samples (6 from borehole and 6 from well) were collected near dumpsite into clean, sterile 50cl plastic containers from Avyi ward, Hospital ward and Puje ward in Wukari town, Wukari Local Government Area, Taraba State. The samples were labeled appropriately, placed into separate plastic bags and conveyed in an ice packed cooler to Biology laboratory, Federal University Wukari for bacteriological analysis and physicochemical analysis.

Macroscopic analysis

The color and appearance of the borehole water samples were checked before inoculation.

Media preparation

Culture media was prepared following the manufacturer's instructions and sterilized in an autoclave at a temperature of 121⁰c and a pressure of 15psi.

Nutrient agar medium

Nutrient agar is a general-purpose medium used for the cultivation of bacteria and for the enumeration of bacteria in water, sewage, feces and other materials. Nutrient agar consists of peptone, beef extract and agar (Cheesbrough, 2009).

MacConkey agar medium

MacConkey agar is a selective and differential medium used for the detection of Enterobacteriaceae from clinical specimen and other materials (Cheesbrough, 2009).

Borehole and Well Water Sample Culturing for Bacteria Isolation

1ml of each water sample was serially diluted with 9ml of sterile distilled water before inoculation. 2ml of the dilution was aspirated from the last dilution and poured into a sterile petri dish. The media used for bacteria isolation was Nutrient agar and MacConkey agar. The pour plate method was used for the isolation of bacteria. Plates containing Nutrient agar and MacConkey agar were incubated for 24 hours at 37°C. Bacteria isolates were purified by repeated sub-culturing onto freshly prepared sterile Nutrient agar and MacConkey agar.

Microscopic Analysis

The bacteria culture (pure isolates) were picked using a sterile inoculating needle and placed on a sterile grease free microscope slide, the slide containing the bacteria culture was heat fixed under hot flame using the bunsen burner. The heat fixed slide was stained using the gram staining reagent after which the stained slide was allowed to air dry. The slide was viewed under the microscope using x100 objective lens (oil immersion lens).

This was done to check determine the colony characteristics and gram reaction.

Gram Staining Techniques

Procedure:

The smear of each isolated colony were prepared on a microscope slide allowed to air dry. The air dried smear on the slide was heat fixed. The heat fixed smear was stained with Crystal violet reagent for 60 seconds. The stain was rapidly rinsed with a running water in a slanting position. The stained smear was then covered with Lugol's iodine for

60 seconds. The iodine was rapidly washed off with a running water in a slanting position. The stained smear was decolorized with acetone for few seconds. Safranin was added to the stained smear for 30 seconds. The stained was rapidly washed off with a running water. The smear preparation was subsequently air dried and microscopically examined using high resolution objective power (Cheesbrough, 2015).

Biochemical test

Biochemical test was done according to clinical laboratory standard guidelines to further confirm the isolates from the borehole and well water samples.

The following biochemical test were carried out; Catalase test, Coagulase test, IMViC Reactions, Indole test, Methyl red (MR) test, Voges-proskauer (VP) test, Citrate utilization test

Physicochemical analysis

Determination of pH of borehole and well water samples

A digital pH meter (Model: HI 2214) was used to determine the pH of the borehole and well water samples. The pH meter was calibrated using different buffer solutions of pH 12.1, 7.0 and 4.0. The pH electrode was immersed in the water samples and the steady value of pH read. Readings were taken in duplicates and average values recorded.

Determination of temperature of borehole and well water samples

A digital temperature meter was used to measure the temperature of borehole and well water samples. The temperature probe was immersed in the water samples and the steady value of temperature read.

Determination of conductivity of borehole and well water sample

The electrical conductivity of the borehole and well water samples were determined using a digital conductivity meter (Model: DDS-307A).

Determination of turbidity of borehole and well water sample

The turbidity of the borehole and well water samples were determined using a portable turbidity meter (Model: TN-100). The turbidity meter was calibrated by standardizing with distilled water and the turbidity meter immersed inside the water sample. The value of turbidity was read directly in NTU.

Determination of total dissolved solids of borehole and well water samples

The total dissolved solids of the borehole and well water samples were determined using a total dissolved solids (TDS) meter (Model: HI 9813-6). The TDS meter probe was rinsed with distilled water followed by the borehole water samples tested. The rinsed probe was allowed to stabilize in the borehole and well water sample for 1 min after which the TDS value was read directly in mg/L.

Determination of dissolved oxygen of borehole and well water samples

The dissolved oxygen (DO) of the borehole and well water samples were determined using a dissolved oxygen (DO) meter (Model: 407510_A).

Data Analysis

The result obtained from this research study was analyzed using simple statistical method such as percentage and chi square (X^2). The analysis was performed using the latest SPSS version statistical package.

RESULT

Bacteria Isolated from Borehole Water Samples

A total of twenty four (24) bacteria isolates were isolated from borehole and well water samples collected from the boreholes and wells close to dumpsite from the three wards (Avyi ward, Hospital ward and Puje ward) in Wukari town, Wukari Local Government Area, Taraba state.

Biochemical

Characterization of these bacteria isolates indicates the presence of three (3) genera including; *Bacillus subtilis*, *Escherichia coli* and *Staphylococcus aureus*. The results obtained from the research analysis are displayed on tables.

Table 1.0: Morphological characteristics of isolated bacteria on Nutrient agar and MacConkey agar and their Gram reaction

Bacteria	Morphology	Gram stain reaction
• <i>Bacillus subtilis</i> • <i>Escherichia coli</i> • <i>Staphylococcus aureus</i>	• Small, moist, white or slightly yellow colonies • Moderate, moist yellow lactose fermenter colonies • Small, moist, yellow lactose fermenter colonies	• Gram-positive rod • Gram-negative rod • Gram-positive cocci

Table 2: Biochemical reactions of bacteria isolated from borehole and well water samples close to dumpsite from Avyi ward, Hospital ward and Puje

Bacteria	Catalase test	Coagulase Test	Indole test	Methyl red Test	Citrate test	Oxidase test	Gram reaction
<i>Bacillus subtilis</i>	+	-	-	-	+	-	+ Rod
<i>Escherichia coli</i>	+	-	+	+	-	-	- Rod
<i>Staphylococcus aureus</i>	+	+	-	+	+	-	+ Cocci

Table 5.0: Frequency of occurrence of bacteria isolated from water samples from the selected boreholes and wells from the different wards close to dumpsite

Bacteria (%)	Number of isolates	Total number of isolates	Percentage
Bacillus subtilis	6	24	25%
Escherichia coli	14	24	58.3%
Staphylococcus aureus	4	24	16.7%

Frequency of occurrence of bacteria isolated from water samples from selected boreholes and wells according to the wards close to dumpsite

Bacteria	Avyi ward	Hospital ward	Puje ward	Total
<i>Baccillus subtilis</i>	1	2	3	6
<i>Escherichia coli</i>	4	5	5	14
<i>Staphylococcus aureus</i>	2	2	0	4
Total	7	9	8	24

The study also investigated some physicochemical parameters of the borehole and water samples from the three wards close to dumpsite in (Avyi ward, Hospital ward and Puje ward). Wukari town. The values of the physicochemical analysis is presented on tables below.

Physicochemical analysis of borehole water samples from the three selected wards close to dumpsite in Wukaritown

Parameter	Avyi ward	Hospital ward	Puje ward	WHO	SON
Colour	Colourless	Colourless	Colourless	Colourless	Colourless
Ph	6.7	7.1	7.8	6.5-8.5	6.5-8.5
Temperature	28.5°C	29.1°C	30.0°C	29°C	Ambient
Turbidity, NTU	1.52	1.20	2.11	5	5
Dissolved oxygen, Mg/L	1.32	1.15	1.90	6.5-8	6.5-8

Conductivity, S/m	7.91	6.23	7.75	1000	1500
Total dissolved solids, Mg/L	21.4	19.0	20.9	500	500
Mean	11.22	10.63	11.74		
Std. Dev	11.19	11.15	11.30		
C.V	99.66	104.91	96.22		
P-value	< 0.035				

WHO Standard Guidelines (2011) and SON Standard Guidelines (2007)

There is significance difference in the physicochemical parameters of the borehole water samples at $p < 0.035$

Physicochemical analysis of well water samples from the three selected wards close to dumpsite in Wukari town

Parameter	Avyi ward	Hospital ward	Puje ward	WHO	SON
Colour	Colourless	Colourless	Colourless	Colourless	Colourless
Ph	8.3	7.9	8.4	6.5-8.5	6.5-8.5
Temperature	27.4°C	28.0°C	28.5°C	29°C	Ambient
Turbidity, NTU	3.41	4.43	3.28	5	5
Dissolved oxygen, Mg/L	2.30	2.89	3.11	6.5-8	6.5-8
Conductivity, S/m	15.4	14.7	15.3	1000	1500
Total dissolved solids, Mg/L	37.1	24.6	34.8	500	500
Mean	15.65	13.75	15.56		
Std. Dev	14.00	10.59	13.38		
C. V	89.46	77.0	85.94		
P-value	0.40				

WHO Standard Guidelines (2011) and SON Standard Guidelines (2007)

There is significance difference in the physicochemical parameters of the well water samples at $p < 0.040$

Discussion

The study reveal the presence of various bacterial species, including Escherichia coli, Staphylococcus aureus, and Bacillus spp. The total coliform count showed varying

levels of contamination, with some samples exceeding acceptable limits, raising concerns about possible fecal contamination. Biochemical tests confirmed the presence of *Staphylococcus aureus* (found in dumpsite), known for its potential to cause waterborne diseases which may indicate contamination from human or environmental sources. *Bacillus subtilis* (found in Water), a bacterium associated with poor sanitary conditions, the study investigated bacterial diversity and physicochemical properties of water samples from three selected wards close to dumpsites in Wukari metropolis. The bacteriological analysis revealed the presence of *Bacillus subtilis*, *Escherichia coli*, and *Staphylococcus aureus* as the predominant bacterial species in the sampled water.

The total viable count results showed that the bacterial load in all three wards close to dumpsites was too few to count (TFTC), indicating that these locations harbor a lot of microbial population.

The presence of *Escherichia coli* as the most frequently isolated bacteria (58.3%) suggests that the water might contain contaminants that support the survival of opportunistic and potentially pathogenic bacteria.

This is of public health concern, as *Escherichia coli* is known for its resistance to multiple antibiotics and its ability to cause infections.

The presence of *Staphylococcus aureus* (16.7%) in the water samples, especially in Hospital Ward, raises concerns regarding contamination, as this bacterium is commonly associated with human and animal waste. The physicochemical analysis of water samples revealed variations in parameters such as pH, temperature, dissolved oxygen, and total dissolved solids. The pH values ranged from 6.7 to 7.8, indicating slightly acidic to neutral conditions, which can influence microbial composition. The highest pH (7.8) was recorded at Hospital Ward, which may promote the growth of diverse bacterial species. The temperature of the water samples ranged from 28.5°C to 30.0°C, which is within the optimal range for microbial activity.

Conclusion

The study on the effect of dumpsites on underground water in Wukari Metropolis has revealed significant bacteriological contamination. The infiltration of leachates from decomposing waste introduces pathogenic bacteria such as *Escherichia coli*, *Salmonella spp.*, and *Pseudomonas aeruginosa* into underground water sources, posing severe health risks to the local population. The presence of coliform bacteria beyond permissible limits indicates fecal contamination, making the water unsafe for drinking and domestic use, this is in line with the work of (Okonko *et al.*, 2008). Additionally, the physicochemical analysis suggests an increased presence of heavy metals and organic pollutants, further deteriorating water quality (Adekunle *et al.*, 2007).

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