Scholars Journal of Engineering and Technology
OPEN ACCESS
Abbreviated Key Title: Sch J Eng Tech
ISSN 2347-9523 (Print) | ISSN 2321-435X (Online)
Journal homepage: https://saspublishers.com

Contributions of heavy metals on Underground Water quality of Dumpsite in Rukpokwu, Rivers State, Nigeria

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DOI: 10.36347/sjet.2023.v11i10.003 | **Received:** 18.08.2023 | **Accepted:** 26.09.2023 | **Published:** 18.10.2023

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Abstract **Original Research Article**

Waste dump sites have constituted major challenge to ground water quality in neighbouring environment. This study was carried out to assess the contributions of heavy metals in groundwater from abandoned Rukpokwu dumpsite after a 6-month use. Samples were collected and immediately transferred to the laboratory for standard analysis. The values of parameters of water samples pH ranged from 7.02 – 6.98. were quite below the WHO and NSDWQ limits. Conductivity ranged from 42.73- 19.91, TDS ranged from 10.76 -44.56, Turbidity ranged from 3.87 – 20.02, BOD ranged from 0.92 – 2.90, COD ranged from 1.74 – 3.21, Fe., ranged from 0.02 – 1.13, Zn ranged from 0.00 – 0.19, Cu ranged from 0.00 – 0.14,Pb, Cd and Cr were not detected in all the water samples. This might be that the contaminants could not migrate to the water table or aquifer within the period of use and study of the dumpsite.

Keywords: Heavy metal, Open dumping, Solid waste

INTRODUCTION

Open dumping of solid waste remain the prevailing form of waste disposal in developing countries like Nigeria (Saidu, 2011). Contamination of water bodies has become an issue of serious environmental concern (Akpoveta *et al*., 2010). Urban population is increasing due to various factors like better employment opportunities, and concentration of industries than the rural areas which led to the increase in generation of waste. Municipal solid waste management gets the lowest priority; this might be mainly because disruptions and deficiencies in it do immediately affect public life and cause public reaction (Rao, 2003). For lack of effective management of solid waste generated from residential, commercial and institutional activities, the populace decided to dump their solid waste in any available space within the community, by so doing it is accumulated with time.

Several studies conducted worldwide have highlighted the adverse effects of heavy metal contamination of groundwater quality and its potential health risks to nearby communities. For instance, a study conducted by Amuda and Alade (2011) in Nigeria found elevated concentrations of heavy metals in groundwater near a dumpsite, leading to concerns about public health.

Additionally, the World Health Organization (WHO) and national environmental agencies have established guidelines and standards for safe drinking water quality, including permissible limits for heavy metals. Understanding the extent of heavy metal contamination in the underground water of the Rukpokwu dumpsite area is essential for assessing compliance with these standards and taking appropriate remedial actions.

To address this issue, the research will involve water sampling and laboratory analysis to determine the concentrations of heavy metals in the underground water near the dumpsite. The study will also assess the potential health risks associated with the consumption of contaminated water and propose remediation measures to mitigate the pollution.

In conclusion, the study on the contributions of heavy metals to the underground water quality of the dumpsite in Rukpokwu, Rivers State, Nigeria, is critical for protecting public health and the environment in the region. It builds on existing research on heavy metal contamination in groundwater and emphasizes the need for sustainable waste management practices in urban areas like Rukpokwu.

The supply of adequate fresh water in large quantity to meet the increasing population's demand and maintaining the quality is now a thing of concern (Elinge *et al*., 2011). Hence, contamination of ground water through the infiltration of leachates via the soil and rocks needs to be avoided. Since pipe-borne water is not readily available in many parts of the country and even in the urban areas, the pipe water supply is not adequate (Adelekan, 2010). With these problems, there is need for another source of water supplies which is ground water, but due to lack of proper waste management the ground water is usually affected by the refuse dump site. Water is said to be polluted when the water body is adversely affected by both the organic and inorganic contaminants (Oliver and Ismaila, 2011).

The usual and most neglected cause of water pollution is uncontrolled dumping of municipal solid waste (Igbal, 2009). But monitoring the water quality is very important for environmental safety.

Statement of the Problem

Municipal solid waste normally termed as "garbage" is an inevitable by-product of human activity, which is disposed through dumping. Open dumps are unsightly, unsanitary, and generally smelly. They attract scavenging animals, rats, insects, pigs and other pests. Surface water percolating through the trash can dissolve out or leach harmful chemicals that are then carried away from the dumpsites in surface or subsurface runoff. Among these chemicals, heavy metals are particularly insidious and lead to the phenomenon of bioaccumulation and biomagnifications. These heavy metals may constitute an environmental problem, if the leachate migrates into the ground water. The presence of borehole at the landfill sites to draw groundwater is threatened by the contaminated ground water. The group at risk from the unscientific disposal of solid waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk group includes population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or due to leakage from landfill sites.

Objective of the Study

The objective of this study is for analysis of physicochemical metal quality of underground water of dumpsites in Rukpokwu, Rivers State, Nigeria. The study on the contributions of heavy metals to the underground water quality of the dumpsite in Rukpokwu, Rivers State, Nigeria, is of paramount importance due to its potential implications for human health and the environment. Heavy metals are known to be harmful pollutants that can contaminate water sources when not properly managed, posing severe health risks to those who rely on these water sources for drinking and other domestic purposes.

The presence of heavy metals in dumpsites is primarily due to the improper disposal of various types of waste, including electronic and electrical equipment, batteries, and industrial waste, which contain toxic heavy metals such as lead, cadmium, mercury, and chromium. These heavy metals can leach into the surrounding soil and groundwater, leading to contamination of the underground water.

Scope of the Study

This study deals on the contributions of heavy metals in groundwater from an abandoned Rukpokwu dumpsite. Soil Water samples were collected with the aid of clean water sampling bottles from five water points around the dumpsite. The Samples were immediately taken to the laboratory for standard analysis. Municipal waste is a complex refuse consisting of various materials with different properties. Some of the components are stable while others degrade as a result of biological and chemical processes. Municipal waste generation is increasing at the urban and developing cities around the globe. Dumping of municipal waste on land is a common waste disposal method. Precipitation that infiltrates through the municipal refuse leaches the constituents from the decomposed waste mass and while moving down causes the subsurface soil to be contaminated by heavy metals, organic and inorganic solutes (Nolan, 2003). Due to the use of soil as a medium of disposal of municipal refuse and the use of incineration waste for civil works are becoming increasingly common, the definition of relevant soil biological, physical, and chemical indicators is indispensable to access their environmental compatibility (Perrodine *et al.,* 2002). Many studies have assessed the ecotoxicological effects of leachates from municipal refuse dump on living organisms in soils belonging to eukaryotes (plants and animals) and prokaryotes (bacteria) plant growth inhibition (Hernandez *et al.,* 1999). There are also potential beneficial effects from municipal refuse dump on agricultural and horticultural activities, soil that have been cropped for many years may be deficient in nutrients such as zinc, iron, copper as these metals are essential in soil fertility. However, municipal waste could mitigate such deficiencies (Bruine *et al.,* 2009).

MATERIALS AND METHODS

Study Area

Rukpokwu, located in Rivers State, Nigeria, is an area that has experienced rapid urbanization and industrialization over the years. As a result, the disposal of waste materials, including electronic waste, industrial waste, and household waste, has become a significant concern in the region. Dumpsites are commonly used for waste disposal in many urban areas of Nigeria, often without adequate environmental safeguards in place.

The abandoned dumpsite located in Rukpokwu community between longitude and latitude of 6'54^{0}E-7'73^{0}E and 4'35^{0}N-4'68^{0}N along the major access road linking Rukpokwu and Eneka in Obio-Akpor, Rivers

State. It was a pit dug during the construction of roads near the location area. The pit was operated for six (6) months (April-September, 2011) as a solid waste dumpsite, recipient of general wastes from Port Harcourt and Obio-Akpor metropolises. The pit was abandoned because it was filled and residents around the area were complaining of possible pollution of their borehole water. The study area is represented in the map of the study area indicating sampling points.

Sample Collection

Collection of water samples

Water samples were collected with clean water sampling bottles. Five ground water taps were sampled by allowing the water to run for two minutes before collecting water. The samples were immediately transported to the laboratory for analysis.

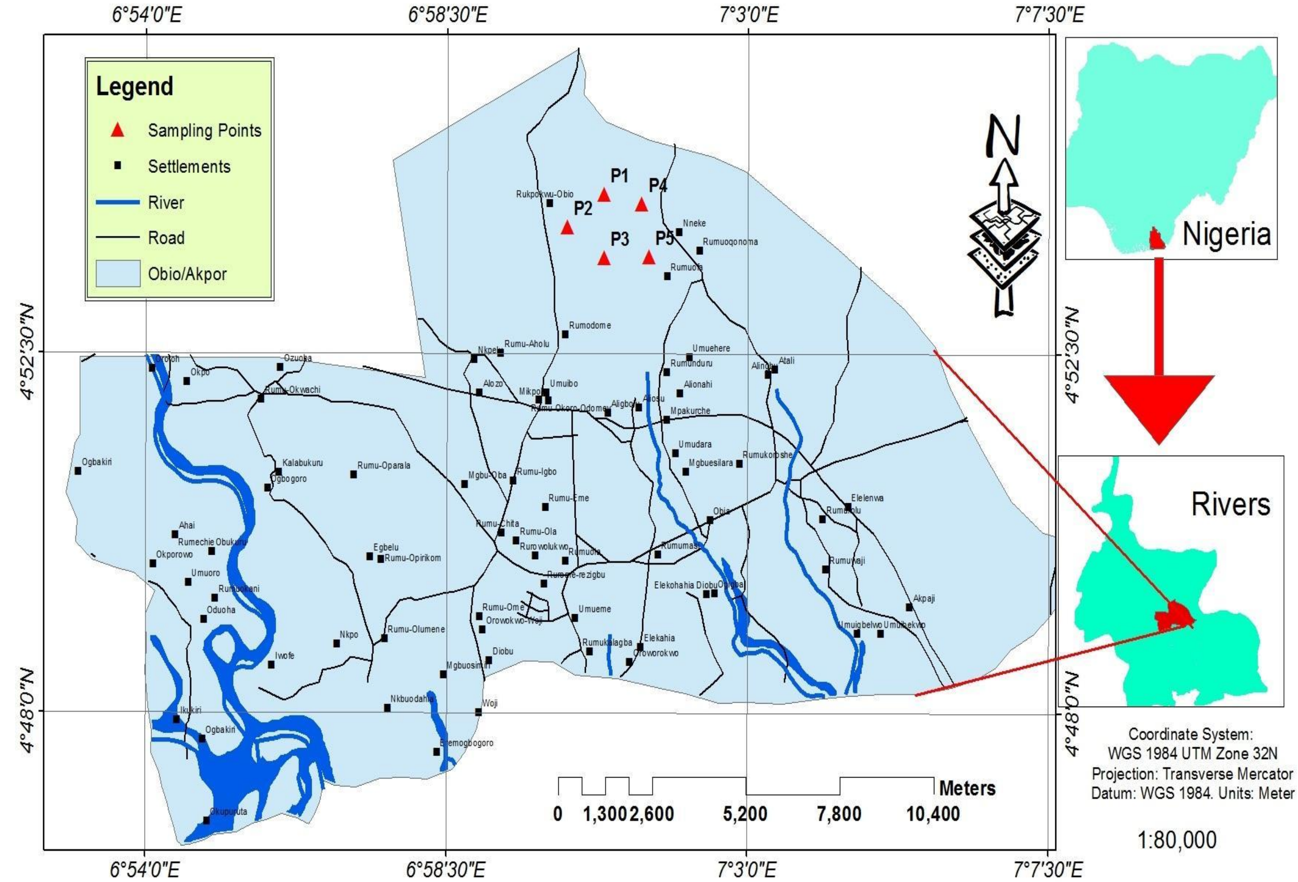

Figure-1: Study area (Rukpokwu) indicating sampling points

Analyses of samples

Water analysis

pH (APHA 4500 H+)

Measurements were carried out by means of a Win Lab pH meter (WinLab 192363, Germany) with a sensitivity of + 0.01**.** Calibration was checked by measuring standard buffer solutions pH 4, and 7.

Conductivity/TDS (APHA-2540-C)

Measurements were carried out by means of a Win Lab Conductivity/TDS meter (WinLab 200363, Germany) with a sensitivity of + 0.01**.** Calibration was checked by measuring standard conductivity solutions.

Turbidity (APHA 2130B)

Turbidity of collected samples were analysed the same day using Horiba U-53 (U-53, Tokyo) multi-parameter water quality meter. Calibration was checked by measuring standard turbidity solution and unit of readings were recorded in NTU.

Chemical Oxygen Demand (APHA 5220 B)

COD was determined using the open reflux method (APHA, 1992), where a sample is refluxed and digested in a strongly acidic solution with a known amount of excess of potassium dichromate ($K_2Cr_2O_7$). After digestion, the excess un-reacted potassium dichromate was read with a spectrophotometer (Lamotte Smart 3, USA)at 600-nm and results were reported in mg/L. Results were also verified by titrating with a standard solution of Ferrous Ammonium Sulphate(FAS).

Aerial View of the Dumpsite at Rukpokwu. (Rivers State ministry of Lands)

Biological Oxygen Demand (APHA 5210B)

BOD, which depends on oxygen uptake by bacteria, was determined using the dilution method according to APHA 5210B (APHA, 1992). The amount of oxygen consumed during a fixed period (usually 5 days) is related to the amount of organic matter present in the original sample. Dissolved oxygen of the samples was first determined using the WinLab Dissolved Oxygen meter (WinLab 196363, Germany) and then incubated for five (5) days at 20^{o}C. DO was again measured after a period of five days and BOD in mg/l was determined from the following calculation and reported accordingly.

$$BOD = \frac{[DOB - DOA] - [DOSB - DOSA]}{D}$$

Where;

D =dilution factor usually 0.5

DOB =DO of sample before incubation

DOA =DO of sample after incubation

DOSB =DO of sample blank before incubation

Heavy Metals (APHA 3030 E)

The concentrations in mg/L of heavy metals in the collected samples were determined (after nitric acid digestion) by means of an Atomic Absorption Spectrophotometer (Biotech Engineering, Phoenix 986-UK). 100mL of the water sample was measured and 5mL of nitric acid was added (Nitric acid digestion) into a beaker. The sample was placed on a hot plate and heated in fume hood until white fumes evolved. The digested sample was allowed to cool and filtered into a 100mL volumetric flask and made up to mark with de-ionised water. The sample was then transferred to 100mL plastic can for AAS analysis. Specific metal standards (AccuStandards, USA) in the linear range of the metal were used to calibrate the equipment. The concentrated and digested samples were then aspirated and the actual concentrations were obtained by referring to the calibration graph and necessary calculations.

Results of Water Analysis

The pH values for the water samples ranged from 6.94±0.05 to 7.07±0.06. The highest value was recorded in sample D while the lowest was recorded in sample B. The pH values varied significantly at P=0.03 from each other. The pH values were within the WHO limit of 6.5-9.2 and Nigerian standard for drinking water quality(NSDQW) of 6.5 – 8.5.The conductivity (µ*S*/cm) values for the water samples ranged from84.23±0.78to 19.63±0.64. The highest QQ value was in sample B while the lowest was in sample A. The conductivity values varied significantly at P=0.00 from each other. The TDS (mg/L) values for the water samples ranged from44.56±0.58to 10.76±0.19. The highest value was in sample B while the lowest was in sample D. The TDS values varied significantly at P=0.00 from each other. The turbidity (NTU) values for the water samples ranged from 20.02±0.23to 3.87±0.12. The highest value was in sample B while the lowest was in sample A. The BOD (mg/L) values for the water samples ranged from2.90±0.09to 0.92±0.04. The highest value was in sample B while the lowest was in sample E. The COD (mg/L) values for the water samples ranged from3.21±0.03to 1.74±0.07. The highest value was in sample B while the lowest was in sample A. The Fe (mg/L) values for the water samples ranged from1.13±0.03to 0.02±0.01. The highest value was in sample B while the lowest was in sample E. The Zn (mg/L) values for the water samples ranged from0.19±0.01to 0.00. The highest value was in sample B while the lowest was in sample A. The Cu (mg/L) values for the water samples ranged from0.14±0.00to 0.00.The desirable limit for copper is 0.05 mg/L and the permissible limit in the absence of alternate source is 1.5 mg/L. The highest value was in sample B while the lowest was in samples A and E.Pb, Cd and Cr were not detected in all the water samples.

DISCUSSION

According to Akpoveta et al. (2010), dumping of solid wastes on open lands has been a major source of contamination for groundwater systems. The major challenge is the contaminant transportation of contaminants in the dumpsite through the soil profile to the ground water. The borrow pit was dug in the course of the construction of Rukpokwu Eneka road. The pit was operated for six (6) months (April-September, 2011) as a solid waste dumpsite, recipient of general wastes from Port Harcourt and Obio/Akpo metropolises. Construction of residential buildings around the dumpsite became a major public health issue considering the effects of the dumpsite on ground water quality. The values of parameters of water samples were quite below WHO and NSDQW limits. This might be that the contaminants could not migrate to the water table or aquifer within the period of use and study. Older dumpsites have higher possibility of infiltration of contaminants to the aquifer than younger dumpsites. The presence of these contaminants might be from the dissolution of organic and inorganic components of the waste stream. Many factors might influence the transport of the heavy metals in the soil into the ground water.

The presence of lead in the samples is of serious health concern. One of the physiological effects of lead is that it is detrimental to the neurological development of children.

Table 1.: Physicochemical analysis of water samples compared with NSDWQ Limit

Parameters	**A**	**B**	**C**	**D**	**E**	**P-value**	**NSDWQ Limit**
pH	6.98±0.03	6.94±0.06	7.02±0.04	7.07±0.05	7.02±0.01	0.03	6.5-8.5
Conductivity µS/cm	19.63±0.64	84.23±0.78	77.07±5.69	42.73±13.54	19.91±0.67	0.00	1000
TDS mg/L	11.07±1.02	44.56±0.58	34.94±5.96	19.45±1.04	10.76±0.19	0.00	500
Turbidity NTU	3.87±0.12	20.02±0.23	15.80±1.14	13.87±0.56	4.55±0.12	0.00	5
BOD mg/L	1.23±0.06	2.90±0.09	2.72±0.17	1.45±0.40	0.92±0.04	0.00	-
COD mg/L	1.74±0.07	3.21±0.03	2.99±0.12	2.14±0.07	1.80±0.11	0.00	-
Pb mg/L	0.00	0.00	0.00	0.00	0.00	-	0.01
Cd mg/L	0.00	0.00	0.00	0.00	0.00	-	0.003
Fe mg/L	0.02±0.03	1.13±0.03	0.99±0.05	0.03±0.01	0.02±0.01	0.00	0.3
Zn mg/L	0.00	0.19±0.01	0.13±0.02	0.01±0.00	0.01±0.00	0.00	3
Cu mg/L	0.00	0.14±0.00	0.13±0.01	0.04±0.05	0.00	0.00	1
Cr mg/L	0.00	0.00	0.00	0.00	0.00	-	0.05

Note: A to E were sampling points

Table 2: Physicochemical analysis of water samples

	Sample A			**Sample B**			**Sample C**			**Sample D**			**Sample E**		
Parameters	A_1	A_2	A_3	B_1	B_2	B_3	C_1	C_2	C_3	D_1	D_2	D_3	E_1	E_2	E_3
Ph	6.95	7.01	6.99	6.97	6.98	6.88	7.01	7.06	6.99	7.01	7.09	7.11	7.03	7.01	7.03
Conductivity	19.03	20.31	19.55	83.60	85.10	84.00	82.10	78.20	70.90	57.10	30.20	40.90	20.46	19.17	2011
TDS	10.08	11.01	12.12	44.31	45.22	44.15	39.16	37.55	28.12	20.21	19.87	18.27	10.84	10.91	10.54
Turbidity	3.80	4.01	3.79	19.70	20.22	20.13	15.61	17.02	14.77	13.22	14.17	14.21	4.50	4.46	4.69
BOD	1.18	1.30	1.22	2.87	3.01	2.82	2.91	2.67	2.58	1.17	1.27	1.91	0.96	0.92	0.88
COD	1.68	1.72	1.81	3.21	3.19	3.25	3.11	3.01	2.87	2.21	2.07	2.13	1.85	1.88	1.67
Pb(mg/kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cd(mg/kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zn(mg/kg)	0.00	0.00	0.00	0.19	0.19	0.18	0.15	0.14	0.11	0.01	0.01	0.01	0.01	0.00	0.00
Cu(mg/kg)	0.00	0.00	0.00	0.14	0.14	0.14	0.12	0.13	0.13	0.11	0.02	0.01	0.00	0.00	0.00
Cr(mg/kg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CONCLUSION

The research uncovered and ascertained physicochemical qualities of groundwater samples from Rukpokwu dump site in Obio-Akpor local government area, Rivers State. The age of the dumpsite might be another interesting factor that might determine the rate of infiltration into groundwater. The waste dumpsite was just operated for six (6) months and abandoned for two years. It might take a longer time for physical and chemical processes in the soil to release contaminants into ground water.

RECOMMENDATIONS

Environmental surveillance and monitoring have remained veritable tools in the control of pollution and maintenance of water quality.

1. There should be continuous water quality monitoring of all ground water sources especially within waste dumpsites to prevent negative health consequences on the inhabitants.
2. Building of houses around waste dumpsite should be prohibited to prevent waterborne diseases outbreak.

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