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ASSESSMENT OF HEAVY METAL AND MICROBIAL CONTAMINATION OF WATER SOURCES IN OGBELE COMMUNITY: A COMPARATIVE STUDY OF SURFACE AND GROUNDWATER

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ABSTRACT

This study was aimed at assessing heavy metal and microbial contamination in the water sources available to inhabitants of Ogbele community in Ahoada East Local Government Area, Rivers State, Nigeria, following the upsurge in industrial activities in the area. Water samples were collected from five different locations along the Sombreiro River (surface water) as well as five dugout wells and boreholes (groundwater) in selected locations in the community and analyzed. Heavy metal content of the water was analyzed using AAS (GBC XplorrAA model) and microbial load was analyzed using standard APHA methods. Results of heavy metal content in the surface water showed Lead (Pb) 1.81±0.01 mg/L, Chromium (Cr) 0.003±0.0001 mg/L, Cadmium (Cd) 0.004±0.0001 mg/L and Nickel (Ni) 0.374±0.002 mg/L. Concentration of Pb, Cr, Cd and Ni in the dugout well water was 2.10±0.01 mg/L, 0.010±0.0001 mg/L, 0.297±0.008 mg/L and 0.237±0.002 mg/L respectively. The borehole water had Pb (1.88±0.01 mg/L), Cr (0.003±0.0001 mg/L), Cd (0.004±0.0001 mg/L) and Ni (0.546±0.002 mg/L). The levels of Pb, Cd and Ni in all the water samples were above the regulatory limits of 0.01 mg/L, 0.003 mg/L and 0.02 mg/L respectively. Results of microbial load indicated negligible presence of Faecal Coliform Bacteria (FCB) and Total Coliform Bacteria (TCB) in the surface, dugout well and borehole water. However, the Total Heterotrophic Bacteria (THB) count in surface water was 140.0 CFU/mL and 440.0 CFU/mL in dugout well water. This study concludes that sources of water in Ogbele community contain levels of Pb, Cd and Ni which exceed the regulatory limits set by WHO, NESREA

and NSDWQ. Therefore, there is need for decontamination and continuous monitoring of the water quality to prevent potential toxicity associated with heavy metal and microbial contamination of the water resources.

KEY WORDS: Ogbele community, Water quality, Heavy metals, Microbial load, Toxicity.

INTRODUCTION

Water resources, including rivers, streams, lakes and aquifers are directly and indirectly exposed to environmental and anthropogenic activities. The Sombreiro River running through Ogbele Community, like many rivers in the Niger Delta, is subject to pollution from oil spills, industrial discharges, and agricultural runoff. Nduka & Orisakwe[1] documented high levels of metals such as lead, cadmium, and mercury in surface water bodies in the Niger Delta, attributing these levels to extensive oil exploration activities.

Surface water quality can vary significantly with seasons. During the rainy season, increased runoff can lead to higher concentrations of pollutants in rivers, as observed by Chindah & Braide [2]. Conversely, during the dry season, lower water levels can concentrate pollutants, exacerbating contamination levels. Furthermore, river systems provide water for various uses, including drinking, agriculture, industry, and recreation. Rivers also play a crucial ecological role, supporting diverse habitats and species. Surface water quality is influenced by several factors, including natural processes and human activities. Rainfall can wash soil, nutrients, and pollutants into rivers, affecting water quality [3]. Effluents from factories and refineries can introduce toxic substances and metals into river systems [4].

Groundwater, often accessed through boreholes, is typically considered to be of higher quality than surface water due to natural filtration processes as water percolates through soil and rock layers. However, several studies highlight that groundwater is not immune to contamination. Industrial activities, particularly in oil-rich regions like the Niger Delta, introduce pollutants such as hydrocarbons, metals, and other industrial chemicals into groundwater systems. These contaminants pose significant health risks to local populations who rely on such borehole water for drinking and domestic use [5].

Despite its relative protection from direct pollution, groundwater quality can be affected by various factors including geological composition and drilling activities. The mineral content of aquifers can influence the chemical characteristics of groundwater, sometimes leading to issues like hardness or the presence of trace elements such as arsenic and fluoride [6]. The hydrogeology of the Niger Delta, characterized by alluvial and deltaic deposits, significantly influences groundwater dynamics. Studies by Abam and Nwankwoala [7] indicate that the region's sedimentary formations, while rich in groundwater, are also highly susceptible to pollution from surface activities. The shallow aquifers, commonly used for the extraction of borehole water in the region, are particularly vulnerable to contamination from agricultural runoff and industrial spills.

Humans and other animals discharge large number of intestinal microorganism in stool into the environment. Therefore, pathogens may appear in water sources contaminated with stool containing indicator organism like faecal coliform (*Escherichia coli*), faecal *Streptococci* (*Enterococcus*) and *Clostridium perfringens* [8]. Microbial contamination of groundwater may also arise with pathogens from sewage and waste infiltrating borehole water supplies [9]. It is therefore imperative that microbial monitoring and modelling has an important part to play in establishing and linking different microbial populations and habitats through environmental transfers for effective application of preventive measures [10].

As industrial, agricultural and domestic activities continue to impact water sources, sustainable management practices and innovative solutions are essential to safeguard the health and well-being of local communities. There is dearth of data on comparative analysis of surface and groundwater quality in Ogbele community, hence this study was designed to bridge the gap and assess the relative levels of toxic heavy metals and microbial load of surface and groundwater in the community located on the banks of Sombreiro River.

MATERIALS AND METHODS

Heavy Metal Analysis

Water samples were collected from five (5) different locations along the Sombreiro River and 5 selected dugout wells and boreholes. All sample containers were rinsed with the water being sampled before putting the sample into the containers. The water samples for heavy metal analyses were collected in plastic vials and fixed with 2% nitric acid to preserve the integrity of the samples before taking them to the laboratory. All laboratory analyses were carried out at the Institute of Pollution Studies, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt using an Atomic Absorption Spectrophotometer (AAS) (GBC XplorrAA model) in line with standard protocols and manufacturer's recommendations.

Microbial Analysis

Total Coliform Bacteria (TCB) and Total Faecal Coliform Bacteria (FCB) **parameters** in the water samples were determined using the **Most Probable Number (MPN) method** following the steps outlined in **APHA (**9221B) [8].

Total Heterotrophic Bacteria (THB) was determined using the pour plate method as recommended in APHA (9215B) [8] The water samples were inoculated in nutrient agar and the results observed expressed as CFU/mL

Data Analysis

The data obtained were analyzed using Microsoft Excel office and values expressed as mean values ± standard deviation of triplicate determinations.

RESULTS

Heavy metal content of Sombreiro River (surface water) and groundwater samples in Ogbele community is presented in Table 1.

The concentration of Pb, Ni and Cd in the water samples exceeded the regulatory limits stipulated by WHO, NESREA and NSDWQ.

Table 1: Heavy Metals Content of Surface and Groundwater in Ogbele Community.

Parameters	**Surface Water**	**Dugout Well Water**	**Borehole Water**	**WHO / NESREA / NSDWQ Standard**
Pb (mg/L)	1.81 ± 0.01	2.10 ± 0.01	1.88 ± 0.01	0.01
Cr (mg/L)	0.003±0.0001	0.010±0.0001	0.003±0.0001	0.05
Cd (mg/L)	0.004±0.0001	0.297 ± 0.008	0.004±0.0001	0.003
Ni (mg/L)	0.374 ± 0.002	0.237 ± 0.002	0.546 ± 0.002	0.02

*Values are expressed as mean of triplicate determinations ± Standard Deviation

WHO = World Health Organization; NESDREA = National Environmental Standards and Regulations Enforcement Agency; NSDWQ = Nigerian Standard for Drinking Water Quality

Results of the bacteriological properties of surface and groundwater in Ogbele community are contained in Table 2. Heterotrophic bacteria were detected in the surface and dugout well water at levels below the WHO limits.

Table 2: Bacteriological Properties of Surface and Groundwater in Ogbele Community.

Parameters	Surface Water	Dugout Well Water	Borehole Water	WHO Standard
TCB (MPN/100)	ND	ND	ND	0.00
FCB (MPN/100)	ND	ND	ND	0.00
THB (MPN/100)	140±0.00	440±0.00	ND	500

*TCB = Total Coliform Bacteria; FCB = Faecal Coliform Bacteria; THB = Total Heterotrophic Bacteria; **MPN = Most Probable Number; ND = Not Detected**

DISCUSSION

The results for heavy metal concentration in surface water from the Sombreiro River and groundwater sources in Ogbele community revealed substantial deviations from regulatory standard limits, particularly for the toxic heavy metals; Lead (Pb), Nickel (Ni) and Cadmium (Cd). The Pb concentration in all the water sources in the community was relatively high (Table 1), far exceeding the standard limit of 0.01 mg/L. Lead content in the dugout well water was the highest (2.101 mg/L), which is about 13.755% higher than the surface water (1.81 mg/L) and 10.376% higher than the borehole water (1.883 mg/L). This difference may be attributed to the restricted flow of water and greater anthropogenic activities in the dugout well leading to possible Pb accumulation. This high level of Pb may pose a serious health risk to humans and wildlife. Nduka & Orisakwe[1] found similar elevated Pb levels in river systems close to oil production sites, suggesting that oil exploration and industrial activities may contribute to Pb pollution in Ogbele community. Immediate intervention is critical to reduce Pb levels in portable water, which can cause neurological and developmental issues, especially in children [4,6].

The concentration of Nickel (Ni) in all the water samples exceeded the regulatory standard limit of 0.02 mg/L with the highest level of 0.546 mg/L recorded in borehole water, the major source of water used for drinking and cooking in the area. This signals an extensive contamination of the water resources with Ni, requiring immediate mitigation efforts to reduce these levels. Nickel contamination in the Niger Delta is often linked to industrial discharge, mining activities and agricultural runoff [14]. It is a highly toxic heavy metal which requires urgent attention due to its potential health risk and long-term impact, including carcinogenic effects [15] as well as kidney and lung damage [16,17].

The cadmium (Cd) concentration in surface water from the Sombreiro River was 0.004 mg/L, which exceeded the regulatory standard limit of 0.003 mg/L [13]. Similar findings were reported by Amadi *et al*. [14] in the Niger Delta, where the slightly above regulatory standard levels were attributed to industrial discharges and agricultural runoff. The concentration of Cd in the dugout well water was 98.653% higher than the surface and borehole water (Table 1). This is a significant increase attributable to heightened anthropogenic activities and subsequent accumulation of the heavy metal in the well water compared to the other sources. Cadmium is a highly toxic heavy metal even at low concentration; long-term exposure poses substantial health risk particularly with respect to kidney damage and bone fragility [15]

Chromium (Cr) levels were below the regulatory standard of 0.05 mg/L. However, there was 70.0% more Cr in the dugout well water compared to the surface and borehole water (Table 1). These results indicate minimal Cr contamination in the Sombreiro River, consistent with findings from Mmom & Arokoyu [12], who reported negligible Cr contamination in rural water sources in the Niger Delta. Regardless, continuous exposure to low levels of Cr may lead to bioaccumulation and exacerbation of potential toxic effects.

The microbial assessment of the water resources in Ogbele Community was limited to the determination Total Coliform Bacteria (TCB), Faecal Coliform Bacteria (FCB), and Total Heterotrophic Bacteria (THB). TCB and FCB which emanate from soil, vegetation, or human and animal waste, serve as potent indicators of bacteriological quality of water and its suitability for drinking and other purposes. The absence of detectable levels of TCB and FCB in the water samples from the Ogbele community is a positive indicator of good bacteriological quality. No FCB is an indication that the water is free from faecal contamination, which would otherwise be harmful due to the presence of pathogens such as *Escherichia coli*. This result meets both drinking water and river water standards indicating that there is no public health risk from faecal pathogens in the water samples [8,13].

The Total Heterotrophic Bacteria (THB) count of 140 CFU/ml for surface water and 440 CFU/ml for dugout well water (Table 2) are below the standard limit of 500 CFU/ml. While heterotrophic bacteria are usually harmless, a high count could indicate organic pollution. In this case, the low count suggests minimal bacterial growth and higher organic contamination of the dugout well water compared to the river water. Consequently, the bacteriological quality of the water samples falls within acceptable limits for both drinking and river water standards [8,17].

CONCLUSION

Assessment of the microbial contamination status of surface and groundwater in Ogbele community indicated levels that fall within acceptable standards for drinking and river water quality. However, the levels of Lead, Nickel and Cadmium in both surface and groundwater sources exceeded the regulatory standards of World Health Organization (WHO), Nigerian Standard for Drinking Water Quality (NSDWQ) and National Environmental Standards and Regulations Enforcement Agency (NESDREA). These variations are of particular concern, as they indicate potential risk to the environment and human health, including; neurological damage, kidney damage, reproductive issues, respiratory issues and increased cancer risk. Immediate action is required to address these contaminants, which may originate from industrial activities, oil exploration, or improper waste disposal practices commonly seen in the Niger Delta. Strategies such as water treatment, filtration, and the strict enforcement of environmental regulations should be implemented to reduce the concentrations of these heavy metals to maintain the ecological health of water systems.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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