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RESEARCH ARTICLE **OJER0301001-292**

HEAVY METAL POLLUTANTS AND MICROBIAL CONTAMINANT IN DRINKING WATER FROM WASH BOREHOLES IN PANTISAWA, YORRO L.G.A. OF TARABA STATE

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ABSTRACT

Borehole water remains a source of potable water in Nigeria. Therefore, regular monitoring of the safety of drinking water cannot be over-emphasized. Hence the need to study the safety of water in wash borehole from Pantisawa Yorro Local Government of Taraba State, Nigeria. A total of 15 samples from wash boreholes were randomly collected aseptically using sterilized bottles and igniting with a flame lighter on the surface of the water outlet from the five different zones (Pantisawa Main Market YM, Kapazang YG, Dola YD, Kallau YK and Zabi YZ) of Pantisawa. The pour plate technique was used to ascertain microbial load while trace metals in water samples were determined using Atomic Absorption Spectroscopy (AAS) PG-990. The total bacteria coliform count in the borehole water samples ranged between 1.00×10^6 cfu/ml and 9.00×10^5 cfu/ml which generally exceeded the World health organization (WHO) standard limit of 1.0×10^2 cfu/ml for water. The most prevalent or predominant bacteria is *Staphylococcus aureus* with 40% distribution occurrences from four sample sites (YG, YM, YD and YK). *E.*coli had a 20 % distribution while *Bacillus spp, Enterococcus spp, Salmonella spp, Streptococcus spp, Staphylococcus and Shigella spp* showed low percent distribution. The trace metal analysis for the water revealed the absence of Pb in all the water samples analyzed, Zn, Fe, Mn and Cu were below the admissible limits for all the sites except for Fe in sites YG which fall above the standard. All other elements (Ni, Cd, As and Co) were above the threshold limit set by National Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO) respectively. Thus, the presence of pollutants and microbial contaminants may have serious health risks to the people using such water for drinking and other domestic activities.

Keywords: *Wash boreholes, Pantisawa, Heavy metals, microbes, WHO, NSDWQ*

INTRODUCTION

The increase in the human population poses a great pressure on the provision of safe drinking water, especially in developing countries like Nigeria (Okonko *et al*., 2009). Consequently, water-borne diseases such as cholera and typhoid often have their outbreak especially during the dry season probably due to a decrease in the volume of water which allows microorganisms to thrive (Banu and Menakuru, 2010).

Pantisawa has limited water sources that include both surface and groundwater sources (Hamidu *et al.,* 2017). In a bid to promote healthy living among inhabitants of Pantisawa, reliable potable water access is essential for sustainable development, health, food production, and poverty alleviation (Edbert *et al.,* 2017). Water shortage and pollution of readily accessible water sources are evident in many regions of developing nations (Muhammad *et al.,* 2017). The objective of the present study was to determine the presence of heavy metal pollutant and microbial contamination in drinking water from wash boreholes in Pantisawa, Yorro Local Government and the results was compared with the standard guidelines set by WHO and NSDWQ.

MATERIALS AND METHOD

THE STUDY AREA

Pantisawa is the capital of Yorro Local Government of Taraba State, located in North-Eastern Nigeria. It covers more than 1,275 km^2 of different land units and has a population of 89,410 (NPC, 2006). It is located between the latitude $8^0$43’0” N and longitude $11^0$37’0” E with an elevation of 802m above sea level. Pantisawa and its immediate environments lie within the Woodland Savannah and Mountain Grassland Vegetation, with heavy annual rainfall of about 800 to 1000 mm and the average daily temperature ranging from 22 to 35°C, before the onset of the rains in late March to October followed by a dry season from November to early March. It has mainly clay sandy loam soils. The Local Government is dominated by Mumuye people which are the major ethnic group in the State. The inhabitants of this area are predominantly Hunters, Traders, and Commercial farmers cultivating crops such as Groundnut, Yam, Maize, Millet, Cassava and Guinea Corn. It is divided into fifteen (15) different geographical zones. In this study, five geographical zones were randomly selected; these include Kapazang, Zabi, Dola, Kallau and Pantisawa Main Market. The choice sampling sites was purposively selected based on their closeness to refuse and waste disposal sites. The study was conducted from July 2019 to August 2019.

WATER SAMPLE COLLECTION AND STORAGE

A total of fifteen water samples were collected from five wash boreholes located in five different geographical zones within Pantisawa town using sterile 250 ml plastic bottles for each sample. To ensure the sterility of the samples, the borehole taps were sterilized using cigarette lighters, after which the taps were opened to flow for 2 minutes. Then, the plastic bottles (250 cm^3) were filled with water up to 200 ml leaving some space to allow shaking before analysis. The samples were stored in an ice pack container and transported to the microbiology laboratory department, Federal University Wukari, Taraba State within 4hrs of collection (APHA 2005; WHO, 2017).

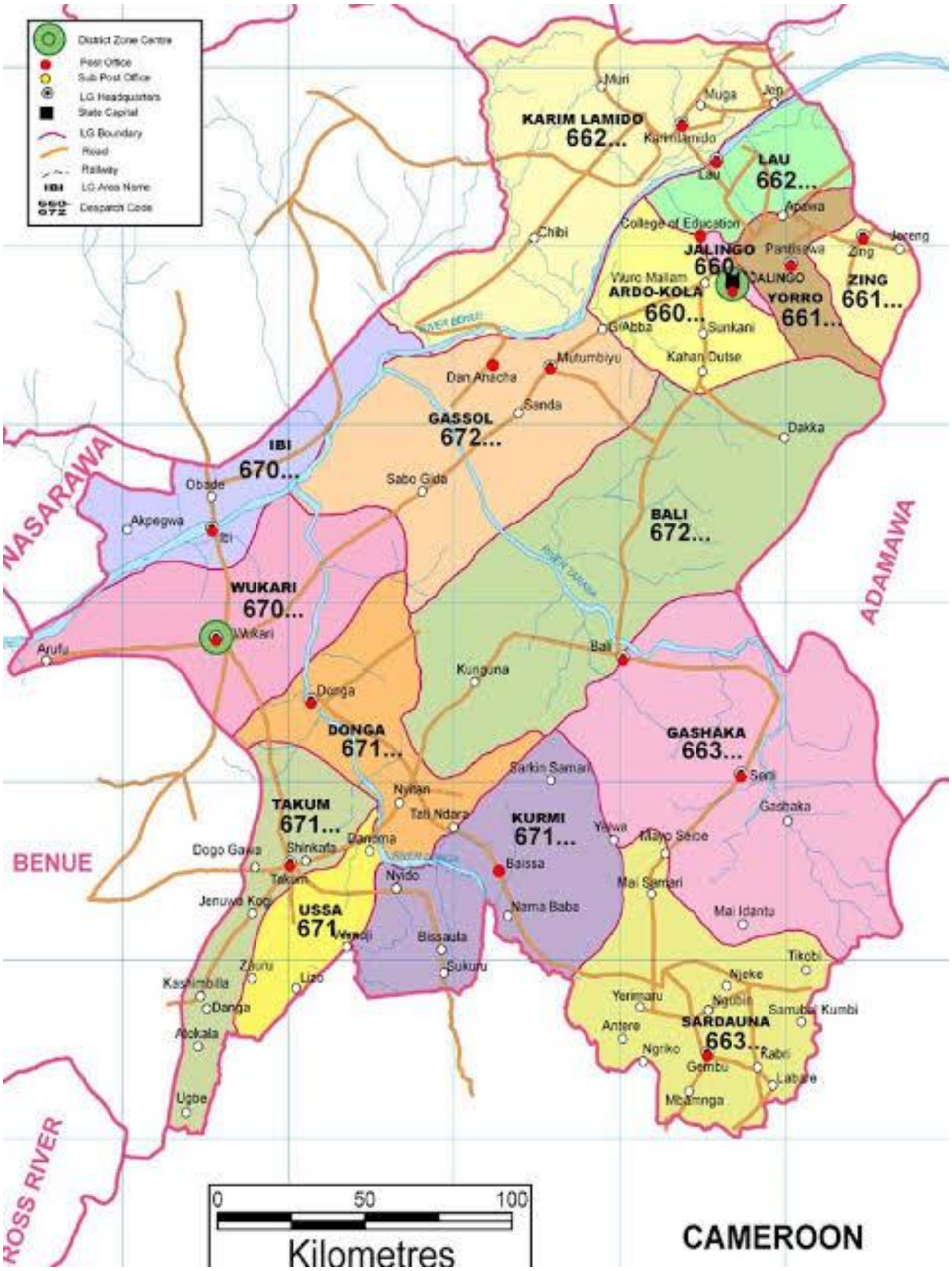

Figure 1: The Map of Taraba State showing sample locations [NPC,2006]

ELEMENTAL ANALYSIS OF WATER SAMPLE USING ATOMIC ABSORPTION SPECTROSCOPIC (AAS)

50ml of each water sample was acidified with 10ml $HClO_4$. About 100mL each of the well-mixed acidified water was digested on the hot plate for 1hr at 100^oC and transferred to100 ml volumetric flask dilute with distils water and mix thoroughly. The digested sample was analysed for Cu, Co, Cd, As, Fe, Mn, Ni, Pb and Zn using an Atomic Absorption Spectrophotometer (Model: PG-990 AAS) at (analytical laboratory) Nigeria Institute of Geological Mining Jos, Plateau State (Dargo *et al.,* 2015)

MICROBIOLOGICAL ANALYSIS OF WATER SAMPLE

Bacteria Isolation: Total heterotrophic bacteria counts were isolated using Nutrient agar (NA) by pour plate method. About 1 ml of the 10^{-5} dilutions of the samples was used to incubate the plate in triplicates; the plates were incubated at 37°C for 48 hrs. Thereafter the mean counts of the bacteria colonies were taken. The bacteria isolates were further sub-cultured to obtain pure cultures. The pure cultures were then characterized and identified to determine the bacteria species using the standard microbial method (ASTM, 2012).

RESULT & DISCUSSION

The Mean values and standard error of the mean trace metals concentration obtained from a different borehole and their corresponding WHO, NSDWQ Limits in Drinking Water. The results of the analysis showed that trace amounts of heavy metals (such as Fe, Cu, Mn, As, Ni, Cd, and Zn) were detected in all the sample locations (YM, YG, YK, YD and YZ) with different concentration and when compared with the standard set by WHO and Nigerian Standard for Drinking Water Quality, they were found to be above the said limit. The standard limits are 0.07ppm and 0.02ppm for Nickel Ni, 0.01ppm for Arsenic As, and 0.003ppm for cadmium Cd. However, Zinc (Zn) metal was only detected in one (1) sample location (YZ) out of the five (5) while lead (Pb) metal was not detected in all the sample locations listed above (Table 1).

Table 1: Mean concentration (ppm) and standard error of the mean for heavy metals obtained from Boreholes in five different sampling points.

	Site						
Metals	**YM**	**YG**	**YK**	**YD**	**YZ**	**WHO**	**NSDWQ**
Pb	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.01	0.01
Fe	0.09±0.00	0.33±0.24	0.08±0.01	0.09±0.00	0.09±0.00	0.30	0.30
Mn	0.04±0.00	0.03±0.00	0.03±0.00	0.03±0.00	0.03±0.00	0.10	0.20
Cu	0.05±0.00	0.05±0.00	0.04±0.00	0.03±0.00	0.03±0.00	2.00	1.00
Ni	0.03±0.00	0.12±0.00	0.12±0.00	0.13±0.00	0.08±0.04	0.07	0.02
Cd	0.05±0.00	0.05±0.00	0.03±0.00	0.04±0.00	0.04±0.01	0.003	0.003
Zn	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.55±0.00	3.00	3.00
As	0.43±0.07	0.53±0.02	0.04±0.00	0.05±0.00	0.05±0.00	0.01	0.01
Co	0.05±0.00	0.05±0.00	0.05±0.00	0.05±0.00	0.05±0.00	0.005	0.01

Key: YM: Pantisawa Main Market, YG: Kapazang, YK: Kallau, YD: Dola, YZ: Zabi, WHO: World Health Organization 2017, NSDWQ: Nigerian Standard for Drinking Water Quality 2007.

The absence of Lead (Pb) implies that all the samples analysed within the vicinity of Pantisawa are free from lead poisoning originating from occupational settings or workplaces (battery workers and smelters) (Manju, 2015). This agrees with the investigation done by Ahemd, (2018) where Lead (Pb) was not detected in all the samples analysed.

Iron (Fe) Copper (Cu), Zinc (Zn) and (Mn) are among the essential and important heavy metals needed for the proper functioning of the human system and good health because they are not considered hazardous (Garba et al., 2016). However, Zinc contamination can occur in the aquatic environment due to industrial wastes, metal plating, plumbing, and acid mine drainage (Ahemd, 2018). Nickel, Cadmium and Arsenic were detected above the admissible limit set by WHO and NSDWQ, Exposure to nickel and its compound through drinking of the nickel contaminated water may result in the development of cancer (kidney, lungs, Nose) and dermatitis known as "nickel itch" in sensitized individuals (Manju, 2015). Nickel in the water may be a result of metal works taken place around the borehole environment most especially from Dola (YD) Table 1. High cadmium concentration in the wash borehole water could be attributed to the rocks through which the water passes or the aquifer from which the pantisawa inhabitants get their water (Kolo et al., 2009). Cadmium affects the nervous system, causes damage to the DNA and the immune system, impacts the kidney and enhances the development of cancer (Musa et al., 2017). Heavy metals like cobalt are toxic because of their solubility in water. A low concentration of heavy metals has damaging effects on man and animals because there is no mechanism for their elimination in the body. (Oladeji and Saeed, 2015).

Long term exposure to inorganic arsenic in drinking water in Taiwan has caused black foot disease, in which blood vessels in the lower limbs are severally damaged, resulting eventually in progressive gangrene (Manju, 2015). This result agrees with Dargo and Brhane, (2015) report on the level of heavy metals in potable water in Dowhan, Erop wereda, Tigray Ethiopia and Abdullahi *et al.,* (2018) report on the evaluation of heavy metals concentration in drinking water collected from local wells and boreholes of Dutse Town, Northwest, Nigeria. The result from the study conducted indicated that the presence of the heavy metal above the contamination level could be from the sources such as transportation, atmospheric deposition, geological impact etc. thus since there are no industrial activities or mining taking place in the Study Area, the sources of the heavy metals contamination of the groundwater in pantisawa may be attributed or associated to weathering and dissolution of minerals in the underground formation (Akinola et al., 2015).

Mean values and standard error of the mean of bacteria counts (coliform forming units) of various water samples at a different location. The mean and standard error mean of the water sample were determined, and the results show that the water sample from the Zabi wash borehole has the least value of 1.00×10^{6}cf/ml while the highest mean values of 9.00×10^{5}cfu/ml were recorded in the sample from Dola wash borehole (Table 2). However, all the mean values estimated for all the wash boreholes were found to be above the standard limit of (1.0×10^{2}cf/ml) by the international regulatory agencies for monitoring drinking water.

The presence of those microorganisms isolated in the areas mentioned above may be related to the water runoff from farmlands carrying manures, pesticides, toilet, or septic waste that is situated within the market environments, and also hygiene status or sanitary conditions that are in place within the surrounding of the boreholes in the areas (Onajite *et al*., 2018). *Salmonella* is widely distributed in the environment, but some species or serovars show host specificity. The pathogens typically enter water systems through faecal contamination. Water-borne *Salmonella* outbreaks have devastating public health implications. *Salmonella* is transmitted to humans via the faecal-oral route. An infected individual sheds the bacteria in his faeces, and the bacteria are viable for months in the environment in water, soil, and manure (Moyo, 2013).

Table 2: Mean values and standard error of the mean for bacteria counts (coliform forming units) of water samples obtained at different borehole locations

Sample Code	Total Bacteria Counts (cfu/ml)
YM	$1.63\times10^6 \pm 6.01 \times10^5$
YG	$8.33\times10^5 \pm 4.04 \times10^5$
YK	$1.73\times10^6 \pm 1.20 \times10^5$
YD	$9.00\times10^5 \pm 1.76\times10^5$
YZ	$1.00\times10^6 \pm 2.08 \times10^5$
The standard limit for WHO (2017), EPA (2003).	1.0×10^2

Keys: YM= Pantisawa Main Market Borehole, YG= Kapazang Borehole, YK= Kallau Borehole, YD= Dola Borehole, YZ= Zabi Borehole

FREQUENCY OCCURRENCE OF BACTERIA ISOLATES OBTAINED FROM DIFFERENT WASH BOREHOLES

The frequency of occurrences of the bacteria isolates obtained from the water sample shows that *Staphylococcus aureus* is the most prevalent microorganism detected in four (4) among the five (5) locations (Table 3), *E. coli* was isolated from two sample locations (YM and YG) while *Staphylococcus epidermis* and *Salmonella Spp.*, are the least prevalence bacteria isolated from sample locations YK and YZ respectively (Table 3).

Table 3: Frequency Occurrence of Bacteria Isolates obtained from Different Wash Borehole.

Isolates	YM	YG	YK	YD	YZ
Staphylococcus aureus	+	+	+	+	-
Staphylococcus Epidermis	-	-	+	-	-
Streptococcus spp.	-	+	-	-	-
Escherichia coli	+	+	-	-	-
Shigella spp.	-	+	-	-	-
Proteus mirabilis	-	-	-	-	+
Salmonella spp.	-	-	-	-	+
Pseudomonas aeruginosa	-	-	+	-	-
Bacillus spp.	-	-	-	-	+
Enterococcus spp.	-	-	-	+	-

Keys: YM= Main Market Wash Borehole, YG= Kapazang Wash Borehole, YK= Kallau Wash Borehole, YD= Dola Wash Borehole, YZ= Zabi Wash Borehole, + = present, - = absent.

THE PERCENTAGE FREQUENCY OF DISTRIBUTION OF BACTERIA ISOLATES FROM DIFFERENT WASH BOREHOLES

The percentage frequency distribution of bacteria isolated ranged from 40% to 10% as shown in figure 2. The results showed that *Escherichia coli* had 20% while *Staphylococcus aureus* had the highest percentage value (40%) while *Shigella spp.* and *Bacillus spp*, showed the minimum lowest value of 10% each.

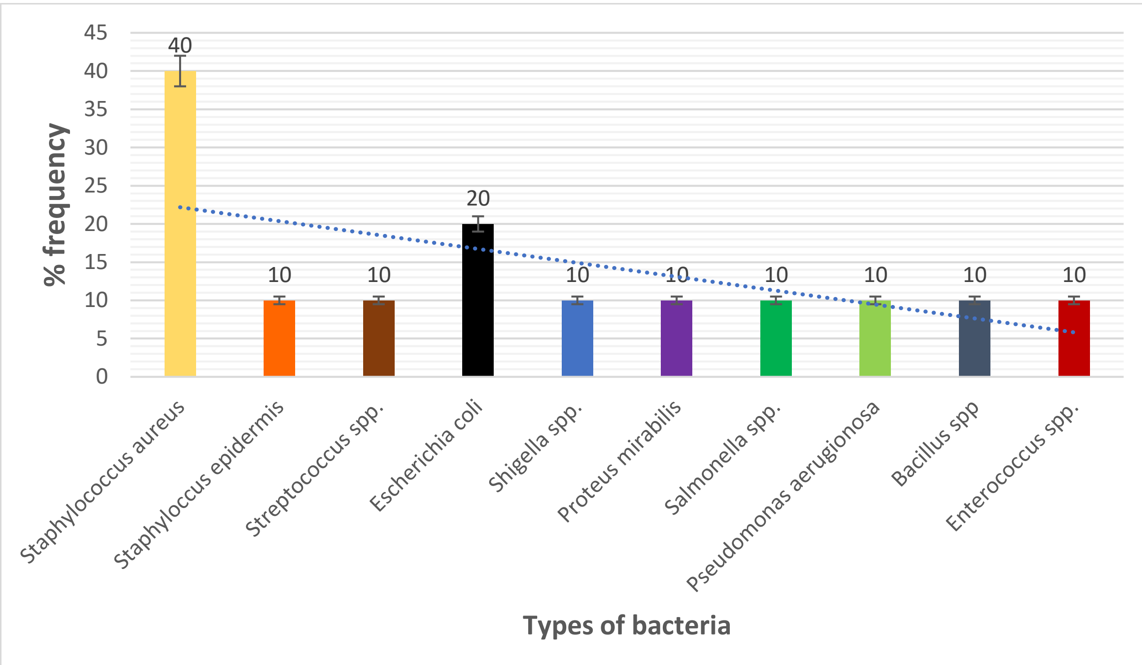

Figure 2: Percentage frequency of bacteria isolate against types of bacteria.

The frequency of occurrence of the bacteria isolates revealed *Staphylococcus aureus* and *Escherichia coli* as the most prevalent isolates. While *Salmonella spp*., *Streptococcus spp*, *Staphylococcus epidermis*, *Shigella spp* and *Bacillus spp* appears to be the least prevalent (Table 3). The percentage frequency distribution of bacteria isolated ranged from 10% to 40% as shown in figure 1. *Staphylococcus aureus* had the highest percentage value of 40% followed by *Escherichia coli* recording a value of 20% while all other bacteria showed percentage values of less than 15% (figure 1). Microbial contamination of groundwater exists among rural communities and Pantisawa is not an exception as shown by the level of microbial count (Foka *et al.*, 2018). Significantly, microbial contaminants such as coliforms, *E. coli*, *Cryptosporidium parvum*, and *Giardia lamblia* compromise the safety of the water (Opara and Nnodim, 2014).

CONCLUSION

The study revealed the presence of heavy metals such as arsenic, cadmium and cobalt which exceeded the required standard set by WHO and NSDWQ. The high level of these metals may be because of refuse dumpsites, transportation, atmospheric deposition, auto repairs workshops and high chemicals used for agricultural activities. The microbial analysis of the water sample showed the presents of *coliforms* from all sites, *E. coli* in sample sites YM and YG, *salmonella* in YG, *Shigella* in YD and *Enterococcus* in YZ while Staphylococcus *aureus* was only absent in sites YZ. This might be due to improper design and construction of shallow boreholes, the proximity of boreholes to the toilet and refuse dumpsites as well as industrial sewages.

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AUTHORS' DECLARATION

The authors hereby declare that the work presented in this article is original and has not been previously submitted in any journal.

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