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ASSESSMENT OF HEAVY METAL CONTAMINATION IN BOREHOLES AROUND MECHANIC WORKSHOPS IN UYO METROPOLIS, AKWA IBOM STATE, NIGERIA

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ABSTRACT

This study was aimed at determining heavy metal contamination in boreholes around mechanic workshops in Uyo Metropolis, Akwa Ibom State, Nigeria. Water samples were collected in sterilized sample bottles from three locations where mechanic workshops were located. The water samples were analyzed for the presence of some heavy metals like lead, cobalt, nicked and cadmium. Atomic Absorption spectroscopy and standard microbiology procedures were used to determine the physico-chemical and microbiological quality of sampled water. The result showed that physico-chemical parameters; P^H ranged from (7.1-7.5). Others are TDs which was in the range of 250-440mg/l. The results also showed that the concentration of lead was found to be within WHO limit ($Pb \leq 0.01ppm$). The concentrations of Nickel and cadmium were also found to be within WHO limits (0.02ppm and 0.003ppm) for Ni and Cd respectively. However, the concentration of cobalt in the samples was high above WHO limit (≤ 0.1 ppm)in Coliform and E. coli test, all the samples revealed that total coliform and E. Coli values are in agreement with the NSDWQ, NAFDAC and WHO requirement value. It is therefore recommended that water from boreholes need to be treated further before consumption in order to get rid of contaminants; and also a survey of borehole sites should be conducted prior to drilling to prevent areas of potential hazard to ground water.

Key Words: Boreholes, heavy metals, contamination, water physiochemical parameters, microbiological quality.

INTRODUCTION

The importance of water to man and his environment cannot be overemphasized. Potable water is an essential ingredient for good health and the socio-economic development of man [10]. However, this essential commodity is lacking in many societies. Therefore, adequate supply of water which is chemically, physically and microbiologically wholesome is necessary for human and animals survival and health benefits [3]. All natural waters contain many dissolved substances. Contaminants, such as bacteria, viruses, heavy metals, nitrates and other salts have polluted water supplies as a result of inadequate treatment and disposal of wastes from

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human, livestock, industrial discharges and overuse of limited water resources [9].

In most developing countries, people are not opportune to have access to safe drinking water. This to some extent is largely due to under-development; lack of education and the region in which they dwell in. The major sources of water for these people include surface water, shallow wells, borehole water, streams, lakes, rain water etc. pure water does not exist in nature. Water is considered polluted when it is altered in composition or condition so that it becomes less suitable for any or all of the functions and purposes for which it would be suitable in its natural state [12].

The quality of ground water (borehole) in an area is highly affected by human activities in the area, rainfall level and natural processes occurring in the area [7]. Rain water can easily pick up impurities while passing through the atmosphere, while streams and rivers collect impurities from surface run-off and from sewage discharges and industrial effluents. These are subsequently carried into rivers, lakes or reservoirs that supply our drinking water. These days too, borehole water get polluted with anthropogenic activities.

Many industries release their wastes directly into the environment without pre-treating it. Thus toxic substances such as bromates, ammonia and some heavy metals will accumulate and mix with borehole water. Heavy metals are sometimes referred to as trace elements because they occur in minutes quantities in a sample. They are the metallic elements of the periodic table. Among all forms of water pollution, heavy metal pollution has received great health and environmental concern because most of them are toxic (above certain concentrations) and would persist in the environment for a long period of time (compared to other pollutants). Impacts of bioaccumulation of heavy metals contaminated water is magnified when the metal is transferred along the food chain [6]. Some heavy metals are toxic even at very minute concentration and can create excessive toxicity if not checked [5].

However within the framework of environmental investigation, they have become of particular interest in recent times probably due to the fact that highly sensitive analytical procedures are now available for determining and detecting metal content in samples with high precision.

Landfills also contaminate ground water when rain water leaks into aquifers below the landfill. The percolating water leaches toxic chemicals from batteries, broken fluorescent bulbs, electronic equipment, discarded household chemicals paints and solvents. Other important ground water contaminants are pesticides and herbicides. The extensive use of these chemicals may lead to bioaccumulation.

Besides these, several other microbial contamination are also responsible for livestock diseases which include Escherichia Coli. Burkfolderia, Pseudomallel, Cryptosporiduim

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Parrium, Giardia Lamblia, salmonella, Novovirus and other viruses as well as other parasitic worms. In order to avoid these incidents, it is better to analyze water in both chemical and biological point of view. From what is known today, borehole wells should be located far from any sources of potential pollution. Good well design and construction are important in the prevention of underground water pollution. It has been known that during borehole construction, drilling fluids, chemicals and other materials may find their way into the well thereby polluting the water source. An open hole during the construction stage can also be a direct not for contaminates from the surface to the aquifer thereby providing an ideal opportunity for chemicals and bacteriological pollution to occur. Lasting damage can be avoided if the well is completed and disinfected within a short space of time. The likelihood of contamination increases if there is a lengthy delay in completing the well.

STATEMENT OF THE PROBLEM

The contamination of water is directly related to water pollution. Water pollutants mainly consist of heavy metals, micro-organism, fertilizers and thousands of toxic organic compounds. Heavy metals in water occur in trace levels but are more toxic to the human body. There is therefore need to continuously assess the quality of underground and surface water sources especially those used for drinking and other domestic purposes. Heavy metal toxicity has fatal effects which includes damage to mental and central nervous functions as well as lower energy level. They also cause irregularities in blood compositions, adverse effects on vital organs of the body such as kidney and liver. Long term exposure to those metals results in physical, muscular neurological degenerative processes that cause Alzheimer's disease (brain disorder) Parkinson's (degenerated brain disease), muscular dystrophy processes (skeletal muscle weakness) multiple sclerosis (a nervous system disease that affects brain and spinal cord). [2]. Potable drinking and domestic water should be free of metals and microbial contamination [4]. This study therefore, aimed at assessing the physicochemical, microbiological and chemical quality of selected borehole water samples around mechanic village in Uyo, Akwa Ibom State.

MATERIALS AND METHODS

Study Area

Uyo is the capital city of Akwa Ibom State South-South Nigeria with a estimated population of 1,265000 and its geographic coordinates are latitudes $5^{0}33^{1}$N and longitudes $7^{0}25\mathit{1}^{-}$E. Its altitude is about 148 ft above sea level. Cross River and Qua Iboe River flow across the state to meet the various water needs of the people.

Sample Site Selection

A purposive sampling technique (PST was employed in the selection of the three mechanic workshops out of the many sites scattered around

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the city based on the size of the workshop. Twelve (12) boreholes, four from each of the three locations Mechanic village Abak Road, Mbiabong by Timber Junction and Ifa Atai along Oron Road respectively were randomly selected for the study.

Three control boreholes water were also selected using randomized sampling techniques (RST) in each of the locations.

Data Collection Procedure

Borehole water samples were collected from three (3) selected automobile workshops within the study area using polyethene containers. At each location, the samples were taken from four (4) different points making a total of twelve (12) sampling points for the study. The three (3) control samples around each of the three selected mechanic workshops were collected from the borehole water which was about 100m away from the influence of any auto-mechanic activities.

The locations of the control samples were at the same geological level within the study area. The sampling containers were washed previously with detergent and distilled water, 10% v/v HNO_3. The containers were labeled according to the locations. Mechanic village site were labeled V1, V_2, V_3, V_4 and V_c Mbiabong site were labeled M_1, M_2, M_3, M_4, and Mc while Ifa Atai site – I_1, I_2, I_3, I_4 and I_c respectively. They were pre-rinsed with the borehole water to be collected before collecting the sample water. The sample water collected from these boreholes were kept in a refrigerator at about $^-4^0$c prior to analysis. Fast changing parameters such as temperature P^H, electrical conductivity (EC) were measured in-situ using portable PH/EC/temperature meter (HANNA H1991301 model). While dissolved oxygen was measured using a DO meter. For other parameters such as alkalinity Biological oxygen Demand (BOD) sulphates (SO_4^{2-}) and nitrates ($N0_3^-$) samples were preserved in an ice chest without adding any reagent and taken to the laboratory. In the laboratory, samples were stored in the refrigerator maintained at below 4^0C for between 1 to 7 days prior to analysis. Water samples from each of the boreholes was used for microbiological analysis disinfected with sodium hypochlorite (Naocl) and neutralized with sodium thiosulphate ($N_{a2}S_2O_3$) to eliminate any contamination due to anthropogenic activity or any external natural occurrence. Each borehole was flushed for about three(3) minutes to remove nay externally induced contamination and then the boreholes were then pumped to fill the water bottles leaving an air space for oxygen such that organisms do not die before testing in the laboratory. The bottles were then transported to the laboratory in an insulated box to prevent external factors like high temperature from altering/changing some of the water parameters. Water samples for trace metal analysis were collected into separate 100ml polyethylene containers and acidified in-situ with 2.0ml trioxo nitrate (v) acid (HNO_3). This was to enable the dissolved metals to be kept at ironic form because this will enable the detection of the dissolved metals by Atomic Absorption spectrophotometer (AAS) machine. They were then placed in an ice chest and taken to the laboratory for analysis. The samples were filtered through Whitman No.1 filter paper and stored in polyethylene bottles and kept at <4^0c until analysis. Membrane filtration method was used in the determination of total coli forms and E. coli described by united states Environmental protection Agency.

Method of Data Analysis

1. **Physical Analysis:** Determination of temperature: Temperature of the different borehole water samples were determined in-situ using a centigrade thermometer capable of reading from 0^0c to 11^0c

- **Determination of P^H:** The P^H of the borehole water samples were determined with a P^H meter was calibrated using standard buffer and deionized water. The electrode was cleaned, dried and dipped into the different samples and the readings recorded when it became stable.
- **Determination of electrical conductivity (ED):** The electrical conductivity of the boreholes water samples were determined with a conductivity meter which was calibrated using conductivity solution at 25^0c with 50ml of each of the sample.
- **Determination of total dissolved solid (TDS):** This determination was done using a clean platinum evaporating dish placed in an oven set at 100^0c for one hour.
- **Turbidity:** This was determined using a portable turbidity meter (TB2001R-ID).
- **Microbiological Analysis:** Determination of microbiological analysis of borehole water samples. This analysis was done in triplicate. Plate count method was used for the analysis. Samples were cultured on a nutrient media which was a petri dish that was sealed and incubated at 22^0c for 24 hours. A second plate was at 37^0c for 24 hours. Data obtained were subjected to analysis of variance (ANOVA) and the least significant difference (LSD) was used to separate their means.

Chemical Analysis

- **Determination of Trace Metals**: Heavy metals for this study were determined using Atomic Adsorption spectrophotometer (AAS). Pretreatment of samples for the determination of these metals was done using 2.0ml concentrated nitrate (v) acid ($HN0_3$) for each location. Metals determined included- Pb, Co, Ni and Cd.

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Map of Akwa Ibom State showing location of Uyo Local Government Area

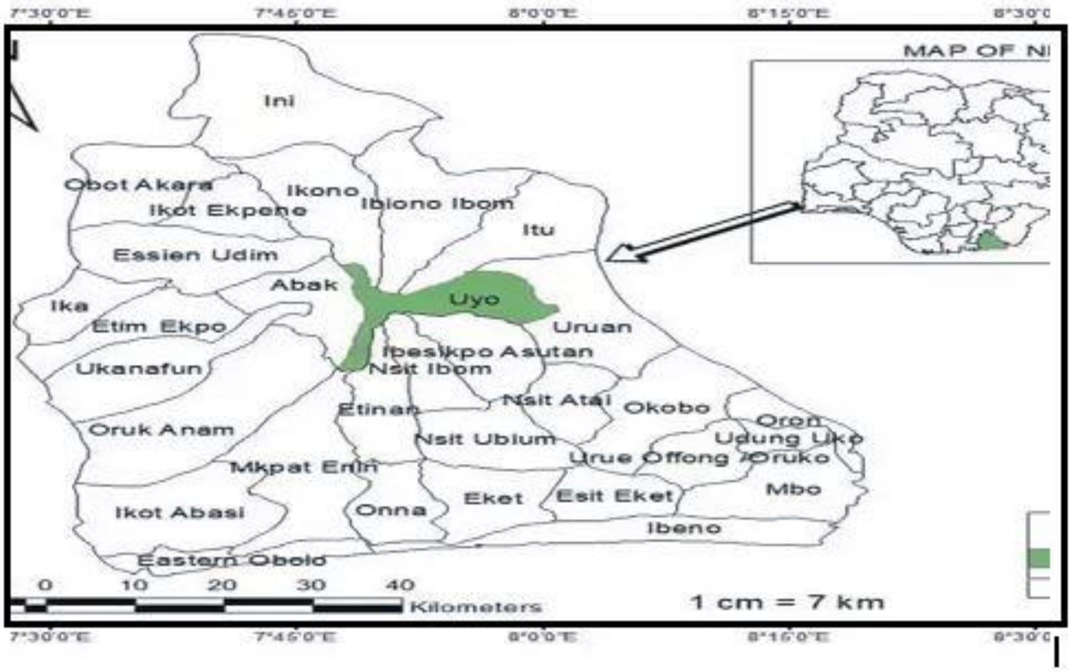

Figure 2: Map of Uyo Local Government Area showing sampling points

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RESULTS AND DISCUSSION

Table 1: Selected locations in Mechanic Village Area

LOCATIONS	AREA CODE
Iya street axis (north)	V_1
Inam street axis (south)	V_2
Afia street axis (east)	V_3
Ekpo street axis (west)	V_4

Table II: Selected locations in Mbiabong Area

LOCATIONS	AREA CODE
Anyanya street axis (noth)	M_1
Uweme street axis (south)	M_2
Mbakara street (east)	M_3
Ufia street axis (west)	M_4

Table III: Selected locations in Ifa Atai Area

LOCATIONS	AREA CODE
Ifiayong street axis (north)	I_1
Etofia street axis (south)	I_2
Amanam street axis (east)	I_3
Udoanana street axis (west)	I_4

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Table IV: Levels of heavy metals detected in water samples from boreholes located at Mechanic village, Mbiabong and Ifa Atai Areas.

WATER SAMPLES	**Mean concentration of heavey metals (ppm)**			
	Lead (pb)	Cobalt (co)	Nickel (Ni)	Cadmium (cd)
V_1	0.0122$\pm$ 0.00032	0.232$\pm$0.00031	0.0073$\pm$0.00033	0.005$\pm$0.00003
V_2	0.0145$\pm$0.00031	0.233$\pm$0.00033	0.0051$\pm$0.00033	0.006$\pm$0.00002
V_3	0.0132$\pm$0.00065	0.305$\pm$0.00032	0.01$\pm$0.00035	0.004$\pm$0.00004
V_4	0.0125$\pm$0.00033	0.323$\pm$0.00033	0.004$\pm$0.00034	0.005$\pm$0.0003
M_1	0.0125$\pm$0.00032	0.2229 $\pm$0	ND	ND
M_2	0.0116$\pm$0.00067	0.231$\pm$0.00033	ND	ND
M_3	0.0211$\pm$0.00065	0.234$\pm$0.00033	ND	ND
M_4	0.0212$\pm$0.0001	0.224$\pm$0.00033	ND	ND
1_1	0.0312$\pm$0.00034	0.432$\pm$0.00032	ND	ND
1_2	0.0314$\pm$0.00032	0.426$\pm$0.00033	ND	ND
1_3	0.0222$\pm$0.00033	0.236$\pm$0.00067	ND	ND
1_4	0.0244$\pm$0.00032	0.341$\pm$0.00033	ND	ND
WHO limit 2004	$\leq$0.01	$\leq$0.1	$\leq$0.02	$\leq$0.003

Values were expressed as mean $\pm$ SD; ND= Not detected;

WHO = World Health Organization.

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Table V: COMPARISON OF THE PHYSICO-CHEMICAL PROPERTIES AND OTHER PARAMETERS OF BOREHOLE WATER AROUND MECHANIC WORKSHOPS IN UYO METROPOLIS WITH WORLD HEALTH ORGANIZATION (WHO) NATIONAL AGENCY FOR FOOD AND DRUG ADMINISTRATION AND CONTROL (NAFDAC) AND THE NIGERIA STANDARD OF DRINKING WATER QUALITY (NSDWQ) STANDARDS

Parameters		**WHO**		**NAFDAC**	**NSDWQ**	**Sites**			
		Highest Describable Level	Maximum permissible level			Mechanic village	Mbiabong	Ifa Atai	Comment
1	Colour	Colourless	Clear	Clear	Clear	Clear	Clear	Clear	Within limit
2	Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Unobjectionable
3	Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable
4	Temperature (^{0}c)	Ambient	Ambient	Ambient	Ambient	Ambient	29.5	30.2	Within limit
5	Turbidity NTU	5	5	5	5	0	0	0	Below limit
6	Conductivity Us/cm	1000	100	100	100	628.5	500	572.8	Below limit
7	P^H	6.5-7.5	6.5-7.5	6.5-8.5	6.5-8.5	7.5	7.2	7.1	Within limit
8	Total Dissolved solid (TDS)	500	500	500	500	440	401	350	Below limit
9	Lead (pb) (ppm)	≤ 0.01	≤ 0.01	≤ 0.01	≤ 0.01	0.013	0.018	0.0027	Within limit
10	Cobalt (c_0) (ppm)	≤ 0.1	≤ 0.1	≤ 0.1	≤ 0.1	0.273	0.229	0.358	Above limit
11	Nickel (Ni)	≤ 0.02	≤ 0.02	≤ 0.02	≤ 0.02	0.0066	ND	ND	Below limit
12	Cadmium (cd) (ppm)	≤ 0.003	≤ 0.003	≤ 0.003	≤ 0.003	0.003	ND	ND	Within limit
13	Total plate bacteria cfu/ml	100	100	100	100	58	48	28	Below limit
14	Coliform cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Within limit
15	E. coli cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Within limit

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Discussion

The result of the physiochemical analysis of water show that the P^H of the water samples from samples V, M and I comply with Nigeria standards for drinking water quality guidelines values. Their values are within the range limits of P^H (6.5-8.5) recommended by SON, WHO, NAFDAC and NSDWQ. Even though P^H has no direct effect on human health, its indirect action on physiological processes cannot be over emphasized [1].

Also Total Dissolved solid (TDS) of the three borehole water samples V, M and I analyzed are below the standard recommended by the WHO, NAFDAC and NSDWQ (500mg/l). The TDS is the term used to describe the inorganic salt and small amount of organic matter present in solution or water. The principal constituents are usually calcium, magnesium, sodium, potassium cation, carbonates, hydrogen carbonate, sulphate and nitrate ion [12]. The presence of TDS in water may affect its taste [12]. It has been reported that drinking water with extremely low concentration of TDS may be unacceptable because of its flat insipid taste [12].

The turbidity of all water samples used in this study is in agreement with both NWDSQ and WHO standard. Water turbidity is very important because high turbidity is often associated with high level of disease causing micro-organisms, such as bacteria and other parasites [8].

All the water samples analyzed in this study have unobjectionable colour, odour and taste which is in conformity with the standards of WHO NAFDAC and NSDWQ.

Table IV shows the mean concentration of the selected heavy metals in borehole water samples collected from mechanic workshops in Mechanic village, Mbiabong and Ifa Atai, all in Uyo metropolis. The concentration of lead (Pb) was within the WHO, NAFDAC and NSDWQ limits ($\leq$0.01 ppm). The concentration of cobalt (Co) was the highest concentration in Ifa atai (0.355 ppm), followed by mechanic village (0.273ppm) and then 0.229 ppm for Mbiabong. The overall result is that the three samples contained Co, above the WHO, NAFDAC and NSDWQ limits. Similarly, Nickel concentration in mechanic village recorded 0.0066 ppm which is below WHO, NAFDAC and NSDWQ standard of 0.02ppm. Nickel concentrations were detected at Mbiabong and Ifa Atai mechanic workshop sites. In the same vein, Cadmium (Cd) concentration in mechanic village was 0.003ppm which was within the WHO, NAFDAC and NSDWQ minimum limits of $\leq$0.003. No cadmium was detected at Mbiabong and Ifa Atai mechanic workshop sample sites. Finally, total coliform counts and E. coli of all the three borehole water samples were Nil. These values indicate the absence which is in agreement with the standard requirement. The implication of finding shows the possibility of the absence of pathogens in the analyzed samples.

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Generally, underground water is often considered as the purest form of water [8], although its vulnerability to contamination could be due to improper construction, animal waste, proximity to toilet facilities, sewage, refuse dump site and various human activities surrounding it [8]. However, no E. Coli were detected in all the water samples which indicate that all the water samples are free from recent faecal contamination. The ability to detect faecal contamination in drinking water is necessary, as pathogenic micro-organisms from human and animal faeces in drinking water pose the greatest danger to public health [4].

CONCLUSION

From the result of the study, it can be concluded that borehole water obtained from the sample areas were contaminated with cobalt, but the presence of lead (Pb), nicked (Ni) and cadmium in the analysed samples were within the WHO, NAFDAC and NSDWQ standards of safe, potable water. Furthermore, the study recorded satisfactory laboratory result for parameters like coliform and E. Coli. Total Coliform count and E. Coli of all the samples analysed were Nil, which is indicative of the fact that water obtained from the sample sites were free from bacteria, and therefore safe for drinking.

However, awareness on the possible risks associated with consuming borehole water contaminated with heavy metals and microbes should be given to rural communities. There is also overwhelming need for awareness to be created to enlighten people on the borehole site selection, as well as in the treatment of water obtained from such borehole to remove any traces of heavy metals or micro-organisms which may be injurious to health.

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