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# Determination of Heavy Metal Concentration in Selected Boreholes in the Vicinity of Dana Steel Rolling Mills in Katsina Metropolis, Katsina State, Nigeria

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## Abstract

In the current study, groundwater samples from five (5) boreholes near the Dana Steel Rolling Mill in Katsina, Nigeria, were examined for variations in the concentrations of specific heavy metals (Cd, Fe, Cu, Cr, and Pb) and their physicochemical parameters, about World Health Organization (WHO) permissible limits, to evaluate their safety for human consumption, using standard methods. For locations A, B, C, and D, respectively, the concentration levels of Cd were 0.036 mg/kg, 0.011 mg/kg, 0.077 mg/kg, 0.041 mg/kg, and 0.057 mg/kg; Pb was 0.789 mg/kg, 0.622 mg/kg, 0.889 mg/kg, 0.756 mg/kg, and 0.556 mg/kg; Fe was 0.158 mg/kg, 0.207 mg/kg, 0.170 mg/kg, 0.178 mg/kg, and 0.178 mg/kg; Cr was 0.089 mg/kg, 0.068 mg/kg, 0.059 mg/kg, 0.102 mg/kg, and 0.091 mg/kg, and Cu was 1.034 mg/kg, 0.997 mg/kg, 0.998 mg/kg, 0.578 mg/kg, and 0.997 mg/kg for locations A, B, C, and D, respectively. Of all the metals examined, only copper was observed to have dropped below the health regulatory organizations' standard, suggesting concentration below the allowable limit. The results of the physiochemical parameters of the water samples revealed that the water is safe for drinking.

**Keywords:** Borehole, Heavy Metal, Pollution, Contamination, Groundwater.

## Introduction

The activities of man have resulted in the contamination and pollution of the natural environment. As a result of these continuous activities, man's natural environment such as soil (land), water, and air has been greatly degraded. The continuous neglect and improper implementation of programs to mitigate these activities may have a resultant effect on the life of man and other organisms that occupy the face of the earth, (Adesemoye, et al., 2006; Edon et al 2016). Water is essential to the proper functioning of life. Man's capacity to obtain potable water for consumption is solely dependent on its accessibility. The availability of water for drinking and other uses is essential to the well-being of all living things, including humans (Halilu et al., 2011). A global concern is the appropriate management of water resources and their accessibility to humans, particularly in the continents of Africa and Asia (WHO, 2004). Water is used for domestic, industrial, and agricultural purposes It is a crucial tool for life on Earth. To achieve a healthy lifestyle, there is a growing demand for clean water for home, industrial, agricultural, and drinking purposes due to global population growth Elinge et al. (2011) . Water is essential to the growth, development, and foundation of cities and societies (Waziri, et al., 2011). , which is why humans depend on it for their survival.

To combat the threat of insufficient water supply, private boreholes have been indiscriminately drilled by individuals, corporate organizations, and even government agencies in their various homes and office environments in Nigeria. This is because the country's various levels of government are unable to provide water for its citizens (Edori, *et al*., 2016; LAWMA, 2000). The goals of sustainable development are undermined by the uncontrolled alternate water supply sources that are offered, as they have a detrimental effect on both surface and groundwater resources (Abii, and Nwabievanne, 2013). Water is susceptible to contamination since it is a universal solvent. In certain situations, it is not appropriate to utilize contaminated water. Water pollution is a result of human activity and influence, including mining, agriculture, metal processing, and oil exploration and exploitation (Edon *et al* 2016 Kolo, and Baba, 2004: Adeyemi, *et al.,*2010). Surface water and subsurface water are often the main sources of water. The wells and borehole water are examples of underground water, whereas rivers, lakes, oceans, estuaries, creeks, and streams are examples of surface water sources (McMurry, *et al*., 2004). The majority of natural water sources for home and agricultural purposes are primarily found underground (in boreholes) (Belkhiri, *et al*., 2018). Groundwater is currently contaminated as a result of human activity brought on by urbanization and progress(Ozturk, *et al*., 2009: Momodu and Anyakora,2010). The urge to use land grows along with the population, and because groundwater is vulnerable, this has led to pollution and contamination of the water. Groundwater pollution and contamination are results of anthropogenic activities that may release chemicals and pollutants into the environment unintentionally or on purpose. Restoring contaminated groundwater to its original condition is a challenging and expensive process (Belkhiri, *et al*., 2018).

Heavy metals are introduced into groundwater by borehole pollution, however heavy metals are normally present underground. One of the main pollutants influencing the subterranean water (borehole) system is heavy metals, which are well-known contaminants of underground water (Marcovecchio *et al.,* 2007). Heavy metals, often known as trace metals, are highly dense and tend to build up in any system that isn't thoroughly inspected. The potential for toxicity of heavy metals is contingent upon their environmental abundance. When the surface soil is unable to hold onto heavy metals, they seep into the groundwater and can subsequently be consumed by humans and other living things. It is impossible to destroy heavy metals (Underwood, 1956: Belkhiri *et al*., 2018). When present in water, heavy metals can exist in three different phases: particulate, dissolved, and colloidal (Adepoju-Bello, *et al*., 2009). It is expedient, therefore to assess the physicochemical parameters and the heavy metal contents in selected boreholes/ well water of the Katsina metropolis in the vicinity of Dana Steel Rolling Mill.

## MATERIALS AND METHODS

### The Study Area

The study area is selected because a significant percentage of the population living around Dana Steel Rolling Mill, Katsina depends on the entirely new N.G.O hand pump water system as their source of drinking water.

### Sample Collection

Water samples from the sampling units were collected following the standard procedure as described by (APHA, 1998). Pre-cleaned plastic bottle was used to collect water samples for the physico-chemical parameters analysis. Sample containers were labeled on the field using appropriate codes and water samples were temporarily stored in the ice-packed cooler, and transported to the laboratory then stored in a refrigerator at about 4 ºC before analysis (APHA, 1998).

### Sample analysis

Standard laboratory methods as described by Akan et al. (2008) for the examinations of water samples were employed for the analysis of Total Suspended Solid (TSS) and Total Dissolved Solids (TDS). Turbidity was determined using a nephelometric turbidity meter (SAP, 1999). Electrical Conductivity and pH were determined using Conductivity and pH meters respectively (APHA, 1998: Sinha, and Biswas 2011).

**Procedure for Digestion**

50 ml of sample was transferred into a beaker after which 5 ml of concentrated nitric acid was added, it was boiled slowly on a hot plate. About 20ml was evaporated and then a further 5ml of concentrated nitric acid was added, and covered with a watch glass, then heated until the solution appeared and was slightly coloured and cleared. The solution was filtered and transferred into a 50ml volumetric flask and allowed to cool and was then made up to the mark with deionized water ( Hoffman, *et al*., 1996).

## RESULTS AND DISCUSSION

### Results

**Table 1:** Mean Concentration of Heavy Metals (mg/L) in Boreholes Samples behind Dana Steel Rolling Mill Katsina

| Samples ID | Heavy Metal concentration (mg/L) | | | | |
|---|---|---|---|---|---|
| | **Pb** | **Cd** | **Fe** | **Cr** | **Cu** |
| **A** | 0.789 | 0.036 | 0.158 | 0.089 | 1.034 |
| **B** | 0.622 | 0.011 | 0.207 | 0.068 | 0.997 |
| **C** | 0.889 | 0.077 | 0.170 | 0.059 | 0.798 |
| **D** | 0.756 | 0.041 | 0.178 | 0.102 | 0.578 |
| **E** | 0.556 | 0.057 | 0.178 | 0.091 | 0.997 |
| **Mean Conc.** | **0.722** | **0.084** | **0.178** | **0.082** | **0.881** |
| **WHO limit** | **0.01** | **0.003** | **0.30** | **0.05** | **2.00** |

**Table 2:** Mean Concentration Levels of Physicochemical Parameters in Borehole Samp behind Dana Steel Rolling Mill Katsina

| SAMPLE | pH | EC (µS/cm) | Turbidity (NTU) | TSS (mg/L) | TDS (mg/L) |
|---|---|---|---|---|---|
| **A** | 6.57 | 4.77 | 0.32 | 1.08 | 9.88 |
| **B** | 6.72 | 7.00 | 0.41 | 1.03 | 7.48 |
| **C** | 7.05 | 6.10 | 0.47 | 1.13 | 5.56 |
| **D** | 6.77 | 6.32 | 0.51 | 0.88 | 9.23 |
| **E** | 6.81 | 5.70 | 0.44 | 1.47 | 8.75 |
| **Mean** | **6.82** | **5.98** | **0.43** | **1.12** | **8.18** |
| **WHO limit** | **6.5-8.5** | **150** | **5** | **50** | **500** |

### Discussion

**Lead Concentration**

Higher levels of lead were found in the entire samples ranging from 0.556 - 0.889 mg/L. it is therefore seen that all the samples had lead levels above the WHO allowable limit of 0.01 mg/L (WHO, 2011). This could be a result of the use of leaded petrol in cars, and generators and may even be a result of some previous activities in the steel rolling mill. The abnormal concentration of the Lead ion could also be a result of composed manure deposited on the farms around the study area or also as a result of littered petrol cars, generators, and water pumps which can pose a threat to humans that depend on groundwater for drinking and domestic purposes as it can cause cancer, interfere with vitamin D as well as damage the nervous system and cause vegetative posture.

**Cadmium Concentration**

The results of the concentrations of Cd from water samples collected from the boreholes were all above the permissible limit (0.003mg/L) (WHO, 2011). The metal index for Cd was high which indicates significant contamination. The high concentration of Cd in water sources in the area could be due to their waste disposal method, natural processes, anthropogenic activities, and human activities due to the previous discharge of wastes from the nearby steel rolling mill (WHO, 1998, Patrick, *et al*., 2002 and Ejikeme 2003). Yakasai, (2004) revealed that the concentration of Cd and other heavy metals in groundwater is dependent on the closeness of the water source to the roads with high traffic density, industrial activities like metal melting and coal refining, and oil-fired power stations, electroplating plants, rate of development of the area, the topography of the land, climatic conditions and solid waste disposals. Environmental exposure to Cd has detrimental health hazards as it is toxic and has a cumulative effect (Ferrer *et al*., 2000 and Klaassen, 2001) Kidney being the major storage organ for Cd is the critical organ that first displays signs of toxicity (Nordberg *et al.,*2001).

**Iron Concentration**

Iron is a naturally occurring metal in the form of magnetite, hematite, etc. It enters into the water during the extraction of metal from its ore. It also enters into the water from aluminum waste products which contain iron, are discharged into water. Iron is an essential element for the dietary requirement most of organisms, and it is a central atom in hemoglobin and helpful to transport the oxygen into various organs through the blood. Iron content in the body if exceeded the tolerable limit is stored in the liver, pancreas, and heart, which tends to damage these organs. Its defects lead to anemia (Ayotte, *et al*.,1999). In this present study, all the samples recorded low levels of iron in all the samples compared to the WHO standard of 0.30mg/L in drinking water (WHO, 2011). The results were in agreement with the safe limit (Table 3.2).

**Chromium Concentration**

All the samples have chromium levels higher than WHO permissible levels for drinking water (0.05mg/L) (WHO, 2011). The high level of chromium in these samples could be due to the presence of chromium in varying concentrations in nearly all uncontaminated aquatic and terrestrial ecosystems. Also, the presence of chromium in soaps and detergents used for washing and bathing could be responsible for the high chromium level in the two samples (Ali *et al*., 2005) The chromium level above the WHO limit could pose a threat to human health in these localities.

**Copper Concentration**

Copper is a common heavy metal found in the environment and spread through the natural ecosystem. It is widely used in industries and agriculture. It enters into groundwater due to industrial wastes that contain copper, agricultural pesticides are released into drinking water sources through corrosion of copper pipes. It is a trace essential element for human health. However, large concentrations of copper can cause eminent health problems. High levels of copper in drinking water have been found to cause kidney and liver damage in some people. Children under one year of age are more sensitive to copper toxicity because it is not easily removed from their system. People with liver damage or Wilson's disease are highly susceptible to copper toxicity (Lantzy and Mackenzie 1979). In this present study, all the samples fall below the acceptable values set by WHO.

**pH**

The pH values of the water samples ranged from 6.57 to 7.05, thus, falling within the standard requirement limits (6.5-8.5) recommended by (WHO 2011 and NIS,2007). The pH values (Table 2) show slightly (weakly) acidic water with the lowest value of 6.57 in location A, which is attributed to the discharge of acidic materials into the groundwater through agricultural and domestic activities, while location C has the highest pH value of 7.05, which can be attributed to previously disposed wastes from the Dana Steel Mill into the groundwater of the studied area.

**Electrical Conductivity**

Electrical Conductivity is the ability of a solution to conduct an electric current that is governed by the migration of solution which is exclusively dependent on the nature and number of ionic species in that solution. From Table 2 above, it has been revealed that all the water samples were in agreement with the World Health Organization set limit of 150 µS/cm (WHO, 2011).

**Turbidity**

Turbidity is the expression of optical property. It is the cloudiness of water caused by a certain variety of particles. It is also related to the content of disease-causing organisms in water which may come from soil run-off. A low level of turbidity was recorded for four samples. The turbidity values as revealed in Table 2, were 0.32 NTU, 0.41 NTU, 0.47 NTU, 0.51 NTU and 0.44 NTU for locations, B, C, D, and E respectively. This indicated a low degree of pollution as the average turbidity of 0.42 NTU is within the permissible limit of 5 NTU, recommended by the World Health Organization(WHO,2011).

**Total Suspended Solids**

The maximum recommended total suspended solids for safety limit set by the World Health Organization is 50mg/L. The TSS values of all four samples of the sampling site were found to be within the recommended World Health Organization value (WHO,2011). The TSS values of all the water samples as shown in Table 2 above are 1.08 mg/l, 1.03 mg/l, 1.13 mg/l, 0.88 mg/l and 1.47 mg/l for samples A, B, C, D and E respectively. The average TSS value in all the five samples is 1.12 mg/l.

**Total Dissolved Solid**

Total Dissolved Solids are the inorganic matter and small amounts of organic matter that are present as solutions in water. TDS indicates the salinity behavior and the amount of other substances dissolved in the water. The TDS value ranged from 5.56-9.88 mg/L. The average value obtained in this study was 8.81mg/L, which is below the permissible limit of 500 mg/L (WHO,2011).

**CONCLUSION**

The results obtained from the study of physicochemical analysis of water from selected boreholes in the vicinity of Dana Steel Rolling Mill, Katsina showed that the water samples analyzed are safe for human consumption. The results obtained indicated that only the concentrations of lead and cadmium were found to be slightly above the World Health Organization and Nigerian Drinking water quality standard allowable limits.

**RECOMMENDATION**

Regular and sustainable monitoring of groundwater in the studied area is advocated. Strict legislation to control the excessive use of agrochemicals as farming input and indiscriminate dumping of wastes is highly advocated. Anthropogenic activities that lead to land and underground water degradation should be strictly regulated.

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