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Analysis of Heavy Metals in Water around Gidan Saru Mining Site, Zamfara State, Nigeria

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Abstract

Mining processes result in large amounts of toxic waste Particles, mine tailings might be carried by wind to contaminate broad areas, including water bodies. Chemicals and heavy metals contaminate nearby water sources in most mining areas of Nigeria where Artisanal and Small-Scale Gold Mining is commonly practiced. Five water samples from one of the gold mines of Zamfara state were analysed for heavy metals (Mn, Zn, Pb, Cd, Ni, Fe and Cu) using Atomic Absorption Spectrophotometer. The analysed samples shows mean concentrations (mg/l) ranged of 0.00-29.40, 9.49-15.70, 10.16-382.44, 1.61-3.91,8.73-19.20,14.11-244.01 and 68.22-103.22mg/l respectively. When compared with the maximum allowed limits set by World Health Organisation (WHO), National Standard Drinking Water Quality (NSDWQ) and United State Environmental Protection Agency (USEPA) for drinking water, the samples are totally contaminated with all heavy metals being analysed. The pH value ranged between 5.24-6.72 out of five hand dung wells only one has meet the standard of WHO, NSDWQ and USEPA. This study concluded that the study area was polluted. A possible solution is needed from appropriate agencies to overcome the problems.

Keywords: *Heavy metals, Mining, Water, Pollution, Environment.*

1.0 INTRODUCTION

Water is indispensable. It is not only essential for the survival of man but also for other living organism (Rasheed and Amuda, 2014). It is an essential nutrient that is involved in every function of the human body and constitutes about two-third of the human body (Pavendan *et al.*, 2011,) The importance of water in our daily life makes it imperative that thorough microbiological and physio-chemical examinations be conducted on water. (Pavendan *et al.*, 2011,) Water for human consumption must be free from microorganisms and chemical substances in concentrations large enough to cause environmental imbalance and disease (Rasheed and Amuda, 2014). Ground water is one of the major sources of drinking water in the study area hence it was important to assess the ground water quality with respect to heavy metal contamination. Water pollution around the

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mining and smelting areas has been clearly demonstrated by high concentrations of heavy metals in water, sediments, and aquatic organisms (Jung, 2001). Contamination of soil and water occur in a number of ways simply classified as geochemical processes and human activities such as metal smelting industries, coal combustion and animal waste (Galadima *et al.*, 2010). Mining of solid minerals has been identified as a major source of heavy metals in the environment because ore bodies generally include a range of minerals containing both heavy and essential metals (Tsafe *et al.*, 2012a) Heavy metals enter the environment by natural and anthropogenic means. Such sources include: natural weathering of the earth's crust, mining, soil erosion, industrial discharge, urban runoff, sewage effluents and pest or disease control agents applied to plants, air pollution fallout (Vinodhini and Narayanan, 2008). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms (Storelli *et al*., 2005).

2.0 MATERIALS AND METHODS

2.1 SAMPLE COLLECTION:

The samples were collected from four (4) different hand dug wells and a Bore hole in Gidan Saro village of Bungudu local government, Zamfara state. Sample containers were thoroughly washed with detergent, rinsed with water followed by distilled water before soaking in 5% HNO_3 for some hours. Water Samples were collected from hand dug wells and borehole water in acid washed polypropylene plastic containers and transported to the laboratory.

2.2 SAMPLE DIGESTION AND ANALYSIS

Digestion of water samples was carried out by taking 50cm^3 of the sample and adding 10cm^3 of concentrated HNO_3. The mixture was heated on a hot plate. Heating continued until the solution boiled and evaporated to 20cm^3. The boiled mixture was allowed to cool and then filtered with whatman filter paper. The solution was transferred into 50cm^3 volumetric flask and made up to the mark with distilled water (APHA, 2005). Spectrophotometer calibrated with standard solutions and the digested samples were analyzed for concentrations of Lead, Cadmium, Chromium, Nickel, Manganese, Copper, Iron and Zinc at their respective detection wavelengths (Galadima, *et al.*, 2010). For blank sample, 10cm^3 of concentrated nitric acid was heated on hot plate to almost dryness. The heating was stopped after appearance of white dense fume and clear solution. Upon cooling, it was diluted and made to mark in a 50cm^3 volumetric flask (Akinsola, 2004).

3.0 RESULTS AND DISCUSSIONS

Table 2.1 above Shows pH and heavy metals concentration in (mg/L) of water samples from hand dung wells around Gidan Saru mining site. The highest concentration of heavy metal was Pb with range between 10.16-382.44mg/L. The lowest concentration of heavy metals was Cd with the range between 1.61-3.91mg/L, and highest was detected in W2 and lowest at W1.

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Table 1. Mean±Standard deviation of heavy metals in hand dung wells

pH	^{a}5.41±0.02	^{a}6.49±0.09	^{a}5.24±0.08	^{a}5.37±0.11	6.72±0.49	7.56±0.30
Element	W1	W2	W3	W4	BH	Control
Pb	^{d}23.61±0.43	^{c}49.20±0.10	^{a}382.44±0.41	^{b}83.45±0.19	^{e}10.16±0.16	ND
Cd	^{ab}1.61±0.15	^{a}3.91±0.28	^{a}3.30±0.37	^{a}3.59±0.24	^{a}2.69±0.46	^{a}2.48±0.13
Mn	ND	ND	ND	29.40±0.65	ND	ND
Fe	^{a}244.01±0.14	^{e}48.10±0.37	^{d}65.88±0.20	^{c}78.90±0.12	^{b}193.10±0.14	^{f}14.11±4.50
Zn	^{b}10.75±2.48	ND	^{b}11.64±0.29	^{a}12.37±3.64	^{a}15.70±2.22	^{b}9.49±0.21
Cu	^{a}103.22±1.89	^{c}85.86±0.53	^{c}88.46±8.04	^{ab}98.47±1.10	^{a}99.09±0.37	^{d}68.22±1.97
Ni	^{c}8.73±0.61	^{b}14.02±0.34	^{ab}17.28±1.55	^{a}19.20±0.63	^{a}18.37±2.75	^{b}12.41±2.78

ND Means not detected
Mean with the same superscripts are not significantly different.

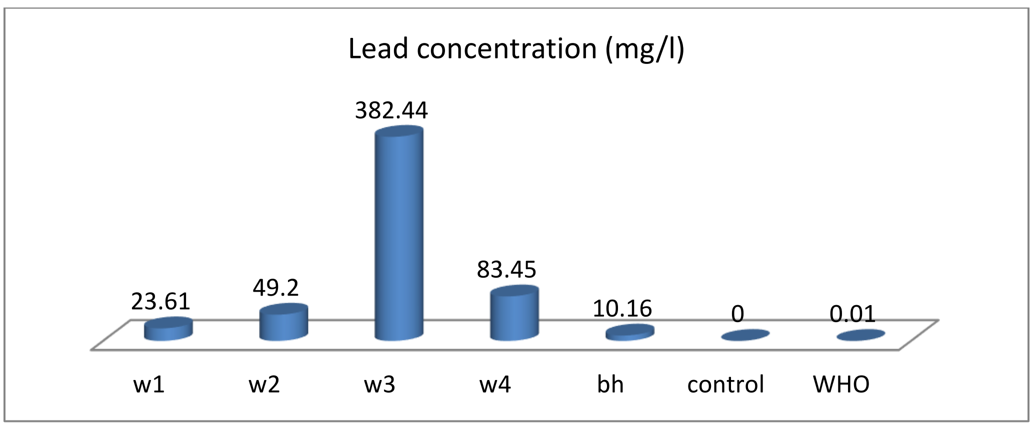

Figure 1. Pb level in the Samples.

The minimum and maximum concentrations of lead were 10.16-382.44mg/l respectively. According to the Figure 1, the lowest level up to 10.16mg/l was detected in borehole water sample, but no concentration was determined in wells water of the control area this might attributed to limited or lack of anthropogenic activities especially by artisanal Gold miners in the area. However, such high concentration in all samples is directly associated to massive environmental contamination from artisanal mining and processing of gold. Thus, the values are much higher than the 0.01ppm permissible limits of World Health Organization and Nigeria Standards for Drinking Water Quality. When the concentration levels in this work compared to a non-mining area, a mean level concentrations of 0.019 to 0.083 Mg/L was observed in surface and groundwater by Reddy *et al.*, (2012), Galadima *et al.*, (2010) have documented 0.548 to 2.096 ppm in waste water from University students' halls of residence. Scientists have suggested that all exposure to lead should be avoided and that there is no safe exposure concentration. This

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would imply that even the relatively low concentrations found might be a risk, especially for young children (UNEP, 2010). Many authors national and international have documented a lot of findings concerning Lead concentration in drinking water considering its impact. A range of 10-320µg/l, <10-322µg/l and <10-434µg/l were reported in communal and private wells in Abare, Kirsa and Bagega village of Anka Zamfara State by UNEP, (2010).

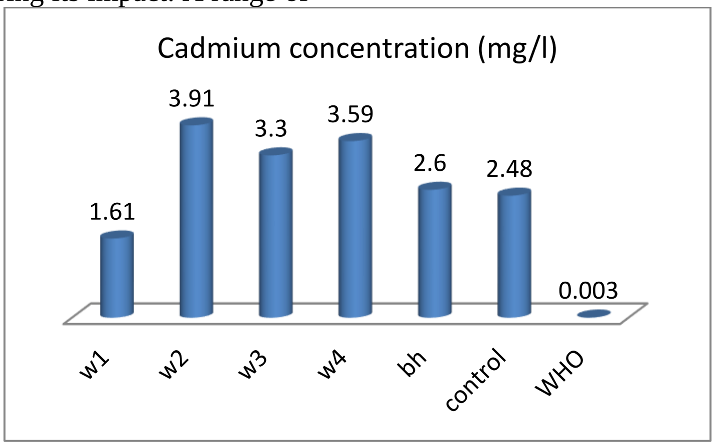

Figure 2. Cadmium Level in the Samples.

The highest Cadmium concentration of 3.91 mg/l was detected in W2 as shown in figure 2.. The minimum and maximum Cadmium concentrations varied between 1.61mg/l to 3.91mg/l. There is no significant difference between W2 and W4. The values obtained were exceeded the permissible levels 0.003mg/l and 0.005mg/l of World Health Organization, Nigeria Standards for Drinking Water Quality and United States Environmental Protection Agency. The values are higher when compared to 0.27mg/l observed in waters around the Imcheon Au–Ag mine, Korea, by Jung (2001); 0.16mg/l was reported for surface water of Oko-Afa Canal Isolo Lagos, Nigeria by Yahaya *et al*, (2012); a range between 0.001 to 0.005ppm was also observed in waste water from University students' halls of residence by Galadima *et al*, (2010).

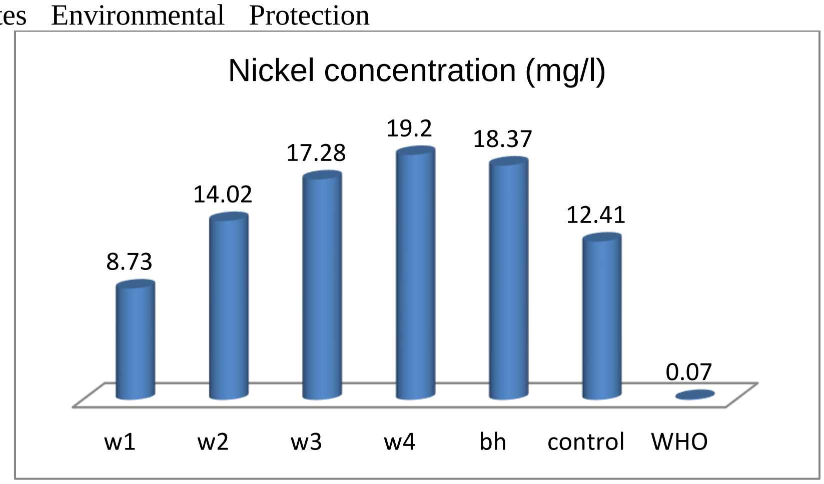

Figure 3. Nickel level in samples.

Nickel occurs naturally in soils as a result of the weathering of the parent rock. The underlying rocks and soil-forming processes strongly influence the amount of Nickel in soils. Anthropogenic activities have resulted in the widespread atmospheric deposition Nickel from

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the burning of coal and oil and mining activities (ATSDR, 2005). According to figure 3, W4 has the highest concentration of 19.2.mg/l and W3 has the lowest of 8.73.mg/l which in turn lower than the value 12.41.mg/l of control area. The values obtained in hand dug wells, borehole and control area are higher than the 0.07ppm and 0.03mg/l permissible limits of World Health Organization and Nigeria Standards for Drinking Water Quality, Hence, the study area was severely polluted. Many authors have documented similar works. The value obtained in this work is high when compared to a mean value 0.611 ± 0.494081 mg/l detected in drinking water points of Dareta by Udiba *et al*, (2012a) also, 1.19±0.266mg/l was reported by Tsafe *et al*, (2012a) in a study conducted at Yargalma mining community and also 8.1mg/l observed in water of Ex-Mining Area Bestari Jaya, Peninsular Malaysia by Ashraf *et al*, (2010). However, a high mean value 23ppm has recorded for hand dug wells of sunke village of Anka, Zamfara State by Oladipo *et al*, (2014).

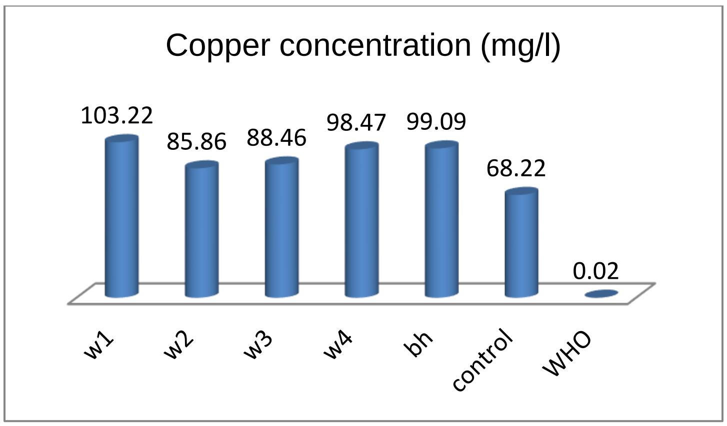

Figure 4. Copper level in the samples.

The copper concentration in control area was not found, the values obtained in W1, W2, W3, W4 and bh respectively ranged between 68.22l-103.22mg/l as shown in figure 4.. There was no significant difference between W2 and W3; W1, bh and W4 respectively. The level contents across hand dug wells and borehole have exceeded the permissible levels of 0.02mg/l, 1mg/l and 1.3mg/l of World Health Organization, Nigeria Standards for Drinking Water Quality and United States Environmental Protection Agency. Mean concentration of copper of 1.028ppm was recorded in Surface Water of Kutcheri, Zamfara State by Rasheed and Amuda, (2014), 0.0201ppm was observed in Seasonal River in Maru Town, Zamfara State as reported by Salawu *et al*, (2014), mean value of 75mg/l have documented for Water of Ex-Mining Area Bestari Jaya, Peninsular Malaysia by Ashraf *et al*, (2010), Oladipo *et al*, (2014) have recorded up to 30ppm in hand dug wells of Sunke mining community of Zamfara, lower value of 0.079ppm was detected in a study conducted at Artisanal Gold Mining in Bagega Village of Zamfara State by Nuhu *et al*, (2014).

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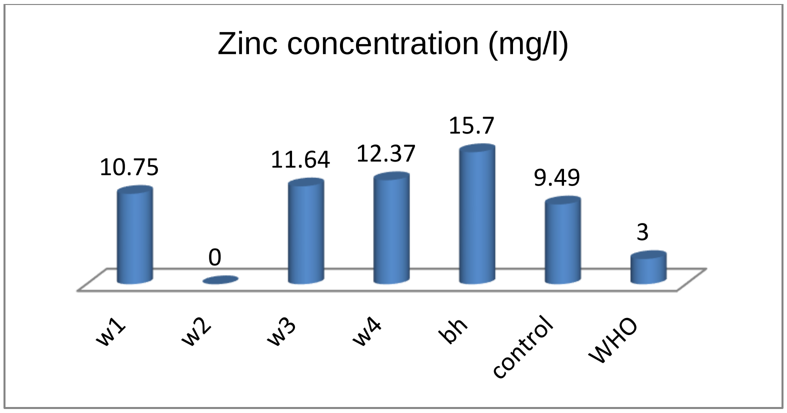

Figure 5. Zinc level in the samples.

According to figure 5, the level concentrations of copper across W1, W2, W3, W4, and control range between 9.49-15.70mg/l. The highest value of 15.88mg/l was recorded in bh and lowest 9..49mg/l around control area. Statistically, there is no significant difference across W1, W3, W4 and control area,. Zinc is an important element the body needs to function properly. A small amount of Zinc is necessary for a balanced human diet. It helps maintain immune function, cell division and repair, and helps in the metabolism of carbohydrate. Zinc is also needed for the sense of taste and smell (Udiba *et al*, (2012a). The recommended daily Zinc intake for adults is between 9 and 11 mg and maximally 20mg per day. However, exposure to excess amount of Zinc can result to Zinc poisoning and might cause acute effects such as vomiting and gastrointestinal irritation (nausea, cramps and diarrhea) (ATDRS, 1995). The value obtained from this work is higher than the 3mg/l permissible limits of World Health Organization. Tsafe *et al*, (2012a) have documented 9.66±0.079mg/l in hand dug well of Yargalma mining community. Similarly, 25.39±13.39mg/l was reported for water drinking points of Dareta mining community Zamfara, Nigeria by Udiba et al, (2012a). Meanwhile, 1.1367ppm was reported by Salawu *et al*, (2014).

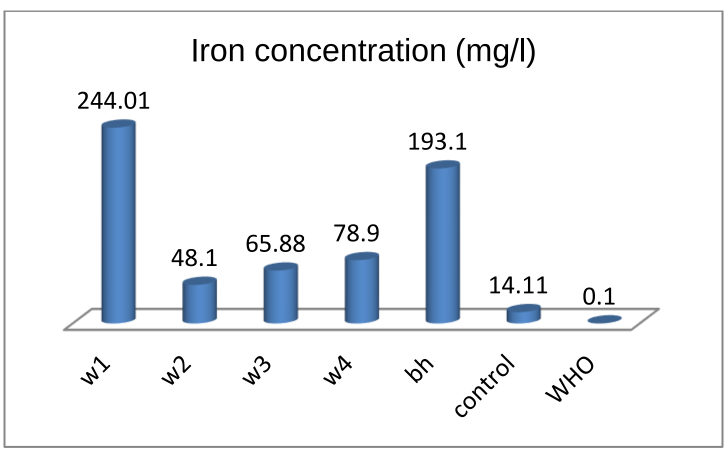

Figure 6. Iron levels in the samples.

The mean value of Iron concentrations obtained in hand dug wells, bore hall and control area were ranged between 14.11-244.91mg/l as shown in figure figure 6. The highest value was obtained in W1. This high concentration could be due to the fact that the W1 is located nearby

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tailings, where the actual mining activities are taking place. However, such high concentration is in accordance with relative abundance of Fe in the earth crust and solid minerals Tsafe *et al*, (2012a). The values are much higher than the 0.10ppm and 0.3mg/l permissible limits of World Health Organization and Nigeria Standards for Drinking Water Quality. The values 314ppm, 380ppm reported for hand dug wells of Sunke and Dareta mining community by Oladipo *et al*, (2014), 14mg/l was recorded in Water of Ex-Mining Area Bestari Jaya, Peninsular Malaysia by Ashraf *et al*, (2010), mean concentration 19.072±0.45mg/l of iron observed in water samples from a hand dug well in mining community of Yar galma by Tsafe *et al*, (2012a).

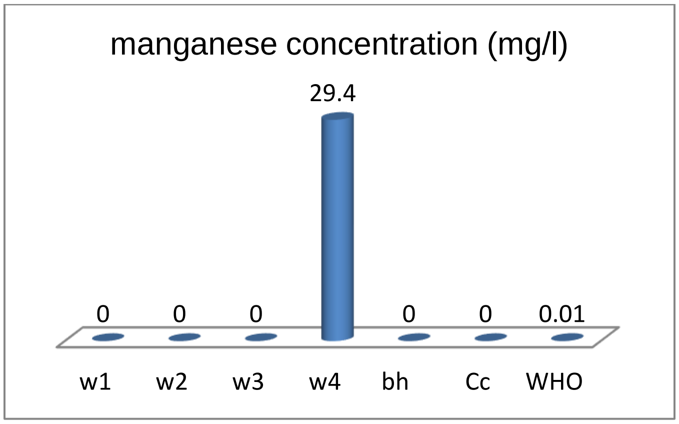

Figure 7. Manganese level in the samples.

The mean value of Manganese up to 29.40±0.650mg/L was only detected in W4. No concentration was found in W1, W2, W3, BH and control area. Such high concentration in W4 was not surprising, because the mobility of heavy metals from tailings to stream waters as a result of leaching behavior of the tailings into water bodies through precipitation and desorption Tsafe *et al*, (2012a). Oladipo *et al*, (2014) documented up to 49ppm and 66ppm in hand dug wells of Sunke and Dareta Gold mining sites of Zamfara state, 26.82ppm have also reported high concentrations in waste water from Sudanese Fermentation Industry by El-Hadi *et al*, (2010), Thus, the manganese concentration detected inW4 is much higher than acceptable limits of 0.2mg/l of the World Health organization (WHO) and National Standards for Drinking Water Quality (NSDWQ).

4.0 CONCLUSION

The levels of Lead, Nickel, manganese, Zinc, Iron, Copper and Cadmium in the water samples of hand dug wells and bore hole of Gidan Saru village, Bungudu LGA of Zamfara state were thoroughly analysed. The analysis revealed that the levels of analysed heavy metals recorded in the study area were above both the Nigeria Standard Drinking Water Quality (NSDWQ) and World Health Organisation (WHO) Maximum Permissible Limits. Thus, the study area was severely contaminated by heavy metals. The elevated levels of the analysed metals might be attributed due to anthropogenic activities of illegal Gold mining in the study area.

4.1 RECOMMENDATIONS

In view of the results obtained, the following recommendations are hereby suggested:-

I. Provision of portable drinking water. This would stop inhabitants from drinking contaminated waters.
II. Water bodies such as River and Lakes should not be used in floatation to separate the ore after crushing which is commonly practice by artisanal miners.
III. There is need for national and international agencies to set certain guidelines for effective mining.

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