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Health Risk Assessment of Heavy Metals in Water Samples from Hand Dug Wells in Isoko Local Government Areas, Delta State, Nigeria

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Abstract **- Water is of major importance and is intensively exploited for domestic and industrial uses. Some hand dug wells in Isoko South and North local government areas of Delta State were analyzed for heavy metals using the Atomic Absorption Spectrophotometer (AA320N). For the samples analyzed, Iron, zinc, nickel, chromium and lead concentration range were 0.001 – 0.743mg/l, 0.001 – 0.105mg/l, 0.001 – 0.050mg/l, 0.001 - 0.062 and 0.001 – 0.053mg/l respectively. All water samples were within the WHO and SON permissible limits and fit for drinking with the exception of few wells. Also, the estimated health quotient for Fe, Zn, Ni, Cr, and Pb were less than the safety threshold of 1 except Fe in sample from well2 in Oleh that is 3. Although, these values are relatively low, exposure through the regular consumption of well water in the study area over a long period of time may pose potential health issues to the population. It is recommended that relevant authorities should help to enlighten the people on the necessity for treatment of the water before they can be used for drinking and domestic purposes.**

Keywords **– heavy metal, Isoko, well, health risk, AAS etc.**

I. INTRODUCTION

Water is very important to life and existence. Due to its importance as the lifeblood of the environment the key to the survival of all living things: plants animals and humans; it is important to maintain it clean and unpolluted (Alhibshi et al., 2014)

According to Tar et al, as cited in Atiku et al., (2017) studies have shown that over one billion people in the world lack access to safe drinking water and 2.5 billion people do not have access to adequate sanitation services. Many have resorted to the use of underground water due to the incapacity of the government to convene the ever increasing water demand abate in the country (Adebawore et al., 2017).

People from around the world have used groundwater as a source of drinking water. Even today, more than half the world's population depends on groundwater for survival. The value of groundwater lies not only in its widespread occurrence and availability, but also in its constituent good quality, which makes it an ideal source of drinking water (Dusa et al., 2017).

Water is of major importance and is intensively exploited for private, domestic and industrial uses. A major source of groundwater abstraction for use is by means of a hand dug well. A well is a hole or shaft sunk into the earth for the purpose of obtaining water and other fluid from an underground supply. Hand dug wells are of vital importance as a source of domestic (drinking) water in most developing countries (Oyatayo et al., 2015).

A recent study by Adebawore et al., (2017) showed that the general belief in the rural areas that groundwater is clean and potable is not absolutely true and that hand dug water despite being underground can still be contaminated by mineral elements and other activities around the well. The study also revealed that changes in seasons do have impact water on the concentrations of heavy metals and the quality of drinking water.

The spilling, leaking, improper disposal or intentional application of chemicals at the land surface can result in run off that contaminates nearby streams and lakes or infiltration that contaminates that contaminates underlying aquifers. The type and severity of water contamination often is directly related to human activities, which can be quantified in terms of the intensity and type of land use in the source areas of water to streams and aquifers (Oyatayo et al., 2015).

Millions of people around the world get exposed to high level Millions of people around the world get exposed to high levels of heavy metals in the drinking-water. The threat that heavy metals pose to human and animal health is aggravated by their low environmental mobility, even under high precipitations, and their long term persistence in the environment (Muhammad et al., 2013). There are a lot of water reserves but people are

not educated to make best use and keep contaminating and thronging the contaminated water uncared. Excessive levels can be damaging to the organism. Although individual metals exhibit specific signs of their toxicity, the followings have been reported as general signs associated with cadmium, lead, iron, zinc, and copper poisoning: gastrointestinal (GI) disorders, diarrhoea, stomatitis, tremor, hemoglobinuria causing a rust-red colour to stool, ataxia, paralysis, vomiting and convulsion (Duruibe et al. 2007). The nature of effects can be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic (Ayotunde 2012).

Many chemicals containing sulphates, nitrates an phosphates contaminates aquifers making them unfit for drinking. These anions especially nitrates are mostly used in rural areas. They can enter the system from a variety of natural and anthropogenic sources (mainly fertilizers usage) (Allamin et al., 2015).

The major issue of national and international interest is how water pollution problems could be fully assessed and mitigated and how potable water can be made available to the masses especially in the rural and semi-urban regions.The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Ground water occurs in weathered portion, along the joints and fractures of the rocks (Chindo et al., 2013). However, the health risks for a population exposed to heavy metals have rarely been estimated in this study area.

The aims of this study are:

- To quantify the concentrations of Ni, Pb, Zn, Cr and Fe.
- To investigate the daily intake values of values of heavy metals.
- To present the health quotient for heavy metals through the drinking of well water.

II. MATERIALS AND METHODS

1. The Study Area

Isoko is in Delta South senatorial District of Delta state and is inhabited by the Isoko people. The region is divided into two local government areas, Isoko North and Isoko South with their headquarters in Ozoro and Oleh respectively.

The study area is in the tropical rain forest of the Niger Delta. The area experiences high rainfall and high humidity most of the year. The climate is equatorial and is marked by two distinct seasons. The dry season lasts from about November to April and is significantly marked by the cool harmattan dusty haze from the North-east winds. The rainy season spans May to October with a brief dry spell in the month of August (Eteng Inya,1997; Etu-Efeotor, 1998).

2. Sample Collection

Two (2) water samples each were collected from selected hand dug wells in seven (7) communities in Isoko South and Isoko North Local Government Areas of Delta State. Samples of water of about 500ml were collected in clean plastic bottles and properly labeled before taken to the laboratory for analysis. To ensure that no foreign substance was introduced into the sample, the plastic containers were washed with the samples before final collection.

3. Procedures

Sample preparation for turbid and waste water a representative portion of the well mixed sample (100ml) was transferred into a beaker and 5ml of conc. HNO3 was then added. The solution was evaporated to near dryness on a hot plate, making sure that the sample does not boil. A gentle refluxing action of the solution was set by increasing the temperature of the hot plate. Heating was continued with addition of acid as necessary until digestion was completed (light coloured residue was obtained).

The beaker was allowed to cool and another 5ml of Conc. HNO3 was added. The beaker was covered with a watch glass and returned to the hot plate. 1.2ml Conc. HNO3 was then added to dissolve the residue. The residue was washed with distilled water and filtered to remove silicate and other insoluble material. The volume of the solution was adjusted to 100ml in a volumetric flask. A reagent blank determination was carried out, samples and reagent blank was analyzed for total heavy metals with the flame AAS. Detailed procedure can be found in literature (Emumejaye,2012).

III.HEAVY METAL RISK ASSESSMENT

1. Exposure Assessment

Heavy metal exposure to human occurs through three primary routes namely inhalation, ingestion and dermal absorption (APHA.2005).The average daily dose (ADD) through drinking water intake is calculated using equation 1 (US EPA, 1998).

$$ADD = \frac{X * IR * ED * EF}{BW * AT} \quad (1)$$

Where X, IR, ED, EF, BW, AT represents the heavy metal concentration in water (mgl^{-1}), water ingestion rate 2 ($L\ day^{-1}$), exposure duration (assumed 65 years), exposure frequency (365 days $year^{-1}$), body weight (70kg) and average life time (23,725 days), respectively.

2. Human Health Risk Assessment

Here, the chronic risk level was assessed. Generally, the Health Quotient (HQ) can be estimated by using equation (2) (US EPA, 1998).

$$HQ = \frac{ADD}{RfD} \quad (2)$$

Where RFD is toxicity reference dose values shown in Table 1. The health risk generally occurs when the HQ values were >1 (Khan et al., 2008)

Table 1 Toxicity reference dose values

Heavy Metal	Toxicity reference dose(RfD)($mgkg^{-1}day^{-1}$
Iron	0.007
Lead	0.004
Chromium	1.500
Zinc	0.300
Nickel	0.020

Source- US EPA 2007

IV. RESULTS AND DISCUSSION

1.Heavy Metal The results obtained for the heavy metal analysis are shown in the table 3. The concentration levels of iron in all the water samples with range of < 0.001 – 0-080mg/L are below the permissible level of both WHO and SON. Nickel concentrations in the water samples conform to the WHO and SON values (0.02mg/L) except Uzere 1, Uzere 2, Iyede 2, Owhe 2, Oleh 2

Table2 Concentration of heavy metals in well water from selected towns in Isoko LGAs

S/N	Locations	Fe	Ni	Cr	Pb	Zn
1.	Olomoro 1	0.021	0.020	0.046	0.001	0.001
2.	Olomoro 2	0.028	0.001	0.034	0.001	0.061
3.	Uzere 1	0.080	0.040	0.062	0.023	0.061
4.	Uzere 2	0.014	0.030	0.049	0.023	0.001
5.	Iyede 1	0.040	0.001	0.031	0.001	0.050
6.	Iyede 2	0.092	0.030	0.009	0.020	0.070
7.	Irri 1	0.014	0.001	0.003	0.001	0.001
8.	Irri 2	0.001	0.001	0.001	0.001	0.001
9.	Owhe 1	0.071	0.030	0.034	0.050	0.065
10.	Owhe 2	0.028	0.001	0.001	0.001	0.001
11.	Oleh 1	0.014	0.001	0.001	0.001	0.001
12.	Oleh 2	0.743	0.050	0.046	0.001	0.105
13.	Ozoro 1	0.028	0.030	0.049	0.053	0.017
14.	Ozoro 2	0.014	0.001	0.001	0.001	0.017
who	-	0.300	0.020	0.050	0.010	5.000
son	-	0.300	0.020	0.050	0.010	3.000

Ozoro1.With the exception of Uzere1, the concentrations of chromium in all the water samples were within the limits for both WHO and SON. Uzere 1,Uzere2,Iyede2,Owhe1 and Ozoro1have concentration value of lead to be above the limit of both WHO and SON. All the water samples have zinc concentration below the limit of both WHO and SON.

V. HEALTH RISK ASSESSMENT

Table 3 Average Daily Dose Assessment Values

Location	Fe	Ni	Cr	Pb	Zn
Olomoro 1	1.31E-03	5.71E-04	1.31E-03	2.86E-05	2.86E-05
Olomoro 2	8.00E-04	2.86E-05	9.71E-04	2.86E-05	1.74E-03
Uzere 1	2.29E-03	1.14E-03	1.77E-03	6.57E-04	1.74E-03
Uzere 2	4.00E-04	8.57E-04	1.40E-03	6.57E-4	2.86E-05
Iyede 1	1.14E-03	2.86E-05	8.86E-04	2.86E-05	1.43E-03
Iyede 2	2.63E-03	8.57E-04	2.57E-04	5.71E-04	2.00E-03
Irri 1	4.00E-04	2.86E-05	8.57E-05	2.86E-05	2.86E-05
Irri 2	2.86E-05	2.86E-05	2.86E-05	2.86E-05	2.86E-05
Owhe 1	2.03E-03	8.57E-04	9.71E-04	1.43E-03	1.86E-03
Owhe 2	8.00E-04	2.86E-05	2.86E-05	2.86E-05	2.86E-05
Oleh 1	4.00E-04	2.86E-05	2.86E-05	2.86E-05	2.86E-05
Oleh 2	2.12E-02	1.43E-03	1.31E-03	2.86E-05	3.00E-03
Ozoro 1	8.00E-04	8.57E-04	1.40E-03	1.51E-03	4.86E-04
Ozoro 2	4.00E-04	2.86E-05	2.86E-05	2.86E-05	4.86E-04

The average daily dose estimated values shown in Table 3 is below world average for the sample locations in the study area.

2. Health Quotient

Table 4 Health Quotient Assessment Values

Locations	Fe	Ni	Cr	Pb	Zn
Olomoro 1	8.76E-04	2.86E-02	8.76E-04	7.14E-03	9.52E-05
Olomoro 2	1.14E-01	1.43E-03	6.48E-04	7.14E-03	5.81E-03
Uzere 1	3.27E-01	5.71E-02	1.18E-03	1.64E-01	5.81E-03
Uzere 2	5.71E-02	4.29E-02	9.33E-04	1.64E-01	9.52E-05
Iyede 1	1.63E-01	1.43E-03	5.90E-04	7.14E-03	4.76E-03
Iyede 2	3.76E-01	4.29E-02	1.71E-04	1.43E-01	6.67E-03
Irri 1	5.71E-02	1.43E-03	5.71E-05	7.14E-03	9.52E-05
Irri 2	4.08E-03	1.43E-03	1.90E-05	7.14E-03	9.52E-05
Owhe 1	2.90E-01	4.29E-02	6.48E-04	3.57E-01	6.19E-03
Owhe 2	1.14E-01	1.43E-03	1.90E-05	7.14E-03	9.52E-05
Oleh 1	5.71E-02	1.43E-03	1.90E-05	7.14E-03	9.52E-05
Oleh 2	3.03E0	7.14E-02	8.76E-04	7.14E-03	1.00E-02
Ozoro 1	1.14E-01	4.29E-02	9.33E-04	3.79E-01	1.62E-03
Ozoro 2	5.71E-02	1.43E-03	1.90E-05	7.14E-03	1.62E-03

The health quotients for all metals of interest in this study are shown in table 5. For iron in the study area ranged from 0.000876 to 3.03. Nickel had a range of 0.00143 to 0.0714. For chromium, its values ranged from 0.000019 to 0.000933. Lead and zinc have a range of 0.00714to 0.379 and 0.0000952 to 0.1 respectively.

From Table 4, the water samples could be declared safe with the exception of Oleh 2 as the only potential health hazard with respect to iron concentration. This is because its health quotient is greater than 1 (3.03).

Table5 Average Daily Dose of present work compared with reports from other places

Country	Fe	Ni	Cr	Pb	Zn	Reference
Nigeria	-	-	1.44	1.81	2.83	Emuedo et al., (2014)
Egypt	0.834	-	0.046	0.015	-	Badr et al.,(2011)
Iran	0.03	-	0.07	-	-	Sakizadeh&Mirzaei,(2016)
Ethopia	2019	-	1.1	5.8	19.6	Haileslassie&Gebremedhin (2015)
Present work	0.085	0.017	0.026	0.013	0.032	

These values in Table 5 agree with results from Iran and Egypt but are lower. Similar work done in Nigeria indicated high values compared with the present study.

Table 6 Health quotient values of present study compared with reports from other works.

Country	Fe	Ni	Cr	Pb	Zn	Reference
Nigeria	1.27	2.5	-	0.36	0.2	Maigari et al., 2016
South Africa	-	0.2	-	4.9	0.0	Elumalai etal.,2017
Present work	0.34	0.024	0.0005	0.091	0.003	

The present work values agree well with the reports of Maigari et al and Elumalai et al, although they are much lower than these reported values.

VI.CONCLUSION

The importance of access to good quality water cannot be overemphasized. Most of the wells in the study area are found have heavy metal concentrations below permissible limits; however, a few of them exceed these limits set by WHO. It is therefore important that this water be treated before it is used for drinking and other domestic purposes particularly in areas with concentrations higher than the permissible limits.The estimated ADD and HQ of the considered heavy metals (Fe, Ni, Cr, Pb and Zn) are below the recommended dietary allowance levels within the study area, except for water samples from Oleh. The HQ of these water samples are greater than1.Long term exposure to Cr, Pb and Ni by consumption of the water in the study area may pose potential health problems to the population of the area. Therefore attention should be given to the potential health risks due to consumption of water with these heavy metal concentrations in this area.

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