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Heavy Metals Concentration and Human Health Risk Assessment in Groundwater and Table Water Sold in Tudun Murtala Area, Nassarawa Local Government Area, Kano State, Nigeria

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ABSTRACT: This study determines the level of some heavy metals and as well assess human health risk due to chronic intake of metals in water samples obtained from Tudun Murtala area of Nasssarawa local government area, Kano state. Results obtained showed that Pb, Cd, Cr, Fe and Zn concentrations in water samples were within the range of 0.295- 0.579, 0.471- 0.529, 0.550- 1.000, 0.3636 - 0.4545, 0.0814 - 0.173 respectively, while the Chronic daily intake calculated for the metals respectively were also within the range of 0.0086 – 0.0165, 0.0135 – 0.0186, 0.0034 – 0.0262, 0.0023 – 0.0049, 0.0104 – 0.0130. The total hazard quotient for non-cancer risk of Pb and Cd were found highly elevated, being at the range of 21.5 – 41.25 and 27.0 – 37.2 respectively while that of Cr, Zn and Fe where found to be below the standard limit of one. The hazard index of metals also showed a risk in exposure to Pb and Cd and a tolerable range was observed for Cr, Fe and Zn. The incremental lifetime cancer risk of metals developed through oral route showed elevated level in Pb, Cd and Cr, revealing that exposure to the heavy metals in the water samples posed an unacceptable potential cancer risk. While for the other metals, it showed a less or tolerable risk to the inhabitants.

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Water is one of the most important ingredients for the well-being of people. This is because human body take up essential metals from water to maintain normal metabolism (Canh and Ahn, 2013). The water that provides body with essential elements can be contaminated by some environmental pollutants, such as sewage, heavy metals and microbial load. These contaminants are hazardous to humans when ingested. Environmental contamination and human exposure to heavy metals such as Hg, Cd, Pb, As and Ni is a serious problem throughout the world (Orisakwe, 2014). Heavy metals have a number of ways through which they can enter into the human body and pose a lot of risk to the human; they accumulate in the environment through emissions of industries, industrial effluents, use of leaded gasoline and paints, agricultural activities, indiscriminate disposal of municipal wastes and incineration of toxic substances (Muwanga and Barifayo, 2006). These elements find their way into water supplies as a result of inadequate treatment disposal of waste and industrial discharge (singnh and Mosley, 2003). The discharge of toxic heavy metals is a serious pollution problem affecting water quality especially in wet lands and other water masses due to their toxicity and bio accumulative effect, creating a direct hazard to human health (Ogoyi *et al*., 2011). These metals in general disturb growth, development, reduce hemoglobin, create cancer, damage the body organs and the nervous system, and in extreme cases death of living organism (WHO, 2011). Human exposure to toxic metals is a global environmental health burden. The level of health risk posed by heavy metals in soils and water are determined using different indices, including transfer factor, daily intake of metals and health risk index or hazard quotient as reported by Liu *et al*., (2005) and Khan *et al*., (2008).Therefore the aim of this research was to investigate the concentration and evaluate the human health risk of heavy metals in groundwater and table water sold in Tudun Murtala area of Nassarawa Local Government area, Kano state, Nigeria.

MATERIALS AND METHODS

Background of study site: Kano state is located in the northern part of Nigeria, it is in the sahelian geographical region, south of the Sahara, it is the second largest city in Nigeria after Lagos and the most populous state in the whole country with about 9,383,682 people (census 2006).its bounded by the latitude 12° 00^{I} 0.43^{II} N and longitude 8° 31^{I} 0.19^{II} E. Nassarawa is one of the local governments of Kano, it has an area of 34 Km^2 and its densely populated and constitutes various industries and roadside occupational sites, mainly mechanic workshops and

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heavy duty servicing sites. This area was selected for this study due to its density of industries and high levels of pollution.

Sample collection: The samples were collected from groundwater and table water. A total of thirty four water samples were collected; twenty four samples from groundwater and ten from table water sold in the area. The samples of groundwater were strategically collected from Nassarawa local government, Kano state from the houses situated in Tudun Murtala and from a distance of 250 m away from the site, and then bore hole water, samples from these strategic locations were collected using $1dm^3$ pet bottle for the analysis. The samples were collected in the months of September 2015. At each sampling site, the sample bottles were labeled correctly, rinsed twice with the water before collection. Information's such as date of collection, location , serial identifications about each sample collected was recorded on labels pasted on each container.

Sample analysis: To determine the level of metal in water, the first objective is to obtain the metal in concentrated form, which is separated from as many source of interference as possible and this is usually carried out using a process called digestion. In the process of digestion, 100 cm^3 of each of the representative water samples were transferred into beakers and $5cm^3$ of concentrated HNO_3 were added. The beaker with the content was placed on a hot plate. The samples were boiled slowly and then evaporated on the hot plate to the lowest volume of $20cm^3$.the beaker were allowed to cool and another 5 cm^3 of concentrated HNO_3 was added. The beaker covered with watch glass and returned to the hot plate. Heating was continued and HNO_3 was added as necessary until the solution appeared light coloured and cleared (i.e. digestion was complete).The watch glass and beaker walls were washed with distilled water and filtered to remove insoluble materials that could clog the atomizer. The filtrates were transferred to 100 cm^3 volumetric flasks and diluted to the mark with distilled water. These solutions were then used for the analysis (Akan *et al*., 2007).

Human Health Risk Assessment: The health risk assessment of each potentially toxic HM was done based on the quantification of the risk level and expressed in terms of cancer and non-cancer health risks (Sun *et al*., 2015). In order to assess both non-cancer and cancer risk from ingestion of drinking water, the chronic daily intakes (CDI) of toxic metals were calculated as modified from USEPA (1992) and Chrostowski (1994) and adopted by Kavcar *et al*., (2009):

$$CDI = C \times IR / BW \qquad (1)$$

Where: CDI is the chronic daily intake (mg/kg/day); C is the concentration of the contaminant in water samples, IR is the ingestion rate per unit time (1 L/day for child and 2 L/day for adult); and BW is the body weight in (70 kg for adult).

The hazard quotient, (HQ) is calculated using the following equation (USEPA, 1992. Kavcar *et al*., 2009):

$$HQ = CDI / RfD \qquad (2)$$

Where: HQ = non-cancer hazard quotient; CDI = chronic daily intake (mg metal/kg/day); RfD = chronic oral reference dose, which is an estimate of a daily oral exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (Bamuwamye *et al*., 2015).

The cancer risk were calculated using

$$ILCR = CDI \; X \; CSF \qquad (3)$$

Where: ILCR = incremental lifetime cancer risk; CDI = chronic daily intake (mg/kg BW/day); CSF= cancer slope factor $(mg/kg/day)^{-1}$.

Cancer risks were expressed in terms of incremental lifetime cancer risk (ILCR), which is the probability that one may develop cancer over a 70-year lifetime due to a 24 hour exposure to a potential carcinogen (Adamu *et al*., 2015). Cancer risk was calculated as the product of CDI (mg/kg-day) and cancer slope factor (CSF) measured in $(mg/kg/day)^{-1}$.

*Statistical Analysis***:** Statistical analyses were performed using SPSS statistical package (version 16; SPSS, Chicago, IL). The one-way analysis of variance (ANOVA) was used to verify significant differences in trace element concentrations among the water samples.

RESULTS AND DISCUSSION

The trace element concentrations were expressed as microgram per litre (w/v). Values were given in means ± standard deviation. Pb levels in the four sampling sites were found to be high and also greater than the permissible limits of lead in drinking water as set by WHO, this might be due to the use and processing of lead materials in various forms such as leaded gasoline, smelting of lead and its combustion, battery recycling, lead based painting, lead containing pipes, grids and pigments. It might also be due to refuse dumped in the area containing lead, and because of lead's non-biodegradable nature, it tends to accumulate in the environment. So also the levels of Cd was found to be higher than the permissible limits of 0.003 mg/dm3 set by WHO, this may be due to soil composition and environmental pollution or due to the application of biosolids or manures in the environment, it might also be linked to various air borne sources of metals such as emission of gas or vapour streams in the study area.

Table 1. Concentrations of metals (Means ± SE) in water samples

Locations/Analyte	Pb	Cd	Cr	Zn	Fe
Well water from Tudun Murtala	0.579±0.511	0.529±0.214	0.550±0.350	0.173±0.106	0.411±0.252
Borehole water from Tudun Murtala	0.452±0.192	0.652±0.443	0.781±0.282	0.110±0.072	0.422±0.174
Well water from Kwanar jaba	0.362±0.240	0.471±0.148	1.000±0.530	0.118±0.056	0.455±0.198
Table water from Tudun Murtala	0.300±0.130	0.492±0.275	0.917±0.306	0.081±0.055	0.363±0.194

Same applies for the level of Cr, as the samples contained higher concentrations than the 0.05 mg/dm3 set by WHO, Cr exist naturally on rocks and sands and it might contaminate water due to weathering and erosion of soils, alternatively it might be due to corrosion of chromium discharge from steel and pulp mills, or erosion of natural deposits. The level of Zn in the samples were below the permissible limits of WHO set at 3.00 mg/dm^3. The levels of Fe were slightly higher than the permissible limits of WHO set at 0.3 mg/dl.

Non cancer Risk: Table 2 shows the calculated CDI and THQ of metals, with the THQ of Pb (41.25, 32.25, 25.75, 21.5) and Cd (30.2, 37.2 , 27.0, 28.2) skyrocketing and also having values greater than one in folds, indicating a potential risk over a lifetime duration to those who use the water for drinking, and that of Cr, Zn and Fe being moderate and indicating no risk within a prolonged period of time, signifying that the drinking waters have no risk with respect to Cr, Zn and Fe to those exposed to the water.

Table 2; location of water samples, chronic daily intakes and total hazard quotients

Water	Metals	CDI	THQ
WTM		0.0165	41.25
BW	Pb	0.0129	32.25
WKJ		0.0103	25.75
TW		0.0086	21.5
WTM		0.0151	30.2
BW	Cd	0.0186	37.2
WKJ		0.0135	27.0
TW		0.0141	28.2
WTM		0.0157	0.011
BW	Cr	0.0223	0.0149
WKJ		0.0034	0.0191
TW		0.0262	0.0175
WTM		0.0049	0.0163
BW	Zn	0.0031	0.0103
WKJ		0.0034	0.0113
TW		0.0023	0.0077
WTM		0.0117	0.0167
BW	Fe	0.0121	0.0173
WKJ		0.0130	0.0186
TW		0.0104	0.0149

Table 3: Oral reference dose and cancer slope factor of various metals respectively

Metals	CSF	RfD
Pb	0.0085	0.0004
Cd	6.3	0.0005
Cr	42	1.5
Zn	-	0.3
Fe	-	0.7

*RfD: Oral reference dose; CSF: Cancer slope factor (**Source: USEPA, 2016).*

Table 4: Hazard index of metals calculated

Metal	HI
Pb	120.75
Cd	122.6
Cr	0.0625
Zn	0.0456
Fe	0.0675

Table 4 presents the hazard index of metals present in all water samples with values for Pb and Cd being very high, showing greater tendency to cancer risk on exposure to this metals, in contrast to them are values of Cr, Zn and Fe which shows limited and tolerable range, which means cancer exposure to them is to a large extent very low.

Table 5; the incremental lifetime cancer risk of metals

Water	Metals	ILCR
WTM		1.4025×10^{-4}
BW	Pb	1.0965×10^{-4}
WKJ		8.755×10^{-5}
TW		7.31×10^{-5}
WTM		9.513×10^{-2}
BW	Cd	1.117×10^{-1}
WKJ		8.505×10^{-2}
TW		8.888×10^{-2}
WTM		6.594×10^{-1}
BW	Cr	9.366×10^{-1}
WKJ		1.2012
TW		1.1004

Lifetime cancer risk through the ingestion of Pb were found to be high according to the table above, those of Cd were also high within the range of 8.505×10^{-2} - 1.117×10^{-1} showing a great concern, Cr levels were extremely high even reaching up to one (1) which signifies a very great risk and measures have to be taken to prevent its elevation or else people consuming these water will be at high risk to Cr.

Conclusions: Heavy metals contaminations were high in all water samples in Tudun Murtala, with only Zn being within the set limit of WHO (2008). The health risk assessment for all sites indicated that inhabitants are at high risk of Pb and Cd toxicity, and would have a tendency of developing cancer. This calls for concern to those exposed to the water through ingestion and also calls for proper monitoring of these drinking waters by the concern agencies.

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