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Heavy Metals In Water Sources For Three Irrigation Schemes In Katsina State

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Abstract
The research was designed to assess the levels of some heavy metals in water sources of three irrigated areas in Katsina state which are Kofar Marusa water way (KMW), Zobe dam (ZBD) and Mairuwa dam (MRD) irrigation schemes. The water samples were collected from the three irrigation areas in Katsina State in the dry and wet seasons for one year using standard procedures. Pre-cleaned one liter polythene containers were used in collecting the water samples from five locations situated along the Kofar Maurusa Stream and in the east, west, north, south and midpoint of the two dams. The levels of some heavy metals (Pb, Fe, Cu, Cr, and Cd) were analyzed, in quadruplicate determination and presented in the form of mean ± Standard deviation. The results obtained showed high concentrations of iron (0.276, 0.260, 0.964) ppm as compared to other heavy metals used in the study. The levels of lead obtained were 0.181ppm, 0.258ppm and 0.213ppm for Kofar Marusa, Zobe and Mairuwa respectively. The levels of chromium obtained were 0.064ppm, 0.029ppm and 0.019ppm for Kofar Marusa, Zobe and Mairuwa respectively. However, Copper and Cadmium were not detected in the samples from all the three irrigation schemes in Katsina state. The high concentrations of iron recorded by all the samples analyzed could be attributed to its anthropogenic release into the environment in addition to its relative abundance in earth. It is recommended among others that well equipped laboratories should be established in our hospitals where heavy metals toxicity could be easily diagnosed.
Keywords: Heavy metals, Water sources, Irrigation schemes, Mairu Dam, Zobe Dam, Kofar Marusa Stream.

INTRODUCTION

In many developing countries, information on heavy metals and toxic effects is not readily available (Bruce and Bergstrom, 1983). Trace heavy metals are significant in nutrition, either for their essential nature or their toxicity. Toxic metals, including "heavy metals," are either individual metals or their compounds that negatively affect human health. Heavy metal bioaccumulation in the food chain especially can be highly dangerous to human health (Mark, Clint and Larry, 2013). Heavy metals enter the human body mainly through two routes namely: inhalation and ingestion, ingestion being the main route of exposure to these elements in human population (Ejaz ul, Xiao-e, Zhen-li, and Qaisar, 2007). Acute exposure usually a day or less may lead to gastrointestinal hemorrhage (bleeding), hemolysis (red blood cell destruction), and acute renal failure (Bruce and Bergstrom, 1983). While chronic exposure may causes pulmonary fibrosis (lung scarring) lung cancer often months or years (Barceloux, 1999 and Harvey, Handley and Taylor, 2015).Some examples of heavy metals, their toxicities and sources are as follows:

Cadmium is an extremely toxic metal commonly found in industrial workplaces, particularly where ores are being processed or smelted. Several deaths from acute exposure have occurred among welders who have unsuspectingly welded on cadmium-containing alloys or with bead or silver solders (Valkovic, 1975).

Lead: Occupational exposure to lead is one of the most prevalent over exposures. Industries with high potential exposures include construction work, most smelter operations, radiator repair shops, firing ranges and electrical gadgets repair shops (Hervy, Handley and Taylor, 2015). Lead-based paint and its dust, usually found in older buildings, are common sources of exposure. Young children are especially at risk. Occupational exposure, such as welding, is a common cause for adults.

Iron: Iron is an essential element in the formation of red blood cells, liver and spleen. The normal human body contains 60 – 70 mg/kg of iron. Deficiency of iron causes anemia, while its excessive intake causes haemochromatosis and siderosis (Valkovic, 1975).

Copper: It is an essential element for living organisms, including humans, and in small amounts-necessary in our diet to ensure good health. However, too much copper can cause adverse health effects, including vomiting, diarrhea, stomach cramps, and nausea. It has also been associated with liver damage and kidney disease (Minnesota Department of Health, 2016).

Chromium: Chromium is an important environmental pollutant, particularly in areas with high anthropogenic activities. Their presence in the atmosphere, soil and water, even in traces can cause serious problems to living organisms. Compounds of chromium such as Calcium chromate, chromium trioxide, lead chromate, strontium chromate, and zinc chromate are known human carcinogens. An increase in the incidence of lung cancer has been observed among workers in industries that produce chromate and manufactured pigments containing chromate ions. (Sobukola, et.al, 2010).

Vegetables are valuable sources of vitamins, minerals, dietary fibres and anti oxidants (Sharma, Agrawal and Marshall, 2009). Recently, there has been an increased trend of consumption of vegetables, particularly among the urban communities. However, both vital and lethal elements are present in those kinds of vegetables. These elements usually originate from contaminated soil and irrigation water sources. Furthermore vegetables have the ability to absorb metals deposited on plant surfaces exposed to polluted environments (Sobukola, et.al, 2010). Although certain heavy metals (Cr, Mn, Ni, Zn, Cu, and Fe) are essential components for various biological activities within the body, elevated levels above certain critical values can cause numerous health consequences to mankind. In contrast, Cd, Hg and As are non essential, toxic elements which are associated with many chronic diseases in human beings (Thilini, Jagath and Anil, 2012).

An environment that is heavily polluted with heavy metal effluents is unsafe for human life. Rapid industrialization and urbanization have caused significant increase in traffic activities in and around our capital cities which subsequently contributed to substantial release and accumulation of heavy metals in roadside environments (air, water and soil). In addition, wide range of small scale industries including textile, battery production and charging, metallurgical and cable coating industries, brick kilns, diesel generators, re-suspended road dust etc, have also contributed to the heavy metal accumulation in the environments. Consequently, these toxic metals can be absorbed through the water or soil or may be deposited on the vegetables surfaces during their production, transport or marketing (Sobukola, Adeniran, Odedairo and Kajihausa, 2010; Sharma, Agrawal and Marshall, 2009). Furthermore, due to the persistent nature and cumulative behavior of heavy metals, they have the ability to concentrate through the food chains and cause toxic effects to humans (Sharma *et al.*,2009). Heavy metals also find their ways into the food chain in the form of environmental contaminants through the application of agricultural inputs, such as pesticides, insecticides, herbicides and fertilizers. Hence, there is need to continuously monitor and analyze the levels of toxic metals in the water and food items to ensure that the levels of these elements comply with permissible limits specified by local and international health agencies.

Statement of the Problem

Heavy metals have been used by humans for thousands of years. Although several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing at an alarming rate in most parts of the world, particularly in developing countries, though emissions have declined in most developed countries over the last 100 years. Cadmium compounds are currently being used in re-chargeable nickel-cadmium batteries. Cadmium emissions have increased dramatically during the 20th century, one reason being that cadmium-containing products are rarely re-cycled, but often dumped together with household wastes. Cigarette smoking is a major source of cadmium exposure. In non-smokers, food is the most important source of cadmium exposure. Recent data indicate that adverse health effects of cadmium exposure may occur at lower exposure levels than previously anticipated, primarily in the form of kidney damage and possibly bone effects and fractures (Jarup, 2003).

The pollution of rivers and dams with chemical contaminants has become one of the most critical environmental problems of the century. Chemical pollution entering rivers and dams can be classified according to the nature of its sources into: point source pollution and nonpoint source pollution. Point source pollution involves pollution from a single concentrated source that can be identified, such as an outfall pipe from a factory or refinery. Nonpoint pollution involves pollution from dispersed sources that cannot be precisely identified, such as runoff from agricultural or mining operations or seepages from septic tanks or sewage drain fields (Hart, 2008). Biosurveys may identify pollution problems that are difficult or expensive to detect using chemical testing procedures (Karr, 1981).

Aim and Objectives of the Research

The aim of this research is to determine the levels of heavy metals in the water sources for three irrigation schemes in Katsina State namely, Kofar Marusa water way (KMW), Zobe (ZBD) and Mai Ruwa (MAR) Dams.

The objectives of the research are as follows:

1. Determine the levels of some heavy metals in the irrigation water of KMW, ZBD and MAR dams.
2. Compare the values obtained with reference Standards as recommended by international and local health agencies.

METHODOLOGY

The instruments used in this research include but not limited to thermometer, pH meter, photometer, salinity meter, oxygen meter, turbid meter, glass wares. Analar grade reagents and deionized water were also used throughout. All glasswares and plastic containers were washed with detergent, 20% nitric acid and then rinsed with tap water and finally with distilled water. A mixture of perchloric acid and nitric acid in the ratio of 1:2 was used as the wet digestion mixture (Burton and Peterson, 1979). Atomic absorption spectrophotometer AA280FF model was used in the determination of metal levels in solution. Each result was taken in four sequential readings and presented in the form of mean ± SD.

The Study Area

Katsina is a 33 years old state. The state lies between latitude 11. 7. and 13. 22. North and longitude 6. 52. and 9. 2 East. It occupies a total land area of about 23,930 km^2, with an estimated human population of 5.2 million of which majority live in the rural areas. The state extends to three major savannah vegetation zones: dry Sahel zone in the north and Sudan and Guinea savannas in the middle and the southern zones respectively (Katsina State Water Board, 2009). It is bounded in the East by Kano and Jigawa States, in the West by Zamfara State, in the South by Kaduna state and in the North by Niger Republic.

Four distinct seasons are experienced in the area, these are: dry and cool, dry and hot, wet and warm and dry and warm seasons respectively. The State is one of the few states in Nigeria where crops are grown all year round. Apart from farming during the rainy season, dry season farming is done along river banks and along the numerous dams built by the State and Federal Governments (Katsina State Water Board, 2009). One water way and two dams will be used in this study namely; Kofar Marusa water way (KMW) in Katsina Local Government Area, Zobe dam (ZBD) in Dutsinma Local Government Area, and Mairuwa dam (MRD) in Funtua Local Government Area.

Sampling and Sample Treatment

Pre-Field Work: The pre-field work started with preliminary reconnaissance to the water reservoirs under study for verification and familiarization.

Samples Collection: Water samples were collected from the two dams and the water way in the dry season, for one year using standard procedures by immersing the sample containers nozzle down 0.5 meters and slowly allowing them to fill (APHA, 1992). Pre-cleaned one liter polythene containers were used in collecting the samples from five locations situated along the Kofar Marusa water way and in the east, west, north, south and midpoints of Zobe and Mairuwa Dams; giving the total of 15 water samples which were thoroughly mixed, homogenized and analysed.

The sampling was conducted as follows:

1st Sampling	-	November, 2017 – February, 2018	Early dry season
2nd Sampling	-	March, 2018 – May, 2018	Late dry season
3rd Sampling	-	June, 2018 – July, 2018	Early wet season
4th Sampling	-	August, 2018 – October, 2018	Late wet season

Digestion Procedure

The homogenized water samples were digested using a standard procedure reported in joint publication of the American Water Works Association (AWWA), American Public Health Association (APHA) and Water Environment Federation (WEF).

Data Analysis

Metal concentrations (Pb, Fe, Cr, Cu and Cd) were determined on an Atomic Absorption Spectrometer (AAS) with initial background correction. Calibration curves of absorbance versus concentrations were plotted for the heavy metal and the concentration of each metal was determined from the calibration plot by extrapolation.

Quality Assurance

Appropriate safety measures and quality assurance procedures were followed in ensuring the reliability of the test results. Properly cleaned glasswares, utensils and distilled water were also applied during the research. Reagent blank determination was carried out to correct the instrument readings. Moreso, samples were cautiously handled to minimize cross-contaminations.

RESULTS

The results obtained in this research are presented in tables.

Table 1.0: Heavy Metal Levels in Kofar Marusa Steam Water

	Metal Levels (ppm)				
Sample	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**
1st Sampling	0.000	0.000	0.000	0.546	0.216
2nd Sampling	0.000	0.000	0.000	0.557	0.122
3rd Sampling	0.000	0.055	0.000	0.000	0.319
4th Sampling	0.000	0.036	0.000	0.000	0.065
Mean	0.000	0.023	0.000	0.276	0.181
STD (±)	0.000	0.027	0.000	0.318	0.059
WHO MCL	0.003	0.050	1.200	0.300	0.010

Table 2.0: Heavy Metal Levels in Zobe Dam Water

	Metal Levels (ppm)				
Sample	**Cd**	**Cr**	**Cu**	**Fe**	**Pb**
1st Sampling	0.000	0.000	0.000	0.707	0.184
2nd Sampling	0.000	0.000	0.000	0.334	0.005
3rd Sampling	0.000	0.000	0.000	0.0v00	0.844
4th Sampling	0.000	0.116	0.000	0.000	0.000
Mean	0.000	0.029	0.000	0.260	0.258
STD (±)	0.000	0.058	0.000	0.337	0.287
WHO MCL		0.05		0.300	

Table 3.0: Heavy Metal Levels in Mairuwa Dam Water

	Metal Levels (ppm)				
Sample	**Cadmium**	**Chromium**	**Copper**	**Iron**	**Lead**
1st Sampling	0.000	0.000	0.000	0.474	0.243
2nd Sampling	0.000	0.000	0.000	3.382	0.000
3rd Sampling	0.000	0.075	0.000	0.000	0.607
4th Sampling	0.000	0.000	0.000	0.000	0.000
Mean	0.000	0.019	0.000	0.964	0.213
STD (±)	0.000	0.038	0.000	1.630	0.287
WHO MCL	0.003	0.050	1.200	0.300	0.010

DISCUSSION

The results of the heavy metals analysis in tables 1.0 to 3.0 shows that cadmium and copper were not detected in all the three irrigation schemes. Absence of mechanics around the area who might discharge lubricating oil which is a major source of cadmium. In addition, other anthropogenic activities releasing cadmium may also be absent. The concentration of chromium in water across the seasons and sampling sites was in the range of 0.000 to 0.116 which may be linked to use of chromium electroplated materials in agricultural process. However, Chromium was not detected during the early and late dry seasons in all the irrigation schemes.

High levels of iron were observed in first and second sampling for all the irrigation schemes but absent in the third and fourth sampling in all the areas. The high concentrations of iron recorded by all the samples analyzed in the 1st and 2nd sampling could be attributed to its role in chlorophylls synthesis in plants in addition to its relative abundance in earth (Audu and Lawal, 2005).

The concentration of lead in the samples were found to be generally high at all sampling points with values ranging between 0.005 to 0.844 which may be as a result of waste agricultural discharge from battery manufacturing and charging points in addition to application of chemicals such as fertilizers, pesticides and manure applied on farm lands around the areas. On the contrary, the fourth sampling result obtained from the water at Zobe and Mairuwa Dams showed absence of lead in the samples.

The mean levels of Cd, Cr and Cu were in all cases within the maximum contaminant levels (MCL) recommended by World health Organization (WHO). However, the mean levels of iron in Mairuwa Dam water and lead in all the three irrigation schemes exceeded the WHO standards of the metals in drinking water. This may be dangerous as crops irrigated with the water may be contaminated which when eaten by humans may pose some health risks because Pb especially is a very toxic metal with high tendency to cause a lot of health problems.

CONCLUSION

The findings of this research showed that Cd and Cu were totally absent in the water sources of all the three irrigation schemes irrespective of seasonal variation. Cr, Fe and Pb were however present at levels in most cases higher than the WHO recommended MCL for the metals. Since Pb is a highly toxic metal, the consumption of the vegetables grown with the water could be dangerous as that could be capable of posing serious health concerns to humans.

RECOMMENDATIONS

- Researches on remediation studies of heavy metals in soil samples in the irrigation areas should be encouraged.
- It is recommended that government should sponsor and mount enlightenment campaign on the dangers of using waste water for irrigation.
- There should be proper monitoring and evaluation of heavy metals in soil, irrigation water and vegetables grown with the water in those areas.

- Well equipped laboratories should be established in our hospitals where heavy metals toxicity could be easily diagnosed.

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