HEAVY METALS LEVEL ASSESSMENT OF IRRIGATION WATER SOURCES IN SOME SELECTED LOCAL GOVERNMENT AREAS OF KEBBI STATE NIGERIA

Sanda, A. R[1]., Sani Abdulkadir[2],Ahmed Idris[1], Aliyu Abubakar Kele[1] and Ramatu Idris[1].

1. Department of Soil Science, Faculty of Agriculture, Kebbi State University of Science And Technology Aliero, P.M.B. 1141, Birnin Kebbi, Kebbi State, Nigeria.

2. Soil Science Department, Kano University of Science and Technology, Wudil, Nigeria.

IJASR 2020
VOLUME 3
ISSUE 5 SEPTEMBER – OCTOBER **ISSN: 2581-7876**

Abstract – This study was conducted to investigate the concentration of heavy Metals in irrigation water, sampleswere collected from Yauri, Bunza, Birnin Kebbi and Augie for the determination of Pb, Cu, Zn, Cd, Co, Ni, Cr and pH using flame atomic absorption spectrometry (FAAS). The concentration of some heavy metals exceeded their respective permissible limits in the water samples.The average concentrations of Pb (0.81±0.07) mg/l, Cu (1.40±0.74) mg/l, Zn (0.97±0.01) mg/l, Cd (0.57±0.01), Co (0.86±0.01) mg/l, Ni (0.84±0.03) mg/l, Cr (0.97±0.01) mg/l, pH (6.76±6.10) mg/l, obtained from water samples in all the locations were higher than the recommended maximum concentration for irrigation. This study revealed that in Bunza borehole + stream have the highest concentrations of heavy metals investigated compared to the other sampled locations. And also, in Birnin Kebbi stream has the highest concentration than borehole, and borehole + stream. In Augie, stream water has more concentration of heavy metals than borehole + stream and borehole. This exceeded the recommended limit set by the WHO, NIS and EUL.

Keywords: irrigation water, heavy metals, permissible limit, stream water, bore hole water

INTRODUCTION

There is a growing human population in the world which means there is need for an increase in food production. However, food production to feed this growing population is decreasing due to poor agricultural practice (Sanda et al., 2014). One means to ameliorate this problem is the use of irrigation practices, however, irrigation is associated with a number of problems ranging from water mis-management to the use of poor quality irrigation water as a result of salinity, turbidity, heavy metals pollution and other chemical constituents that make irrigation water of low quality for crop production (Sanda et al., 2014).The chemical constituents of irrigation water usually affect plant growth directly through toxicity or deficiency, or indirectly by altering plants available nutrients (Ayers and Westcott, 1985). Quality of ground water varies from place to place and from season to season.The important of water quality due to introduction of pollution is a problem faced by most industrial cities around the world. Agricultural activities as well as domestic and industrial activities that are carried out to boost production such as application of manures, fertilizers, pesticides and herbicides, use of effluent water and municipal waste bring in contaminants into the water and soil. Heavy metals are natural constituents of the Earth's crust. Because they cannot be degraded or destroyed, heavy metals are persistent in all parts of the environment. In small amounts, they enter the human body via food, drinking water and air. Living organisms require varying amounts of some "heavy metals". Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans. When cadmium is present in soils it can be extremely dangerous, as the uptake through food will increase (Xian, X. 1989a).Cadmium derives its toxicological properties from its chemical similarity to zinc (Xuan and Li (1989).Excessive levels can be damaging to the organisms. Therefore, heavy metals can be described as any metallic element that has a relatively high density and is toxic or poisonous at low concentrations. Human activities affect the natural geological and biological distribution of heavy metals through pollution of air, water, and soil. Humans are also responsible for altering the chemical forms of heavy metals released to the environment. Such alterations often affect a heavy metal's toxicity by allowing it to bio-accumulate in plants and animals, bio-concentrate in the food chain, or attack specific organs of the body. Bioaccumulation refers to an increase in the concentration of a metal in a biological organism over time. Many metals and other chemicals accumulate in living things any time they are taken up and stored faster than they are broken down' (metabolized) or excreted.Some heavy metals such as mercury and lead are toxic metals that have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of animals can cause serious illness.Copper is an essential element for human life, but excessive intake results in its accumulation in the liver and produces gastrointestinal problems, anemia, liver and kidney damage (Nuhoglu and Oguz; 2003).AlsoNriagu (1989) stated that zinc is toxic also for aquatic biota.

. Certain elements that are normally toxic are, for certain organisms or under certain conditions, may be beneficial. Examples include vanadium, tungsten, and even cadmium. Heavy metals are stable and persistent environmental contaminants since they cannot be degraded or destroyed. Therefore, they tend to accumulate in the soil, seawater, freshwater, and sediments. In small quantities, certain heavy metals are nutritionally essential for a healthy life(e.g., iron, copper, manganese, and zinc). Some of these are referred to as the trace elements. These elements, or some form of them, are commonly found naturally in foodstuffs, in fruits and vegetables. Metals in the environment may be present in the solid, liquid or gaseous state. They may be present as individual elements, and as organic and inorganic compounds. The movement of metals between environmental reservoirs may or may not involve changes of state. The geosphere is the original source of all metals (except those that enter the atmosphere from space in the form of meteorites and cosmic dust). Within the geosphere, metals may be present in minerals, glasses, and melts. In the hydrosphere, metals occur as dissolved ions and complexes, colloids, and suspended solids. In the atmosphere, metals may be present as gaseous elements and compounds and as particulates and aerosols (Nriagu; 1989). Gaseous and particulate metals may be inhaled and solid and liquid (aqueous-phase) metals may be ingested or absorbed, thereby entering the biosphere. In addition to being the original source of all terrestrial metals, the geosphere may represent a sink for metals. The atmosphere and hydrosphere also constitute sinks for metals; however, from a geological perspective, they are more likely to be considered as agents of transport.The main source for metal input to plants and soils is atmospheric deposition. Volatile metalloids such as Hg, As, Se, and Sb can be transported over long distances in gaseous forms or enriched in particles, while trace metals such as Cu, Pb, and Zn are transported in particulate phases (Adriano, 2001). In terrestrial ecosystems, soils are the major recipient of metal contaminants, while in aquatic systems sediments are the major sink for metals (Sparks, 2005). Freshwater systems are contaminated due to runoff and drainage via sediments or disposal, while groundwater is impacted through leaching or transport via mobile colloids (Adriano2001). A number of biogeochemical processes take place at the heterogeneous interfacebetween the rock, soil, water, air and living organisms (Spark, 2005). These processes or interactions in turn control the solubility, mobility, bioavailability and toxicity of metals (Sparks, 2005). Metals are found in soil solution as free ions or complexed to inorganic or organic ligands. Both die free ions and the metal-ligand complexes can be (i) taken up by plaints, (ii) retained on mineral surfaces, natural organic matter, and microbes, (iii) transported through the soil profile into groundwater via leaching or by colloid-facilitated transport, (iv) precipitated as solid phases, and (v) diffused in porous media such as soils.Microorganisms can transform metals such as Hg, Se, Sn, As and Cr by means of oxidation-reduction and methylation (the process of replacing an atom, usually a H atom, with a methyl group) mechanisms and demethylation reactions. These processes affect transport or mobility and solubility or toxicity of metals (Adriano 2001; Sparks 2005). For example, methylated (organic) forms of Hg are more toxic than inorganic forms of the element and they bio-accumulate in organisms. Methylation is favored in environments characterized by low oxygen levels, low pH, and high soil organic matter (SOM) contents.Heavy metal contamination of soil is a far more serious problem than air or water pollution because heavy metals are usually tightly bound by the organic components in the surface layers of the soil. Consequently, the soil is an important geochemical sink which accumulates heavy metals quickly and usually depletes them very slowly by leaching into groundwater aquifers or bioaccumulation into plants (Infotox, 2000). Heavy metals can also be very quickly translocated through the environment by erosion of the soil particles to which theymay be adsorbed or bound and re-deposited elsewhere.The transport, cycling, fate, bioavailability and toxicity of heavy metals are markedly influenced by their physico-chemical forms in water, sediments and soil. Whenever a heavy metal or its compound is introduced into an aquatic environment, it is subjected to a wide variety of physical, chemical and biological processes. These include hydrolysis, chelation, complexation, redox, bio-methylation, precipitation and adsorption reactions. Often, heavy metals experience a change in the chemical form as a result of these processes and so their distribution, bioavailability and other interactions in the environment are also affected. They can leach into living systems from natural ore deposits and other sources such as waste disposal of heavy metal containing waste. In fact, waste disposal accounts for higher percentage of most heavy metals including manganese in the environment.Therefore, a study this study is aimed at assessing the heavy metals content of irrigation water sources in some selected local government areas of Kebbi State.

MATERIALS AND METHODS:

The study was conducted in four distinct locations namely Augie (12^0 54'2"N, 20 36'2^0"E), Birnin Kebbi (12^0 27'14"N, 4^0 11'51"E), Bunza (12^0 5'3"N, 4^0 1'15"E), and Yauri (10^0 46'55"N, 4^0 48'28"E). The climate of the study area is classified as semi-arid equatorial Tropical, consisting of a long dry (October - May) and a short wet (June – September) season. Mean annual rain fall ranges from 860mm at Yauri to 690mm and 591mm at Augie, Birnin Kebbi and Bunza respectively.The water samples were taking from the Bore holes, Streams, and Bore holes + Streams water from irrigation farms in Yauri, Bunza, Augie, and Birnin Kebbi local government area.The water from River Niger was collected at three different points of 200m intervals and the surface water sample was mixed to have a representative surface water sample. The sub-surface water bore-hole in irrigation farms was collected at three different point of 200m interval and the sub-surface water sample was mixed to have a representative sub-surface water sample.The water samples were taking from the Bore holes, Streams, and Bore holes + Streams water from irrigation farms in Yauri, Bunza, Augie, and Birnin Kebbi local government areas.Atomic absorption atomic spectroscopy was use in the determination of the heavy metals.The amount of light as a resonant wave length of each of the element was measured as it passes through the cloud of atoms. The qualitative amounts of the analyte element present were determined and data recorded. The data obtained were analyzed through simple descriptive statistics and analysis of variance (ANOVA) for the heavy metals concentration of irrigation water to determine the significant differences between the heavy metals concentrations and were implemented by (SPSS Software version 20.0).

Figure 1: Map of Kebbi State showing the study area.

RESULTS AND DISCUSSIONS

Table 1: Mean heavy metals concentration of irrigation water (mg/L) and coefficient of variation of concentration of Yauri at 3 different sources.

Water sources	Pb	Cu	Zn	Cd	Co	Ni	Cr	pH
Bore hole	0.78	1.57	1.12	0.57	0.66	0.44	0.63	6.49
	(0.12)	(0.90)	(0.42)	(0.14)	(0.11)	(0.21)	(0.10)	(5.83)
Stream	1.00	1.67	1.31	0.44	0.67	0.34	0.58	6.52
	(0.20)	(1.00)	(0.61)	(0.01)	(0.12)	(0.11)	(0.08)	(5.85)
Bore hole & Stream	0.77	1.59	1.29	0.45	0.57	0.31	0.25	6.47
	(0.11)	(0.92)	(0.59)	(0.02)	(0.02)	(0.08)	(0.02)	(5.80)
Total Mean Value	**2.55**	**4.83**	**3.72**	**1.46**	**1.90**	**1.09**	**1.46**	**19.48**

Table 2: Mean heavy metals concentration of irrigation water (mg/L) and coefficient of variation of concentration ofBunza at 3 different sources.

Water sources	Pb	Cu	Zn	Cd	Co	Ni	Cr	pH	
Bore hole		0.81	1.40	0.97	0.57	0.86	0.84	0.97	6.76
	(0.07)	(0.74)	(0.39)	(0.01)	(0.01)	(0.03)	(0.01)	(6.10)	
Stream	0.87	1.55	0.68	0.61	0.83	1.04	0.33	6.71	
	(0.13)	(0.89)	(0.10)	(0.03)	(0.00)	(0.10)	(0.00)	(6.05)	
Bore hole & Stream	0.88	1.38	0.79	0.58	0.86	1.67	0.33	6.62	
	(0.14)	(0.72)	(0.21)	(0.00)	(0.03)	(0.73)	(0.00)	(5.96)	
Total Mean Value		**2.56**	**4.33**	**2.44**	**1.76**	**2.55**	**3.55**	**1.63**	**20.09**

Table 3: Mean heavy metals concentration of irrigation water (mg/L) and coefficient of variation of concentration of Augie at 3 different sources.

L/G	Area	Pb	Cu	Zn	Cd	Co	Ni	Cr	pH
Augie	Bore hole	0.77	1.20	1.10	0.51	0.57	0.69	0.64	6.46
		(0.09)	(0.51)	(0.39)	(0.01)	(0.10)	(0.02)	(0.10)	(5.79)
	Stream	0.80	1.69	1.30	0.51	0.51	0.71	0.59	6.69
		(0.12)	(1.00)	(0.59)	(0.01)	(0.04)	(0.04)	(0.05)	(6.02)
	Bore hole & Stream	0.78	1.32	1.32	0.50	0.48	0.69	0.57	6.62
		(0.10)	(0.63)	(0.61)	(0.00)	(0.01)	(0.02)	(0.03)	(5.95)
Total Mean Value		**2.35**	**4.21**	**3.72**	**1.52**	**1.56**	**2.09**	**1.8**	**19.77**

Table 4: Mean heavy metals concentration of irrigation water (mg/L) and coefficient of variation of concentration of Birnin Kebbi at 3 different sources.

Water sources	Pb	Cu	Zn	Cd	Co	Ni	Cr	Ph
Bore hole	0.76	1.67	0.92	0.46	0.73	0.81	0.72	6.49
	(0.11)	(1.01)	(0.10)	(0.02)	(0.03)	(0.22)	(0.06)	(5.82)
Stream	0.80	1.66	0.99	0.45	0.81	0.76	0.75	6.58
	(0.15)	(1.00)	(0.17)	(0.01)	(0.11)	(0.17)	(0.09)	(5.91)
Bore hole & Stream	0.74	1.58	1.25	0.44	0.75	0.70	0.71	6.57
	(0.09)	(0.92)	(0.43)	(0.00)	(0.05)	(0.11)	(0.05)	(5.90)
Total Mean Value	**2.30**	**4.91**	**3.16**	**1.35**	**2.32**	**2.27**	**2.18**	**19.64**

In this study it was observed that irrigation water (borehole, stream and borehole + stream), in the four locations (Yauri, Bunza, Augie and Birnin Kebbi) were contaminated with all the heavy metals that were studied (Pb, Cu, Zn, Cd, Co, Ni, and Cr) with the exception of Ni, Cr, Co and Cd which were at the lowest concentration.

The high concentration of Pb, Cu, Zn, Cd, Co, and Cr with the pH ranging from 6.47-6.52mg/L show that the heavy metals were significantly different in Yauri borehole and stream water for irrigation, these metal contaminates the irrigation water through improper disposal of solid and liquid waste around the stream and also the off-site effect of the use of agro-chemicals, these accumulate Zn to the soil sediments and can be washed underground to contaminate the borehole water in the farm site, phosphate fertilizer application also increase Cu in the soil and a water source from acidic soil can be contaminated with Cd, Pb and Cr are from hazardous waste with ore and steel materials. Most of the metals are also available in air which settle to the ground or are taken out of the air in rain. All these high contamination occurs in borehole water and stream water of Yauri because of the above mentioned factors. Also the low concentration of Ni (0.31-0.44mg/L) in Yauri irrigation water source can be traced to the low presence of iron and manganese in the soil sediment which nickel can attached itself to before taking to the underground water.

In Bunza, Cr (0.33-0.97) was found to be in low concentration because there are no steel industries in Bunza which can trigger it high concentration and also the fact that the concentration of Cr in air is generally low. Other heavy metals (Pb, Cu, Zn, Cd, Co, Ni) are high in concentration.

Co an Cd are low in concentration in Augie and Birnin Kebbi respectively because the soil in are not acidic which can make the concentration of Cd to be high. Co is low in Augie irrigation water because generally the element does to exist freely in the environment and do not bound to soil or sediment particles. Other metals (Pb, Cu, Zn, Ni, and Cr) are at high concentration in the two locations. In the wet season, heavy rainfall dilutes the irrigation water, which lowers the heavy metal concentrations. Similarly, the same characteristic observed in cultivated soil indicates the strong effect of diluted irrigation water on the low concentration of heavy metals in soil during the wet season. However, the order of heavy metal concentration in soil was different from that of irrigation water. Therefore, some factors might be responsible for the contamination. Dudal et al., stated that the mobility of heavy metals along with soluble organic matter might be affected by heavy rainfall events. On the other hand, chemical and physical properties of soil influence the bioavailability and movement of heavy metals, which depend not only on the heavy metal concentration but also on environmental factors, adsorption–desorption characteristics of soils, precipitation reactions, and toxic metal properties.

SUMMARY AND CONCLUSION

In this study which was carried out in some selected local Government areas of Kebbi State namely, Yauri, Augie, Bunza and Birnin Kebbi to assess the level of some selected heavy metals from the three irrigation water sources that farmers within the study areas were commonly using, it was found that there is a presence of all the metals studied especially within the stream and the boreholes which might likely be as a results of washing away of the residues from farmers farms that normally uses fertilizers, herbicides, pesticides and other chemicals that were potential carriers of these metals, in addition to this, some waste from the slaughter houses, mechanic workshops could also be another sources since the research was conducted during the wet season which is characterized by a surface run-off especially when it rains.

It can then be rightly concluded that heavy metals accumulation are on the increase especially during the wet season within the study areas due to surface run-off, therefore careful plan has to be made to find a more safer method of disposing wastes and farmers should be discourage from the use of untreated sludge and manures, and also minimizes the use of synthetic chemicals as a pesticides and herbicides.

Acknowledgement

The authors wish to acknowledge and thank the entire management of TETFUND for given us financial grant to undertake this study and that of Kebbi State University of Science and Technology Aliero for recommending us for the grant and allowing us to use some facilities in the Couse of our laboratory work.

REFERENCE

1. Adriano DC. 2001 Trace Elements in the Terrestrial Environment. Springer-Verlag, New York, 880 pp.
2. Akcay, H., Oguz, A., and Karapire, C., 2003. Study of heavy metal pollution and speciation in Buyak Menderes and Gediz river sediments. Water Res. 37(4): 813
3. Ayers, R.S.; Westcot, D.W. 1985. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29 Rev.1; FAO, Rome, Italy.
4. Dudal, Y.; Sévenier, G.; Dupont, L.; Guillon, E. 2005. Fate of the metal-binding soluble organic matter throughout soil profile. Soil Sci. 170, 707–715.
5. Infotox C. C.2000. Heavy metal accrual in soils and crops grown in the peri urban areas of Jabaal purr district of Madhya Pradesh, India using geospatial techniques.International journal of current microbiology and applied sciences. Vol 8 No 2.
6. Nriagu, J. 0., 1989. A global assessment of natural sources of Atmospheric traces metals. Nature. 3, 8,pp. 47-49.
7. Sanda, A.R., Musa Ahmed Augie, Idris Ahmed and Samson 2014. Assessment of irrigation water quality of the Jega flood plains and their influence on soil properties. International journal of Agricultural and Soil Science. Vol 2(6) pp. 94-98.
8. Sparks DL. 2005. Toxic Metals in the Environment: The Role of Surfaces. Elements. 1 pp 193-197.
9. Xian, X. 1989. Effect of chemical forms of cadmium, zinc, and lead in polluted soils on theiruptake by cabbage plants. Plant Soil 113:257-264.
10. Xian, X. 1989a. Response of kidney bean to concentration and chemical form of cadmium,zinc, and lead in polluted soils. Environ. Pollution. 57:127-137.
11. Xuan X-Z and Li J-Y. 1989. Relation of arsenic exposure to lung cancer among tinminers in Yunnan Province, China. Ind. Med 46: 881-886.
12. Y. Nuhoglu and E. Oguz.2003. Removal of copper(II) from aqueous solutions by bio sorption on the cane biomass of Thuja orientalis; Process Biochemistry 38 1627-1631.