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RESEARCH ARTICLE

Spatial Variation in Concentration of Selected Heavy Metals in Galma Dam, Zaria, Nigeria

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Abstract

The paper examined the spatial variation in concentration of Pb, Cr, Fe, Cd, Co, Ni, Zn and Cu in Galma dam, Zaria, Nigeria. The main source of data for the study was surface water samples from the upper and the lower regions of the dam. The samples were prepared in the laboratory according to standard method and the Atomic Absorption Spectrometer (AAS) technique was adopted in the analysis of the data. The results of the analysis showed high concentration of Pb, Cr, Zn, Co, Fe and Cu in the entire Galma dam. Fe and Cu showed higher concentration levels in the upper and the lower regions of the dam respectively, and the statistical t-test confirmed that there is significant difference in concentration of these heavy metals between the lower and upper regions of the dam. The spatial variation in distribution and concentration of these heavy metals can be linked to their related sources within the Galma catchment area. Heavy metals such as Fe whose sources are linked to weathering activities appeared to be in higher concentration in the upper section of the dam where farming activities are much common and chemical elements such as Cu, Zn, Cr, Cd, Co and Zn which are linked to other human practices especially household materials are distributed more in the lower region of the dam which is close to semi-urban and urban settlements, although there is no statistical proof to confirm that there is significant difference in concentration of these elements between the two regions, except for Cu.

Introduction

Water is absolutely essential for life, it is undoubtedly the most precious natural resource on our planet (Igbinosa *et al*., 2012). The quality of water available and accessibility to a community has great impact on their living standard and wellbeing; those global and local efforts are widespread at ensuring adequate provision of clean and safe water to the growing population (DWAF, 2003). It is in the quest to supply Zaria community with potable water that the Galma dam was constructed. Igbinosa *et al* (2012) observed that water plays an essential role in supporting human life and biodiversity, it also has a great potential of transmitting diseases when contaminated. Dike *et al* (2004) is of the opinion that population growth coupled with other factors such as urbanization, agricultural activities, industrial and commercial process have resulted in the accumulation of wastes and pollutants which end up in water bodies, thereby altering the quality, species, composition and biodiversity in many aquatic systems.

The rate of water pollution of all types has increased much more as compared to other fields of pollution due to discharge of all sorts of obnoxious matter into it. Adakole and Abolude (2012) observed that global concern about heavy metals in the environment stems from their persistence, toxicity, and bioaccumulation in the tropic chain. When heavy elements enter water bodies they alter water quality, bind to sediments and accumulate in aquatic biota causing anemia, disturbances of human functions and mortalities of fish (Post, 1983).

The greater challenges facing the water supply profession today are the control and removal of poisonous metal contaminants (Butu and Iguisi, 2013). Water pollution occurs in various forms and is caused by different factors. Butu (2013) identified 29 metal pollutants in River Kubanni Zaria at various levels of concentrations and their major sources are linked to anthropogenic activities and released from regolith system within the Kubanni catchments area. Iguisi (2001) reported the presence of heavy metals in Kubanni dam and further observed that several chemicals in the reservouir have their origins from the decomposing high refuse dumps that dotted the landscape of the built up sections of the catchment area of Kubanni dam. Several other studies have shown that a considerable number of chemical elements are leached from refuse dumps during rainy season into groundwater and streams (Farouk, 1987: Olofin, 1991).

The generation and disposal of wastes in the world is a problem that continuous to grow with the development of industrialization and growing population. Wastes disposal is one of the major environmental problems that developing countries are faced with. Mchivir (2013) observed that for effective management of river as water there is need to protect the river banks and coastal zone from environmental degradation and pollution. In the current world economic paradigms, sustainable socio-economic development of every community depends much on the sustainability of the available water required to meet growing household, industrial and agricultural needs (Tiri *et al*., 2011).

Chemical elements are introduced into aquatic systems as result of the weathering of soils and rocks, from volcanic eruptions and from variety of human activities involving mining, processing, or use of metals and or substances that contained metal pollutants (Butu, 2011). Several studies have been done on assessment of metal concentrations in water bodies. Balarabe and Oladimeji (1991) observed that metals concentration in surface water and sediment in the Makwaye (ABU farm) Lake varied significantly from season to season and the concentration in the sediment were much higher than in the surface water. Masoud *et.al* (2001) identified Cd, Cu, Fe, Mn, Pb and Zn in sediments of Lake Burullus, Egypt at various levels of concentration. Gamboa-Rodriguez *et al* (2012) analyzed water sample from Tabasco, Mexico and observed that the values of Pb and Zn were significantly above detection limits and attributed the presence of these metals to pluvial discharges from the city around the lagoon that washed rusted metal roofs and carry domestic discharges, paints and combustion particles from automobiles combustion. Christopher *et al* (2011) assessed toxic metal (Cd, Pb, Cu) contamination in Nokoue Lake, Benin Republic and observed that the pattern of trace elements accumulated varied according to soil texture of the lake.

The contamination of inland water ways are globally known to impact negatively on the environment and the Galma dam cannot be an exception. Thus, WHO (1993) suggested that in the choice of a source of drinking water and its maintenance in a satisfactory condition, sanitary and topographic aspects of the basin should be of paramount concern and that ideally situated sources should be catchment areas that have experienced minimal human activities that may cause pollution. This condition hardly exists in developing countries and there is no certainty about the level of pollution. The Galma dam is the largest dam in Zaria and its environs, it's important that the level of contamination of the dam is assessed periodically in relation to spatial distribution of the metal contaminants. Therefore, the aim of this study is to examine the spatial variation in concentration of selected heavy metals in Galma dam Zaria, Nigeria.

The study area

The Galma river catchment area belongs to the north eastern part of Kaduna river basin which borders the Chad basin to the north. The Galma river is one of the main tributaries of River Kaduna. It has its headwaters near the north western edge of the Jos Plateau and falls near the Magami village into Kaduna plains. The main tributaries of Galma river are Shika river in the middle course and the River Kinkiba and Likarbu in its lower course. The Galma dam which is popularly called Zaria dam was constructed across the Galma River in 1975. The lake has the following characteristics (WAPDECO, 1991);

a. It covers 18.8 hectares of land.
b. Dam catchment area = 3200Km^2.
c. Gross storage capacity= 16.0 x 10^{6}m^3.
d. Maximum Dam height = 14.9m.
e. Length of the Dam Crest = 640m.
f. Length of the Lake = 32Km – 35 Km at maximum flood water level.
g. Water Supply Capacity= 872 million litres.

Zaria city is situated close to River Galma and its tributary Shika which are the main sources of water in the reserviour. The geology of the study area is composed mainly of fine grain gneisses and magnetite with same coarse-grained granitic outcrops in few places. The gneisses are moderately to weakly foliated, principally made up of quartz and oligoclase, depth of weathering is irregular but thorough the depth ranges from 10m to deep pockets occasionally extending to about 60m (WAPDECO, 1991). The Galma river catchment lies within the tropical wet and dry climate zones characterized by strong seasonality in rainfall and temperature distribution.

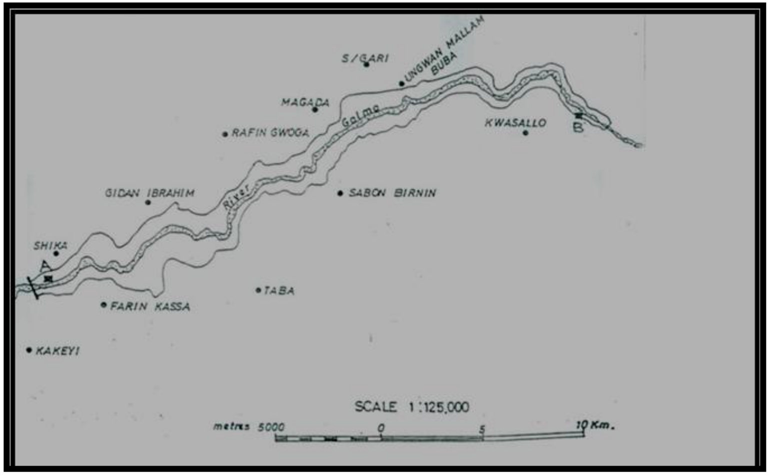
Materials and Method

Materials. The raw water sample was collected from the dam which spanned to about 35Km. Two sampling points were used; one in the upper and another in lower regions of the dam as shown on Figure 1. In each of the sampling points the raw water was collected at the banks and the middle of the lake (across the lake profile) and mixed in a pre washed 300ml plastic sample bottom. The samples were treated immediately on site with Nitric acid (HNO_3) at PH of 2 to preserve them before laboratory analysis. The samples were collected by dipping the plastic bottle into the water and collecting the surface water. Heavy elements are known to be more concentrated in sediments and aquatic animals (Rognerad and Fjield, 1993; Caccia et al., 2003; Pekey, 2006; Marchand et al., 2006). However, the need to assess the actual level of concentration of these heavy elements that are directly pumped out to the end users necessitated the choice of surface water for the study. The samples were collected for a period of 24 weeks fortnightly between the months of October to March. The samples were stored in the refrigerator till the time of laboratory analysis.

Sample Preparation. Each sample was filtered in the laboratory using Watman Brand filter paper of 0.45um to remove clay and other suspended colloids in the water sample. 100ml of the filtered sample was collected and stabilized with Nitric acid in each sample. The standard curves of Pb, Cr, Fe, Cd, Co, Ni, Zn and Cu were prepared bearing in mind that these elements occur in trace concentration. Standard solutions were prepared from 1000 parts per million (ppm) stock solutions. 1ml of the 1000 ppm was pipette into 100ml volumetric flask and made up with distilled water. This solution was 10 ppm of the solution. From this solution, standard solutions of 0.2, 0.4, 0.6, 0.8 and 1 ppm were prepared by taken 0.2, 0.4, 0.6, 0.8 and 1ml portions into 10ml volumetric flasks and made to mark. These were then run in the Air Acetylene flame and standard curves for the various elements were obtained.

Data Analysis. To analyze the samples, 100ml of the digest in each sample was run one after the other on the UNICAM 969 Atomic Absorption Spectrometer (AAS) which uses air acetylene flame. By choosing the correct wavelength of the various elements and running a known standard curve of the various elements, the absorbance values of the chemical elements present in the samples were determined. Using the standard absorbance of the various elements, the absorbance from the various heavy elements as contained in the samples was converted to ppm values as their levels of concentration. This was repeated three times for every element in every sample and the mean concentration was taken as the actual level of concentration of the heavy element in ppm. Finally, the entire data generated by laboratory analysis of the water samples were summarized by some simple descriptive statistics.

Figure 1. Study area Zaria (Galma) Dam



A and B: Sampling points
Source: Adopted from WADPCO (1991)

Results and Discussion

The result of the analysis as shown on Table 1 showed that there is no significant difference in the concentration of Pb between the lower and the upper regions of Galma dam. This therefore means there is a common source that drains Pb into the dam; it also implied that the chemical element is uniformly distributed in the lake probably as a result of thorough mixing of the surface water. The result of the analysis showed a slight variation between the two regions in level of concentration of Cr, the concentration of Cr in the lower region appeared slightly higher, but the statistical test showed that there is no significant difference in level of concentration of Cr. Cr is suspected to have come from the use of materials that are electroplated with Cr within the lake's catchment area. The results as showed on Table 1 showed a great variation in the level of concentration of Fe between the two regions.

The concentration of Fe is higher in the upper region of Galma dam, it is confirmed by the statistical test that there is significant difference in concentration of Fe between the upper and lower regions of Galma dam. The reason for this spatial variation may be because there are more farming activities in the upper region of the dam which facilitated physical weathering to release a lot of laterites which are rich in Fe content into the upper part of the dam, it may also be that Fe compound from the vast arable lands are being drained into the dam thereby increasing Fe content in the upper region of the dam.

The results of the analysis as shown on Table 1 showed a lower concentration of Cd both in the lower and upper regions of Glama dam. The results clearly showed that there is no difference in concentration of Cd between the two regions. The statistical test also confirmed that there is no evidence to show that there is significant difference in concentration of this metal in the dam. Cd occurs as a minor component and in most Zn ores and therefore a by-product of Zn production; it is a rare earth element which is used as pigment and corrosion resistant in plating. It could also be used as Ni – Cd batteries. Cd has no biological functions in humans, but could be toxic to the kidney when consumed in quantities above permissible limit. The presence of this metal at higher concentration at the lower regions of Galma dam could be explained by loading of debris containing the element into the dam during storm runoff from nearby populated area of Sabon Gari, Zaria.

The results of the analysis as shown on Table 1 revealed that there is a slight variation in the level of concentration of Co between the two regions. This was confirmed by the results of the statistical test that there is no significant difference in concentration of Co between the lower and upper regions of Galma dam. The observed minor variation as it appeared on Table 1 could be explained by draining of chemical elements containing this metal into the lower part of the dam from the urban settlements. The levels of concentration of Ni at both regions of the dam are below detectable limits. This therefore means that the dam is not polluted by Ni. The concentration of Zn is slightly higher in the lower region than the upper region. The statistical test revealed that there is no significant difference in concentration of Zn between the upper and lower regions in the dam. The presence of more Zn in the lower region may be attributed to release of the element from anthropogenic sources in the lower part of the dam. Zn is commonly found in Zinc and rain pipes, car tyres commonly contain Zn, motor oils, from Zn tank, Zn components in fungicides and insecticides which are commonly found in the lower part of the Galma catchment area. Zn is a common metallic element in the environment and of low toxicity to human and animals (Lantech, 2009).

There is higher concentration of Cu at the lower region of Glama dam than at the upper region. The result of the statistical test confirmed that there is significant difference in concentration of Cu between the lower and the lower the upper regions. The reason for this great spatial variation is mainly because the lower section of the dam is characterized by urban and semi-urban settlements which are likely to have contributed substances containing Cu into the dam. Cu is used for plating in electronic appliances which are common items found in the urban communities which must have been thrown into gutters/channels and finally end up into the lower part of the dam. Heavy elements such as Fe and Zn are embedded in geologic formation (bedrocks) and when these rocks undergo complete chemical weathering, the elements are released into the weathering environment from where they can be washed into the dam. Lateritic soils of the catchment area of Galma dam is very rich in Fe content and is suspected to account for 80% of the Fe content in the lake (Wright and McCurry, 1970). Other chemical elements such as Cr, Cd and Ni are used for electroplating of materials and can readily disassociated under favourable climatic conditions and be released into the environment and finally drained into the dam. Several other metals such as Cu and Pb are used in electrical and electronic equipment and are released into refuse dumps and drainage system from where they are drained into Galma dam, especially in the lower region. Chemical elements can also enter the dam through the atmospheric dust fallouts, although this is a rare source.

Conclusion

The results obtained from this study showed that there is high concentration of some heavy metals such as Pb, Cr, Zn, Co, Fe and Cu in Galma dam. It is observed that there is spatial variation in concentration of some of the elements. Fe showed a higher concentration levels in the upper region and Cu showed higher concentration in the lower region of the dam. The spatial distribution of these metals in the dam is explained by their related sources. Chemical elements such as Fe whose sources are related to weathering activities seem to be high in the upper parts of the dam while anthropogenic sources related elements such as Cu, Cr, Cd, Co and Zn showed some dominance in the lower part of Galma dam.

Table 1.Concentration of some heavy metals in the Lower and Upper Regions of Galma dam and their statistical comparison using t – Test.

	Lower Region		**Upper Region**		**Calculated t-values and significant of the difference between the two Region**	
Metal (ppm)	**Metal (ppm)**	**SD**	**Metal (ppm)**	**SD**	**t-Cal**	**Significance**
Lead	0.127	0.052	0.126	0.048	0.08	Not significant
Chromium	0.287	0.066	0.340	0.205	0.40	Not significant
Iron	2.121	0.606	2.730	1.795	2.83	Significant
Cadmium	0.0005	0.00000015	0.0001	0.0000014	0.79	Not significant
Cobalt	0.261	0.147	0.169	0.42	0.66	Not significant
Nickel	-0.018	-0.0004	-0.021	-0.0038	-	Not tested
Zinc	0.152	0.027	0.126	0.046	0.33	Not significant
Copper	0.209	0.093	0.139	0.085	3.0	Significant

The critical (t-test) value for all the compared values is. 166; the degree of freedom is 58 at 0.05 level of significance.

References

Adakole, J.A. and D.S.Abolude. (2012). Pollutional status of Kubanni Lake through metal concentration in water and sediment columns, Zaria, Nigeria.*Research Journal of Environmental and Earth Science, 4 (4): 424 – 427.*

Balarabe, M.L. and A.A.Oladimeji. (1991). Some metals concentration in the surface water and sediments of Makwaye (ABU Farm) Lake Samaru. *Paper presented at the National Seminar on water Quality Monitoring and Status in Nigeria*.

Butu, A.W. (2011). Sources and Levels of Metal contaminants in River Kubanni., Zaria, Nigeria. Unpublished Ph.D Thesis, Department of Geography Ahmadu Bello University Zaria, Nigeria.

Butu, A.W. and E.O.Iguisi. (2013). Concentration of Heavy Metals in Sediment of River Kubanni, Zaria, Nigeria. *Comprehensive Journal of Environment and Earth Science, 1 (2): 10 – 17.*

Butu, A.W. (2013). Concentration of Metal Pollutants in River Kubanni, Zaria, Nigeria. *Journal of Natural Sciences Research. 3(2): 19- 25. www.iisle.org*

Caccia, V.G.; F.T. Millero and A. Palangues. (2003) The Distribution of Trace Metals in Florida Bay Sediment. *Marine pollution Bulletin, 46 (11): 1420 – 1433.*

Christopher, K.; G. Patient.; K. Nelly.; A.E. Patrick and A. Rodrigue. (2011). Evaluation of Heavy Metals Pollution of Nakoue Lake. *African Journal of Environmental Science and Technology, 5 (3): 255 - 261.*

Dike, N.I.; A.U. Ezealor and S.J. Oniye. (2004). Concentration of Pb, Cu, Fe and Cd during the dry season in River Jankara, Kano. Nigeria. *Chemical Classification Journal 1: 78 – 81.*

DWAF (2003). (Department of Water Affairs and Forestry). Strategic Framework for Water services. Government printer, Pretoria, South Africa.

Farouk, B.B.A. (1987). Water Quality and uses of some surface water bodies in Kano Metropolitan Area. Unpublished B.Sc. Dissertation, Department of Geography Bayero University, Kano, Nigeria.

Gamboa - Rogrignez, T.; R. Gamboa – Adeco.; Saldiver – Osorio and R. Gumez – Cruz (2012). Metals in water samples from an Urban Lagoon in Tabasco, Mexico. *African Journal of Environmental Science and Technology 6(3): 170 – 175.*

Igbinosa , E.O.; O.O. Ugi.; E.E. Odjadjare.; C.U. Ajuzie.; P.O. Orhue, and E.N. Adewole. (2012). Assessment of Physiochemical Qualities of Heavy Metal Concentrations and Bacterial Pathogens in Shanomi Creek in Niger Delta, Nigeria. *African*

Journal of Environmental Science and Technology, 6 (11): 419 – 424.

Iguisi, E.O.; I.I. Funtua and O.O.Obamuwe. (2001). A Preliminary study of Heavy Metal Concentration in the Surface water of Kubanni, Reserviour, Zaria, Nigeria. *Nigerian Journal of Earth Science, 1 (2): 26 – 34.*

Lentech (2009). Drinking water standards. Lentech Water treatment and Air purification Holding BV. (1998 - 2009). Retrieved from: www.who.cu-water standards.html.

Marchand, C.A.; E. Lallier.; F. Verges.; F. Baltzer.; D. Alberic and P.Baillifi. (2006). Heavy Metals Distrtibution Mangrove Sediment along the Mobile Coastaline of French Guinea. *Marine Chemistry 98: 1-17.*

Masoud, M.S.; M.A. Fahmy.; A.E. Ali and E.A. Mohammed. (2011). Heavy Metal Speciation and their accumulation in Sediments of Lake Burullus, Egypt. *African Journal of Environmental Science and Technology, 5 (4): 280 – 298.*

Mchivir, C. (2013). Dumping of Refuse in River Benue: Environmental Hazard. *Environmental Digest. A Monthly Environmental Publication, Nigeria, 1 (1): 1.*

Olofin, E.A. (1991). Surface water pollution: A Menace to the Quality of life in Urban Area. *Paper presented at the 34th Annual Conference of the Nigerian Geographical Association (NGA) Owerri.*

Pekey, H. (2006). The Distribution and Sources of heavy metal in Izmit bay surface Sediments affected by a polluted stream. *Marine Pollution Bulletin, 52 (10): 1197 – 1208.*

Post, G. (1983). *Textbook of Fish Health.* T.F.H Publication Inc New Jersey: 45 - 46.

Rognerad, S. and E. Fjeld. (1993). Regional survey of metal in Lake sediment. *Ambio, a Journal of the Human Environment,. Published by the Royal Swedish Academy of Science, 22(4):206-212*

Tiri, A.; L. Belkhiri.; A. Brudoukha and N. Lahbar. (2011). Characterization and Evaluation of the factors affecting the Geochemistry of surface water of Kondiat Medouar Basin, Algeria. *African Journal of Environmental Science and Technology, 5 (5): 355 – 362.*

WAPDECO. (1991). (Water and Power Development Company Ltd). Kaduna State Water Board Rehabilitation Studies: Zaria Water Supply Systems: 1-2

WHO. (1993). (World Health Organization). Guidelines for Drinking Water Quality, (2nd edn), Vol 1 Geneva, WHO: 130.

Wright, J.B. and P. McCury. (1970). "Geology of Zaria." In Mortimore, M.J. (ed), Zaria and its Regions. *Occasional Paper No. 4.* Department of Geography, Ahmadu Bello University Zaria, Nigeria.