HEAVY METAL CONCENTRATIONS IN A WEST AFRICAN SAHEL RESERVOIR

[1]IDOWU, Rachel Toyisi., [2]INYANG, Nicholas Matthias and [3]EZENWAJI, Henry Maduka Godfery
[1]Department of Biological Sciences, University of Maiduguri, Borno State, Nigeria
[2&3]Department of Zoology, Fisheries and Hydrobiology Research Unit, University of Nigeria, Nsukka, Enugu State, Nigeria.

Corresponding author: IDOWU, Rachel Toyisi, Department of Biological Sciences, University of Maiduguri, Borno State, Nigeria

ABSTRACT

Heavy metal concentrations were investigated over a period of 12 months in five stations in Alau reservoir, Maiduguri, in the North – east sahel zone of Nigeria. The mean concentrations of zinc, copper, lead, iron and manganese were 0.17 ± 0.02 mg/l (range 0.14± 0.03 - 0.19± 0.02 mg/l), 0.56 ± 0.06 mg/l (range 0.52± 0.01 - 0.64± 0.01 mg/l), 0.56 ± 0.02 mg/l (range 0.54± 0.03 - 0.58± 0.06 mg/l), 0.09 ± 0.02 mg/l (range 0.07± - 0.12± 0.01 mg/l) and 0.19 ± 0.27 mg/l (range 0.04± 0.01 - 0.66± 0.01 mg/l) respectively. Except for lead, mean concentrations varied significantly between stations (P<0.05). The concentrations of heavy metals were below contamination levels and fall within the limits reported for other West African small sahel reservoirs.

Key Words: Heavy metals, Pollutants, Environment, Alau reservoir, Sahel, Enrichment

INTRODUCTION

Water pollutants may be classified according to their chemical characteristics, physical state, environmental compartments in which they are discharged or found, sources and effects on target organisms (Calamari and Chiaudari, 1984).

In natural aquatic ecosystems, metals occur in low concentrations, normally at the nanogram to microgram per litre level. In recent times, however, metal contamination of aquatic ecosystems, especially the heavy metals, has become a problem of increasing concern. This situation has arisen as a result of the rapid growth of population, increased urbanization, expansion of industrial activities, exploration and exploitation of natural resources, extension of irrigation and other modern agricultural practices as well as the lack of environmental regulation (Bincy *et al* 1994) The problems associated with heavy metal contamination of water bodies arising from domestic discharges and agricultural practices have been studied (Forstner and Wittman, 1981; Solomons and Forstner, 1984; Nriagu, 1989). Furthermore, Dejoux (1988) and Philips (1991) provided further information on various environmental problems of heavy metal pollution in African inland waters in particular and tropical aquatic ecosystems in general. These publications showed that the existing information on Africa is scanty.

In spite of the relatively low level of industrial activity in less developed regions of Africa, there is growing awareness of the need for rational management of aquatic resources, including control of waste discharges into the environment (Goldberg, 1976). As Alau reservoir provides portable water for domestic use, it is important to monitor it's metal levels which may be elevated as a result of the other uses of the reservoir in irrigation of farm lands and in watering livestock. This study therefore provides information on heavy metal concentrations in Alau reservoir. This will serve as baseline data for effective water pollution control and management.

MATERIALS AND METHODS

The Study Area: Alau reservoir is located in Maiduguri, Borno state of Nigeria, along Maiduguri-Bama road. The lake lies between longitude 12^0 13^E latitude 13^0-14^E. It is about 20 km long with a total storage capacity of

65.0 km^2 (CBDA 1986). It was constructed in 1987 by damming river Ngadda, which was the first in a series of impoundment's in Borno-state, and it lies entirely within the Nigerian savannah.

Three seasonal periods - dry hot, dry harmattan and rainy season - typical of the North-eastern sahel zone of Nigeria dominate. The seasonal rainfall causes flooding of the lake and this increases the water level during the rainy season. The rainy season lasts from June to September. The dry harmattan season is characterized by low temperature and high harmattan wind, and lasts from October to February. The dry hot season has pronounced high temperature and causes extreme aridity between March and May (Bankole *et al.,* 1994; Odunze *et al.*, 1995).

Sampling Methodology and Analysis: Water samples were collected bimonthly at five sites on Alau reservoir, from October 2001-September 2002. Surface water samples were collected using fabricated 2 litre water samplers. Samples were placed in acid washed (10 % HCl) 250 ml polyethylene bottles and taken to the laboratory. In the laboratory, 200 ml aliquot of each original sample was filtered using 0.45 μ membrane filter, for dissolved metal analysis. The filtered sample was acidified with 1 ml of concentrated analytic grade HCl and stored in a polyethylene bottle at 50 ^{0}C. All glass wares, pipettes and filters used in these procedures were rinsed with 10% HCl, deionized water and distilled water. Analysis of concentrations of copper (Cu), iron (Fe), manganese (Mn), lead (Pb) and zinc (Zn) were performed on the filtered, acidified samples (following appropriate dilution or concentration procedures), using a Perkin-Elmer Atomic Absorption Spectrophotometer (Model 403), as described by Olsen (1975), APHA (1976, 1980), Mackereth *et al.* (1978), and Boyd (1979). Comparison of data between stations and sampling periods was made using one-way ANOVA and t-test at 5% level of probability.

RESULTS AND DISCUSSIONS

The heavy metal concentrations in water from the different stations in Alau reservoir are presented in Table 1. The table shows that the concentration of dissolved Zinc (Zn) in Alau reservoir ranged from 0.14 ± 0.3 mg/l in station 5 to 0.19 ± 0.02 mg/l in stations 1 and 3. There was a significant difference ($P < 0.05$) between the value recorded in station 5 and all other stations. The values in other stations were not significantly different ($P > 0.05$). The concentration of zinc showed little fluctuation between stations. This may be due to the effect of fertilizers that were applied to the irrigated farm land around the reservoir. The values of zinc observed in this study were lower than those recorded in Jankara reservoir which ranged from 0.8 to 2.10 mg/l (Adeniji and Mbagwu, 1990). Bincy *et al* (1994) reported a higher zinc concentration (2.85 mg/l) for lake Nakuru, Kenya. The values recorded in Alau reservoir exceeded the permissible pollution limit of 0.10 mg/l recommended by Deininger (1980), but was below the WHO limit of 1.5 mg/l (Kaluku *et al.*, 1987).

The copper concentration ranged from 0.52 ± 0.01 mg/l in stations 1 and 3 to 0.64 ± 0.01 mg/l in station 5. There was no significant difference ($P > 0.05$) between the values in stations 4 and 5, but these were significantly different ($P < 0.05$) from the values recorded in stations 1, 2 and 3. The copper values of this study were lower than 0.95 mg/l recorded in Arizona desert reservoir (Olsen and Sommerfield, 1977) and showed little variation between stations. The significant increase in copper concentration in stations 4 and 5 may be linked to the activities occurring in these stations, such as excessive run off into the water, human navigation activities and washing of fishing equipment directly into the water.

The highest mean value of lead (Pb) was 0.58 ± 0.06 mg/l recorded in station 4, while the lowest mean value of 0.54 ± 0.03 mg/l was recorded in station 2. No significant difference was observed between the stations ($P > 0.05$). The value recorded for lead remained stable throughout the study period. This concentration of lead in Alau reservoir was lower than the concentration recorded in Kainji lake where UNIFE (1986) observed a range of 0.16 to 0.87 mg/l. The value recorded in Alau reservoir may be regarded as adequate for photosynthesis and phytoplankton productivity. GESAMP (1988) observed that low concentration of less than 0.02 mg/l may affect photosynthesis, as well as delay embryonic development and reduce growth in adult fish, molluscs and crustaceans. Mombeshora *et al.* (1983).

Table 1: The distribution of heavy metals in different stations in Alau reservoir (mean± SD measured in mg/l)

	STATIONS					
Heavy metals	**1**	**2**	**3**	**4**	**5**	**Mean**
Zinc (Zn)	0.19±0.02[a]	0.18±0.03[a]	0.19±0.02[a]	0.16±0.03[a]	0.14±0.03[b]	0.17±0.02
Copper (Cu)	0.52±0.01[b]	0.52±0.02[b]	0.52±0.01[b]	0.60±0.00[a]	0.64±0.00[a]	0.56±0.06
Lead (Pb)	0.54±0.06[a]	0.54±0.03[a]	0.56±0.04[a]	0.58±0.06[a]	0.57±0.02[a]	0.56±0.02
Iron (Fe)	0.09±0.00[b]	0.07±0.00[b]	0.08±0.00[b]	0.09±0.00[b]	0.12±0.00[a]	0.09±0.02
Manganese (Mn)	0.05±0.01[b]	0.04±0.01[b]	0.09±0.02[b]	0.09±0.01[b]	0.66±0.01[a]	0.19±0.27

The values with the same superscript on the same row are not significantly different at P = 0.05

reported much higher levels of lead in their studies of streams and lakes around Ibadan Increase in lead can be largely due to increase in car washing, high traffic density around the lake, as well as discharges from a local industry, and increased anthropogenic sources especially from automobiles. The mean values for Iron (Fe) ranged between 0.07 ± 0.001 mg/l in station 2 and 0.12 + 0.001 mg/l in station 5. There was no significant difference between the values recorded for stations 1, 2, 3 and 4 ($P > 0.05$) but station 5 was significantly different ($P<0.05$) from these stations. The concentration of iron is consistent with the low solubility of Iron in desert reservoirs (Olsen and Sommerfield, 1977). The fairly stable concentration of iron in Alau reservoir may be due to direct or indirect discharges and run off from soil excavation sites into the reservoir.

The result of the concentration of manganese showed that the lowest mean value of 0.04 ± 0.01 mg/l was recorded in station 2, while the highest mean value of 0.66 ± 0.01 mg/l was recorded in station 5. There was no significant difference ($P>0.05$) between stations 1, 2, 3 and 4, but they were significantly different ($P < 0.05$) from station 5.

The concentration of manganese showed considerable variations within the lake. The highest level of contamination in various stations could be associated with the domestic washing with soap, effect of fertilizers, herbicides and pesticides applied to irrigated farm lands. Odiete (1999) reported that domestic sewage and agricultural effluents have the capacity to precipitate manganese salts which may exact a toxic effect on aquatic organisms. Such effects were not observed in the reservoir.

Manganese may also result from sediment transport as observed by Okoye *et al*. (1991), who reported anthropogenic manganese enrichment in the Lagos lagoon and implicated land-based urban and sediment transport as well as industrial sources.

Most stations in Alau reservoir showed low to moderate metal concentrations which clearly indicate low level of pollution. Thus, there is at present no environmental concern for the reservoir. We conclude that heavy metal concentrations in Alau reservoir are comparable with what obtains in other West African sahel reservoirs (Baijot *et al.,* 1997). The little variations in the concentration of heavy metals in the reservoir stations are attributed mostly to the discharge of wastes water from domestic and agricultural activities as well as direct deposition of dry and wet particles by harmattan winds and flood. Based on the results Alau reservoir showed no significant heavy metal contamination.

REFERENCES

ADENIJI, H. A and MBAGWU I. G. (1990). *Study of some physico-chemical factors and heavy metals in Jakarta reservoir in Kano state*. Annual Report NIFFRI. pp. 136 - 140.

APHA (1976). *Standard methods for examination of water and waste water 16th edition.* America Public Health Association and water Pollution control Federation. Washington DC 10860.

APHA (1980): *Standard methods the examination and water waste water* 17th Edition America Public Health Association. Washington DC. 1134 pp.

BAIJOT, E., BOUDA, S. and OUEDRAOGO, L. (1997). Physical, chemical and biological characteristics of reservoirs in

Burkina Faso. Pages 29 – 55. *In: Hydrobiological aspects of fisheries in small reservoirs in the sahel region.* Technical centre for Agricultural and Rural Cooperation, Wageningen, Netherlands.

BANKOLE, N. O., SULE, O. D., OKWUNDU, E. C. and AMADI M. (1994). *Preliminary investigation on the frame and catch assessment survey of Alau reservoir*, Annual Report of NIFFRI 28 p.

BOYD, C .E. (1979). *Water quality in warm water ponds*. Craft Master Print. Inc. Auburn Alabama 353 pp.

CALAMARI, D. and CHIAUDARI, G. (1984). Problems and methods in defining water quality criteria of micro pollutants in aquatic ecosystems. Pages 302 – 320. *In: Proceedings of the third conference of prevention by substances derived from wastes, Rome.*

CBDA (1986). *A resettlement plan for the Alau reservoir dam and Jere bowl scheme*. Report submitted to Chad Basin Development Authority. Askoning Nigerian Limited, 59 pp.

DEJOUX, C. (1988). La pollution des eaux continental africines. Experience acquice situation actuelle et perspectives. *Trav. Doc .inst. fr. Rech. Sci. Dev. Coop., 213*: 513.

DENINGER, R. A. (1981). A water quality index for rivers and lakes. *Water International, 5(3):* 16 - 21.

FORSTNER V. and WITTMAN G. T. (1981). *Metal pollution in the aquatic environment.* 2nd Edition. Berlin. Spriner. 486 pp.

GESAMP (Joint Group of Experts on the scientific Aspect of Marine pollution) (1988). Review of potentially harmful substances. *Rep. Stup. GESAMP, 28:* 17 p.

GODBERG. E.D. (1976). *The health of the ocean*. Paris, UNESCO 172 p.

KAKULU, S. E. and OSIBANJO, O. (1987). Comparison of digestion methods for trace metal determination in fish. *International Journal Environmental Studies, 13:* 247 - 251.

KAKULU, S. E. and OSIBANJO, O. (1992): Pollution studies of Nigeria rivers: Trace levels of surface water in the Niger Delta area. *International Journal Environmental Studies*, *41*: 287 - 292.

MACKERETH, F. J. and HERON, J. J. F. (1978). Water analysis. Some revised methods for limnologist. *Fresh water Biological Association scientific publication, 36*: 112p.

MOMBESHORA, C. O., OSIBANJO, O. and AJAYI, S. O. (1987). Pollution studies on Nigeria rivers. The on sit of lead pollution of surface water in Ibadan. *Environment International,* 9: 81 - 84.

NRIAGU, J. O. (1989). *Trace metals in lakes.* International conference on trace metals in lakes. Hamilton, Ontario Science.

ODIETE W. O. (1999). *Environmental physiology of animals and pollution.* Diversified Publisher Limited, Lagos. 261 pp.

ODUNZE, F. C., AMOJOBI, R. and NTAKIGM, R. T. (1995). Preliminary fisheries survey of Alau reservoir Maiduguri. *Paper presented at the workshop on sustenance management and conservation of fisheries and other aquatic resources of lake Chad and the sahel zone of Nigeria*. Held on the 16th –17th January. 10 pp.

OKOYE. B. C. O., AFOLABI, O. A. and AJAO, E. A. (1991). Heavy metals in the Lagos lagoon sediments. *International Journal of Environmental Stud*ies, *37:* 35 - 41.

OLSEN R. D. (1975): *The phytoplankton ecology of a desert lake*. PhD Dissertation. Arizona State University, Arizona. 321 pp.

OLSEN, R. D. and SOMMERFIELD, M. R. (1977). The physical, chemical limnology of a desert reservoir. *Hydrobiologia, 53(2):* 117 – 129.

PHILLIPS, D. J. H. (1991). Selected trace elements and the use of biomonitors in subtropical and tropical aquatic ecosystems. *Review of Environmental Contamination and Toxicology, 120:* 105 - 129.

SOLOMON, W. and FORSTNER, U. (1984). *Metals in the hydrocycle*. Berlin, Springer. 349 pp.

UNIFE (1986). *Determination of organochlorine pesticides and some heavy metals in Kainji lake ecosystems*. Final Report submitted to Kainji lake Research Institute. Institute of Ecology, University of Ife. Ile Ife. 167 pp.