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Pollution studies on Nigerian rivers: heavy metals in surface water of warri river, Delta State

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Abstract

Surface water samples from Warri river in Delta State of Nigeria were analyzed quantitatively for the concentration of nine heavy metals, namely: Cadmium, Chromium, Copper, Iron, Lead, Manganese, Nickel, Vanadium and Zinc, using Atomic Absorption Spectrophotometer. Iron (Fe) recorded the highest mean value of 1.9304mgl^{-1} while Lead (Pb), had the least mean concentration of 0.0001mgl^{-1}. Warri river receives effluents from industrial, agricultural and domestic sources. Cadmium, Chromium, Manganese and Nickel had higher concentrations than values in standard guidelines for potable water, pointing to the existence of risks to public health. There is need, therefore for a constant monitoring of the heavy metals concentrations in the surface water as well as a comprehensive conservation efforts by relevant organizations.

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Introduction

Heavy metals are inorganic elements essential for plant growth in traces or very minute quantities. They are toxic and poisonous in relatively higher concentrations. Two factors contribute to the deleterious effects of heavy metals as environmental pollutants. Firstly, they cannot be destroyed through biological degradation as in the case of most organic pollutants. Secondly, they are easily assimilated and can be bioaccumulated in the protoplasm of aquatic organisms (Egborge, 1994). Well known examples of heavy metals include: Iron, Lead and Copper. Others include: Arsenic, Mercury, Cadmium, Chromium, Nickel, Zinc, Cobalt and Vanadium (Garbarino *et al.,* 1995; WHO, 2003).

The aquatic system receives a large amount of heavy metals from natural occurring deposits/natural processes and anthropogenic activities. Heavy metals are transported as dissolved species in water or as an integral part of suspended sediments. These potentially toxic pollutants can endanger public health by being incorporated in the food chain, or being released into overlying waters which serve as drinking water supplies.

Warri river is one of the major coastal rivers in the Niger Delta of Nigeria that is significantly influenced by anthropogenic activities, resulting in pollution and deterioration of the surface water. There are a number of agricultural, oil, iron and steel based industries, markets etc discharging wastes, which include heavy metals, into the surface waters.

For the majority of the people in communities living along the banks and catchment area of Warri river, their only source of water for drinking and other beneficial uses, is the river. And so, it becomes necessary to examine the water quality in relation to acceptable limits of heavy metals in drinking water as specified by organizations concerned with standard guidelines.

However, in spite of the very hazardous nature of heavy metals in aquatic environment, studies of these metals in Warri river are scanty (Atuma and Egborge, 1986; Egborge and Benka-Coker, 1986; Egborge, 1991, 1994; Ezemonye, 1992; Edema, 1993 and Agada, 1994).

This study aims at investigating the current status of heavy metals concentrations in the surface water of Warri river. It attempts to provide a baseline data upon which future computations of the water quality as a result of increased industrialization and urbanization, would be based.

Materials and methods

The Study Area

Warri river is one of the most important coastal rivers of the Niger Delta of Nigeria. From its source near Utagba-Uno, the river flows past the industrial towns of Aladja and Warri. It joins the Forcados estuary and empties into the Atlantic Ocean. It is about 150km in length and covers a surface area of about 255sq.km (NEDECO, 1961).

The climate of the study area is tropical with two recognizable annual seasons. The dry season lasts between November and February (4 months) while the rainy season lasts between March and October (8 months) at Warri sampling stations. The vegetation comprises predominantly of mangrove plants, namely: *Rhizophora racemosa* (red mangrove) and *Avicenia africana* (white mangrove).

Two sampling stations at Warri were selected. Station A is located at a distance of eight kilometers from station B, along the winding banks of Warri river. Surface water samples were taken monthly from the sampling stations for twelve months. The samples were fixed with concentrated nitric acid (to pH not exceeding 2.0) and transported to the laboratory. Atomic Absorption Spectrophotometry using AAS model, Solaar 969 Unicam Series, was used to determine the heavy metals concentrations in the samples. The mean value from the two sampling stations was recorded for each metal.

Results

The heavy metals concentrations in the surface water samples from Warri river decreased in the sequence: Fe>Mn>Zn>Cu>Ni>V>Cr>Cd>Pb. Iron (Fe) had values that ranged between 0.03mgl^{-1} and 5.02 mgl^{-1}; Manganese (Mn) recorded values of between 0.02 mgl^{-1} and 0.68 mgl^{-1}; Zinc (Zn) had values that ranged between 0.0 mgl^{-1} and 0.63 mgl^{-1}. The range of values of other metals were: Copper (Cu): 0.0 mgl^{-1} to 0.26 mgl^{-1}; Nickel (Ni): 0.0 mgl^{-1} to 0.32 mgl^{-1}; Vanadium (V): 0.0 mgl^{-1} to 0.26 mgl^{-1}; Chromium (Cr): 0.0 mgl^{-1} to 0.06 mgl^{-1}; Cadmium (Cd): 0.0 mgl^{-1} to 0.05 mgl^{-1} and Lead (Pb): 0.0 mgl^{-1} to 0.001 mgl^{-1} mgl^{-1}. The mean values of the heavy metals concentration in surface water of Warri river are shown by statistical analysis in Table 1.

Table 1. Statistical analysis of the heavy metals concentrations in surface water of Warri river, Delta State.

Heavy metals (mg/l)	N	Mean	Std. Dev.	Std. Error	Min.	Max.
IRON (Fe) STATION A	12	2.5584	1.53501	.44312	.11	5.02
STATION B	12	1 .3025	.97996	.28289	.03	3.00
Total	24	1.9305	1.41339	.28851	.03	5.02
MANGANESE (Mn) STATION A	12	.2442	.22617	.06529	.03	.68
STATION B	12	.2085	.20525	.05925	.02	.62
Total	24	.2263	.21200	.04327	.02	.68
ZINC (Zn) STATION A	12	.0876	.15488	.04471	.00	.57
STATION B	12	.0818	.17436	.05033	.00	.63
Total	24	.0847	.16131	.03293	.00	.63
COPPER (Cu) STATION A	12	.0472	.07136	.02060	.00	.26
STATION B	12	.0342	.06298	.01818	.00	.23
Total	24	.0407	.06616	.01350	.00	.26
CHROMIUM (Cr) STATION A	12	.0106	.01773	.00512	.00	.06
STATION B	12	.0048	.00744	.00215	.00	.02
Total	24	.0077	.01362	.00278	.00	.06
CADMIUM (Cd) STATION A	12	.0072	.01105	.00319	.00	.04
STATION B	12	.0074	.01401	.00404	.00	.05
Total	24	.0073	.01234	.00252	.00	.05
NICKEL (Ni) STATION A	12	.0449	.09271	.02676	.00	.31
STATION B	12	.0328	.09154	.02643	.00	.32
Total	24	.0389	.09031	.01844	.00	.32
LEAD (Pb) STATION A	12	.0001	.00029	.00008	.00	.00
STATION B	12	.0001	.00029	.00008	.00	.00
Total	24	.0001	.00028	.00006	.00	.00
VANADIUM (V) STATION A	12	.0326	.07709	.02225	.00	.26
STATION B	12	.0166	.04868	.01405	.00	.17
Total	24	.0246	.06358	.01298	.00	.26

A comparison of the mean and range values of some heavy metals concentration (mgl^{-1}) in Warri river with some standard guidelines for drinking water quality are shown in Table 2. N = Number of samples analyzed.

Table 2. Some heavy metals concentration (mgl^{-1}), mean and range values, compared with some standard guidelines values of drinking water quality.

Guidelines	Cd	Cr	Cr	Pb	Mn	Ni	References
Standard Organization of Nigeria (SON)	0.005	0.05	2.00	0.01	0.20	0.02	SON, 2007
World Health Organization (WHO)	0.003	0.05	2.00	0.01	0.40	0.07	WHO, 2003
Environmental Protection Agency (EPA)	0.003	0.05	1.30	0.05	0.02	0.04	EPA, 2002
2008 Study of Warri River	0.0073	0.0077	0.040	0.0001	0.226	0.038	Mean values (mgl^{-1})
	0.0 to 0.05	0.0 to 0.06	0.0 to 0.26	0.0 to 0.001	0.02 to 0.68	0.0 to 0.32	Range values (mgl^{-1})

A comparison of the mean values of some heavy metals concentration in surface water (mgl-1) with those of earlier studies on Warri river is shown in table 3.

Discussion

Heavy metals have been used as indices of pollution because of their high toxicity to human and aquatic life (Omoigberale and Ogbeibu, 2005). Tarig *et al.,* (1991); Egborge (1991); Ezemonye (1992) and Edema (1993) have linked the high concentrations of heavy metals in the aquatic ecosystems with effluents from industries, refuse and sewage.

Table 3. A comparison of the mean values of some heavy metals concentration of the surface water (mg/l) with those of earlier studies (Source: Egborge, 1994).

Heavy metals	1981/1982 (Atuma and Egborge, 1986)	1986 (Egborge, 1991)	1989/1990 (Chukwuogo, 1990)	1991/1992 (Ezemonye, 1992)	2008: This study
Cadmium (Cd)	0.0008	0.2290	0.0031	0.275	0.0073
Copper (Cu)	0.009	0.1870	0.0290	0.019	0.0407
Iron (Fe)	0.1610	1.9000	0.1551	2.770	1.9304
Lead (Pb)	0.0020	1.0810	0.0073	0.086	0.0001
Nickel (Ni)	-	0.9640	0.0148	*	0.0389
Zinc (Zn)	0.025	0.5050	0.0300	*	0.0847
Chromium (Cr)	-	0.5930	*	0.059	0.0077
Manganese (Mn)	0.0220	*	*	0.563	0.2263

* Not determined.

In this study, the nine heavy metals concentrations in surface water of Warri river were decreased in the sequence: Fe>Mn>Zn>Cu>Ni>V>Cr>Cd>Pb (Table 1). Iron (Fe) recorded the highest mean value of 1.9304mgl^{-1} while Lead (Pb) concentration value of 0.0001mgl^{-1} was the lowest. The high concentration level of Iron was expected as the Iron and Steel industry at Aladja discharges its effluents into the river.

A comparison of the concentration values of some of the heavy metals with standard guideline values for drinking water is shown in Table 2. The result obtained in this study showed that Cadmium, Chromium, Manganese and Nickel, had maximum values that were greater than recommended values by the Environmental Protection Agency (EPA) (2002), World Health Organization (WHO) (2003) and Standard Organization of Nigeria (SON) (2007). The concentration levels of these metals would markedly impair the potability of the water.

A comparison of the mean values of some heavy metals concentrations of the surface water (mgl^{-1}) with results obtained from earlier studies on the Warri river (Source: Egborge, 1994) is shown in Table 3. Iron concentration level had continued to maintain its top position in relation to the concentration levels of other heavy metals in the surface water of Warri river in all investigations carried out to date. This could be attributable largely to effluents the river receives from many iron based industries located along its banks.

By 1981/82, industrial activities and the inflow of their effluents into the river was low. At the peak of industrial activity in 1985/86, the heavy metals concentration in Warri river increased and rendered the water unfit for human consumption (Egborge, 1994). There was an apparent recovery of the river waters between 1989/1990 and 1991/1992 over the 1985/86 figures with respect to Copper, Lead and Cadmium. This apparent recovery could be the result of a combination of factors. According to Egborge (1994), these factors include: storage in bottom sediments; reduced industrial activity; self purification activities of the river; speciation; adsorption of ions and bioaccumulation.

Results from this study, showed that there was a reduction in the concentration of Cadmium, Iron, Lead and Manganese compared with the figures obtained in 1992. However, the mean concentration of Copper and Chromium rose above the values recorded in 1992.

Warri river receives a lot of wastes from industrial, agricultural and domestic sources. It serves as the main source of drinking water, fish and irrigation for the various communities settling along its banks and catchment area. With more industries discharging their effluents into the river, the prospects of a greater pollution is high, so also is an increased risk to public health. There is need, therefore, to constantly monitor the concentration levels of heavy metals in the river as well as mounting comprehensive conservation efforts by relevant organizations.

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References

Agada EGO. 1994. Heavy metals concentration in selected fish fauna of Warri river and its tributaries, Ph.D. Thesis, University of Benin, Benin City.

Ajayi SO, Osibanjo M. 1981. Pollution studies on Nigerian rivers. II Water Quality of some Nigerian rivers. Environ. Pollu. Ser. **32,** 87-95.

APHA (American Public Health Association). 1998. American Public Health Association, American Water works and Water Pollution Control Federation. Standard methods for the examination of water and waste waters. 16th ed.

Atuma SS, Egborge ABM. 1986. Insecticides and Metals in Nigerian Surface Water – Warri River. Inter. J. of Environ. Studies **27,** 139-142.

Censi P, Spots SE, Saiano E, Sprovieri M, Mazzola S, Nardone GD, Geronimo SI, Punturo R, Ollonello D. 2006. Heavy metals in coastal water system. A case study from the North Western Gulf of Thailand. Chemosphere. **64,** 1167-1176.

Chukwuogo EI. 1990. Effects of industrial activities in Warri area on the surface water quality M.Sc. Thesis, University of Benin, Benin City, Nigeria.

Don-Pedro KN, Oyewo EO, Otitoloju AA. 2004. Trend of heavy metal concentration in Lagos Lagoon ecosystem, Nigeria. West Afri. J. of Appl. Eco. **5,** 103-114.

EC (European Commission). 2005. Commission Regulation (EC) No.78/2005 of 19 January, 2005 amending regulation (EC) No. 466/2001 as regards heavy metals, 116/43-45.

Edema CU. 1993. Heavy metals in shell fishes of Warri river catchments area, Ph.D. Thesis, University of Benin, Benin City, Nigeria.

Egborge ABM. 1991. Industrialization and heavy metal pollution in Warri river. 32nd Inaugural Lecture. University of Benin, Benin City.

Egborge ABM. 1994. Water Pollution in Nigeria. Vol.1. Biodiversity and Chemistry of Warri river, Ben Miller Books, Warri, p.331.

Egborge ABM, Banka-Coker J. 1986. Water quality index application in Warri River. Environ. Pollut. Bullet. **12,** 27-40.

EPA (Environmental Protection Agency). 2002. Risk Assessment: Technical background information. RBG table. Available online from http://www.epa.gov./reg3hwmd/risk (Online Update: April 23rd, 2011).

Ezemonye LIN. 1992. Heavy metals concentration in water, sediment and selected fish of Warri river and its tributaries. Ph.D. Thesis, University of Benin, Benin City, Nigeria.

FEPA (Federal Environmental Protection Agency). 1991. Guidelines to standard for Environment Pollution Control in Nigeria, Lagos, Nigeria.

Fufeyin P, Egborge ABM. 1998. Heavy metals of Ikpoba river, Benin City, Nigeria. Trop. Freshwater Biol. **7,** 27-36.

Garbarino JR, Hayes HC, Roth DA, Antweller RC, Brinton TI, Taylor HE. 1995. Heavy metals in the Mississippi river. U.S. Geological Survey Circular 113 Reston, Virginia. http://Water.er.usgs.gov/pubs/circ133/heavymetals.html).

Handa BK. 1984. Water quality and water pollution problem on the Indian sub-continent. In: E. Ericsson (Ed.) Hydro-chemical balances of freshwater ecosystems. Int.Assoc.Hydro.Sci.Publ. **150,** 313-322.

Meybeck M, Helmer R. 1989. The quality of rivers from pristine stage to global pollution. Palaegeogr. Palaeoclimatol. Palacocol. Global Planet Change Sec. **75,** 283-309.

Mombeshora C, Ajayi SO, Osibanjo O. 1981. Pollution studies on Nigeria rivers: Toxic heavy metals status of surface waters in Ibadan City. Environ. Inter. **5,** 49-53.

NEDECO (Netherlands Engineering Consultants). 1961. The waters of the Niger Delta. The Hague, (2nd) Revised edition. P. 317.

Omoigberale MO, Ogbeibu AE. 2005. Assessing the environmental impacts of oil exploration and production on the Osse river, Southern Nigeria, I. Heavy metals. Afri. J. of Environ. Pollu. and Health **4(1),** 27-32.

SON (Standards Organization of Nigeria). 2007. Standards for drinking water quality. www.unicef.org/nigeria/ng publications. Nigerian Standard for Drinking Water Quality.pdf. (Online Update; April 23rd, 2011).

Tarig I, Jaffar M, Moazzam M. 1991. Concentration correlations between major cations and heavy metals in fish from the Arabian sea. Marin. Pollut. Bull. **22(1),** 562-565.

Welz B, Sperling M. 1999. Atomic Absorption Spectrophotometry, 3rd Edn., Wiley-VCH, Weinheim.
WHO (World Health Organization) 2003. Guidelines for drinking water quality. Background document for preparation of WHO guidelines for drinking water quality. Geneva, World Health Organization. (WHO/SDE/WSH/03.04/4).