Environmental implications of adsorbed and total trace metals concentrations in bottom-sediments of an urban drainage network in a developing country

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Abstract: Assessment of urban drainage system in Osogbo-Township, SW-Nigeria, revealed impacts of untreated wastes discharge on dissolve trace metal concentrations on one hand. On the other hand the observed adsorbed and most especially the total trace metals enrichment in the stream sediments over the baseline concentration pose serious environmental implication in terms of possible remobilization into the water phase.

Key words: urban drainage network, contamination, trace metals, water quality, sediments

Introduction

In the recent past, there has been increasing interests regarding trace/heavy metal contaminations in the environments, apparently due to their toxicity and perceived persistency within the drainage/aquatic systems (Salomons and Foestner, 1984). However, the environmentally significant bio-available portion of trace metal contamination is a function of ratio of the adsorbed portion to the total metal concentration within the sediment phase. The environmental significance of the adsorbed concentrations lies in relative ease of re-solubilization into the water phase. Hence, this study presents the contamination assessment of an urbanized drainage catchment in Osogbo-Township, SW-Nigeria, and highlights possible impacts of urbanization and associated anthropogenic activities on the drainage network of the study area in. In this study we (a) describe the distribution of the adsorbed and total concentrations of selected trace metals in the sediment phase and (b) assess the influence of anthropogenic activities on trace metals contaminations in both water and bottom-sediments of the urban drainage network.

Study area and methods

The study area, Osogbo-Township is a regional capital located in south-western Nigeria (Fig. 1) and characterized by urban anthropogenic activities while lack of proper municipal waste disposal systems had resulted in serious impacts on the overall environmental quality of the urban drainage system. In this study a total number of thirty-eight (38) bottom sediment samples and the corresponding surface water samples were

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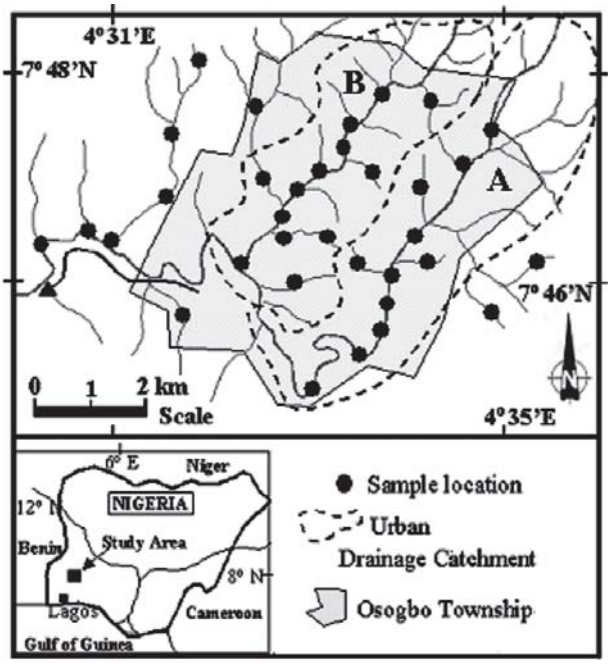

Figure 1. Map of the Osogbo township area showing the samples locations.

collected. Subsequent to initial sample preparation including sieving of the clay fractions, the dissolved and adsorbed of selected trace metals (Mn, Cu, Pb, Zn, Ni, As, Cr, Co) were analyzed using ICP-AES method (*Perkin Elmer; model OPTIMA 3000*) while the total concentrations were analyzed using X-ray florescence (XRF) method (*Rigaku ZSX, Japan)*. Data evaluations involved quantification contamination indices such as anthropogenic factor (AF), metal contamination Index (MCI), geo-accumulation index (I_{geo}) and contamination factor (CF) following the procedures of SUTHERLAND (2000) and MAYBECK ET. AL. (2004).

Table 1. Summary of trace metal concentrations and metal contamination indices*

TM	Sediment (mg/kg) N=38 (Adsorbed concentration)				Sediment (mg/kg) N=15 (Total concentration)				Dissolved (mg/l) N=38	
	Mean	AF	Igeo	MCI	Mean	AF	Igeo	MCI	Mean	CF*
Mn	20.27	0.089	-5.0	-0.91	1,204	5.27	1.73	4.27	2.08	10.2
Cu	0.34	0.027	-6.3	-0.97	115.2	9.31	2.48	8.31	0.05	1.4
Pb	0.23	0.003	-9.2	-1.00	237.2	3.49	0.86	2.49	0.05	15.9
Zn	3.01	0.043	-5.7	-0.96	533.4	7.54	2.01	6.54	0.50	5.9
Ni	0.03	0.002	9.4	-1.00	30.3	2.65	-9.42	1.65	0.01	12.2
As	0.10	0.065	-4.5	-0.93	-	-	-	-	0.08	1.1
Cr	0.09	0.001	-10.4	-1.00	86.7	1.04	-0.55	0.04	0.10	1.1
Co	0.28	0.066	-5.1	-0.93	18.2	4.42	1.50	3.42	-	-

* TM = Trace metals; AF = Anthropogenic factor; Igeo = Geo-accumulation Index; MCI = Metal contamination Index; CF = Contamination factor.

Results and discussion

Table 1 presents the average distribution of adsorbed, total and dissolved concentrations of selected trace metals in sediment and water phases of the study urban drainage systems. The average dissolved concentrations of the trace metals (Cu, Pb, Zn, Ni, As, Cr) vary from 0.01 to 0.5 mg/l compared to 0.1 to 3.1 mg/kg of the adsorbed portions in the sediment phase. However, the dissolved As, Cu and Cr exhibit concentrations similar to the background concentrations in the pristine peri-urban stream waters, compared to higher concentrations of Pb, Zn, and Ni in the analyzed urban stream waters, hence an indication of anthropogenic inputs. On the other hand, the adsorbed trace metals in the sediment phase are considerably lower representing about 1 to 3 % of the respective total concentrations, as indirect reflection of geogenic metal release from the catchment.

Contamination Indices and Environmental Implications: For the water phase, the estimated single metal contamination factors (Table 1) indicate that As, Cu and Cr have low degree of contamination in all the analyzed water samples compared to other trace metals (Mn, Pb, Zn, Cd and Ni) which have CF>5, indicating moderate to very high contamination. Furthermore the observed variability of Cu, Pb and Zn in both water and sediment phases alongside with the total dissolved solids is a clear indication of the fact that the sources of the metals contamination especially in the water phase are related point-source anthropogenic inputs of household wastes into the stream channels within the urban stretches of the study area. For the sediment phase, the high estimated AF of 1.1 to 9.3 (Table 1) and positive values of the estimated Igeo (0.9 – 2.0) and MCI (2.5 – 8.3) for the total metal concentrations indicate an medium to high level enrichment (of 2 to 10 factor) for most of the metals with respect to the local background concentration (LBC) in the bedrock units (with the exception of Cr and Ni which exhibit very low enrichment level). Although the adsorbed metal concentrations in the sediment samples suggests little/no contamination with respect to the LBC, the enrichment revealed by the total concentrations in the stream sediment is an indication of potential contamination threat due to possible remobilization into the water phase.

Conclusions

This study highlighted, on one hand, the negative influence of anthropogenic activities in terms of trace metals contamination of urban drainage systems, especially in populated urban areas of developing countries, characterized by lack of proper waste disposal / management practices. On the other hand, the observed dominant total trace metal enrichments in the stream sediments pose serious environmental implication in terms of possible remobilization and release into the water phase. Such remobilization could be favored by changes in the physico-chemical milieu (pH, Eh, etc) resulting from the anthropogenic inputs of untreated domestic and municipal effluents from urban catchment.

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REFERENCES

MAYBECK, M., HOROWITZ, A.J., GROSBOIS, C. (2004): The geochemistry of Seine River Basin particulate matter: Distribution of an integrated metal pollution index. *Sci. Tot. Environ.;* 328, 219-236.

SALOMONS, W., FOESTNER, U. (1984): *Metals in Hydrocycle.* Springer-Verlag, Berlin, Heidelberg.

SUTHERLAND, R.A. (2000): Bed sediment-associated trace metals in an urban stream, Oahu, Hawaii. *Environ Geol.*; 39, 611 – 627.