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Assessment of Heavy Metal Contamination of River Sediment–A Review

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Abstract—*Rivers are main conduits of natural and anthropogenic discharges carrying huge amount of solid materials as sediments. Along with water, the sediment also gets contaminated from numerous natural and anthropogenic sources as evident from their signatures. Metal accumulations in sediment provide a record of their spatial and temporal pollution history. Heavy metals in river sediment are persistent pollutants having tendency of bioaccumulation and eco-toxicity affecting living organisms. These metals enter into the aquatic system and gets deposited in the downstream basin, it contaminate the water, soil, agricultural land, etc. thereby having serious effects on human population as revealed by researchers throughout the world. The analytical tools such as geoaccumulation index, contamination factor, modified degree of contamination are used for assessment of heavy metals in sediment. This manuscript reviews the various anthropogenic sources of contamination, their effects, and analytical tools used for study of heavy metal contamination in the sediment.*

Keywords: *Heavy metal; river; sediment; contamination; pollutants.*

1. INTRODUCTION

Heavy metal contamination of river sediment is one of serious environmental issues throughout the world (Singh *et al.,* 2005). It causes bioaccumulation of metals in aquatic organisms which result potential long term effects on human health and ecosystem (Carman et al. 2007). The study of river sediments provides information about quality of the water body and its impact on human beings (Singh *et al.,* 1997). Sediment is considered as one of the ultimate sink of heavy metals discharged into the aquatic environment (Stephen and Oladele, 2012). The major sources of heavy metals in river system are industrial discharge, sewage, agricultural runoff and mining activities. The degree of pollution of sediment sample is determined by comparing concentration of metal in polluted sediment sample with its concentration in unpolluted sample or a pristine substance comparable with studied sample. As different researchers use different reference materials and enrichment calculation methods, there are considerable variations in quantification of anthropogenic pollution on a given site (Abra him and Parker, 2008). Therefore study of different assessment methods and their inferences will provide an understanding of the sediment contamination in rivers and their potential harmful impacts.

2. SOURCES AND ECOLOGICAL IMPACT OF HEAVY METAL CONTAMINATION OF RIVER SEDIMENT

Both natural and anthropogenic processes are responsible for hevy metal contamination of river sediment. Natural sources are erosion of rock strata and soil of surrounding area and its demineralization in the complex river ecosystem. Another natural source is atmospheric deposition of particulate matters present in air (Idrees, 2009). The concentration of these metals in aquatic ecosystem considerably increases with acceleration of anthropogenic activities such as discharge of industrial and agricultural waste, sewage, infrastructure and rapid economic development (Gao *et al.,* 2014; Yang *et al.,* 2012). It has been observed that heavy metal contamination in the vicinity of road side, mining, smelting and other industrial sites are high (Maiz *et al.,* 1997). Runoff from these areas contaminate the river sediment rapidly. The environmental risks of metal contamination in sediments are of great concern due to their direct and indirect impacts over ecosystem. It may cause growth retardation, impaired reproduction and lower species diversity of aquatic organisms (Praveen a *et al.,* 2007). Bioaccumulation of these metals in aquatic organisms are transferred to human beings through food chain. Major sources of different heavy metals and their effects on human beings are provided in Table 1.

Table 1: Sources and impacts of some toxic metals on human beings

S. No	Pollutants	Major sources	Effect on human
1	Lead	Paint, pesticide, batteries, crystal, glass preparation	Cognitive impairment in children, peripheral neuropathy in adults, developmental delay
2	Copper	Electroplating, pesticide production, mining	Headache, nausea, vomiting, diarrhoea and kidney malfunctioning

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3	Zinc	Effluents from electroplating industries, sewage discharge, the immersion of painted Idols	Vomiting, diarrhoea, I, liver and kidney damage
4	Nickel	Stainless steel manufacturing units, electroplating factory discharge	Neurotoxin, genotoxic and carcinogenic agent Ni-dermatitis
5	Cadmium	Electroplating, preparation of Cd-Ni batteries, control rods, shields within nuclear reactors, television phosphorus	Kidney and liver damage, renal dysfunction, gastrointestinal damage
6	Chromium	Mines, electroplating	Gastrointestinal, hepatic, renal, neuronal damage

Source: Malik *et al.,* 2014

3. SUITABLE ANALYTICAL TOOLS FOR EVALUATION OF TOXIC METAL CONTAMINATION OF SEDIMENT

There are various analytical tools for analyzing toxic metal contamination in sediment. The most common are Geoaccumulation index (Igeo), Pollution load index (PLI), Contamination factor (CF), Modified degree of contamination (mCd).The Igeo estimate extent of sediment contamination with respect to background shale value of element. The PLI gives information about contamination of sediment by all the metals species combinedly. The extent of heavy metal contamination in sediment is expressed in term of contamination factor (Banu et al., 2013). Abrahim and Parker (2008) proposed mC_d to overcome the limitation of C_d. The details of these pollution indices are described in table 2.

Table 2: Analytical tools with their threshold values for analysis of metal contamination in sediment

Index/ factor	Formula	Notation	Threshold values
Geoaccumulation index (Igeo)	Igeo = $\log_2 C_n / 1.5B_n$	C_n: concentration of metal in sediment sample Bn: background value of metal, 1.5: constant factor to minimise variation in background data due to lithogenic effect	Igeo ≤ 0: uncontaminated,0 <Igeo <1: uncontaminated to moderatelycontaminated, 1<Igeo< 2: moderate contaminated, 2 <Igeo< 3: moderate to heavy contaminated, 3 <Igeo< 4: heavy contaminated, 4 <Igeo< 5: heavy to extremely contaminated, Igeo> 5: extremely contaminated (Muller 1969)
Pollution load index (PLI)	PLI = $(Cf1 x Cf2 x Cf3— CfN)^{1/N}$	N= number of metals Cf = contamination factor	PLI < 0: unpolluted, 0 < PLI ≤ 1: baseline level of pollutant present, 1< PLI ≤ 10: polluted, 10 < PLI < 100: highly polluted, PLI > 100 progressive deterioration of environment (Tomlinson et al. 1980)
Contamination factor (CF)	CF = $C_m$sample/C_m background	$C_m$sample = oncentration of given metal in ediment $C_m$background = concentration of metal in background sediment	CF<1: Low contamination; 1≤CF<3: Moderate contamination; 3≤CF<6: Considerable contamination; CF>6: Very high contamination (Hakanson, 1980)
Modified degree of contamination (mCd)	$mC_d = \frac{\sum_{i=1}^{n} C}{n}$	n = number of analysed element, i = element, C_f = contamination factor	mCd<1.5: Zero to very low degree of contamination; 1.5<mCd<2: Low degree of contamination; 2<mCd<4: Moderate degree of contamination; 4<mCd<8: High degree of contamination; 8<mCd<16: Very high degree of contamination; 16<mCd<32: Extremely high degree of contamination; mCd≥32: Ultra-high degree of contamination

4. CONCLUSION

The above review confirms that heavy metals are serious pollutants of river sediment worldwide, where metals like Cu, Zn, Cd, Pb, Cr and Ni were found to be most common toxic metals. Mining, sewage disposal, industrial effluents and solid waste disposal along river bank are major source of heavy metals in river. There are number of tools for evaluation of extent of heavy metal contamination in the sediment but none of them are universally accepted and used. Therefore the result vary according to tools used and background concentration of metals selected by researcher for their studies. So there is ample scope to develop a most reliable analytical tool to study the level of sediment toxicity for heavy metals.

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