METAL POLLUTION ASSESSMENT OF SEDIMENT AND WATER IN THE RIVER HINDON, INDIA

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Abstract. The metal pollution in water and sediment of the River Hindon in western Uttar Pradesh (India) was assessed for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn. The metal concentrations in water showed wide temporal variation compared with bed sediment because of variability in water discharge and variations in suspended solid loadings. Metal concentrations in bed sediments provided a better evaluation of the degree and the extent of contamination in the aquatic environment, Santagarh and Atali being the most polluted sites of the river. The ratio of heavy metals to conservative elements (Fe, Al, etc.) may reveal the geochemical imbalances due to the elevated metal concentrations normally attributed to anthropogenic sources. Metal/Al ratios for the bed sediments of the river Hindon were used to determine the relative mobility and general trend of relative mobility occurred Fe > Mn > Zn > Cr > Ni > Pb > Cu > Cd.

Keywords: bed sediments, metal pollution, mobility

1. Introduction

The introduction of metallic pollutants into a river, whether it is natural (erosion) or artificial (anthropogenic), can occur in dissolved and particulate form. Depending on physico-chemical conditions, the pollutants in dissolved form can later precipitate. They can also be adsorbed by the iron or manganese oxides and hydroxides or co-precipitated with these, or form dissolved organic or inorganic complexes (Salomons and Forstner, 1984; Drever, 1988). Metal partitioning appears to be metal specific and the eventual fate of various metals is a function of the distribution between the aqueous phase, suspended sediments and bed load of the river (Salomons and Forstner, 1984; Forstner, 1985; Luoma, 1990). The analysis of heavy metals in sediments permits us to detect pollution that might not be detected by analysis of single water samples (Forstner and Salomons, 1980; Salomons and Forstner, 1984; Erel et al., 1991).

Sakai et al. (1986) analyzed the distribution of Cd, Cr, Cu, Mn, Pb and Zn, in water and sieved sediment samples taken from the main stream of the Toyohira River, Japan and reported that the heavy metal concentrations generally increased with decreasing particle size of sediments. Sabri et al. (1993) determined the concentrations of various metals in water, suspended solids and surficial sediments of
the River Tigris at Samarra impoundment and found that the concentrations of most of the elements in the surficial sediments (except for Mn and Fe) were lower than those in the suspended solids indicating the importance of the suspended solids in transportation of heavy metals. Combest (1991) evaluated sediment trace metals in White Rock Creek watershed located in Dallas and Collin Counties of north central Texas, in relation to sediment sorption characteristics. Bertin and Bourg (1995) studied the geochemical characteristics of sediments in the Lot River basin contaminated by heavy metals (Cd, Pb and Zn) and reported that the heavy metal transport in the river takes place mainly in particulate form. Dupre et al. (1996) studied the three main phases (suspended load, dissolved load, and bed load) of materials carried by Congo River and its main tributaries for twenty five major and trace elements and reported that 80% of the material is transported through dissolved load. Viers et al. (2000) studied chemical weathering processes and element transport mechanisms in the Nyong River basin of the Congo craton in Central Africa and found that there was a progressive increase of chemical weathering intensity with the decrease of the watershed drainage area. Chemical weathering mainly occurred in swamp zones where organic matter favors mineral dissolution.

Horowitz et al. (1999) analysed bed sediment, suspended sediment and fresh floodplain samples from the Seine River basin in France. The concentrations associated with floodplain sediments indicate that within the basin, trace element concentrations vary spatially by as much as three orders of magnitude, which may be attributed to increase in the population as well as concomitant increases in industrial activity.

In our earlier papers, we have reported the role of river bed sediments in controlling the metal pollution (Jain and Ram, 1997a,b; Jain and Ali, 2000; Jain and Sharma, 2001, 2002). In the present work, an attempt has been made to establish the role of bed sediments as indicators for assessing the metal pollution. The extent of contamination has been determined and relative mobilities of different metals presented.

2. The River System

The River Hindon is one of the important rivers in western Uttar Pradesh (India) having a basin area of about 7000 km$^2$ and lies between latitude 28°30′ to 30°15′ N and longitude 77°20′ to 77°50′ E (Figure 1). The river originates from Upper Shiv- aliks (Lower Himalayas) and flows through four major districts, viz., Saharanpur, Muzaffarnagar, Meerut and Ghaziabad, a distance of about 200 km before joining the river Yamuna downstream of Delhi. Physiographically the area is generally flat except the Shivalik hills in the north and north east. Deep gorges have been cut by nalas and rivers flowing through the area.

The major land use in the basin is agriculture, with little forest cover. On the basis of land use map, the study area can be demarcated into five categories: agriculture