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Anthropogenic Light Rare Elements in Gomati River Sediments, Ganga Alluvial Plain, northern India: Hydrodynamics of Transportation and Enrichment

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Light rare earth elements (LREE; La, Ce, Pr, Nd and Sm) are commonly used in modern technologies over the last two decades, and are increasingly being studied as emerging micro-pollutants in many river systems. River sediments contain records of surface processes and also document anthropogenic chemical changes. The present study focuses on anthropogenic LREE carried by the sediments of the Gomati River. The 900-km long Gomati River (a Ganga River tributary) flows through 2 to 25-m deep incised valley and drains 30,437 km^2 area of Ganga Alluvial Plain, India. The Gomati River is characterized by LREE-enriched sediments containing 91% of total REE. Average LREE content in the bedload (n=29; 170 µg/g) and suspended load sediments (n=28; 182 µg/g) are higher than World Average Sediments, World Major Rivers Suspended Sediments. The highest values of LREE in the bedload and suspended load sediments (629 and 330 µg/g, respectively) display 5-folds and nearly 3-folds enrichment, respectively; which is particularly interesting and represent pooling of anthropogenic LREE (Figure 1A). High LREE concentration in bedload sediments is due to high organic carbon, very fine silt and clay fractions, as compared to suspended load sediments. Potential Ecological Risk Index showed that LREE pose moderate to strong ecological risk, mostly by Pr and Sm; whereas the most abundant LREE was Ce.

LREE-enriched Gomati River sediments were further amplified as Fe oxides and oxy-hydroxides have high adsorption capacity. In the lower river segment, slack-water flood deposits are significantly enriched in anthropogenic LREE, due to settling and deposition, co-transportation on bedload, as well as on the suspended load sediments (Figure 1B). These river sediments were hydro-dynamically deposited due to rising of the flooding stages in Gomati (~5m) and Ganga rivers (~10m at confluence), by nearly 20-folds and 50-folds increase in their flood water discharges during the monsoon season, respectively. The coupling of LREE monitoring and hydrodynamic understanding of the flood deposits, help to demonstrate the transportation and deposition of anthropogenic LREE in alluvial rivers, and is important for understanding the micro-contaminant redistribution at a continental scale; where rivers supply ~30% of global sediment input into oceans.

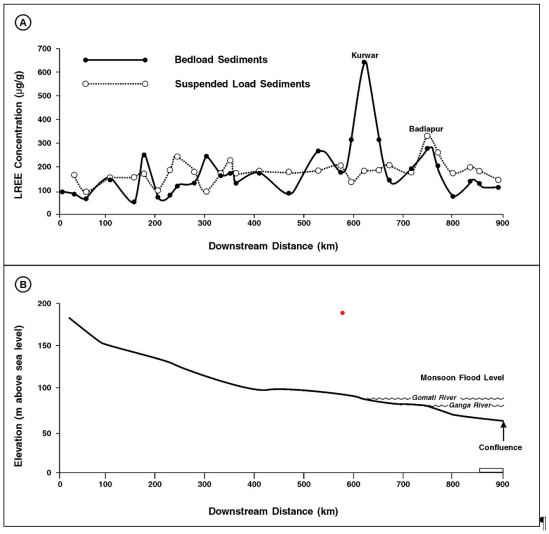

Figure 1: (A) Downstream variations of total LREE concentrations in the bedload and suspended load sediments of the Gomati River. Note the cyclic pattern with observed isolated peak in lower river segment at Kurwar and Badlapur. (B) Longitudinal profile of the Gomati River along with the position of slack-water flood deposits in lower river segment linked with flooding stages of the Ganga and Gomati Rivers during the monsoon season.