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Extracellular enzymes detecting heavy metal pollution in the Ganga River

India with more than 1.25 billion peoples is facing a significant challenge in meeting the growing water supply needs of burgeoning human population. Ganga, the most sacred river of India, that supplies water to over one fourth of the country's population to meet their drinking and agricultural needs, is under tremendous pressure of environmental pollution. Large input of untreated to partially treated sewage and industrial waste water in the river has massively enhanced the levels of organic and metal pollutants. The Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India is striving hard to solve the problem and rejuvenate the river.

Fig. 1. The study area showing sampling sites at the Ganga River.

Agencies such as Central Pollution Control Board use parameters such as BOD, carbon, nutrients, chlorophyll **a**, heavy metals etc. as diagnostic criteria for river health assessment. These water quality parameters, however, suffers from hydrodynamic disturbances. The riverbed sediment provides a relatively stable test bed for more accurately assessing water quality changes. Two researchers of Banaras Hindu University (India), Prof. Jitendra Pandey and Ms. Deepa Jaiswal took a completely novel approach studying it from an altogether different angle to address this most critical problem of the Ganga River. The authors assume that because the microbial loop constitutes a significant part of nutrient and energy flow in aquatic ecosystems, linking microbial extracellular enzyme activities with metal toxicants in riverbed sediment can be used as a sensitive indicator of anthropogenic perturbations. The authors show that the sediment based interaction of microbial activities and extracellular enzymes with heavy metals can be a more appropriate indicator of river ecosystem 'response' in an eco-toxicological perspective. The enzymes tested were found to be highly sensitive even to

small changes and show quick response to carbon and metal enrichment. Beside this, being substrate specific, these can be used as an important tool for investigating carbon and nutrient pollution (eutrophy) and metal toxicity (eco-toxicology) in human impacted rivers. To collect evidence, the authors conducted two years (2016-2017) of study during low flow along with a 518 km long middle stretch of the Ganga River between Kanpur upstream and Varanasi downstream. This part of the middle segment with highest population density and a large number of industrial areas is considered as the most polluted segment of the river. The study was conducted at eight sites; Nawabganj, Jajmau, Dalmau, Hatwa, Sangam, Sitamarhi, Bypass and Rajghat (Fig. 1) to measure carbon, nutrients, six heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) and four extracellular enzymes (β-D-glucosidase, alkaline phosphatase, protease and FDAase) in the riverbed sediment of the Ganga River. The object was to obtain a real understanding of the effect of carbon and nutrients (a signature of eutrophy) and heavy metals in an eco-toxicological perspective. As the organic carbon is known to partly nullify the toxic impact of heavy metals, they tested whether this effect continue to work at high concentrations of heavy metals; and how the enzymes were 'responding' collectively towards *in situ* substrate and toxic enrichment? They show that the enzyme activity was influenced proportionately to the substrate availability (C, N and P). However, the sites with toxic enrichment showed adverse effects (Fig. 2).

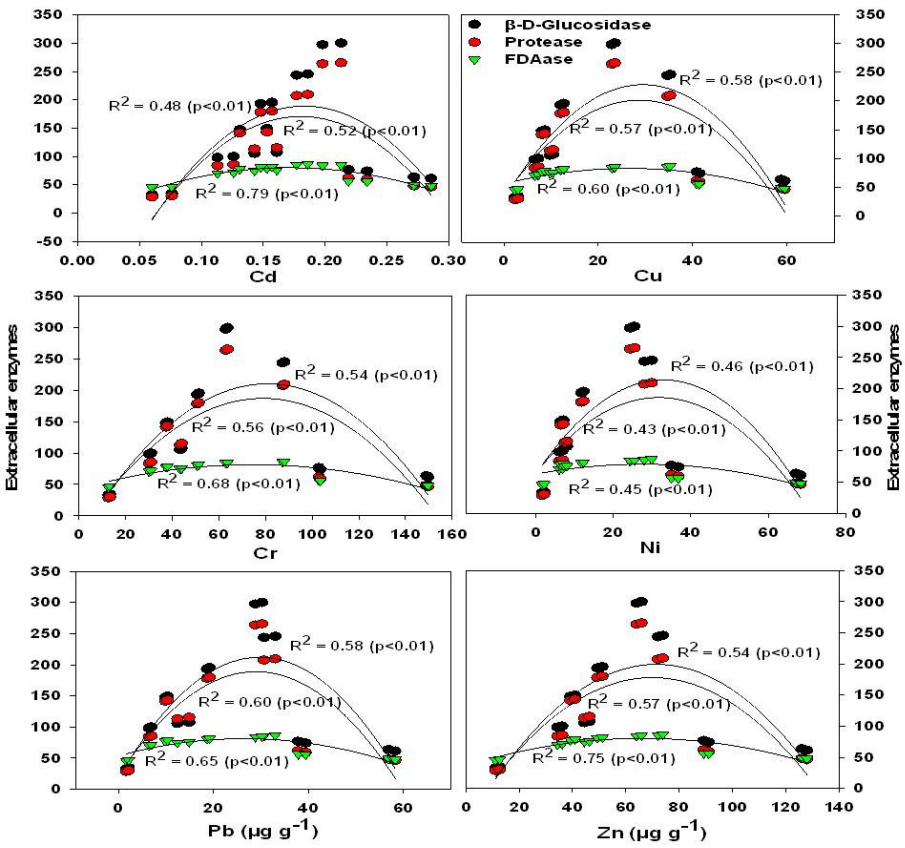

Fig. 2. Dynamic fit model for heavy metals and extracellular enzymes in the riverbed sediment. B-D-glucosidase in µg p-NP g-1 hr-1; protease in µg L-tyrosine g-1 hr-1; FDAase in µm fluorescein g-1 hr-1.

The study reports that two sites of middle stretch, Jajmau and Rajghat downstream, are the most polluted sites with respect to heavy metal contamination. The study forms the first report on the use of metal-microbial enzyme interactions in the Ganga riverbed sediment as an alternative and a more reliable indicator of metal pollution. The striking feature of this study is that it provides clear understanding of river ecosystem 'response' to human perturbations useful to design action plans for river rejuvenation.

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