Received: 30 April 2022 | Revised: 23 June 2022 | Accepted: 13 August 2022

DOI: 10.1002/tqem.21918

REVIEW ARTICLE

WILEY

Five-wheel framework for system-based monitoring of heavy metal pollution in rivers

Pankaj Kumar[1,2] | Vandana Mishra[1,3] | Saiyami Bhardwaj[1] | Shafali Garg[1] | Ludovic F. Dumée[4,5,6] | Radhey Shyam Sharma[1,7]

[1]Bioresources and Environmental Biotechnology Laboratory, Department of Environmental Studies, University of Delhi, Delhi, India

[2]Department of Environmental Studies, Shaheed Bhagat Singh College, University of Delhi, Delhi, India

[3]Centre for Inter-Disciplinary Studies of Mountain & Hill Environment (CISMHE), University of Delhi, Academic Research Centre, Delhi, Delhi 110007, India

[4]Department of Chemical Engineering, Khalifa University, Abu Dhabi, United Arab Emirates

[5]Research and Innovation Center on CO_2 and Hydrogen, Khalifa University, Abu Dhabi, United Arab Emirates

[6]Center for Membrane and Advanced Water Technology, Khalifa University, Abu Dhabi, United Arab Emirates

[7]Delhi School of Climate Change & Sustainability, Institute of Eminence, University of Delhi, Delhi, India

Correspondence
Radhey Shyam Sharma, Biresources and Environmental Biotechnology Laboratory, Department of Environmental Studies & Delhi School of Climate Change & Sustainability, Institute of Eminence, University of Delhi, Delhi-110007, India.
Email: rads26@hotmail.com

Abstract

Sectorial approach for monitoring heavy metal pollution in rivers has failed to report realistic pollution status and associated ecological and human health risks. The increasing spread of heavy metals from different sources and emerging risks to human and environmental health call for reexamining heavy metal pollution monitoring frameworks. Also, the sources, spread, and load of heavy metals in the environment have changed significantly over time, requiring consequent modification in the monitoring frameworks. Therefore, studies on heavy metal monitoring in rivers conducted in the last decade were evaluated for experimental designs, research frameworks, and data presentations. Most studies (~99%) (i) lacked inclusiveness of all environmental compartments; (ii) focused on "one pollutant – one/two compartment" or sometimes "one pollutant – one compartment – one effect" approach; and (iii) remained "data-rich but information poor." An ecological approach with integrative system thinking is proposed to develop a holistic approach for monitoring river pollution. It is visualized that heavy metal monitoring, risk analyses, and water management must incorporate tracking pollutants in different environmental compartments of a river (water, sediment, and floodplain/bank soil) and consider correlating it with riverbank land use. The systems-based pollution monitoring and assessment studies will reveal the critical factors that drive heavy metals pollutant movement in ecosystems and associated potential risks to the environment, wildlife, and humans. Also, water quality and pollution indexing tools would help better communicate complex pollution data and associated risks among all stakeholders. Therefore, integrating systems approaches in scientific- and policy-based tools would help sustainably manage the health of rivers, wildlife, and humans.

KEYWORDS
ecological risk, environmental compartments, human health risks, pollution index, system approach

