

PL-07

Bioremediation of heavy metal-contaminated wastewater: process performance and risk assessment in a One Health framework

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Background. Heavy metals in wastewater can move through water, sediments, organisms and food, linking environmental contamination to chronic exposure. This work examines microbial bioremediation as an upstream primary-prevention strategy, connecting process performance with exposure pathways and residual risk within a One Health framework.

Materials and Methods. A VOSviewer analysis explored research on heavy metals, bioremediation and wastewater. Glutamicibacter bergerei and Vibrio harveyi were screened for tolerance to cadmium (Cd), lead (Pb) and copper (Cu), and for metabolic responses to Cd. G. bergerei was tested in triplicate in saline BP7 medium containing urea, calcium and Cd. Dissolved metals were quantified by inductively coupled plasma analysis. The congress case study was complemented by updated 30-day data and precipitate characterization using electron microscopy, Raman spectroscopy, X-ray diffraction and infrared spectroscopy.

Results. Bibliometric findings highlighted increasing research activity and links between wastewater and bioremediation. Screening identified Cd as the target contaminant and revealed marked metabolic inhibition. The case study reported up to 80% Cd removal. Updated 30-day data showed 99.61 ± 0.11% removal relative to a nominal initial Cd concentration of 50 mg/L, with residual dissolved Cd of 0.20 ± 0.06 mg/L (mean ± SD). Calcite was the dominant mineral phase, without clear evidence of separate crystalline $CdCO_3$; the specific retention mechanism remained unresolved.

Conclusions. Microbial bioprecipitation may provide a source-control barrier before environmental dispersion and biological uptake. However, removal efficiency alone does not demonstrate reduced human, animal or ecosystem risk. Risk assessment must consider residual Cd, speciation, bioavailability, exposure pathways, vulnerable receptors and intended uses of treated effluents. Quantitative abiotic-control results are needed to establish the microbial contribution. Validation in real wastewater should assess mixed-metal effects, ammonium generation and mineral stability, alongside integrated environmental and biological exposure monitoring.

References. 1. One Health High-Level Expert Panel (OHHLEP), Adisasmito WB, Almuhairi S, Behravesh CB, Bilivogui P, Bukachi SA, et al. One Health: a new definition for a sustainable and healthy future. PLoS Pathog. 2022;18(6):e1010537. doi:10.1371/journal.ppat.1010537. 2. Jomova K, Alomar SY, Nepovimova E, Kuca K, Valko M. Heavy metals: toxicity and human health effects. Arch Toxicol. 2025;99(1):153-209. doi:10.1007/s00204-024-03903-2. 3. Omoregie AI, Ouahbi T, Basri HF, Ong DEL, Muda K, Ojuri OO, et al. Heavy metal immobilisation with microbial-induced carbonate precipitation: a review. Geotech Res. 2024;11(4):188-212. doi:10.1680/jgere.23.00066.