A review on bioaccumulation of heavy metals using genetically modified microorganisms

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Abstract

Heavy metals contamination is becoming a great concern to the government policies and also for having awareness about environment. Several heavy metals removal technologies including chemical precipitation, ion exchange, reverse osmosis, electrodialysis, ultrafiltration and phytoremediation are commonly used in industries. However, these technologies are becoming uneconomical and unfavourable to remove heavy metals from industrial wastewaters. With increasing environmental attention and legal constraints on discharge of effluents, a need of cost effective technology is essential. Recently, more focus is given on using microbial biomass as a biosorbent to sequester metal ions from contaminated effluent. Specifically, bioaccumulation is a natural biological phenomenon where microorganisms use proteins to uptake and sequester metal ions in the intracellular space to utilize in cellular processes like enzyme catalysis, signaling, stabilizing charges on biomolecules. Recombinant expression of these import-storage systems in genetically engineered microorganisms allows for enhanced uptake and sequestration of heavy metal ions. This has been studied for over two decades for bioremediative applications, but successful translation to industrial-scale processes is virtually non-existent. Demand for metal resources are increasing while discovery rates to supply primary grade ores are not. This review re-thinks how bioaccumulation can be used and proposes that it can be developed for bioextractive applications, the removal and recovery of heavy metal ions for downstream purification and refining, rather than disposal. This review consolidates previously tested import-storage systems into a biochemical framework and highlights efforts to overcome obstacles that limit industrial feasibility, thereby identifying gaps in knowledge and potential avenues of research in bioaccumulation.