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Molecular Characterization and Arsenic Mobilization Properties of a Novel Strain IIIJ3-1 Isolated from Arsenic Contaminated Aquifers of Brahmaputra River Basin, India

Authors : Soma Ghosh, Balaram Mohapatra, Pinaki Sar, Abhijeet Mukherjee

Abstract : Microbial role in arsenic (As) mobilization in the groundwater aquifers of Brahmaputra river basin (BRB) in India, severely threatened by high concentrations of As, remains largely unknown. The present study, therefore, is a molecular and ecophysiological characterization of an indigenous bacterium strain IIIJ3-1 isolated from As contaminated groundwater of BRB and application of this strain in several microcosm set ups differing in their organic carbon (OC) source and terminal electron acceptors (TEA), to understand its role in As dissolution under aerobic and anaerobic conditions. Strain IIIJ3-1 was found to be a new facultative anaerobic, gram-positive, endospore-forming strain capable of arsenite (As3+) oxidation and dissimilatory arsenate (As5+) reduction. The bacterium exhibited low genomic (G+C)% content (45 mol%). Although, its 16S rRNA gene sequence revealed a maximum similarity of 99% with Bacillus cereus ATCC 14579(T) but the DNA-DNA relatedness of their genomic DNAs was only 49.9%, which remains well below the value recommended to delimit different species. Abundance of fatty acids iC17:0, iC15:0 and menaquinone (MK) 7 though corroborates its taxonomic affiliation with B. cereus sensu-lato group, presence of hydroxy fatty acids (HFAs), C18:2, MK5 and MK6 marked its uniqueness. Besides being highly As resistant (MTC=10mM As3+, 350mM As5+), metabolically diverse, efficient aerobic As3+ oxidizer; it exhibited near complete dissimilatory reduction of As5+ (1 mM). Utilization of various carbon sources with As5+ as TEA revealed lactate to serve as the best electron donor. Aerobic biotransformation assay yielded a lower Km for As3+ oxidation than As5+ reduction. Arsenic homeostasis was found to be conferred by the presence of arr, arsB, aioB, and acr3(1) genes. Scanning electron microscopy (SEM) coupled with energy dispersive X-ray (EDX) analysis of this bacterium revealed reduction in cell size upon exposure to As and formation of As-rich electron opaque dots following growth with As3+. Incubation of this strain with sediment (sterilised) collected from BRB aquifers under varying OC, TEA and redox conditions revealed that the strain caused highest As mobilization from solid to aqueous phase under anaerobic condition with lactate and nitrate as electron donor and acceptor, respectively. Co-release of highest concentrations of oxalic acid, a well known bioweathering agent, considerable fold increase in viable cell counts and SEM-EDX and X-ray diffraction analysis of the sediment after incubation under this condition indicated that As release is consequent to microbial bioweathering of the minerals. Co-release of other elements statistically proves decoupled release of As with Fe and Zn. Principle component analysis also revealed prominent role of nitrate under aerobic and/or anaerobic condition in As release by strain IIIJ3-1. This study, therefore, is the first to isolate, characterize and reveal As mobilization property of a strain belonging to the Bacillus cereus sensu lato group isolated from highly As contaminated aquifers of Brahmaputra River Basin.

Keywords : anaerobic microcosm, arsenic rich electron opaque dots, Arsenic release, Bacillus strain IIIJ3-1
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