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Akhilesh Kumar Yadav
Saba Shirin *Editors*

Emerging and Innovative Arsenic Removal Technologies for a Sustainable Future

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Contents

Chapter 9
Arsenic Biological Treatment Using Microorganisms in the Environment

Rushda Sharf, Ambrina Sardar Khan, and Yusra Sharf

Abstract The ecology and public health are seriously threatened by arsenic pollution of soil and groundwater. Natural sources such as aquifers and man-made sources account for the majority of primary releases of arsenic into the environment. Both organic (such as methylated) and inorganic (such as arsenate and arsenite) forms of arsenic (As) are prevalent in the environment. Because it is the most effective, economical and environmentally benign means of treating arsenic, the use of microorganisms in biological treatment provides an intriguing substitute for traditional techniques. Biological techniques in certain locations, methods such as arsenic microbial detoxification or phytoremediation employing aquatic plants are commonly accepted. Other techniques such as immobilization by microbial oxidation biological activity and microbiological molecular analysis were necessary, as was coprecipitation or adsorption with Fe oxyhydroxides in the solid phase. Arsenic oxygen is used by certain autotrophic and heterotrophic microorganism species to recover energy. Arsenate is a nutrient that some microorganism species can use in their respiratory processes. One prevalent type of arsenic resistance in microbes is detoxification operons. Therefore, bioremediation may be a practical and affordable means of removing this pollutant from the environment. This chapter summarizes what is now known about the various biological methods for removing arsenic from soil and groundwater.

Keywords Phytoremediation · Arsenic resistance microorganism · Microbial oxidation

R. Sharf (✉) · A. S. Khan
Department of Environmental Science, Integral University, Lucknow, India
e-mail: rsharf@iul.ac.in

Y. Sharf
Department of Zoology, Aligarh Muslim University, Aligarh, India
e-mail: rsharf@iul.ac.in

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9.1 Introduction

In the periodic table, arsenic is a metallic element that belongs to the 'nitrogen' family and has characteristics in common with nitrogen, phosphorus, antimony, and bismuth. There are two main oxidation states for the element: pentavalent arsenate and trivalent arsenite. Although arsenite (As III) is more common in decrease conditions, such as in anaerobic groundwater, arsenate (As V) is typically found in soil and surface water. More poisonous, the As III form can dissolve in water and perhaps infiltrate living cells. Arsenic can enter the environment through natural processes, such as atmospheric emissions and the dissolution of minerals rich in arsenic, and anthropogenic sources, including mining, fossil fuel combustion, metal extraction, and the use of wood preservatives. Both inorganic and organic forms of As are known to cause cancer in humans; the latter is linked to cancers of the skin, lungs, bladder, kidney, and liver. Due to its toxicity, non-biodegradability, persistence, bioaccumulation, and possible carcinogenic qualities, arsenic in soil and water is a global concern (Rahaman et al., 2021; Shirin & Yadav, 2014, 2021; Simon et al., 2024). Arsenic contamination of the environment has been widespread due to rapid urbanization and industrialization. Arsenic-rich groundwater can be found in geothermal zones, mining districts, and areas where sulfide mineral oxidation has taken place. A metalloid that is frequently present in aquatic environments, arsenic negatively impacts plant growth and food production. Soil health refers to the long-term capacity of the soil to serve as a thriving ecosystem. This has a significant impact on the sustainability of agricultural ecosystems (Lehmann et al., 2020). The biological health of the soil is characterized by the presence of a diverse and abundant microbial community, the suppression of harmful pathogens and the support of crop growth (Shahane & Shivay, 2021). The biological health of the soil can be impacted by the presence or lack of hazardous agrochemicals and pollutants.

9.2 Sources of Arsenic

Exposure to arsenic can arise from natural sources, industrial sources, or accidental sources resulting from human intervention. The main causes of inhaled arsenic can be pesticide manufacturing facilities, air emissions from burning arsenic-containing fossil fuels, and tobacco smoke (Fig. 9.1).

9.3 Distribution of Arsenic in Soil

The rhizosphere ecosystem is negatively affected by arsenic contamination, which also negatively affects microbial communities, plant health, and overall soil functionality. The accumulation of arsenic in crops is significantly impacted by the levels