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Editorial Open Access

Hazardous Cocktails: Challenges and Innovations in Bioremediation

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Editorial

Past many decades have witnessed unprecedented contamination of environment emanating from rapid urbanization and industrialization. The environmental deterioration is eventually invading the rural areas as well. The presence of hazardous and toxic contaminants is especially alarming due to immediate as well as long-term health effects. There is a strong need for development of decentralized technologies to deal with such contaminations as conventional technologies are not designed to handle the same. A lot of research has focused on biological remediation, which could offer an attractive decentralized system. However, there has not been much success in translating these results into actual applications. Recent innovations in microbial interventions targeting the ease of applications therefore signify vital advancements.

Extreme variability that characterizes industrial effluents due to cocktail of many toxic metals and synthetic chemicals makes the detoxification task very difficult. Hence, specialized microbial cultures that can sustain the extremes of environmental conditions and resist the toxicity of metals are required for efficient removal of such toxic components. At present, there is a growing interest in the application of fungi for bioremediation of industrial effluent [1,2]. The fungi have a strong potential for use in non-sterile open environment. The mycelial growth gives a competitive advantage over single cells such as bacteria and yeasts, especially with respect to the colonization of insoluble substrates. They have high surface-to-cell ratio characteristics of filaments that maximize both mechanical and enzymatic contact with the substrate. The extracellular nature of the degradative enzymes enables fungi to tolerate higher concentrations of toxic chemicals than would be possible if these compounds had to be brought into the cell. Insoluble compounds that cannot cross a cell membrane are also susceptible to attack.

Although biological processes are suitable for remediating single or binary metal solutions, the efficiency of these processes decrease when employed for multiple heavy metal removal. This is due to the fact that the metals in a multi-metal mix can interact and result in synergism, antagonism or additive effect in terms of toxicity. These mechanisms of interaction may be complex and unique and are dependent on the type of combination of heavy metal and microbial strain. Surprisingly, majority of the studies have targeted or achieved the remediation of a single metal even though complex effluents were dealt with. This happens because the microbial strains may not be able to cope with various other metals present in the effluent. Hence, it is clear that while dealing with actual effluents and waste streams, ability to simultaneously uptake several metals is a more important yardstick for strain selection rather than a high MIC (Minimum Inhibitory Concentration) for a particular metal in isolation. In this regard, the ability of Aspergillus lentulus for the simultaneously removal of various hazardous metals such as Cr, Cu and Pb is remarkable and bears high potential for industrial applications [3]. The alkali, thermo and halo tolerant characteristics of this wastewater isolate coupled with the efficacy for removal of textile dyes further enhance the industrial relevance of such strains [4].

In addition, along with the heavy metals and dyes in the waste water there are other toxic contaminants like pesticides [5]. Under such condition presence of heavy metal and pesticide may cause multiple stresses to the microorganism and may influence its bioremediation properties. Simple studies which examine the single heavy metal or binary heavy metal removal using microbial strain from liquid media can provide useful data about the metal removal capacity but they fail to reflect the real situation in waste water containing metal ions and pesticide together. The investigations targeting bioremediation of metal-pesticide mixtures are scanty. Due to low availability of water resources, farmers in urban and peri urban area utilize heavy metal and pesticide contaminated water for irrigation, which may lead to toxicity in plant resulting in health risk for human. Therefore there is an urgent need to develop a bioremediation technique capable of simultaneously removing heavy metal and pesticide from waste water. This challenge would involve several selection yardsticks to choose the appropriate microflora for application. Ample tolerance of the selected strains against extremes of pH, temperature, salinity, would be required to guarantee a smooth process performance. Further, multiple metal tolerance and capability to simultaneously address metals and xenobiotics is highly desirable. The production of appropriate formulation could be an innovation that would simplify storage, handling and dosing in the industrial processes, especially for the unskilled masses in small scale industries. In this context, the microbial formulation delivering multiple contaminant removal as well as industrially important enzyme production would offer substantial advancement. Also, there is a paucity of work concerning metal & pesticide removal from actual waste streams in continuous reactor systems. Such a testimony is very much required to facilitate field application of bioremediation technology for managing hazardous cocktails.

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