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Review

Genetically engineered bacteria: An emerging tool for environmental remediation and future research perspectives

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ABSTRACT

This minireview explores the environmental bioremediation mediated by genetically engineered (GE) bacteria and it also highlights the limitations and challenges associated with the release of engineered bacteria in field conditions. Application of GE bacteria based remediation of various heavy metal pollutants is in the forefront due to eco-friendly and lesser health hazards compared to physico-chemical based strategies, which are less eco-friendly and hazardous to human health. A combination of microbiological and ecological knowledge, biochemical mechanisms and field engineering designs would be an essential element for successful in situ bioremediation of heavy metal contaminated sites using engineered bacteria. Critical research questions pertaining to the development and implementation of GE bacteria for enhanced bioremediation have been identified and poised for possible future research. Genetic engineering of indigenous microflora, well adapted to local environmental conditions, may offer more efficient bioremediation of contaminated sites and making the bioremediation more viable and eco-friendly technology. However, many challenges are to be addressed concerning the release of genetically engineered bacteria in field conditions. There are possible risks associated with the use of GE bacteria in field condition, with particular emphasis on ways in which molecular genetics could contribute to the risk mitigation. Both environmental as well as public health concerns need to be addressed by the molecular biologists. Although bioremediation of heavy metals by using the genetically engineered bacteria has been extensively reviewed in the past also, but the bio-safety assessment and factors of genetic pollution have been never the less ignored.

1. Introduction

Soil and water are the most vital natural resources on earth. However, in the past few decades, these have been contaminated with several complex toxic compounds including heavy metals. The problem of environmental pollution is escalating day by day due to anthropogenic and natural sources because of increase in huge population, industrialization and urbanization (Fulekar et al., 2009). The contaminants causing environmental troubles leading to inequity in environment is of worldwide apprehension. The model resolution for toxic waste abatement could be bioremediation, which makes use of microbial systems for treatment of contaminants. Although, this novel technology involves multidisciplinary approach, but its vital power may depend on the nature of microorganisms (Shukla et al., 2010). Several microorganisms (*Pseudomonas, Burkholderia, Sphingomonas, Ralstonia, Comamonas, Achromobacter, Alcaligenes, Rhodococcus, Dehalococcoides*) are known to degrade xenobiotics, or to accumulate or detoxify heavy metal pollutants such as Cd, Hg, Pb, Zn, U, etc., (Daly, 2000; Lloyd et al., 2003). An important difference between bioremediation of toxic metals and bioremediation of xenobiotics is the existence of heavy metals under different elemental state (e.g., conversion of Hg^{2+} to the volatile Hg^0, thus moving the metal from the soil to the atmosphere). In contrast, the bioremediation of xenobiotics results in complete mineralization of the toxic substances. In situ bioremediation uses naturally occurring non engineered microorganisms and is often enhanced (biostimulation) by the addition of nutrients, such as N and P, surfactants and oxygen during the treatment (Watanabe, 2001). In such treatments, nature of the microbial ecological niches is unpredictable. Another possible method to improve the bioremediation efficiency is the bioaugmentation, where the indigenously isolated bacteria are injected into the

Abbreviations: arsenic, As; cadmium, Cd; cobalt, Co; deoxyribonucleic acid, DNA; genetically engineered, GE; glutathione S-transferase fusion protein, GSM-MT; lead, Pb; magnesium, Mg; mercury, Hg; metal binding peptide, MBP; metallothionein, MT; nickel, Ni; nitrogen, N; phosphorus, P; phytochelatins, PCs; potassium, K; sodium, Na; suicidal genetically engineered microorganisms, S-GEMS; trichloroethene, TCE; trimethylarsine, TMA; uranium, U; zinc, Zn.

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