

Methanotrophs: promising bacteria for environmental remediation

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Abstract Methanotrophs are unique and ubiquitous bacteria that utilize methane as a sole source of carbon and energy from the atmosphere. Besides, methanotrophs may also be targeted for bioremediation of diverse type of heavy metals and organic pollutants owing to the presence of broad-spectrum methane monooxygenases enzyme. They are highly specialized group of aerobic bacteria and have a unique capacity for oxidation of certain types of organic pollutants like alkanes, aromatics, halogenated alkenes, etc. Oxidation reactions are initiated by methane monooxygenases enzyme, which can be expressed by methanotrophs in the absence of copper. The present article describes briefly the concerns regarding the unusual reactivity and broad substrate profiles of methane monooxygenases, which indicate many potential applications in bioremediation of heavy metals and toxic organic compounds. Research is needed to develop understanding in plant–methanotrophs interactions that optimize methanotrophs utilization in the field of environmental remediation, while supporting other ecosystem services.

Keywords Bioremediation · Heavy metals · Methanotrophs · Organic pollutants

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Introduction

There is a growing concern about global warming worldwide. Methane (CH₄) is one of the greenhouse gases (GHGs), which contributes to global warming. Methane is about 23 times more effective as a greenhouse gas than carbon dioxide (CO₂) (Hasin et al. 2010). Methanotrophs are the only known significant biological sink for atmospheric CH₄ and play a crucial role in reducing CH₄ load up to 15 % to the total global CH₄ destruction (Singh et al. 2010). Methanotrophs exist in a variety of habitats due to having physiologically versatile nature and found in a wide range of pH, temperature, oxygen concentrations, salinity, heavy metal concentrations, and radiation (Barcena et al. 2010; Dubey 2005; Durisch-Kaiser et al. 2005; Lindner et al. 2007; Tsubota et al. 2005). Broad-spectrum methane-oxidizing methane monooxygenase (MMO) enzyme is found only in methanotrophs, which possess two forms, namely membrane-associated or particulate form (pMMO) and soluble or cytoplasmic form (sMMO). The pMMO is found in all known methanotrophs except for the genus *Methylocella* (acidophilic) (Theisen et al. 2005), while the sMMO is present only in a few methanotroph strains (Murrell et al. 2000a, b).

There are several sources that generate huge amount of toxic heavy metals/metalloids (Cr, Cd, Pb, As, Cu, Zn, Ni, Hg, etc.) and organic pollutants into the environment (Wijnhoven et al. 2007). Soils contaminated with heavy metals and/or organic pollutants are generally left abandoned for several years and therefore may not be safe for agricultural production. Recently, microbial bioremediation techniques have been found to alleviate the metal/organic pollutant toxicity of contaminated soils (Hasin et al. 2010; Shukla et al. 2009). Methanotrophs may be promising bacteria for environmental bioremediation