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The Potential of Edaphic Algae for Bioremediation of the Diesel-Contaminated Soil

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Abstract : Algae in soil ecosystems can produce organic matters and oxygen by photosynthesis. Heterocyst-forming cyanobacteria can fix nitrogen to increase soil nitrogen contents. Secretion of mucilage by some algae increases the soil water content and soil aggregation. These actions will improve soil quality and fertility, and further increase abundance and diversity of soil microorganisms. In addition, some mixotrophic and heterotrophic algae are able to degrade petroleum hydrocarbons. Therefore, the objectives of this study were to analyze the effects of algal addition on the degradation of total petroleum hydrocarbons (TPH), diversity and activity of bacteria and algae in the diesel-contaminated soil under different nutrient contents and frequency of plowing and irrigation in order to assess the potential bioremediation technique using edaphic algae. The known amount of diesel was added into the farmland soil. This diesel-contaminated soil was subject to five settings, experiment-1 with algal addition by plowing and irrigation every two weeks, experiment-2 with algal addition by plowing and irrigation every four weeks, experiment-3 with algal and nutrient addition by plowing and irrigation every two weeks, experiment-4 with algal and nutrient addition by plowing and irrigation every four weeks, and the control without algal addition. Soil samples were taken every two weeks to analyze TPH concentrations, diversity of bacteria and algae, and catabolic genes encoding functional degrading enzymes. The results show that the TPH removal rates of five settings after the two-month experimental period were in the order: experiment-2 > expermient-4 > experiment-3 > experiment-1 > control. It indicated that algal addition enhanced the degradation of TPH in the diesel-contaminated soil, but not for nutrient addition. Plowing and irrigation every four weeks resulted in more TPH removal than that every two weeks. The banding patterns of denaturing gradient gel electrophoresis (DGGE) revealed an increase in diversity of bacteria and algae after algal addition. Three petroleum hydrocarbon-degrading algae (Anabaena sp., Oscillatoria sp. and Nostoc sp.) and two added algal strains (Leptolyngbya sp. and Synechococcus sp.) were sequenced from DGGE prominent bands. The four hydrocarbon-degrading bacteria Gordonia sp., Mycobacterium sp., Rodococcus sp. and Alcanivorax sp. were abundant in the treated soils. These results suggested that growth of indigenous bacteria and algae were improved after adding edaphic algae. Real-time polymerase chain reaction results showed that relative amounts of four catabolic genes encoding catechol 2, 3-dioxygenase, toluene monooxygenase, xylene monooxygenase and phenol monooxygenase were appeared and expressed in the treated soil. The addition of algae increased the expression of these genes at the end of experiments to biodegrade petroleum hydrocarbons. This study demonstrated that edaphic algae were suitable biomaterials for bioremediating diesel-contaminated soils with plowing and irrigation every four weeks.

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