Biosurfactant as an additive for the promotion of diesel-contaminated soil phytoremediation

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Keywords: Phytoremediation, petroleum hydrocarbons, biosurfactant, legumes
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Soil contamination caused by oil products is a global problem. It's estimated that there are up to 2.5 million potentially contaminated sites across Europe (Panagos, 2013). In the USA, there are more than 40,000 sites, with over 1,300 listed in the National Priorities List (EPA). One of the most common pollutants found in contaminated soil sites is petroleum hydrocarbons. Due to their toxic effects on human health and the environment, it's crucial to pay attention to soil pollution caused by emerging contaminants (Adipah, 2019).

There are several ways to decontaminate soil contaminated with petroleum hydrocarbons. However, some of the commonly used physical and chemical methods can be harmful to the environment and quite expensive (Ite, 2018). On the other hand, biological treatment technologies are now widely used for cleaning up petroleum hydrocarbon-polluted environments because they are practical and cost-efficient (Shahsavari, 2017). Phytoremediation is a process that can be accelerated by combining certain petroleum-resistant plant species with biological additives. Leguminous plants are particularly effective because of their nitrogen-fixing ability, which can reduce competition for limited soil nitrogen in petroleum-contaminated sites, thus supporting soil remediation efforts (Collins, 2007). One promising approach involves using biosurfactants as process promoters. Biosurfactants are secondary metabolites produced by microorganisms that can enhance the rate of bioremediation by reducing surface tension, promoting emulsification, and micelle formation. This makes hydrocarbons more bioavailable for microbial breakdown (Zahed, 2022).

The aim of the research was to evaluate the efficiency of phytoremediation of diesel-contaminated soil by using *Melilotus albus*, *Medicago sativa* and *Lotus corniculatus* along with the biosurfactant additive in terms of diesel removal and plant response. Selected plant species were cultivated in soil with varying levels of diesel pollution (control, 4 g/kg^{-1}, 6 g/kg^{-1}) for 90 days in a growth chamber. Biosurfactant HydroBreak PLUS at a rate of 1 ml/kg^{-1} was introduced to the soil to examine its effectiveness in diesel phytoremediation with various legume species. The height of the stems was measured periodically to evaluate the morphometric parameters of the plants. At the end of the experiment, the above-ground and underground plant biomass were measured. Additionally, to assess the diesel decomposition rates, the residual concentration of diesel in the soil was analysed by gas chromatography.

The results show that biosurfactant additive can enhance the tolerance of legumes to diesel pollution while also improving the efficiency of contaminant removal. The effectiveness of the biosurfactant in removing diesel is contaminant concentration-dependent, as it decreases when the dosage of diesel exceeds certain levels. Some results are shown in Figure 1.

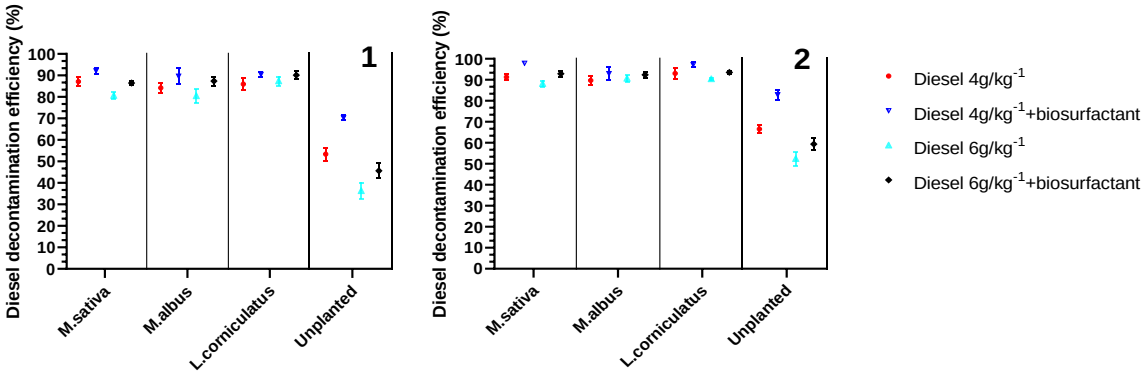

Figure 1. Diesel decontamination efficiency (%) after 45 (**1**) and 90 days (**2**) from the diesel-amended soil and diesel and biosurfactant-amended soil planted with *M. Sativa, M. albus, L. corniculatus* and unplanted soil.

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