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## Remediation of pentachlorophenol contaminated forest soil by the combined action of biostimulation and bioaugmentation techniques

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Pentachlorophenol (PCP) is a recalcitrant compound that could persist in the environment causing serious pollution concerns. Bioremediation of PCP is demonstrating to achieve encouraging results compared to the common physical and chemical techniques.

The aim of this work was to assess different bioremediation processes as biostimulation and/or bioaugmentation approaches of artificially PCP (100 mg kg<sup>-1</sup>) contaminated forest soil (Sc). The biostimulation treatment provided phosphate and three different organic amendments, such as forest compost (FC), municipal solid waste compost (MC) or sewage sludge (SS). Two different microbial consortia B1 and B2 were used as bioaugmentation treatments. The combination of both biostimulation and bioaugmentation techniques was also assessed. Soil physical and chemical properties, PCP amount, soil microbial biomass carbon, soil respiration and some enzymatic activities at zero time (T0) and after 30 d incubation (T30) were evaluated.

No significant changes in terms of main chemical soil properties were observed, but an increment of organic carbon in all organic amendment-based treatments at T0 and T30 was observed. The PCP concentration at T0 was on average 82 mg kg<sup>-1</sup> in all soil samples. After 30 days natural attenuation was responsible for the reduced PCP extractable in Sc (68.5 mg kg<sup>-1</sup>). The combined action of biostimulation and bioaugmentation led to a strong PCP reduction (71%) in Sc+B1+FC sample, whereas a depletion of only 52% and 41% occurred with the single application of FC or B1, respectively. The presence of PCP negatively affected soil microbial biomass carbon and the activity of dehydrogenase and fluorescein diacetate hydrolysis that recovered upon organic amendment also combined with microbial consortia B1 or B2. FC based biostimulation treatment also stimulated soil respiration. These results demonstrate that the simultaneous treatment of biostimulation and bioaugmentation showed a better performance in the PCP removal with more effectiveness than the single techniques.