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AN INNOVATIVE AND ECO-FRIENDLY TECHNOLOGY FOR THE REMEDIATION OF HIGHLY POLLUTED SOILS BY OXIDATIVE BIOMIMETIC CATALYSIS

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Abstract

Anthropogenic organic pollutants may accumulate in soils, waters and sediments, thus endangering human health and environmental quality. The use of oxidative biomimetic catalysts such as metal-porphyrins, may become an innovative and eco-friendly technology for soil remediation. Water soluble iron-porphyrins are non-toxic compounds which were shown to promote the dehalogenation and polymerization of phenols and polyphenols.

The objective of this study was to assess the oxidative capacity of a synthetic water-soluble iron-porphyrin (FeP), in the concomitant presence of an exogenous humic acid from lignite (HA), to decontaminate two heavily polluted soils (A and B) from the contaminated site of ACNA (Aziende Chimiche Nazionali Associate). The ACNA site pertains to the industrial area of Cengio (Savona) that was included in the list of national priorities for environmental remediation. A first series of experiments were conducted by placing 40 g of soil sample (2.0 mm sieved) in Petri dishes, and adding the following solutions to the soil: I) 20 mL of a 1.09×10^{-4} M aqueous solution of FeP catalyst (control 1); II) 3.2 mL of a 8.1 M freshly prepared H_2O_2 solution (control 2); III) both the amounts of FeP and H_2O_2 solutions added in the preceding experiments. A second series of experiments were conducted by first treating 40 g of soil in Petri dishes with 20 mL of 1 mg mL^{-1} of HA aqueous solution. The soils were left to air-dry for 10 days, and then the samples were treated with the following solutions: IV) 20 mL of a 1.09×10^{-4} M aqueous solution of FeP catalyst; V) 20 mL of a 1.09×10^{-4} M aqueous solution of FeP catalyst and 3.2 mL of a 8.1 M freshly prepared H_2O_2 solution. The treated soils were incubated at room temperature for 30 days in the dark, in order to avoid photocatalytic oxidations, then subjected to Soxhlet extractions, and the extracts analyzed by GC-MS.

Results showed the treatment of soil A with FeP in the presence of oxidizing agent (H_2O_2) allowed removal of pollutants by 50% compared to control, while the removal reached 69% in the presence of the exogenous humic acid. For soil B, the combined presence of FeP-oxidizing agent and HA allowed a removal of pollutants greater (90%) than that detected for soil A (69%). The increase in removal efficiency is attributable to the oxidative co-polymerization reaction of the abundant aromatic contaminants in the humic matrix. In conclusion, the use of biomimetic catalysts such as iron-porphyrin may represent an innovative approach to efficiently and rapidly remediate contaminated soils.