
Remediation of MCPA contaminated soils using bacterial biofilms on carrier materials (biocomposites): impact of carrier materials and improvements via surface modifications

Fatima Meite^{*1,2}, Alain Seron², Karine Michel², Claude Lemilbeau¹, Mikael Motelica-Heino¹, and Caroline Michel²

¹UMR 7327 ISTO, CNRS, Orléans university, BRGM, 45071 Orléans – ISTO Orléans – France

²BRGM, the French Geological Survey, Division of Water, Environment, Process and Analyses (DEPA),
3 Avenue Claude Guillemin, 45100 Orléans – BRGM – France

Abstract

Pollution of terrestrial and aquatic systems with pesticides following their use in agriculture and their export to water bodies is of increasing concern because of pesticide effects on human and ecosystems health (Alengebawy et al., 2021; Tang et al., 2021). Among the existing remediation techniques to restore pesticide-polluted soils is the bioaugmentation technique (Castelo-Grande et al., 2010; Morillo and Villaverde, 2017). This technique consists in soil inoculation with microorganisms able to degrade pesticides, and presents higher efficiencies with the use of sessile microorganisms (such as biofilms) than planktonic microorganisms (Cycoń et al., 2017). Moreover, biofilm formation can be improved with surface modifications of carrier materials such as surface enrichment in elements and anions, serving respectively as oligo-elements and nutrients for microorganisms. Lamellar structure of layered double hydroxides (LDH), having positively charged layers of hydroxylated metal cations and interlayers containing hydrated anions for charge balance (Mishra et al., 2018), represents an interesting surface modification of carrier materials.

Hence, MCPA-degrading biocomposites were produced by suspending raw oyster shell powder (OS), pozzolana (P), and zeolite (Z) as carrier materials in a mineral salt medium (MSM, spiked with MCPA at 5 mg L⁻¹) prior to inoculation with a bacterial consortium selected from a pesticide polluted soil to form biofilms. Carrier materials covered with LDH were also used. Surface modification was confirmed by X-ray diffraction (XRD) and transmission electron microscopy (TEM). 1, 2, 5, 7 and 10 weeks old biocomposites were tested for their MCPA degrading efficiency in MSM and in soil using UV-visible spectroscopy. In addition, the bacterial community structure was assessed using terminal restriction fragment length polymorphism (T-RFLP) analysis.

Carrier materials induced changes in LDH characteristics during surface modifications and biofilm bacterial diversity. Better MCPA dissipations were obtained with biocomposites made of modified carrier materials than raw materials. The highest dissipation kinetics were observed using zeolite-made biocomposites, with a full MCPA dissipation obtained within only 2 days of incubation. Dissipation kinetics followed the trend: Z (2 days) > OS (3 days)

*Speaker

> P (6 days), and could be explained by biofilm characteristics.

This study highlights the efficiency and interest of biofilms over planktonic cells for the inoculation of soil in a context of remediation by bioaugmentation. This study also emphasizes the need to understand material surface and microorganisms relationships regarding the formation and tailoring of pesticide-degrading biofilms and regarding soil remediation.

Keywords: MCPA, bioremediation, biofilms, surface modifications, tRFLP, XRD, TEM, agricultural soils