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Characterization of a Three-Electrodes Bioelectrochemical System from Mangrove Water and Sediments for the Reduction of Chlordecone in Martinique

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Abstract : Chlordecone (CLD) is an organochlorine pesticide used between 1971 and 1993 in both Guadeloupe and Martinique for the control of banana black weevil. The bishomocubane structure which characterizes this chemical compound led to high stability in organic matter and high persistence in the environment. Recently, researchers found that CLD can be degraded by isolated bacteria consortiums and, particularly, by bacteria such as Citrobacter sp 86 and Delsulfovibrio sp 86. Actually, six transformation product families of CLD are known. Moreover, the latest discovery showed that CLD was disappearing faster than first predicted in highly contaminated soil in Guadeloupe. However, the toxicity of transformation products is still unknown, and knowledge has to be deepened on the degradation ways and chemical characteristics of chlordecone and its transformation products. Microbial fuel cells (MFC) are electrochemical systems that can convert organic matter into electricity thanks to electroactive bacteria. These bacteria can exchange electrons through their membranes to solid surfaces or molecules. MFC have proven their efficiency as bioremediation systems in water and soils. They are already used for the bioremediation of several organochlorine compounds such as perchlorate, trichlorophenol or hexachlorobenzene. In this study, a three-electrodes system, inspired by MFC, is used to try to degrade chlordecone using bacteria from a mangrove swamp in Martinique. As we know, some mangrove bacteria are electroactive. Furthermore, the CLD rate seems to decline in mangrove swamp sediments. This study aims to prove that electroactive bacteria from a mangrove swamp in Martinique can degrade CLD thanks to a three-electrodes bioelectrochemical system. To achieve this goal, the tree-electrodes assembly has been connected to a potentiostat. The substrate used is mangrove water and sediments sampled in the mangrove swamp of La Trinité, a coastal city in Martinique, where CLD contamination has already been studied. Electroactive biofilms are formed by imposing a potential relative to Saturated Calomel Electrode using chronoamperometry. Moreover, their comportment has been studied by using cyclic voltametry. Biofilms have been studied under different imposed potentials, several conditions of the substrate and with or without CLD. In order to quantify the evolution of CLD rates in the substrate's system, gas chromatography coupled with mass spectrometry (GC-MS) was performed on pre-treated samples of water and sediments after short, medium and long-term contact with the electroactive biofilms. Results showed that between -0,8V and -0,2V, the three-electrodes system was able to reduce the chemical in the substrate solution. The first GC-MS analysis result of samples spiked with CLD seems to reveal decreased CLD concentration over time. In conclusion, the designed bioelectrochemical system can provide the necessary conditions for chlordecone degradation. However, it is necessary to improve three-electrodes control settings in order to increase degradation rates. The biological pathways are yet to enlighten by biologicals analysis of electroactive biofilms formed in this system. Moreover, the electrochemical study of mangrove substrate gives new informations on the potential use of this substrate for bioremediation. But further studies are needed to a better understanding of the electrochemical potential of this environment.

Keywords : bioelectrochemistry, bioremediation, chlordecone, mangrove swamp
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