Removal of chlorpyrifos using micelle–clay complex and advanced treatment technology

Mohannad Qurie a,b, Mustafa Khamis a,c, Ibrahim Ayyad a, Laura Scrano d, Filomena Lelario e, Sabino Aurelio Bufo e, Gennaro Mecca f, Rafik Karaman e,g,*

aDepartment of Chemistry and Chemical Technology, Al-Quds University, Jerusalem, Palestine, emails: mqurie@ccba.alquds.edu (M. Qurie), mukhamis@yahoo.com (M. Khamis), iayad@science.alquds.edu (I. Ayyad)
bCenter for Chemical and Biological Analysis, Al-Quds University, Jerusalem, Palestine
cDepartment of Biology, Chemistry and Environmental Sciences, American University of Sharjah, Sharjah, UAE
dDepartment of European Cultures (DICEM), University of Basilicata, dell’Ateneo Lucano 10, 85100 Potenza, Italy, email: Laura.scrano@unibas.it
eDepartment of Science, University of Basilicata, Via dell’Ateneo Lucano 10, 85100 Potenza, Italy, emails: filomenalelario@hotmail.com (F. Lelario), sabino.bufo@unibas.it (S.A. Bufo), Tel./Fax: +972 2 279 0413; email: dr_karaman@yahoo.com (R. Karaman)
fExo Research Organization, Potenza, Italy, email: g.mecca@exo-ricerca.it
gFaculty of Pharmacy, Department of Bioorganic Chemistry, Al-Quds University, Jerusalem, Palestine

Received 12 June 2015; Accepted 21 August 2015

ABSTRACT

In this study, the stability of chlorpyrifos, a known pesticide, in fresh water and sludge was investigated. The results showed that chlorpyrifos underwent hydrolysis in both media to give two main metabolites: 3,5,6-trichloro-2-pyridiniol (TCP) and diethylthiophosphoric acid (DETP). The hydrolysis reaction in both media was found to follow first-order kinetics with a rate constant of $7.10 \times 10^{-8}$ ($R^2 = 0.999$) in pure water and of $9.30 \times 10^{-8}$ ($R^2 = 0.996$) in sludge. Chlorpyrifos degradation’s half-life value in pure water was 112 d and in sludge was 85.9 d. The efficiency of Al-Quds University wastewater treatment plant demonstrated that the ultrafiltration-hollow fiber unit (UF-HF) was insufficient in removing chlorpyrifos from spiked secondary treated wastewater samples, whereas the combination of ultrafiltration-spiral wound unit (UF-SW) followed by activated carbon (AC) column was quite efficient and yielded a complete removal of the pesticide. Batch adsorption experiments using either AC or micelle–clay complex were performed and the experimental results were fitted to Langmuir and Freundlich isotherms. Adsorption analysis using Langmuir isotherm revealed that $Q_{\text{max}}$ for the AC was higher than that of the micelle–clay complex, while Freundlich isotherm showed almost similar values of $n$ (3.413 vs. 3.745) for both adsorbents, despite the fact that the activated carbon filter showed higher $k_F$ value. Filtration column of mixed micelle–clay complex and sand demonstrated a breakthrough point after the third fraction for chlorpyrifos removal and a complete removal for all fractions collected in the...
TCP experiment. This result reveals that mixed micelle-clay complex and sand column is much more efficient in removing TCP than removing its parent compound, chlorpyrifos.

Keywords: Chlorpyrifos; Micelle-clay complex; Pesticides; Pollutants removal; Activated sludge; Wastewater; Activated carbon