



Degradation Products, Mineralization, and Toxicity Assessment of Pesticides Malathion and Fenitrothion

Marija V. Pergal · Igor D. Kodranov · Miodrag M. Pergal ·
Uroš Gašić · Dalibor M. Stanković · Branka B. Petković ·
Dragan D. Manojlović

Received: 16 April 2020 / Accepted: 29 July 2020 / Published online: 7 August 2020
© Springer Nature Switzerland AG 2020

Abstract The aim of this study was to investigate, analyze, and compare applied techniques suitable for achieving efficient removal of organophosphorus pesticides (OPPs) (malathion and fenitrothion) from aqueous solutions and analyze the degradation products and processes. Pesticide degradation efficiency (%) was monitored by high-performance liquid chromatography (HPLC) equipped with a photodiode array detector (DAD), while mineralization degree was determined by total organic carbon analysis (TOC). *Daphnia magna* was used for screening the environmental safety aspects of the degradation methods, i.e., for assessing the toxicity of solutions obtained after degradation. Additionally, a surface river water was utilized to examine the likely influence of organic matter on the pesticides' degradation. Pesticide degradation products were identified using gas chromatography with a triple quadrupole mass detector (GC-MS/MS) as well as ultrahigh-performance liquid chromatography coupled with a linear ion trap, Orbitrap mass spectrometer (UHPLC-

LTQ Orbitrap MS), and a simple pesticide degradation mechanism is proposed. Removal of pesticides from water using chlorine dioxide was successful, resulting in high degradation efficiency (98% for malathion and 81% for fenitrothion). Partial mineralization was achieved, and *Daphnia magna* mortality decreased in the waters containing degradation products (compared with the parent pesticides), indicating that the solutions formed were less toxic than the parent pesticides. Lower degradation rates (80% for malathion and 72% for fenitrothion) in Sava River water were measured, indicating the influence of the organic matter contained in this naturally occurring surface water. The results prove that chlorine dioxide could be used as an agent for successful removal of these OPPs from water.

Keywords Organophosphorus pesticides degradation · River water · Degradation product and pathway · LC-Orbitrap MS · GC-MS/MS

M. V. Pergal (✉)
Institute of Chemistry, Technology and Metallurgy, National
Institute of the Republic of Serbia, University of Belgrade,
Njegoševa 12, Belgrade 11000, Serbia
e-mail: marija.pergal@gmail.com

I. D. Kodranov · M. M. Pergal · D. D. Manojlović
Faculty of Chemistry, University of Belgrade, Studentski trg
12-16, Belgrade 11000, Serbia

U. Gašić
Department of Plant Physiology, Institute for Biological Research
Siniša Stanković, National Institute of the Republic of Serbia,
University of Belgrade, Bulevar despota Stefana 142,

Belgrade 11060, Serbia

D. M. Stanković
The Vinca Institute of Nuclear Sciences, University of Belgrade,
POB 522, Belgrade 11001, Serbia

B. B. Petković
Faculty of Sciences, University of Priština, Lole Ribara 29, 38220,
Kosovska Mitrovica, Serbia

D. D. Manojlović
South Ural State University, Lenin prospekt 76,
454080 Chelyabinsk, Russia