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Photocatalytic oxidation of six pesticides listed as endocrine disruptor chemicals from wastewater using two different TiO_2 samples at pilot plant scale under sunlight irradiation☆

Nuria Vela[a,*], May Calín[a], María J. Yáñez-Gascón[a], Isabel Garrido[b], Gabriel Pérez-Lucas[c], José Fenoll[b], Simón Navarro[c]

[a] Applied Technology Group to Environmental Health, Faculty of Health Science, Catholic University of Murcia, Campus de Los Jerónimos, s/n, Guadalupe, 30107, Murcia, Spain
[b] Sustainability and Quality Group of Fruit and Vegetable Products, Murcia Institute of Agri-Food Research and Development, C/Mayor s/n, La Alberca, 30150 Murcia, Spain
[c] Department of Agricultural Chemistry, Geology and Pedology, Faculty of Chemistry, University of Murcia, Campus Universitario de Espinardo, 30100, Murcia, Spain

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ABSTRACT

The photocatalyzed degradation of a mixture of six pesticides (malathion, fenotrothion, quinalphos, vinclozoline, dimethoate and fenarimol) with endocrine disrupting activity has been studied in sewage wastewater effluent under natural sunlight at pilot plant scale. The initial level of each pesticide was 0.30 mg L^{-1}. For this, two commercial TiO_2 nanopowders (Degussa P25 and Kronos vlp 7000) were used as photocatalysts. The operational conditions (catalyst loading, effect of electron acceptor and pH) were previously optimized under laboratory conditions using a photoreactor. The results show that the use of TiO_2 alongside an electron acceptor like $Na_2S_2O_8$ strongly enhances the degradation rate of the studied pesticides compared with photolytic tests, especially Degussa P25. The photodegradation process followed pseudo-first order kinetics in all cases. In our experimental conditions, the necessary time necessary for 90% degradation (DT_{90}) varied from 79 to 1270 min (6–108 min as normalized illumination time, t_{30W}) for malathion and fenarimol, respectively for TiO_2 vlp 7000 and 32–817 min (t_{30W} = 3–69 min) for the same pesticides, in the case of TiO_2 P25. The results confirm the efficacy of the treatment to remove recalcitrant pollutants from wastewater using natural sunlight as renewable source.

1. Introduction

The total sales of pesticides for agricultural use reached about 387 thousand tonnes in the EU-28 during 2015. Some Mediterranean countries such as Spain (20%), France (17%) and Italy (16%) lead the EU-28's pesticide market followed by other Central European States like Germany (12%) and Poland (6%) and together they reaching more than 70% of the pesticide sales in the EU-28 [1]. The European Union Directive 2009/128/EC on the Sustainable Use of Pesticides requires all Member States to assume measures to decrease the risk of pesticides for human health and the environment [2]. Many pesticides are endocrine disruptors (EDs), compounds that alter the function(s) of the endocrine system and consequently cause adverse health effects in an intact organism, or its progeny, or sub-populations [3]. In recent years, different public and private institutions have published lists of compounds suspected to be EDs. More specifically, based on the Community Strategy EDs 1999, the European Commission Institute for Environment and Health (IEH), has been developing a list of priority chemical substances based on scientific evidence showing their capacity EDs, as well as production volume, persistence and potential exposure. In 2011, the fourth and final report on the implementation of this strategy was published, emphasizing the need for an evaluation of the cumulative impact of these compounds, especially in relation to human fertility [4].

In this context, there is very clear evidence concerning the presence of many different pesticides in the aquatic environment at European Union (EU) level. Consequently, they need special consideration according the European Water Framework Directive

☆ Electronic Supplementary material.

* Corresponding author.
E-mail address: nvela@ucam.edu (N. Vela).

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Conflicts of interest

There is no conflicts to declare.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jphotochem.2017.11.040.

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