Pesticides decontamination of drinking water networks using Fenton and photo-Fenton advanced oxidation processes

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INTRODUCTION

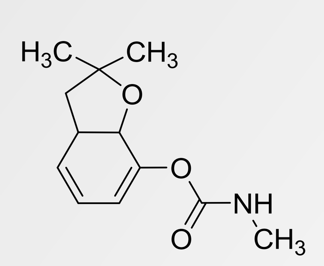
Pesticides may be used to deliberately contaminate drinking water networks and, once detected, the contaminated water needs to be treated for correct disposal or even be reinserted into the distribution system.

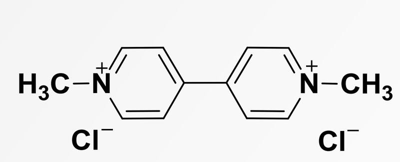
Some classes of pesticides may be used as models to establish simple approaches for rapid and adequate decontamination and among them, paraquat (an extremely water-soluble worldwide used herbicide), **chlorfenvinphos** (an organophosphate insecticide with similar toxicity action as the gas nerve agents) and **carbofuran** (a carbamate insecticide and a cholinesterase inhibitor).

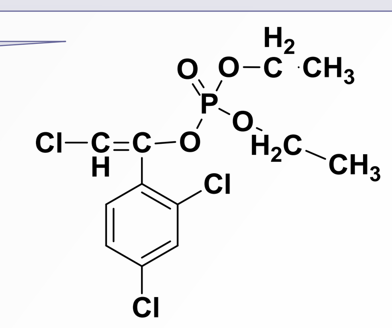
Classic (dark) Fenton and photo-Fenton were used as Advanced Oxidation Processes for pesticides degradation ($Fe^{2+} + H_2O_2$ (+ hν) → HO• + …; Organics + HO• → Oxidation products + HO• → $CO_2 + H_2O$). Degradation performances were compared for the three pesticides under the same experimental conditions.

EXPERIMENTAL

Pesticides Chemical Structures

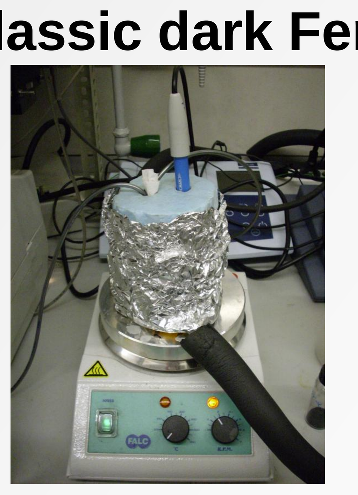

Carbofuran


Paraquat Dichloride


Chlorfenvinphos

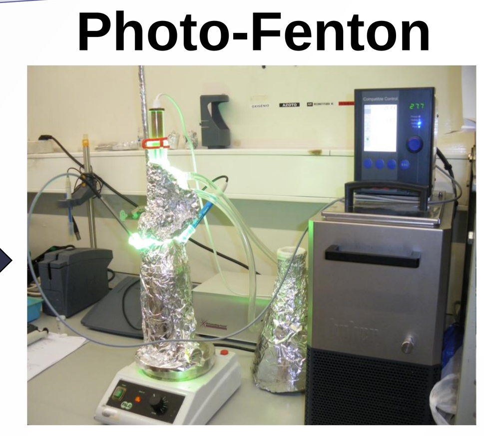
Advanced Oxidation Processes

Classic dark Fenton



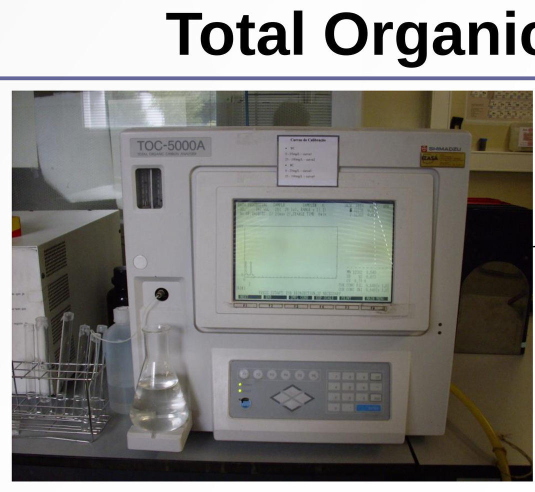
Experimental Conditions
$[Pesticide]_0 = 4x10^{-4}$ M;
$[H_2O_2]_0 = 1.5x10^{-2}$ M;
$[Iron (II)]_0 = 4.6x10^{-4}$ M;
T = 30 ºC;
$pH_0 = 3$

Photo-Fenton


UV-Immersion lamp (TQ 150)

Sample Analysis

Total Organic Carbon Analyser (TOC)


TOC 5000 A analyser

TOC was used to analyse the degree of mineralisation

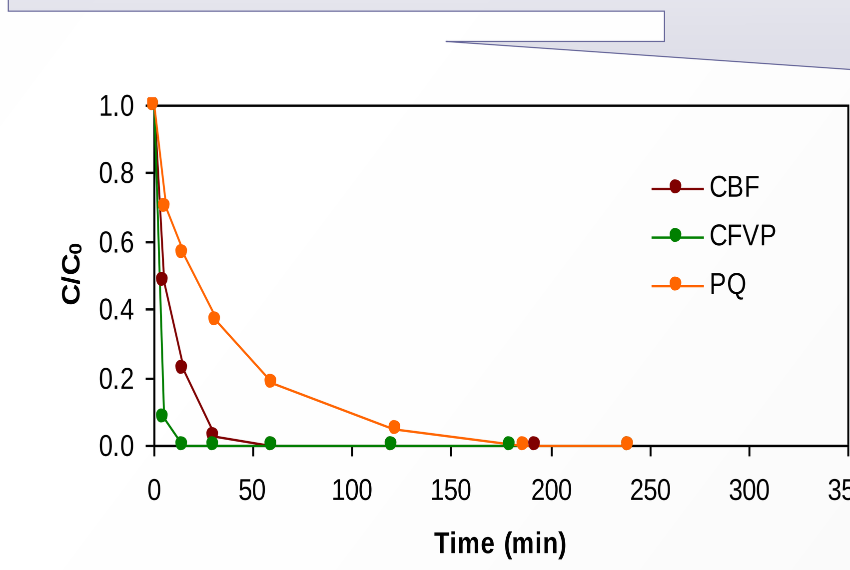
HPLC-DAD

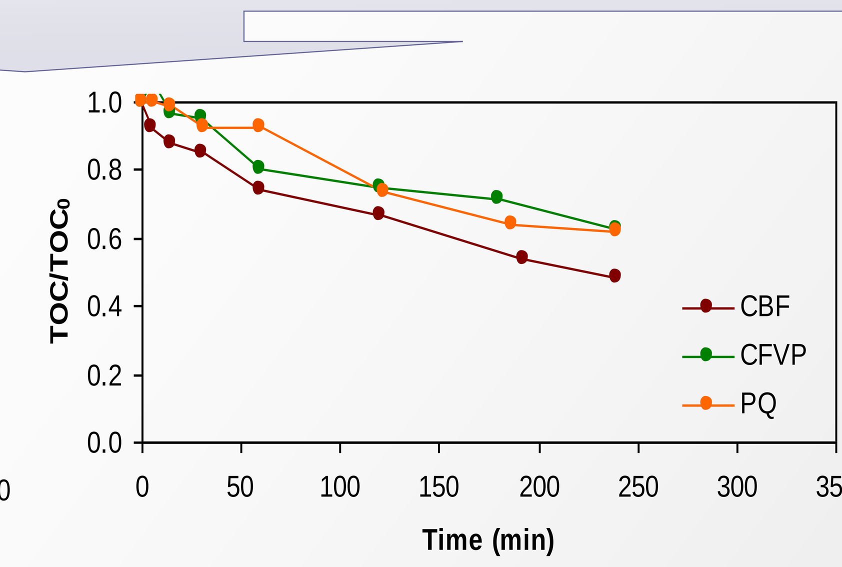
- **Hitachi Elite LaChrom system**
- **RP C18 Purospher® STAR** column (250 mm x 4 mm, 5 μm) for paraquat dichloride (PQ) and **Nucleosil® 100-5 C-18 column** (250 mm x 4 mm, 5 μm) for chlorfenvinphos (CFVP) and carbofuran (CBF)
- **Injection volume:** 99 μL
- **Mobile phase:** 80% HFBA 10 mM + 20% acetonitrile for PQ, 30% water + 70% acetonitrile for CFVP and 80% water+ 20% acetonitrile for CBF.
- **Flow rate:** 1 mL min^{-1}
- **Scanning wavelength:** 220-400 nm
- **Monitoring wavelength:** 259 nm for PQ, 240 nm for chlorfenvinphos and 220 nm for carbofuran.

HPLC was used to analyse the degree of degradation

RESULTS

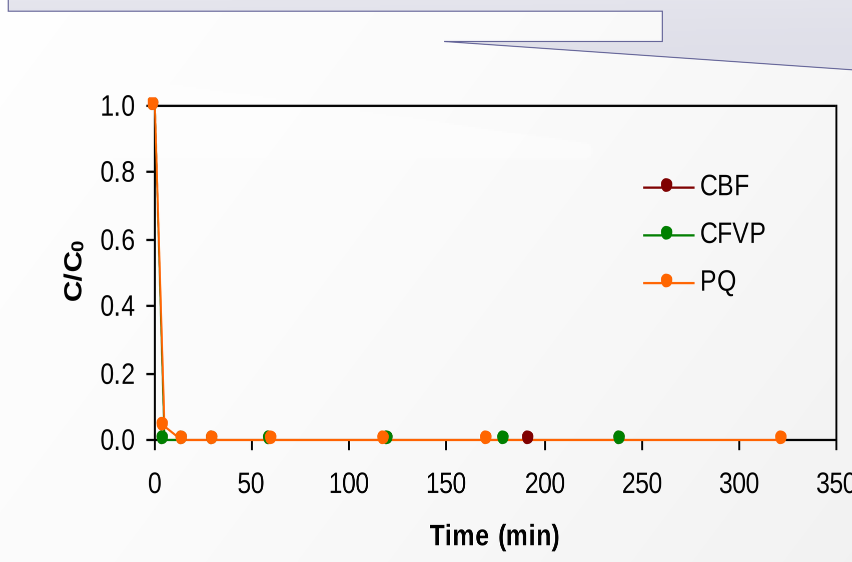
Classic dark Fenton applied to the 3 pesticides

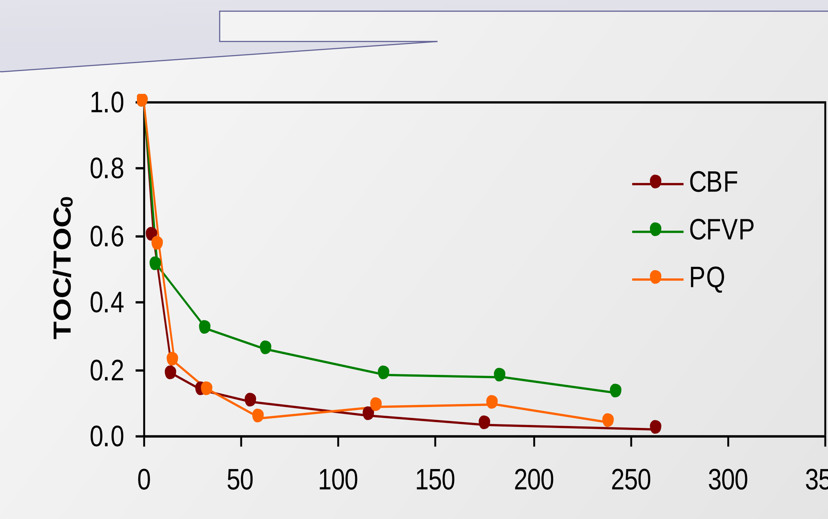




- **Under similar conditions, paraquat dichloride is the compound for which the degradation rate is lower while for chlorfenvinphos is the highest one.**
- **The mineralisation of PQ, CFVP and CBF was only 38%, 37% and 52%, respectively, after 4h of reaction.**

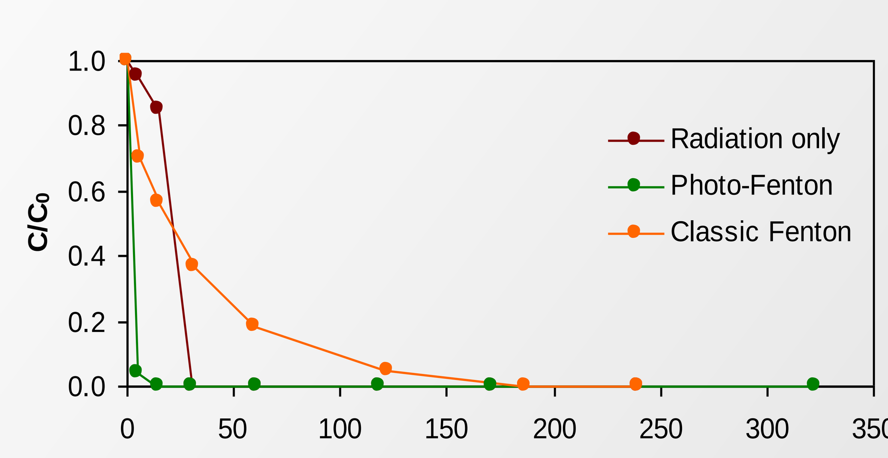
Photo-Fenton applied to the 3 pesticides

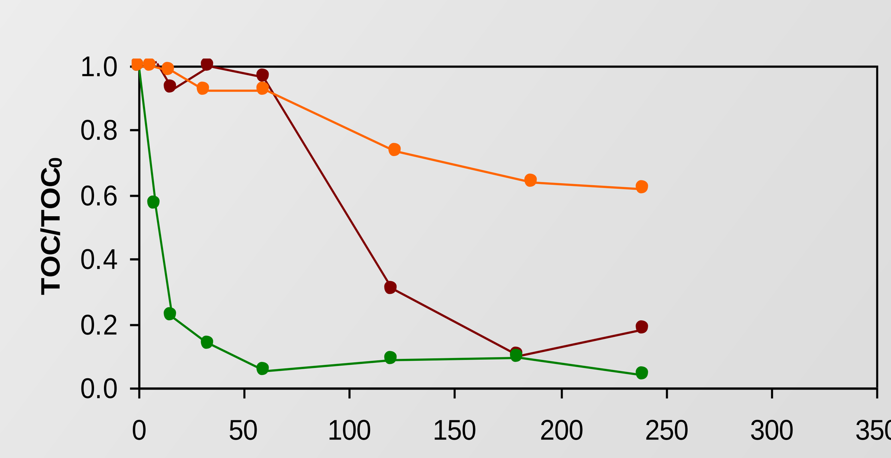




- **All pesticides were rapidly degraded by the photo-Fenton process.**
- **The mineralisation of PQ, CFVP and CBF was 96%, 87% and 98%, respectively, after 4h of reaction.**

Comparison of paraquat degradation by classic dark Fenton, photo-Fenton and using radiation only





- **Radiation by itself is able to oxidise and mineralise paraquat (direct photolysis).**

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CONCLUSIONS

- **Oxidation rates of the pesticides depend on the AOP and parent compound used.**
- **All pesticides could be rapidly degraded by the photo-Fenton process (<5-10 min) and high mineralisation percentage (> 70%) was achieved after only 1 h of reaction.**
- **Pesticides were effectively and completely degraded under offline conditions (within the analytical uncertainties).**