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Fate Of Nitrofurans: Photochemistry, Transformation Products And Toxicity Evaluation In Surface Water Systems

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Abstract Nitrofurans (NFs) consist a group of broad-spectrum antibiotic compounds provided as a basic dietary supplement in livestock husbandry as swine farms, beekeeping and aquaculture. Among nitrofurans furaltadone (FTD) is an antibiotic with a protective effect against bacterial and protozoan infections. Its application has been restricted in EU since 1993 followed by other NFs, as it exhibited toxicological effects in human. However, NFs are still supplied in many developing countries to date, because of high effectiveness and low cost. In this research, the photolytic behavior of NFs in aquatic environment as well as the photochemical transformation products were investigated using a solid phase extraction method coupled with UHPLC-LTQ/Orbitrap HRMS analysis. This study was conducted in distilled, lake, river and sea water under natural and artificial solar irradiation. The determined half-life times demonstrated that this process is the main degradation path of NFs in natural aquatic systems, compared to hydrolysis which presented negligible impact. Furthermore, the mechanism of NFs photodegradation in aqueous environment was exploited based on MS-MS data, indicating that hydrolysis, cleavage of carbon-nitrogen bond, and denitration etc are the dominant photochemical reactions. In addition, acute toxicity evaluation of NFs and photoproducts was performed, using Vibrio Fischeri as tested species. Finally, this study has as ultimate aim the investigation of the fate and impact of NFs and their transformation products, so in surface waters as in the related living organisms.
Keywords: furaltadone, nitrofurans, photolysis, degradation, LC-LTQ/Orbitrap MS, toxicity

1. Introduction

Pharmaceuticals represent the largest part of organic pollutants in the environment, as they can be applied for different medical cases, both in medicine and veterinary. As concerning antibiotics in animal production, they serve a variety of purposes associated to growth promotion, as well as illnesses' prevention and treatment.

Furaltadone is an antibacterial agent that was first applied in the 1950s and belongs in NFs' family. It has been used in human medicine for a variety of purposes, including the treatment of bacterial infections (meningitis, H. pylori, staphylococci and pneumococci) and as a growth promoter in livestock [1]. However, following studies for NFs discouraged its use due to strong indications about negative effects as mutagenicity and toxicity [2].

FTD is metabolized in vivo to 3-amino-2-oxazolidinone (AMOZ), which has been found to be genotoxic and carcinogenic to human [3]. Therefore, European Union has banned the use of FTD and other nitrofuran antibiotics in food-producing animals due to these health concerns. Despite food safety regulations, FTD is illegally supplied until today in livestock and aquaculture, because of low cost and high antibacterial activity and can be detected through its metabolite in animal tissue and products [4].

In aquatic environment, antibiotics undergo different attenuation processes as hydrolysis, photodegradation etc [5]. Photolysis can usually dominate among these processes and may lead to the degradation and removal of antibiotics in aquatic environment.

There is limited knowledge about the fate of FTD in the aquatic environment. Thus, the aim of this study was the investigation of FTD's photolytic degradation in aqueous systems (river, sea, lake water) as well as the evaluation of degradation products (PPs) toxicological activity.

2. Results and discussion

From the investigation of FTD photolytic degradation, the kinetics revealed the following order: sea > lake > river > distilled water (Figure 1), indicating that constituents of natural waters affect furaltadone's decomposition. Furthermore, during the process, nine PPs were determined using the UHPLC-LTQ/Orbitrap MS system, which were generated through mechanisms of photo-hydrolysis, oxidation, denitration and cleavage of the parent compound of FTD, giving as major products hydroxy-FTD and AMOZ.

From the toxicological study during photolytic process, increased toxicity was shown in the first minutes of irradiation, while it was decreased considerably, where the phenomenon of hormesis was presented after 30 minutes of photolysis.

3. Conclusions

In conclusion, the study of the aquatic degradation of furaltadone combined with the toxicological assessment presents a useful tool in order to understand the aquatic behavior and control the impact of antibiotic compounds and their photoproducts so in surface waters as in the related living organisms.

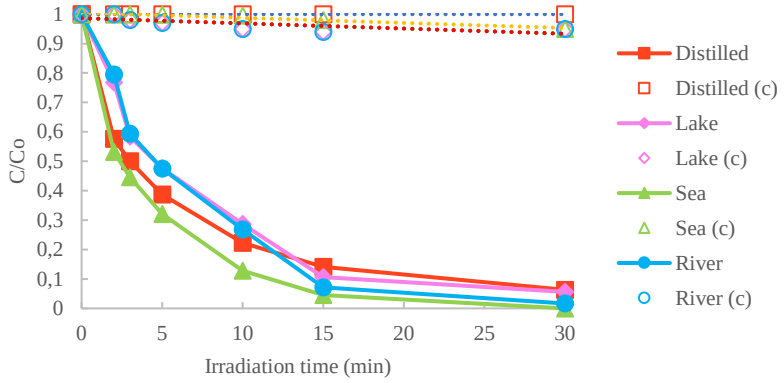

Figure 1. Kinetic of FTD photodegradation in natural waters under artificial solar irradiation (c) : dark controls

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