PHARMACEUTICAL SUBSTANCES: EMERGENT CONTAMINANTS OF COASTAL SYSTEMS

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Abstract
Beside classical chemical contaminants (PAHs, PCBs, pesticides, ...), we find substances such as pharmaceuticals in coastal waters. This communication will deal mostly with the development of analytical protocols in order to analyze different classes of pharmaceuticals in aquatic systems. These developments involve both extraction and purification methods but also analytical developments for identification and quantification by GC or LC coupled to MS or MS/MS. The use of semi-permeable membrane devices (Polar Organic Chemical Integrative Sampler type) to get access to integrative sampling procedure has been also investigated. All analytical developments have been applied to *in situ* studies in various French estuaries, pointing to the dissolved phase as the most contaminated.
Keywords : Pollution, Monitoring, Sampling Methods.

Beside classical chemical contaminants (PAHs, PCBs, pesticides, phtalates, trace metals, dioxins ...), we find pharmaceutical substances in coastal environments [1,2]. They can be classified according to their therapeutic action: hormones, antidepressant, analgesics, antibiotics, lipid regulators, ... Important quantities of these molecules are consumed in our occidental society and are rejected *in fine* in coastal waters via sewage treatment plants (incomplete destruction) [3]. They are increasingly studied as they represent a non negligible environmental risk, considering on one hand the potentially important quantities introduced in aquatic systems and on the other hand the fact that they have been synthesized in order to be biologically active. These compounds could have important toxic effects [4] towards marine organisms but to estimate environmental risks there is a crying need for data documenting the effective contamination of marine environments by these molecules.

Our focus here concerns the development of analytical protocols to analyze different classes of pharmaceuticals in aquatic systems (dissolved phase, particulate matter, and biological tissues). These developments involve both extraction and purification methods such as SPE, SPME and microwave assisted extraction but also analytical developments for identification and quantification by GC or LC coupled to MS or MS/MS.

We have developed an extraction procedure that allows measuring at trace level (ng.l^{-1}) many pharmaceuticals belonging to very different chemical classes: anti-inflammatory drugs, antidepressants, hypolipidic drugs, etc. Reliability and sensitivity have been tested on 18 different compounds (7 neutral compounds and 11 acidic drugs) extracted simultaneously and analyzed with two GC-MS methods. Different applications demonstrate the multi-residue but also multi-matrix characteristics of the developed method.

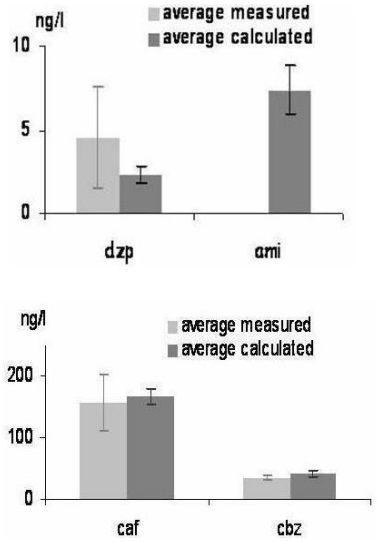

Fig. 1. Comparison of calculated (POCIS) and measured (discrete sampling) concentrations for three days of exposure.

The use of semi-permeable membrane devices (Polar Organic Chemical Integrative Sampler, POCIS type) [5] in order to get access to integrative sampling procedure (necessary, considering the variability of aquatic contamination) has been also investigated. The aim of the study was to determine the sampling rates (Rs; expressed as effective volumes of water extracted daily) of POCIS device for 14 pharmaceuticals in several conditions of temperature, salinity and analyte concentration. These values are influenced by significant changes in water temperature, salinity. Overall POCIS Rs values were independent of aqueous concentrations. Following laboratory experiments, field surveys were undertaken for qualitative application of POCIS devices in contaminated systems: the Seine Estuary and the Mediterranean coast near Marseilles (Figure 1).

All analytical developments were then applied to several *in situ* case studies. Various French estuaries (Seine, Loire, Gironde, Adour) have been studied as well as marine locations (Arcachon Bay and Marseille coast). In all cases it has been possible to detect quite important concentrations of pharmaceutical substances. Measured concentrations fluctuate between a few nanograms per litre and dozens of micrograms per liter depending on compounds, sampling stations and seasons. The results have shown that while the dissolved phase is the most contaminated, the particulate phase could have a large part in the pharmaceuticals spread in coastal systems. When pharmaceuticals occurrence in solid phase is observed, expressed in ng.g^{-1}, some phenomena can be highlighted. High contents have been measured in the upper part of the Seine estuary system (Dam of Poses), with concentrations up to 1,220 ng.g^{-1} for ketoprofen or 260 ng.g^{-1} for naproxen. The solid phase can participate to a quite important extent to the water column contamination.

Understanding the transfer of these compounds to marine organisms and their toxicity, as well as their impact on human health in relation to environmental contamination, is under progress [6]. There are very few data at this moment on this aspect and investigations are really needed to gain a better knowledge.

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