Risk assessment of organophosphate ester flame retardants in aquatic environments using EQS derivation with up-to-date REACH and research monitoring data

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INTRODUCTION
Organophosphate esters (OPEs), are a group of organophosphorus flame retardants (PFPRs) and plasticizers in expanding use worldwide (annual global consumption of PFPRs reached ~300,000 tons in 2011 and a 5% annual increase expected). Latest scientific works highlighted that some OPEs could exhibit similar properties to persistent organic pollutants (POPs), meaning they can be highly persistent, prone to long-range atmospheric transport, bioaccumulate and may have adverse effects in the environment and humans. Recent progress in the EU chemical policies together with the increasing research efforts on the monitoring of OPEs concentrations and on the study of their environmental partitioning and fate represent interesting opportunities to investigate if these chemical substances could present a risk for environmental organisms and humans. First, the new data generated and disseminated through the REACH regulation framework and the up-to-date guidance to derive Environmental Quality Standards (EQS) under the Water Framework Directive (WFD), allow to assess safe concentrations, the so-called Quality Standards (QS), for pelagic and benthic species, top predators and humans. Second, the increase of the number and quality of reports of OPEs concentrations in relevant environmental compartments (e.g. air, inland and marine surface waters, sediments and biota) provide current OPE environmental levels.

OBJECTIVES
The objectives of this work are: (1) to estimate safe levels in (water, sediment and biota) of Tris-[2-chloro-1-(chlormethyl)ethyl]phosphate (TDCP), one of the most widely used organophosphate OPEs, for humans consuming drinking water/food products, pelagic and benthic species and birds/mammals top predators; (2) to assess the suitability and availability of monitoring data in order to identify potential risks for target organisms and humans due to environmental exposure to TDCP.

RESULTS AND DISCUSSION

ESTIMATED (SAFE) THRESHOLD CONCENTRATIONS: Quality Standards (QS)

Existing data were available in three previous reports published by international, European and national authorities. New REACH data disseminated by ECHA allowed us to derive robust QS for:

WATER
Freshwater: QS fw = 0.9 μg L⁻¹ (humans consuming fish products being the most sensitive group after water concentration conversion)
Seawater: QS sw = 0.1 μg L⁻¹ (pelagic species being the most sensitive group)

BIOTA (freshwater and seawater)
TDCP = 104 Kg Kg⁻¹ (humans consuming fish products being the most sensitive group)

SEDIMENTS
Freshwater: QSₘₚ = 390 μg Kg⁻¹(dw)
Seawater: QSₘₚ = 78 μg Kg⁻¹(dw)

Monitoring data (environmental concentrations of TDCP in water, sediment and biota) were extracted from available scientific literature (mostly peer-reviewed) published over the last ten years. Results revealed that most measurements have been carried out in inland surface waters (in particular rivers) with a general lack of data in marine waters. Few studies have been performed in seawaters (mostly coastal) and very few data exists for biota. Many different sampling, analytical approaches and techniques were employed to quantify TDCP concentrations in selected matrices. A particular issue was found with the analysis of TDCP (and other OPEs) in biota. Different parts of the organisms were analyzed (e.g. leaver, muscle, eggs, whole organism) and concentrations were expressed in different units (e.g. normalized by lipids, as dry weigh, as wet weight) difficult to compare and not always useful for the scope of the present work.

CONCLUSIONS AND RECOMMENDATIONS

- Disseminated data of REACH registered dossiers from ECHA website haven’t been reviewed by the authorities and often the information provided is too sparse to allow an in-depth review of their reliability.
- Chronic data on fish (currently missing) would allow to reduce the uncertainties of the QS for waters.
- Although the reported TDCP environmental concentrations were generally below the estimated QS, these safe levels were overpassed in some environments indicating a potential risk. In addition, existing and new data on degradation don’t allow to disregard the potential high persistence of TDCP, which could result in the increase of its environmental concentrations and stocks in the environment. So more efforts on the monitoring side (in particular in marine environments) and on the accurate determination of TDCP degradation rates under environmental conditions are recommended.
- QS should be derived for other OPEs widely used.

An effort should be performed to generate reliable and comparable data on biotic matrices.