# Analysis of tris(1-chloro-2-propyl) phosphate (TCPP) in indoor and outdoor air of the Rhine/Main area,Germany

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Organophosphate flame retardants (PFRs) are a group of chemicals used in a wide range of household and consumer products e. g. as plastizisers (non-chlorinated PFRs) and flame retardants (chlorinated PFRs). The production of all chlorinated PFRs in Europe has been estimated to be around 50000 t/a in 2007 [1]. The most widely used chlorinated PFR is tris(1-chloro-2-propyl)phosphate (TCPP) which is commonly added as flame retardant to polyurethane foam (PUF), resins and automotive body parts. Around 1995, the production and use of TCPP increased significantly since tris(2-chloroethyl)phosphate (TCEP) had to be replaced because of toxicity concern. High amounts of TCPP (~1 µg/L) have recently been detetcted in precipitation, storm water holding tanks and lakes in urban areas [2], indicating that the compound is evaporating from products and that the degree of photodegradation is lower than expected by the EU risk assessment. Even in remote lakes, which do not obtain sewage water, small amounts of TCPP could be detected [3]. Abundant further studies have also shown that TCPP is stable in the aquatic environment and even the degree of biodegradation in sewage treatment plants is negligible. Possible sources for TCPP in the outdoor atmosphere and in precipitation might be located outdoor (polyurethane foam used as insulation materials and automobiles) but also indoor sources such as furniture containing polyurethane have to be considered.

To investigate the relevance of possible sources of TCPP in the indoor and outdoor environment, 33 indoor air samples were collected in 2014 and 2015 in the Rhine/Main area (Germany) in rooms while windows and doors were closed. At the same time 10 outdoor air samples were collected outside from the windows of indoor sampling locations. The samples were taken using a low volume pump, connected to a sampling head containing a quartz fiber filter and a polyurethane foam. All samples were extracted by hexane/aceton and the extracts were analyzed using gas chromatography/mass spectrometry. The results have shown that the concentrations of TCPP in indoor air ranged from1.44 to 246 ng/m3, (median value14.9 ng/m3) which was on average ten times higher than the concentrations mesured at outdoor sampling locations (range: LOD-1.19 ng/m3). The results indicate that the indoor air contribute significantly to the presence of TCPP in outdoor air and that TCPP detected in the aquatic environment originates largely from indoor souces.

In the indoor air, a significant correlation between the concentrations of TCPP and the amount of PUF furniture or the amount of electronic products in the rooms could not be detected. Further sources must, therefore, significantly lead to the high TCPP concentrations in indoor air. Current studies are dealing with the quantitation of TCPP emissions in stores that sell carpets, laminated composites, wallpapers and further materials used indoor. Apart from air exchange from indoor to outdoor, TCPP might also leave housholds via the water phase directly into the aquatic environment through water discharged by washing machines and water used for cleaning of indoor surfaces. The relevance of this pathway is also under investigation.

References:

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[3] Regnery J. & Püttmann W. (2010), *Water Res.* **44,** 4097-4104.