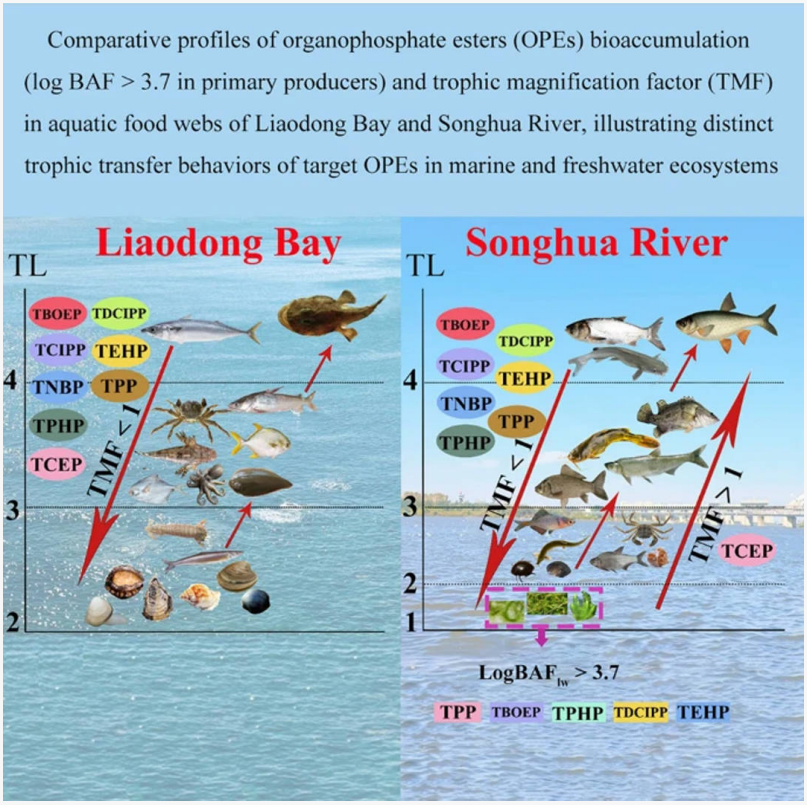
Toxic flame retardants differ in marine vs freshwater webs, study finds: TCEP biomagnifies in rivers, dilutes in oceans

GA, UNITED STATES, September 11, 2026 /EINPresswire.com/ -- Organophosphate esters (OPEs) – chemicals added to countless everyday products to prevent fires or improve flexibility – have become pervasive contaminants in both oceans and rivers. But until now, no study had directly compared how these pollutants accumulate and move through marine versus freshwater food chains. New research changes that, revealing that the same compound can dilute in one ecosystem and concentrate in another. The finding challenges conventional risk assessments and highlights that the environmental fate of these pollutants depends critically on where they end up.



OPEs in marine vs. freshwater food webs: bioaccumulation and trophic transfer.

Organophosphate esters (OPEs) are used in furniture, electronics, textiles and building materials. Because they are physically mixed in rather than chemically bound, they leach out continuously into air, dust and water. Once in aquatic environments, they are taken up by algae, ingested by small animals and passed up the food web. Some OPEs are known endocrine disruptors, neurotoxicants and carcinogens. Most research has focused on either marine or freshwater systems separately, leaving a critical gap: no one knew whether a chemical that dilutes in the ocean might magnify in a river – or the reverse. Given these uncertainties, a systematic cross‑ecosystem comparison became essential.

A team from Changchun Normal University and the Chinese Academy of Sciences has conducted the first side‑by‑side comparison of OPE bioaccumulation and trophic transfer in contrasting

aquatic food webs. The study, published (DOI: 10.1007/s11783-026-2275-9) in the journal ENGINEERING Environment (Volume 20, Issue 11, 2026), analysed 498 organisms representing 34 species collected from Liaodong Bay (marine) and the Songhua River (freshwater) in northeastern China.

The researchers found striking differences. In the marine food web, tri□n□propyl phosphate (TPP) dominated, with median concentrations of 147 ng/g lipid weight. In the freshwater system, tris(2□chloroethyl) phosphate (TCEP) was the most abundant, reaching 266 ng/g lipid weight – nearly double. More importantly, the trophic transfer patterns diverged completely. All eight OPEs underwent biodilution in the bay – their concentrations declined with each step up the food chain. But in the river, TCEP did the opposite: it biomagnified, with a trophic magnification factor of 1.75, meaning levels increased as predators ate contaminated prey. Freshwater phytoplankton emerged as exceptionally strong accumulators, with bioaccumulation factors exceeding a commonly used threshold of 3.7 for five OPEs. The team also identified a “sweet spot” for accumulation: compounds with intermediate hydrophobicity (log K□w between 2.5 and 5) were most readily taken up. Environmental factors – salinity, pH and dissolved organic carbon – all played distinct roles in shaping these patterns.

“We expected differences, but not this dramatic,” the authors said. “TCEP was the real surprise. In the marine web it diluted like the others; in the freshwater web it actually built up. That's a red flag, because TCEP is one of the most widely used flame retardants globally and a known carcinogen. What happens in a river doesn't stay there – our findings suggest we need to pay much closer attention to freshwater systems for this chemical.”

The findings carry direct implications for monitoring and public health. While non□cancer risks from consuming seafood and river fish remained low for all compounds, cancer risk told a different story. In the Songhua River, the incremental lifetime cancer risk (ILCR) for TCEP ranged from 10^{-6} to 10^{-4} in most organisms – a range signalling potential concern. The study also shows that salinity and dissolved organic carbon actively shape whether a pollutant accumulates or dissipates. For regulators, this means marine□derived risk assessments cannot be blindly applied to freshwater ecosystems. For consumers, it means fish from a river may not be as safe as fish from a nearby bay, even when the same contaminants are present.

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