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Assessment of the Environmental Contamination of Irish Soils and Sediments with Hazardous Chemicals (TERRAChem)

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What did the research aim to address?

The use of chemicals brings major societal and economic benefits, but problems arise when hazardous, persistent substances bioaccumulate with the potential to negatively impact human health and the environment. Examples include per- and polyfluoroalkyl substances (PFAS), flame retardants, polychlorinated biphenyls (PCBs), pharmaceuticals, UV filters, and insecticides, all of which have widespread commercial uses.

The TERRAChem project provides a baseline assessment of concentrations of legacy and emerging organic chemicals of concern in inland and coastal sediment samples collected across Ireland. The same target chemicals were also measured in biosolids from wastewater treatment plants.

Risk quotients were used to evaluate the ecotoxicological risks associated with the concentrations detected in sediment, by making comparisons with the predicted “no effect” concentration values for sediment that are promulgated by the Norman Network. Project data were used to identify potential contamination “hot spots” or locations with elevated concentrations of one or more contaminants. These locations may require inclusion in ongoing EPA monitoring programmes.

In addition, TERRAChem included a Best Practice review of legislative requirements and current approaches for monitoring organic chemicals in soils, sediments, and wastewater treatment plant–derived biosolids.

What did the research find?

Of the 92 target organic chemicals studied, most were low risk but some, especially perfluorooctane sulfonate (PFOS), certain organophosphate esters (OPEs), pyrethroids and specific antibiotics, present a high ecotoxicological risk and warrant further investigation. Three potential contamination ‘hot spots’ were identified. The study presents new data of international significance for some of the target chemicals.

Concentrations of most brominated flame retardants (BFRs), OPEs, and PCBs in sediment were comparable to international data and pose low ecotoxicological risk. However, some OPEs including tris(1-chloro-2-propyl) phosphate, tris(2-ethylhexyl)phosphate, and certain PCBs were frequently detected at concentrations which represent moderate to high ecotoxicological risk. Similarly, the same chemicals and others were also found at relatively high concentrations in wastewater biosolids.

Concentrations of antibiotics in sediment present mostly a low ecotoxicological risk, with the exception of clarithromycin, which along with the antibiotic sulfamethoxazole, presents a high ecotoxicological risk. UV filters were detected in both sediments and biosolids at low overall levels compared to international reports, although sediment concentrations of 4-methylbenzylidene camphor, homosalate and ethylhexyl methoxycinnamate present a moderate ecotoxicological risk. Higher concentrations of antibiotics and UV filters in sediment were frequently detected downstream from wastewater emission points.

Of the 39 PFAS investigated, concentrations of PFOS exceed the relevant lowest predicted “no effect” concentration in sediment (PNECsed) in over half of the samples analysed, while those of the other target PFAS rarely if ever exceeded PNECs. Pyrethroids, specifically permethrin, cyfluthrin, cypermethrin, deltamethrin, λ-cyhalothrin were found at levels indicating high ecological risk in sediments, while those of anthelmintics (e.g. albendazole and fenbendazole) presented low to moderate risk but require further study due to limited available data.

How can the research findings be used?

- A comprehensive baseline assessment of 92 target chemicals in sediment is provided which serves as the basis for conducting future long-term trend analysis for many of the target chemicals. Potential contamination ‘hot spots’ will assist in the development of a prioritisation list for future assessments in national monitoring programmes.
- The research supports the implementation of the EU Chemicals Strategy but also informs the inclusion of priority organic chemicals within the scope of future revisions of the Sewage Directive (86/278/EEC), the EU Soils strategy, and the Urban Wastewater Treatment Directive (2024/3019).
- Application of wastewater treatment plant biosolids to agricultural land is a widespread practice in Ireland. The data collected here will inform guidance in relation to these practices.
- Further research is needed to examine concentrations of organic chemicals in soil, particularly soil from land treated with wastewater treatment plant-derived biosolids.
- Results should inform the inclusion of new emerging chemicals in future risk profiling under OSPAR.

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