Policy Brief

Phthalates in the Irish Environment and their Effects on Human Health

This work can inform on the feasibility of using wastewater biomarkers for future compliance and human health monitoring

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Abstract

Phthalates are plasticizers that are ubiquitous in the environment, have the potential to disrupt the endocrine system, and are associated with a wide range of adverse health effects. This policy brief outlines the results from a four year EPA funded project, which was intended to:

- Review the environmental sources and fates of phthalates in Ireland;
- Develop robust methods for the analysis of phthalates in multiple environmental matrices;
- Investigate the feasibility of applying wastewater based epidemiology to assess exposure and health risk.

The phthalates investigated in this study included:

benzylbutylphthalate (BBP), dibutylphthalate (DBP), dipentylphthalate (DPP), diisopentylphthalate (DiPP), diethylhexylphthalate (DEHP), dihexylphthalate (DHP), diisobutylphthalate (DiBP), di-n-octylphthalate (DnOP), diisononylphthalate (DiNP), and diisodecylphthalate (DiDP). This report identifies that these phthalates are pervasive in the Irish environment. The environmental concentrations found in this study were consistent with other European countries and as such Ireland does not present an increased cause for concern. Nevertheless, 100% detection frequency for 10 of the 11 phthalates studied suggests that further steps should be taken to reduce this burden on the environment and prevent any further contamination in the ecosystem. This project has demonstrated that DiBP is one of the most prevalent phthalates in the Irish environment.

The results of this study showed that it is possible that restricted phthalates are remaining in consumer products due to the recycling process. If recyclable material contains more than the recommended levels for these phthalates then recyclable materials should not be used for the manufacture of food contact materials or children's toys. Therefore, relevant recyclable materials should be carefully tested for restricted phthalates to lessen the risk of phthalate contamination in these materials. If a toxicological concern is raised beyond this endpoint, then incineration of plastics should be considered until these compounds have been eliminated. Landfill should be avoided and leachate systems need to be controlled and monitored. The recently announced European Commission Green Deal highlights the intention to implement a zero pollution and toxic free environment, with a circular economy action plan and proposed policy development in areas of sustainable industry and elimination of pollution; management of phthalates must be a prominent feature of this moving forward.

Wastewater effluent was seen to contribute some degree of phthalate contamination to the wastewater discharge point (river or marine system). The levels at the discharge point were significantly higher than at other points of the river. However, the levels in effluent are low, with all phthalates being under the EQS for surface water. The findings of this study suggest that no further action for reduction of phthalates in wastewater effluent needs to be taken. However, phthalates are well retained in wastewater biosolids (sludge) and literature has shown that the transfer of phthalates from fertilizer to soil and hence crops is high. Landspreading is the primary destination of wastewater biosolids in Ireland. Analysis of landspreading practices and the impact on soil and agriculture should be further assessed.

Wastewater based epidemiology is the study of raw sewage to gain information about a given population. The exposure of a population to contaminants (in this case, phthalates) can be measured by the assessment of a signature biomarker in the wastewater. Levels of human exposure, as assessed in this study via analysis of phthalate metabolite levels in untreated wastewater, indicate that there is no immediate risk to human health on a population averaged basis. The study indicates that wastewater based epidemiology can be a feasible, low cost route for large scale biomonitoring at a population level, and could be used to identify changes in exposure levels of the population to contaminants of emerging concern in the environment.

Key Points of the Policy Brief:

- Phthalates are plasticizers that have been identified as being toxic for reproduction. Some phthalates also have endocrine disrupting properties.
- All Phthalates studied are ubiquitous in the Irish environment, with DiBP the most prevalent.
- Phthalate levels in recycleable consumer products should be carefully monitored.
- Phthalate levels in wastewater biosolids, landspreading and soil impacts should be assessed.
- Wastewater based epidemiology could be a feasible, low-cost population biomonitoring approach to assess exposure to chemicals of emerging concern.

Background

Phthalates are synthetic organic compounds, commonly used in plastic and particularly PVC products, with a wide range of end uses including food packaging, cosmetics and personal care products, medical devices, tubing and flooring. Due to the extensive presence and environmental persistence of phthalates, their effects on health have been frequently studied. The ubiquitous nature of phthalates in the environment raises a valid concern for their effects on human health. Phthalates are colourless, odourless compounds that are liquid at room temperature. They are added to give a product flexibility and resilience due to their fluidity, stability, and low volatility. Phthalates are heavily used throughout PVC manufacturing with soft PVC containing up to 40% DEHP. The most common exposure of phthalates in humans identified in the literature is through food consumption (at least 67% of total exposure), but drinking water, air, dermal contact, and cosmetics all contribute to total exposure.

Legislative context

DEHP, DBP, BBP, DIBP, DINP, DIDP and DNOP are legislated for Authorization and Restriction in manufacturing under the REACH Regulation (EC Regulation No. 1907/2006) and the Cosmetics Regulation (EC Regulation No. 1223/2009). Phthalates including DBP, DIBP, BBP, and DEHP are banned or restricted in manufacturing (in particular for items such as children's toys) and as a result these have typically been the most widely studied phthalates. Due to this legislation a number of higher molecular weight plasticizers were

introduced as substitutes to reduce leaching from plastics. However, new research may indicate that these substitute plasticizers have an equally negative impact on human health and this warrants further study.

European Chemicals Agency (ECHA)

ECHA has submitted a recommendation to the European Commission to amend the Authorisation List (Annex XIV to REACH) with the addition of DEHP, DBP, BBP and DiBP as substances of very high concern (SVHCs) due to their endocrine disrupting effects, which will change the authorization requirements for some previously exempted uses. DEHP was also identified for its effects on the environment. The Candidate List entries for these substances were updated accordingly in 2014 and 2017. These four phthalates had earlier been identified as SVHCs (in 2008 and 2009) and subsequently added to the Authorisation List in 2011 and 2012 due to their classification as toxic for reproduction.

Environmental Occurrence

In this study, phthalate levels were assessed in surface water, landfill leachate, soil, municipal wastewater (influent, effluent and sludge) and household wastes. All of the eleven phthalates studied were found in all environmental matrices, at levels comparable to those found in other European countries.

The concentration of phthalates found in wastewater treatment plant biosolids and soil should be monitored. There is currently little assessment of the impact of phthalates or their metabolites in soils or crops.

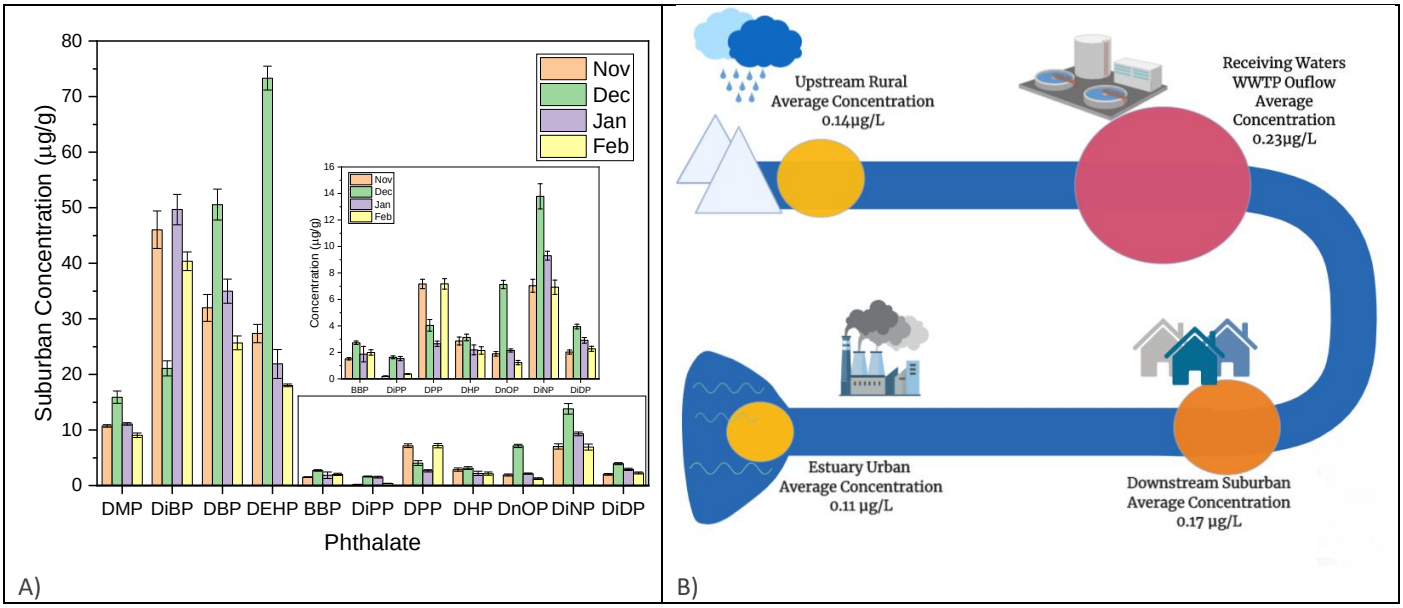


Figure 1: Sample: phthalates in biosolids from a suburban wastewater treatment plant (A) and phthalates in surface waters (B)

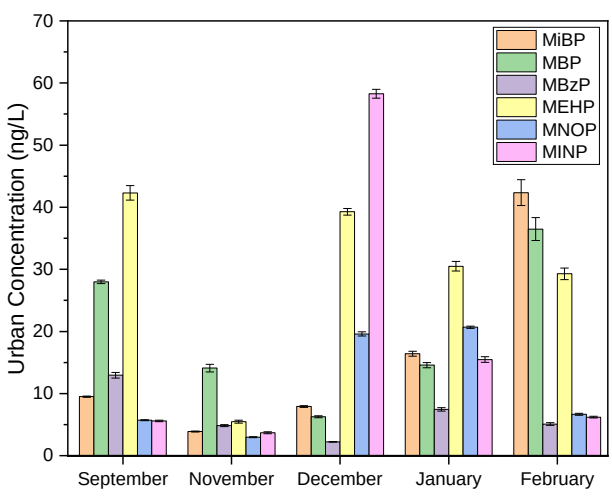
Biomarkers

Humans are exposed to phthalates via ingestion (food and drink), inhalation, and dermal contact. Humans readily metabolise phthalates, generally excreting the phthalate as a number of phthalate metabolites within 1-2 days. Some of the phthalate metabolites will be excreted as a glucuronide-conjugate. Urine is the most widely studied matrix for human phthalate metabolite monitoring although many more (e.g. blood, sweat, breastmilk) have been studied. The simpler forms of phthalates such as DEP and DBP are usually excreted as their corresponding phthalate mono-ester (MEP, MBzP), whereas highly branched phthalates undergo more extensive biological transformations.

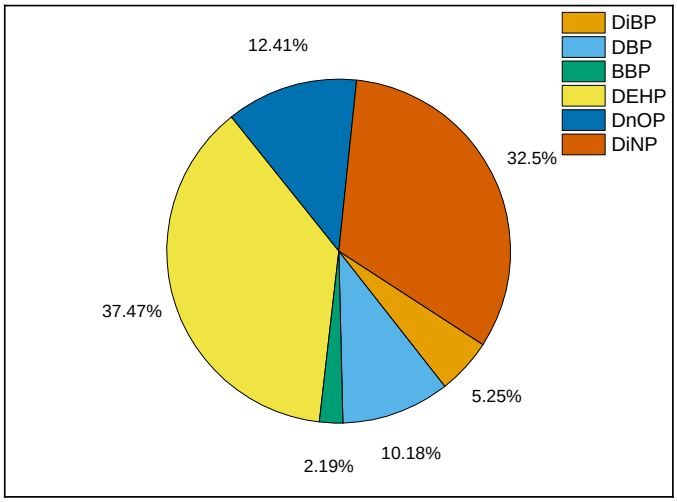
These phthalate metabolites (or biomarkers) (Table 1) are monitored to infer a person's phthalate body burden. There has previously been just one human biomonitoring study in Ireland (DEMOCOPHES), which monitored phthalate metabolites in urine.

Observations

Monitoring of phthalate metabolites in wastewaters at urban, suburban and rural locations in Ireland allowed assessment of exposure of the population to phthalates. The biomarker of exposure is the phthalate metabolite. Exposure is back-calculated on a population (averaged per person/day) basis.



A)



B)

Figure 2: Sample: Mono-ester Concentrations at an Urban Site (A), Breakdown of Exposure to Phthalates in Ireland on population basis (B)

Table 1: Phthalate Diesters Metabolised

Site	**Month**						
Phthalate Metabolite (measured)		*MIBP*	*MBP*	*MBzP*	*MEHP*	*MNOP*	*MINP*
Diester Exposure (calculated)		**DIBP**	**DBP**	**BBP**	**DEHP**	**DNOP**	**DINP**
				(µg/person/day)			
Rural	September	1.25	1.21	0.68	22.84	1.01	2.28
	November	5.95	6.64	0.68	34.91	3.84	8.69
	December	0.67	1.57	0.32	26.30	5.01	19.38
	January	0.46	0.33	1.18	8.50	3.22	1.65
	February	1.28	0.19	0.49	5.75	0.74	1.82
Suburban	September	2.87	7.24	2.43	26.29	3.13	4.56
	November	29.25	84.74	3.07	56.39	11.63	40.03
	December	9.35	10.91	2.97	108.92	23.77	245.42
	January	6.31	4.77	1.79	22.57	31.42	33.66
	February	16.37	38.07	17.54	177.25	64.24	104.95
Urban	September	2.31	6.94	3.00	48.98	6.62	6.48
	November	1.58	5.89	1.89	10.64	5.80	7.19
	December	3.68	4.29	0.67	59.09	29.50	87.69
	January	4.82	4.37	2.09	42.72	28.97	21.68
	February	9.53	8.39	1.09	31.44	7.15	6.67

Summary & Recommendations

1. New legislation recognizing risk associated with phthalate compounds
2. Phthalate levels in recyclable materials and in wastewater biosolids for landspreading should be assessed
3. Results of current research show clear evidence of phthalate human metabolites in all influent samples, suggesting ubiquitous human exposure
4. We recommend a widespread biomonitoring study using wastewater treatment plant influent as an indicator of exposure in order to collect adequate volumes of data for modeling human exposures and linking that to human health
5. This approach can be extended to encompass estimation of exposure of the Irish population to other chemicals of emerging concern

EPA Research Programme 2014–2020

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