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Micropollutants in Urban Wastewater – Literature Review March 2025

Ramboll Deutschland GmbH (Ramboll) was commissioned by Clifford Chance to address the following research questions concerning so-called micropollutants (MP) in wastewater in the course of the recast of the EU Urban Wastewater Treatment Directive (UWWTD): **(i) what are potential sources – according to the public scientific literature – of 'micropollutants' as defined in Article 2(17) of the UWWTD?; (ii) is there a bias/selective assessment in the public scientific literature – with the most intensely studied sources being pharma and cosmetics? and (iii) Is there evidence according to the public literature that other sources of micropollutants (i.e. non-pharma and non-cosmetics) cannot be held responsible for any relevant pollution that might justify applying a precautionary approach following only sources of micropollutants from pharma and cosmetic products should be subjected to the polluter-pays/extended producer responsibility requirements?** In a literature review 1,163 publications were screened for relevance according to their titles and abstracts. Thereof 49 study reports were found to contain relevant data which is summarized in the Ramboll report. This article provides a summary of findings.

Key Findings

- Scientific evidence shows that **various chemicals meet the UWWTD definition** of 'micropollutants' and originate from diverse sources, including products and applications.
- **No data** could be identified that **allow making absolute statements about the percentage of micropollutants in urban wastewater.**
- Public literature **identifies clearly various micropollutant sources** such as pesticides, food additives, pharmaceuticals (veterinary and human), personal care products, biocides, and industrial chemicals (e.g., PFAS, flame retardants, plasticizers). The focus on (human) health and cosmetics products alone as potential contributors is not supported by the available studies.
- Detected micropollutant **concentrations typically range from ppb (parts per billion, i.e. microgram range) to low ppm (parts per million, i.e. milligram range)**, varying by region, weather, season, and methodology.
- Studies on micropollutants in wastewater **often focus on specific substance groups**, **missing a broader spectrum**. Even wide-scope screenings with 200+ analytes do not necessarily capture the full picture. These **limitations are transparently addressed in the literature** highlighting the **need to combine targeted analytic approaches with non-targeted and suspect screening methods**.
- **Non-targeted wastewater screening remains still limited** due to analytical challenges. Further development is needed in protocols, data management, and trained personnel [1].
- Based on the considered references and in particular the selection of target compounds in the individual studies, it can be concluded that **research disproportionately focuses on pharmaceuticals, potentially underrepresenting other micropollutant sources**.
- Evidence confirms micropollutants in urban wastewater **come from more than just pharmaceuticals and cosmetics**. The **pharma and cosmetic industries are not the sole contributors to micro pollution**.
- The Impact Assessment (IA) report from the EU Commission concluded that **pharmaceuticals for human use represent 59% of input quantities** to wastewater treatment plants, as well as **66% of the toxic load**. These figures **could neither be confirmed nor could a definite, reliable figure be identified** in the literature.

Summary

Micropollutants and related sources other than pharmaceuticals could be confirmed

Apart from pharmaceuticals and substances related to personal care products, the present study could identify **scientific evidence of the presence of other micropollutants in wastewater samples**, which is summarised in the following. It needs to be stressed, that the assessment was not exhaustive and systematic. Therefore, the results provide most likely just a snapshot of data that can be collected on micropollutant in wastewater. This thesis is further discussed following the substance summaries.

Pesticides

Studies showed that **pesticides are present in both influent and effluent wastewater**, even in concentrations above set thresholds. One study detected 18 pesticides in effluents, with terburtryn, propiconazole, and tebuconazole being the most common. [2] Carbendazim was found in concentrations higher than the Predicted No Effect Concentration (PNEC) in effluent wastewater in Spain and Germany [3]. Also chlorotoluron, fenpropimorph and DEET was confirmed in effluent samples with concentration above the Annual Average (AA) Environmental Quality Standard (EQS)value for chlorotoluron and above the PNEC for Fenpropimorph [4]. In Sweden Imidacloprid was confirmed in effluent in concentrations above the PNEC for fresh water [5].

PFAS

It is assumed that several thousands of per- and polyfluoroalkyl substances (PFAS) exist and it is therefore challenging to analytically determine a **larger spectrum of these compounds** simultaneously in one sample. PFAS are used in a large number of sectors therefore allocation to a specific polluter seems difficult. Intense legal activities are ongoing in this regard. **PFOS and PFBA –two well-known PFAS - have been confirmed in wastewater** in Portugal, Spain and France [6], [7], [8] and Spain, Portugal, Germany [7], [9], respectively. As another – less investigated PFAS - 6:2 fluorotelomer sulfonic acid was reported for different European wastewater treatment plans (WWTPs) [10], [11].

Industrial chemicals

This category it is very broad and publications do not necessarily reflect on the sector in which a substance is used. The assessment has therefore been sub-grouped in **surface modifiers, plastic additives, process chemicals and other chemicals**. Chemicals of all those categories are reported in the scientific literature. To name examples for **surface modifiers** linear alkylbenzene sulfonates were confirmed in effluent in Greece [12], while 2,4,7,9-Tetramethyl-5-decine-4,7-diol (TMDD) was reported in Greece [13]. Another study identified various siloxanes in different effluent samples in Portugal [14]. For **plastics additives** the study found evidence for presents of flame retardants (tributyl phosphate (TBP), tris(2-chloroethyl) phosphate (TCEP), tris(2-butoxyethyl) phosphate (TBEP), tris(1-chloro-2-propyl) phosphate (TCPP)) [13], [15] as well as the light stabilisers UV 328 and UV 329 [16]. **Process chemicals** (**corrosion inhibitors**) confirmed in the literature are benzotriazole derivatives and triazoles [5], [17], [18]. Also the **cleaning agent** sulfamic acid is reported for German effluent samples [19]. 2-Benzothiazolesulfonic acid formed from Benzothiazole derivates is part of the identified substances in two assessed studies [17], [20], while Bisphenol A is reported in WWTP samples in Romania [21], river samples near a WWPT in France [8], WWTP samples in Italy [22] and Spain [23].

Food ingredients/additives

The assessment showed various scientific publications that confirm the **presence of sweeteners as well as caffeine** in waste water samples. For acesulfame a study on behalf of the European Food Safety authority (EFSA) concluded that research has shown that acesulfame-K undergoes transformation through various degradation processes. Studies investigating these transformation products in aquatic environments have confirmed their presence, with many of these byproducts considered more toxic than the parent compound [24]. Acesulfame could further be reported together with sucralose across different European WWTPs [10]. Sucralose could further be found in samples in Denmark [2]. The study on behalf of the European Food Safety authority (EFSA) concluded that numerous studies have documented the widespread presence of sucralose in surface waters, marine and coastal waters, groundwater, and even drinking water. Available data suggest that sucralose is not highly toxic to aquatic organisms. Further research is needed to assess the potential toxicity of sucralose in terrestrial environments and to better understand its overall environmental risks. Caffein concentrations in water samples worldwide have been assessed, with the highest concentrations in influent of a WWTP in the UK [25]. Also in WWTP samples in Sweden caffein could be confirmed in influent samples [26] and effluent samples [27].

Limitations and bias related to targeted analysis

The above-mentioned identified substances can only be regarded as a part of the expected complex mixture that wastewater presents. It seems obvious that analytical approaches targeting a specific predefined list of chemicals do not appropriately reflect the reality of this complex mixture present in the environment. As a good example for the complexity, the work done by the NORMAN Association can be used, who launched the NORMAN Suspect List Exchange in 2015 to facilitate information sharing on chemicals expected in the environment, supporting suspect screening efforts. Nowadays the NORMAN SusDat database is often referenced in the literature [23], [28] and it contains ~40.000 individual substances. All these substances are expected to be present in the environment, however, confirmation for many of them is still lacking.

The vast majority of literature screened in this project **focussed on targeted analytical approaches** for micropollutants, which tends to focus on specific substances with a **risk of overlooking other potential contributors**. Based on the considered references and in particular the selection of target compounds in the individual studies, it can be concluded that **targeted analytical approaches disproportionately focus on pharmaceuticals, potentially underrepresenting other micropollutant sources**.

The key studies with the highest number of targeted substances in the present project focused on

- 499 substances [10] in effluent samples. From the 155 targeted pharmaceuticals 123 could be confirmed. Besides this, 135 from 197 targeted pesticides and biocides as well as 108 from 147 targeted other pollutants were confirmed. This means that 33.6% of the detected substances were pharmaceuticals.
- 419 substances [29] of which 311 could be identified in treated wastewater discharge. 39.4% were allocated to pharmaceuticals.

The authors of the study, on which the European Commission bases its calculation of shares for the polluter pays principle, transparently state - based on further references - that there is **no simple way to determine if a given list of substances adequately represents all chemicals of concern**. Awareness is limited to the substances one actively measures, while numerous other chemicals within the technosphere remain unidentified, posing potential future concern as "unknown unknowns" [30]. The substance list in this **study by Pistocchi targeted 1,337 substances**, however, the study does not provide a percentage distribution across the substances for each sector as the **focus of the study was not to identify sector allocation** but reduction of wastewater effluent toxicity through advanced treatment solutions in European plants.

Non-target screening and suspect screening have gained prominence over the past two decades with advancements in high-resolution mass spectrometry (HRMS) and increasing concerns about contaminants of emerging concern. The shift from traditional targeted analysis to broader screening methods began in the early 2000s, driven by the need to detect previously unknown or unexpected substances in environmental and biological samples. **Today, non-target and suspect screening continue to evolve, but there is still a need to harmonize methodologies, improve data interpretation tools, and enhance open-access databases** [1].

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