Guidance document on the need of removal of pharmaceuticals from wastewater in the coastal regions of the South Baltic Sea

Project MORPHEUS 2017 - 2019

Lead authors: Gilles, A., Siemen, H., REM Consult Lang + Partner, Germany

Co-authors: Svahn, O., Björklund, E., Kristianstad University, Sweden

Contact information

gilles@rem-consult.eu
erland.bjorklund@hkr.se

Updated publication, 2021

Cover photo

WWTP, Photo: Ivan Bandura on Unsplash

Pharmaceuticals in the Environment – the current state

The constant release of pharmaceuticals into the environment can lead to pollution of water and soils which might constitute a risk to human and other living organisms. Residues of common pharmaceuticals such as painkillers, antimicrobials, antidepressants, contraceptives or antiparasitics may enter the environment during manufacturing and disposal processes. The main sources of releases, however, are human consumption and veterinary use. Due to the metabolic stability of some pharmaceuticals up to 90% of the active ingredients are excreted and end up in the wastewater system and finally in the environment – e.g. accumulated in the Baltic Sea and its living organisms.

The EU and its Member States have in the past few years increasingly recognised the challenge of pharmaceuticals in the environment (PIE). This is exemplified first and foremost by the European Commission's Strategic Approach to Pharmaceuticals in the Environment, but also initiatives at the national level aiming at closing main knowledge gaps in the field, comprehensive monitoring systems and more surveys to detect the occurrence of pharmaceuticals in surface and ground water. Moreover, the OECD has recently published a report on pharmaceutical residues in freshwater that calls for a better understanding of the effects of pharmaceuticals in the environment and policy actions.

However, this has not yet led to the development of indicators and threshold values at the EU level that aid Member States in implementing systematic monitoring schemes for PIE. As long as this situation persists and as long as we still do not sufficiently understand the effects of pharmaceutical residues on the ecosystem and on human health, the question arises: What can be done about PIE at the regional level? The answer to this lies in the precautionary principle – i.e. taking action to prevent harm to the environment even without having exact knowledge of all facets of the problem.

Applying the Precautionary Principle at the Regional and Local Level

Currently, the problem of PIE and related challenges are mostly discussed at the national level, and much more seldomly at the regional level or even local level. One reason is that monitoring of PIE is very limited in EU member states or not existing at all. But even if data are available, these are not sufficiently communicated to relevant stakeholders in the local or regional area. It is thus important to initiate and support such local/regional multi-stakeholder dialogues between researchers, WWTP operators, controlling bodies and authorities. There is a need to exchange data (e.g. via Information Platform for Chemical Monitoring) and expert knowledge, but also to communicate the results to society to increase public awareness and provide politicians at various levels with adequate and relevant knowledge about the present and future environmental status on PIE. Improved knowledge about PIE in local and regional societies may eventually aid in implementing improved environmental legislation, e.g. environmental quality standards, better indicators and binding thresholds for monitoring at regional, national and European level.

When it comes to practical solutions to meet the challenges of PIE on a regional level, several approaches either addressing source-related (production and use) or end-of-pipe strategies (advanced treatment technologies) can be applied. One solution does not exclude the other. In general, it can be stated that many source-related strategies (e.g. awareness raising related to manufacturers' and users' responsibility; improving environmental risk assessment of medicinal products; R&I investments into green pharmacy; stricter legislations on veterinary use; etc.) may be effective only in the long term and predominantly rely on national processes. A more immediate effect at the regional level can be achieved by removing pharmaceuticals and other micropollutants (MPs) from wastewater **with the help of advanced wastewater treatment technologies.**

Applying the precautionary principle at the regional and local level could thus mean to:

- gather consumption data to estimate the emission of pharmaceuticals into a given water system
- measure and assess the actual chemical loads
- compare the two data sets and identify substances of particular local or regional concern,
- use this information to enable wastewater treatment companies/authorities to identify the most suitable advanced treatment technologies to remove regionally relevant pharmaceuticals out of wastewater and take wise investment decisions.

A WWTP specific strategy including a local and season-based monitoring of the consumption and occurrence of PIE in related catchment areas can help to localise suitable technologies and financial concepts for decision processes. This has been the approach of the partner consortium of the MORPHEUS project that was implemented in four coastal regions in the South Baltic in 2017-2019. This approach is described in the following brief guidance for regional and local decision-makers on environmental monitoring and wastewater treatment.

How to implement such a strategy?

1 - Estimate the emission of pharmaceuticals into the wastewater system by region-specific consumption data

Quantifying the consumption of specific pharmaceutical substances and re-allocating it to local levels is a fundamental prerequisite for understanding the pharmaceutical burden to the environment from the emission perspective and to build up a reasonable mass flow from the source (intake by individual humans). Moreover, investigating local consumption patterns helps to understand which pharmaceuticals are most relevant to monitor in specific regions.

MORPHEUS succeeded to apply country specific data of the total consumption of pharmaceuticals per year to region-specific yearly consumption loads as intake per inhabitant [mg/inh./a]. Furthermore, by combining it with the number of real-connected inhabitants instead of the usually applied personal equivalents (PE), the project showed that it is also possible to estimate a WWTP-related inflow of some pharmaceuticals.

This way, the consumption per inhabitant constitutes a useful tool to allocate regional data to local levels, develop scenarios on potentials loads and hot spots and develop suitable mitigation actions for model areas – such as wiser investment strategies for advanced treatment technologies in selected WWTPs. This especially applies to areas where regional monitoring of pharmaceuticals in the environment is very limited.

For more details on consumption data modelled and analysed within MORPHEUS, please refer to Deliverable 3.1 & Policy Brief 1

2 - Measure inflow, outflow and seasonal recipient concentrations of pharmaceuticals in selected WWTP-recipient systems for the assessment of actual chemical load to the WWTP-recipient system

The concentration of pharmaceuticals in water bodies depends on a number of local factors such as consumption rate of medicines, size and removal efficiency of WWTPs, water flow of receiving rivers, and persistence of pharmaceuticals towards transformation or degradation. In order to understand the impact of a specific WWTP on receiving water bodies it is of utmost importance to measure the outflow concentrations of pharmaceuticals and to monitor seasonal recipient concentrations. A minimum of two seasonal recipient samples is required, covering draught and high flow conditions. If resources are available, four seasonal samples are preferable. This information is vital to aid legislators and decision makers in the prioritization process of advanced treatment implementation. Experimental removal rates of selected pharmaceuticals calculated on the basis of these measurements and existing treatment technologies can help to find relations between removal efficiencies, treatment methods, WWTP sizes, inflow loads and/or sludge ages – and thus support the development of suitable strategies to reduce the pharmaceutical burden to the environment.

MORPHEUS succeeded to measure and analyse the seasonal WWTP inflow, outflow and recipient concentrations of selected pharmaceuticals in 15 WWTPs in the project model areas. Removal rates of pharmaceuticals were also calculated. It has to be considered that wastewater treatment technologies in the model areas are mostly based on the activated sludge system and that average removal rates only serve as an indication of the degree of removal. Results showed high removal rates of certain compounds such as paracetamol, ibuprofen, ciprofloxacin (adsorbs to sludge) and estrone, while others such as carbamazepine and diclofenac only were removed to a very limited extent. These more difficult compounds can, however, be removed by the introduction of advanced treatment technologies at the WWTPs. Noteworthy is that there were no major effects observed between removal efficiency and the number of connected inhabitants, the daily flow or the sludge age used in wastewater treatment.

For assessing the actual chemical load to a WWTP, a comparison of *predicted incoming load* (PIL) values, using regional pharmaceutical consumption data, and *measured incoming load* (MIL) values determined by chemical analysis of incoming wastewater turns out to be a suitable approach.

While investigating potential correlations between consumption and occurrence, MORPHEUS results showed that carbamazepine is a good predictor of expected chemical loads to WWTPs. In addition, carbamazepine may also function as an indicator of the chemical burden of (persistent) pharmaceuticals in the environment since it had a very low removal efficiency value in the 15 WWTPs investigated within MORPHEUS – however, not unexpected as carbamazepine is known to be persistent in WWTPs and the environment.

For more details on occurrence data measured and analysed within MORPHEUS, please refer to Deliverable 4.1 & Policy Brief 3.

For more information on relations between consumption and occurrence of pharmaceuticals in the environment and suitable treatment technologies, please refer to Deliverable 4.2.

3 - Use the obtained data to assess the cost-effectiveness of advanced treatment technologies and take wise investment decisions

Currently, the most promising techniques regarded as technically feasible on a larger scale are: I) oxidation with ozone, II) adsorption onto activated carbon (PAC or GAC), or III) a combination of both methods. It is assumed that, appropriately equipped and managed, wastewater treatment plants (WWTPs) may obtain an 80% reduction of many MPs. It is also expected that besides the MPs, ozonation and activated carbon will enhance the removal of other organic compounds and/or improve the hygienic quality of the WWTP's effluent.

For more details on existing and advanced treatment technologies, please refer to Deliverable 5.1, Deliverable 5.2 & Kosek et al. Environmental Science and Policy 112 (2020) 213–226.

The elimination rate is, however, substance-specific and depends on the treatment technology. In addition, the implementation of advanced technologies is cost-intensive and not every private or public WWTP operator can bear the investments or has related expertise to do so.

For more details on reduction rates of specific pharmaceuticals analysed within the MORPHEUS project, please refer to Deliverable 4.1.

To assess the cost-effectiveness of advanced treatment technologies it is therefore essential to know which substances are particularly relevant in a particular WWTP-recipient system. It is also important to consider which technology that is already available at a specific WWTP since this may have consequences for which type of advanced treatment that is best suited for that particular WWTP. There are plenty of WWTPs that have piloted advanced treatment technologies in different settings (e.g. in Switzerland, Germany and Sweden) that can be used as examples and reference points. In a simplified process, the MORPHEUS partners prepared roadmaps for upgrading of four WWTPs of different sizes in the participating regions. While these roadmaps are only a small first step on the way to large scale investments, they have certainly helped to raise awareness of the problem and inspire WWTP operators to take the next steps themselves.

For example, the WWTP in Degeberga in the Municipality of Kristianstad, Region Skåne, Sweden, has been upgraded with a GAC-filter to treat wastewater in full scale: MORPHEUS Success story.

For more details on strategies and customised roadmaps for selected WWTPs with calculations on investment and operating costs developed by MORPHEUS, please download roadmaps at www.morpheus-project.eu/downloads

4 - Get more familiar with the topic, methods and techniques to analyse and reduce PIE and exchange knowledge within stakeholder networks!

Many WWTP operators as well as controlling bodies responsible for quality assessments of the environment, water bodies and public health are not sufficiently trained in chemical analysis to determinate the concentration of micropollutants nor sufficiently familiar with advanced treatment technologies to reduce such contaminants. Moreover, there is currently a lack of regulations on thresholds and indicators – in particular on EU-level – to further push actions on reducing PIE in the member countries.

Thus, MORPHEUS conducted regional trainings for WWTP operators, controlling bodies and authorities to transfer knowledge on analytical methods, advanced treatment technologies and current data on the chemical burden of PIE**. Besides the awareness raising at regional levels on the topic of PIE, such trainings can help to create regional stakeholder networks, to exchange expert knowledge and experience and to develop different mitigation strategies for future actions.**

Educational material produced by MORPHEUS is available at www.morpheus-project.eu/downloads

About the MORPHEUS project

Since 2017 the Interreg South Baltic project MORPHEUS supported partner organisations and stakeholders in the water sector, environmental protection agencies (EPAs) and research institutions from all over the South Baltic to meet the challenge of reducing the constant release of pharmaceutical substances via WWTPs to the South Baltic Sea.

The project measured, analysed and modelled data on pharmaceutical consumption, release rates of selected wastewater treatment plants (WWTPs) as well as environmental occurrence downstream in the coastal regions Mecklenburg (Germany), Skåne (Sweden), Pomerania (Poland) and Klaipeda (Lithuania). By communicating these data to related WWTP operators and EPAs, MORPHEUS provided highly relevant knowledge to better estimate and determine the emission of pharmaceuticals into the wastewater system and consequently – without sufficient removal at WWTP – into the environment of the South Baltic Sea Region.

Moreover, by analysing and assessing advanced treatment technologies suitable to reduce specific substances and by developing customised investment roadmaps for selected WWTPs in combination with high-resolution sample analysis of their pharmaceutical release rates, MORPHEUS provided valuable knowledge for future investments on the most suitable treatment technology to further improve the wastewater quality.

Furthermore, by transferring this knowledge via educational trainings for water companies and controlling bodies and by participating in the flagship initiative “BSR Pharma Platform” under the EU Strategy for the Baltic Sea Region, MORPHEUS helped to improve knowledge on advanced treatment technologies, sample and analysing methods, consumption modelling and current occurrence data in the South Baltic Sea Region and beyond.

MORPHEUS
Model Areas for Removal of Pharmaceutical Substances in the South Baltic

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

Interreg South Baltic

EUROPEAN UNION
European Regional Development Fund