ICPR Recommendations for Reducing Micropollutants in Waters

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1. Introduction

1.1 The problem of micropollutants

In 2008, the ICPR set the objective that "substances in the Rhine water, either individually or in combination, must not have adverse effects on the communities of flora, fauna and micro-organisms, and the water quality must be such that drinking water production can be achieved through simple, natural processing methods. This means avoiding pollution by reducing the introduction, emissions and loss of micropollutants with adverse effects, with the aim of achieving concentrations close to the background values of naturally occurring substances and, in the case of synthetic materials, achieving concentrations close to zero." (cf. ICPR Technical Report No. 181, 2010)

Due to a mandate from the 2007 Conference of Rhine Ministers, the ICPR has laid the foundations for a joint, comprehensive strategy for reducing and avoiding the influx of micropollutants from urban wastewater and other (diffuse) sources into the Rhine and its tributaries, by improving knowledge around emissions and ecotoxicological reactions in the environment, and drafting suitable treatment methods. To this end, the ICPR has compiled and discussed information regarding the relevance of various micropollutants in the Rhine catchment area and approaches to reducing water pollution, and has published the findings in technical reports on specific groups of substances.

Micropollutants can have a negative impact on both the ecology of waters as well as the production of drinking water.

Substances from all substance groups, e.g. pharmaceutical residues and plant protection products, continue to be detected in measurable concentrations in Rhine water and, subsequently, in the sea, as well as in the untreated water at drinking water production plants.[1] The pollution status per substance group is contained in several ICPR technical reports, inter alia in the Summary Report (ICPR Technical Report No. 246).

For many micropollutants e.g. pharmaceutical residues, wastewater from settlement areas via the wastewater treatment plant is the most significant influx pathway into surface waters.

For substances from diffuse origins such as plant protection products, other influx pathways e.g. drainage systems, leaching and surface runoff are relevant.

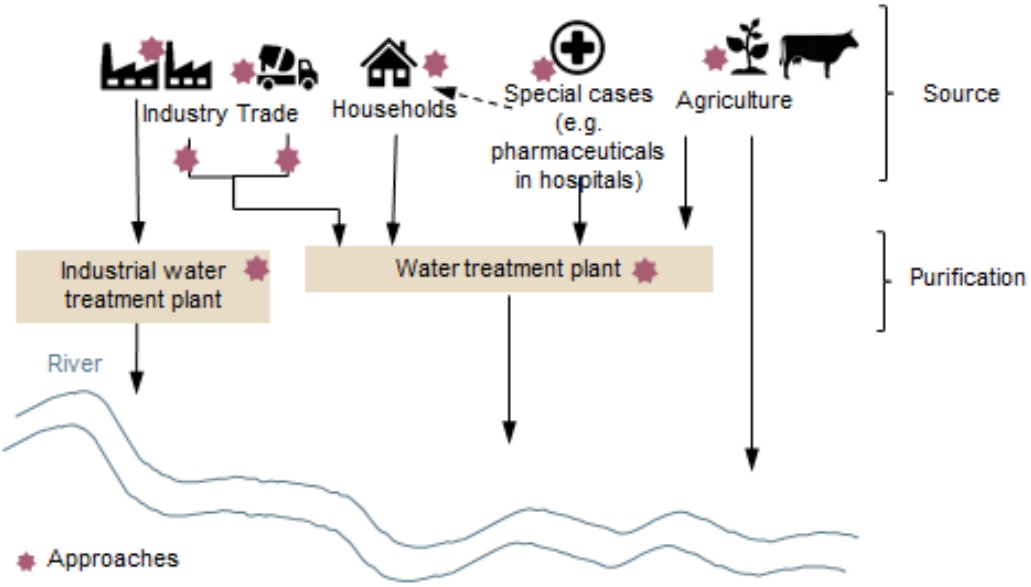
Essentially, with regard to the reduction of micropollutants in waters, measures at source are taken into consideration, in terms of their application, as well as centralized and decentralized measures. In addition, improvements in monitoring/evaluation and public awareness should be taken into account (see Figure 1).

Measures at source are significant because they are particularly relevant in terms of substances with diffuse influxes. Here, the aim is to achieve a reduction in micropollutant influxes through specific authorisation measures, regulations, information regarding disposal or by influencing consumer behaviour.

A reduction directly at source would be expedient for all substances, but is not always sufficiently possible.

[1] ICPR Technical Report No. 246

Figure 1: Main influx pathways of micropollutants into waters (simplified illustration, source: ECOPLAN)



1.2 From problem statement to recommendations

In 2013, on the basis of the "Strategy for micropollutants - Integrated assessment of micropollutants and measures aimed at reducing inputs of urban and industrial wastewater" (ICPR Technical Report No. 203),the 15th Conference of Rhine Ministers agreed that national and international measures should be taken to prevent and reduce the influx of micropollutants.

Due to the fact that many measures exceed the responsibilities of the ICPR and/or the level of the Rhine catchment, the states in the Rhine catchment and the European Commission made a commitment in the Rhine Ministerial Communiqué 2013 to develop activities aimed at preventing and reducing the influx of micropollutants.

The 2013 Conference of Rhine Ministers commissioned the ICPR (Item 19 of the Ministerial Communiqué)

- to put together a summary of the developments identified after three years (i.e. in 2017 for the years 2014, 2015, 2016),
- to further decide which joint measures should be taken to reduce the influx of micropollutants via the main influx pathways (in particular urban wastewater).

In the Summary Report completed in 2017 (ICPR Technical Report No. 246) the pollution status regarding micropollutants was updated, and an overview given of existing and planned national mitigation measures and strategies. It became clear that all of the states were dealing with the topic of micropollutants and that progress was being made in many areas.

In November 2017, based on a prior strategy meeting of the Heads of Delegations, the ICPR Strategy Group decided upon the development of common ICPR guidelines/recommendations for reducing micropollutants in the following three areas:

- Municipal sewage collection and treatment systems (e.g. pharmaceutical residues and X-ray contrast media),
- Agriculture (e.g. plant protection products) and
- Industry and trade (e.g. industrial chemicals).

These recommendations should be reviewed after 6 years and adjusted where necessary.

2. Municipal sewage collection and treatment systems

2.1 Main pollution

Municipal sewage collection and treatment systems are a relevant influx pathway for many of the substance groups under consideration. In addition to household chemicals, biocides and flame retardants, these include in particular the residues of **human medicines** and **X-ray contrast media**. For these groups of substances, the concentrations usually increase as the proportion of wastewater in the water increases. Active pharmaceutical substances are sometimes measured in concentrations above the EU recommendations for environmental quality standards (EU-EQS). X-ray contrast media are partially measured at levels above the precautionary values of the International Association of Waterworks in the Rhine Catchment (IAWR) and health-oriented guidance values (GOW)[2].

Furthermore, substance influxes via mixed water and/or rainwater discharge may be relevant.

2.2 Challenges

Challenges in the implementation of measures can be identified at several levels.

Measures at source begin with the development, authorisation, use and disposal of products. This is a major challenge, particularly for the pharmaceutical substance group. It involves generating and/or fostering the willingness of all parties involved to contribute to the reduction of influxes into waters. A ban on individual substances, such as may be expedient for certain plant protection products, for example, is not sought for pharmaceuticals.

In terms of central measures at the end of the implementation chain (wastewater treatment plants), a number of further developments have already taken place. After mechanical cleaning, biological cleaning and nutrient elimination, wastewater treatment plants in some states have been and are being equipped with an advanced purification stage for micropollutant elimination. The actual costs for the extension of wastewater treatment plants dependent (inter alia) on the chosen process and the peripheral conditions of the respective wastewater treatment plants. As the size of a plant increases, the specific cost per m^3 of wastewater decreases. The financing options must be addressed and the plant operators and/or clients informed accordingly. The national strategies or approaches are currently too diverse to be directly comparable. The costs of an advanced purification stage are in the range of approx. 5-25 Euro per capita per year.

The development of new processes as well as the further development and optimisation of existing processes must be driven forward. The challenge is to eliminate an even wider range of substances and to avoid the development of transformation products as much as possible, at the lowest possible cost for plants of different sizes.

[2] The GOW is considered to be the German precautionary level in drinking water and drinking water resources and/or in waters from which untreated water is extracted for drinking water.

2.3 Measures

The education of the public and raising awareness about the responsible use and proper disposal of products that can lead to pollution with micropollutants are important elements for reducing influxes. In the same vein, appropriate attention must be given to industrial and commercial indirect discharging (see Chapter 4).

Some measures at source are possible, e.g. in the authorisation of substances and products, the proper application - including measures to reduce emissions, and the proper disposal or return of products.

Other available measures for significantly reducing influxes for a wide range of substances (including pharmaceutical residues) are the technical measures (inter alia) available in sewage and wastewater collection systems, and/or more extensive purification processes (e.g. ozonation, activated carbon treatment) in wastewater treatment plants.

Due to the cost of expanding wastewater treatment plants, priorities should be set.

In the first instance, further purification should take place at wastewater treatment plants that are prioritised based on the following criteria:

- Discharge with a high proportion of pollution in the water into which the discharge is made;
- Discharge into ecologically sensitive waters;
- Discharge into waters used for the production of drinking water.

When developing the criteria, different approaches can be used.

In the case of water being used for swimming, systems for reducing micropollutants may be useful as part of an overall strategy, e.g. in terms of hygiene factors.

The final selection of wastewater treatment plants to be equipped with advanced purification technology takes place based not only on the prioritisation criteria, but also upon other aspects such as investment and/or maintenance frequency.

With regard to efficiency, larger plants are usually to be given preference.

2.4 Practical examples from the different states

The states in the Rhine catchment area set different priorities in their strategies for reducing micropollutants, depending on local conditions, in particular on the basis of population density and industrial estates, or the absorption capacity and state of the waters and/or use requirements - such as drinking water production. In some states, the further development of wastewater treatment plants to remove micropollutants is already being promoted, or legally established financing models have already been created.

Information on the proper disposal of waste medicines has been published by several states in the Rhine catchment, contributing to the reduction of micropollutant influxes. In addition, there are projects that train technical staff about environmental issues. Further information can be found in the Summary Report (ICPR Report No. 246).

In Switzerland the further development of wastewater treatment plants has been established by law.[3] The retrofitting of wastewater treatment plants will be financed until the end of 2040 by those polluting the water. In this case, there are clearly defined selection criteria and specifications for the elimination rate to be achieved. Six plants have already installed the necessary purification stage and are reducing micropollutants, in continuous operation, by 80 percent.

In the Principality of Liechtenstein, the emissions of micropollutants at the central wastewater treatment plant are regularly recorded and evaluated. Furthermore, the

[3] ICPR Technical Report No. 246

retention and discharge structures in the sewage system are currently being reviewed, with the aim of minimising direct discharges of pollutants into the water in rainy weather.

In Austria, the combination of processes involving activated carbon and ozonation was investigated as a further purification stage in several constitutive studies and in a large-scale pilot project[4,5]. In active operation, a wastewater treatment plant with very limited preflooder conditions was upgraded; however this was outside the Rhine catchment area.

In Germany there are currently no legal regulations comparable to those of Switzerland for the general extension of municipal wastewater treatment plants. However, possible measures (from source to use, to downstream measures) are currently being discussed in a stakeholder dialogue within the framework of a trace substance strategy. One component is a guidance framework for the expansion of municipal wastewater treatment plants. In the German federal states, there are different approaches depending on the pollution focus area.

In Baden-Württemberg, 13 wastewater treatment plants (as of March 2018) are already equipped with an additional purification stage (activated carbon stage), and another 16 (activated carbon stage or ozonation) are under construction or in planning. Through these measures, the wastewater of up to 2.1 million inhabitants will be further processed[6].

Rhineland-Palatinate has carried out cost-benefit analyses in the River Nahe catchment area for various measures to reduce the influx of micropollutants into waters[7]. In order to avoid influxes at source, the leaflet "Protecting Waters - Avoiding the Discharge of Pharmaceuticals" was distributed to all pharmacies in a comprehensive awareness campaign.

Hessen has submitted a trace substance strategy[8] for its section of the Upper Rhine Plain, which includes (inter alia) measures at municipal wastewater treatment plants, in terms of commercial direct and indirect dischargers, as well as information and communication measures.

In North Rhine-Westphalia, measures are being tested and implemented to eliminate micropollutants at municipal wastewater treatment plants that require attention due to a failure to meet operational objectives[9]. Research projects, feasibility studies and the extension of wastewater treatment plants in order to eliminate micropollutant eliminations have been and are being financed. To date, 30 plants have been expanded or are under construction, and 126 feasibility studies and various large-scale industrial investigations have been carried out.[10]

In the German-Luxembourgian INTERREG project EMISÛRE[11], the use of soil filters is contrasted with the use of activated carbon and ozone as a possible alternative for wastewater post-treatment, which can also be used for smaller/medium-sized wastewater treatment plants, as these are most prevalent in the region.

Even though no wastewater treatment plants are currently equipped with an additional purification stage in Luxembourg, in the case of the wastewater treatment plants currently in planning or under construction with a size of more than 50,000 PE, process management and space requirements for a fourth purification stage are being taken into

[4] https://www.bmnt.gv.at/dam/jcr:0482b219-24f4-46e6-b61b-dccf79a3648f/KomOzon_Endbericht.pdf
[5] https://www.bmnt.gv.at/dam/jcr:eb9b35f3-2f2a-4e23-bf57-b99aefd4858a/KomOzAk%20Endbericht%20-%20Langfassung.pdf
[6] cf. Micropollutants Competence Centre Baden-Württemberg [KomS BW], www.koms-bw.de
[7] cf. Project Micro_N, https://www.bauing.uni-kl.de/fileadmin/siwawi/pdfs/projekte/mikro_n_schlussbericht.pdf
[8] cf. Trace Substance Strategy, Hessian Ried: https://umwelt.hessen.de/umwelt-natur/wasser/spurenstoffstrategie-hessisches-ried
[9] cf http://www.flussgebiete.nrw.de/index.php/WRRL/Bewirtschaftungsplan/2015
[10] cf. www.kompetenzzentrum-mikroschadstoffe.de and layout guidance for the planning and layout of plants for micropollutant elimination cf. http://www.masterplan-wasser.nrw.de/downloads/broschuere-anlagenplanung/
[11] cf. https://www.bauing.uni-kl.de/siwawi/projekte/abwasserbehandlung/entwicklung-von-strategien-zur-reduzierung-des-mikroschadstoffeintrags-in-gewaesser-im-deutsch-luxemburgischen-grenzgebiet-emisure/

account. Feasibility studies are under way or have already been completed at two wastewater treatment plants of more than 100,000 PE [Population Equivalent]. A feasibility study has also commenced at a wastewater treatment plant of 12,000 PE. This already has a sanitation stage, which could potentially be converted to include micropollutant elimination.

In France, a high priority status is currently being given to reductions at source. A number of scientific studies or studies supported by sewage associations have been carried out and/or are being introduced regarding the treatment before or beyond wastewater treatment plants. In 2016, a national call for tender was launched for projects around innovative approaches. The new solutions that emerge must be assessed taking into account the cost-benefit ratio and the benefit-risk balance, before any potential national decision regarding treatment can be made.

In the Netherlands, amongst other things, a hotspot analysis has been carried out to identify the locations where an additional purification stage would be most expedient, and pilot projects are currently being carried out on extended purification stages in wastewater treatment plants. In addition, a programme spanning 2018-2022 has been created to implement the integrated approach regarding 'pharmaceutical residues from water', with measures for all components (development and authorisation, prescription and use, as well as waste and treatment). The Ministry of Infrastructure and Water Management has allocated a budget for measures at source, for pilot projects/investigations of innovative purification techniques in wastewater treatment plants in the medium term (5-7 years) and - for demonstrative purposes - for the installation of currently applicable advanced purification techniques in individual hotspot wastewater treatment plants (minimum duration 10 years). The implementation is taking place based on the motto "learning while implementing". Monitoring of the efficiency of further purification in the wastewater treatment plants is undertaken through chemical measurement of the concentrations of individual key substances, as well as through biological impact measurement.[12,13]

2.5 Recommendations

Measures at source are to be given preference, for avoiding the influx of micropollutants. In order to reduce the unnecessary influx of human medicines, for example, awareness campaigns around the proper disposal of unused medicines can help.

Nevertheless, emissions into waters can only be partially reduced by measures at source.

Wastewater treatment plants represent a relevant influx pathway into surface waters for many of the substance groups under consideration, such as pharmaceutical residues. The technologies that can significantly reduce pollution via this influx pathway are known, available and already implemented at several wastewater treatment plants in the Rhine catchment.

An additional purification stage with a broad range of efficacy is also advantageous from a precautionary standpoint. In this way, new or previously unidentified substances are also reduced; in as far as the purification method used is effective.

Additional purification measures at municipal wastewater treatment plants must not lead to the neglect of decentralized measures (e.g. pretreatment of industrial wastewater) and measures at source.

On the basis of the above-mentioned prioritisation criteria, as well as accumulated experience and, where appropriate, further considerations, the ICPR recommends that states in the Rhine catchment make a selection of suitable wastewater treatment plants

[12] https://www.stowa.nl/sites/default/files/assets/PUBLICATIES/Publicaties%202017/STOWA%202017-42.pdf
[13] https://www.rijksoverheid.nl/documenten/rapporten/2018/06/21/bijlage-1-uitvoeringsprogramma-ketenaanpak-medicijnresten

that should be equipped with an additional purification stage in order to further reduce emissions.

Within the framework of the ICPR, provisions are to be made for regular communication between the states in the Rhine catchment area regarding their experiences of reduction measures in general and various technologies in particular (e.g. ozonation, activated carbon treatment) as well as financing and prioritisation criteria, and for the further development of the national approaches to be implemented. An exchange of ideas could also be integrated regarding the monitoring of additional purification process efficiency, the impact on aquatic ecology and the use of key substances, including analysis methods. It is recommended that individual, reciprocal consultation options are considered, where necessary also cross-border support for individual projects.

2.6 Particular observations: X-ray contrast media

X-ray contrast media (XCM) are developed as biologically inactive substances and hardly degrade in wastewater treatment plants due to their stability. They occur in surface waters in sometimes high concentrations and can be a problem in drinking water production. XCM are mainly used in hospitals and x-ray clinics. The majority of these XCM enter the wastewater within 24 hours either where they are administered or in the household wastewater of patients at home (see ICPR Technical Report No. 187).

Measures at source are of primary importance, as XCM cannot be easily removed in wastewater treatment plants, even with the use of further purification procedures. Pilot projects for the collection and separation of these have already been implemented at several locations, e.g. through the use of urine bags, where contaminated urine can be collected and then disposed of in the normal waste disposal.

The pilot projects showed that with the help of such urine bags, the content of XCM in the wastewater could be reduced[14]. A high level of acceptance of this measure was found among the participating patients and at least partially among the specialist staff[15].

2.7 Recommendations

Based on the results of the pilot studies, the ICPR recommends that states in the Rhine catchment test whether and how the separate collection of XCM in hospitals and x-ray clinics (e.g. by using urine bags) can be applied or expanded. In addition, the relevance for waters should be indicated in the accompanying information. Even if initially only a proportion of the XCM are withheld, such a measure could already (significantly) relieve the burden on the waters in the catchment area.

Furthermore, the ICPR recommends that additional pilot projects regarding other measures such as separate toilets/urinals in health care facilities be (further) tested.

Such an approach will allow the ICPR to gain valuable knowledge in terms of the effects on water pollution, and to further promote acceptance among health professionals and patients. Regular communication about the experience gained should take place within the ICPR.

Taking into consideration medically relevant properties, the ICPR also recommends the development and application of more biodegradable and therefore more environmentally-friendly XCM.

[14] cf. https://merkmal-ruhr.de/ and http://www.nweurope.eu/about-the-programme/our-impact/challenge-3/the-nopills-in-waters-project/
[15] cf. www.minder-rkm.de and https://www.wdodelta.nl/publish/pages/11102/nl_version_12_pages_ia.pdf

3. Agriculture

3.1 Main pollution

In addition to nutrients, plant protection products (PPPs) and veterinary medicinal products from agriculture also enter bodies of water, including groundwater, via diffuse input pathways.

PPPs are one of the most significant substance groups of micropollutants with diffuse influxes. For herbicides, for example, drainage, leaching and surface run-off are the most relevant, diffuse influx pathways (ICPR Technical Report no. 240).

In addition to having sustainably measurable concentrations - e.g. in the case of biocides, PPP pollutant waves from agriculture can have a major impact on ecology and drinking water production. Smaller water bodies are particularly sensitive to peak loads.

Some metabolites of PPPs are poorly degradable and may have higher concentrations in the aquatic environment than the original PPP used.

3.2 Challenges

About half of the surface area of the Rhine catchment comprises land used for agricultural production. It is therefore important to prevent or reduce the negative impact of agricultural production on bodies of water. Reducing the input of PPPs into the water is a challenge. The cooperation between water management entities and agricultural management should take place in all states, both across all disciplines at government level, but also with other parties such as agricultural authorities, Chambers of Agriculture as well as with local farmers. To this end, it is advisable to regularly inform the agricultural authorities or Chambers of Agriculture about water resources. In the long term, in the case of regular findings, application and authorisation restrictions or even bans would need to be discussed. Farmers should also be made more aware of the issues through agricultural consultation, and new application and management techniques should be established.

The purchasing behaviour of the consumer is also an important factor for the success of measures in agriculture. A better awareness of the problem and the education of the population on the issue of water protection, e.g. through the appropriate labelling of products, are, in the opinion of the ICPR, important means of supporting the shift towards more environmentally-friendly agriculture. Agricultural cooperatives, distribution or wholesale markets can also emphasise important approaches.

Other challenges include, in particular, the sometimes high level of pollution in smaller rural waters, their monitoring and the handling of metabolites.

3.3 Measures

As required by the Sustainable Use of Pesticides Directive (2009/128/EC), all EU countries have adopted national action plans to make the use of pesticides more sustainable. Switzerland also adopted an "Action Plan for Risk Reduction and the Sustainable Use of PPPs".

For substances with diffuse influxes, such as agricultural PPPs, the most efficient measures to reduce consumption and mitigate risk are those at source. A detailed overview of possible measures can be found in ICPR Technical Report No. 240.

In general, restrictions on authorisation and the prohibition of use are issued, e.g. in drinking water protection areas.

In the non-agricultural sector, usage bans on sealed public areas, which are already in force in the states in the Rhine catchment area, are an important step. Authorisation

restrictions may also include national bans on certain substances, e.g. metazachlor and S-metolachlor in Luxembourg or metazachlor and terbuthylazine in Austria.

In the agricultural sector, the influxes and their risks can be reduced through e.g. the use of modern, precise application methods or the cultivation of modified crops.

There are currently major differences and/or different approaches between the states in terms of technical measures. For example, buffer strips of land around water bodies are mandatory everywhere, but to varying degrees. In addition to the establishment of such buffer zones, requirements for soil conditions, vegetation coverage, land gradient or the time of application of PPPs are beneficial.

The renovation of farm drainage systems (e.g. washing spaces for PPP sprayers) that drain partly into the sewage system or directly into the nearest stream can greatly reduce PPP influxes and thus be effective.

The influx of PPPs is considerably influenced by major precipitation. Where there is an influx into the sewage system, technical measures for stormwater relief can be a useful measure. The extension of a wastewater treatment plant solely for PPPs is only expedient on a case-by-case basis. Please note also the explanations in Chapter 2.

Awareness campaigns are also taking place across all states in the Rhine catchment, both for the professional public and the general public.

Financial measures range from the promotion of certain environmentally-friendly forms of farming (especially organic farming) to the levying of charges for PPPs.

A review of the European Union's Common Agricultural Policy (CAP) is currently under way, and this will be reformed in 2020. This could also have positive effects on pollution from plant protection products in agriculture.

3.4 Practical examples from the different states

Thanks to the action plans on the sustainable use of pesticides (in accordance with Directive 2009/128/EC) and the action plan on PPPs in Switzerland, there are already comprehensive action plans in all countries.

Specific goals are also formulated in the action plans.

For example in Switzerland, the risk from PPPs is to be reduced by 50% by 2027. The overall objective of the action plan, which comprises around 50 measures, is to halve the risks associated with PPPs. In addition, specific targets for ground and surface waters have been defined. The action plan is based on three pillars: Firstly, the use of PPPs and the associated emissions should be reduced and secondly, the protection of crops should be ensured. In order to achieve a reduction in use, non-chemical plant protection products in particular and/or integrated plant protection must be further developed. A reduction of emissions (discharge of applied PPPs into the waters) requires measures in both farm and field.

The Principality of Liechtenstein is guided by the Swiss action plan. It is also worth noting that there is a general ban on the use of plant protection products in the buffer strips along the water bodies and in the narrower protection zone around the water inlets.

In addition to the measures mentioned under 3.3, there are also regional projects designed, among other things, to reduce the pollution of waters with PPPs, such as the Land Action Plan on Plant Protection Products, Vorarlberg (see also ICPR Technical Report No. 246). The Austrian programme to promote an environmentally-friendly, extensive and habitat-protecting agriculture (ÖPUL)[16], which is being applied across the board, also includes many water protection measures. Here, refraining from using plant protection products or the reduction of the probability of discharge into waters is specifically

[16] https://www.bmnt.gv.at/land/laendl_entwicklung/oepul/oepul2015.html

promoted. The Austrian National Action Plan on Antibiotic Resistance includes inter alia the reduction of the use of antibiotics in veterinary medicine. In intensive livestock farming, the application rates have been significantly reduced in recent years, which has an impact on the discharge into ground and surface waters via manure spreading. In terms of authorisations, the use of metazachlor and terbuthylazine is restricted in primary and secondary protection zones due to their metabolites.

In Germany, the lessons learned from joint drinking water cooperations with farmers in water protection areas are being drawn upon; these approaches should be also be widely adopted. In addition, consultations in agriculture that promote environmentally-friendly farm management and refraining from the use of synthetic chemical production means (such as PPPs) represent an important pillar. In its action plan, Germany has set the goal of a 30% reduction in the risk potential of applied PPPs by 2023. In Germany, there are nationwide agri-environmental programmes for water-friendly agriculture. Amongst other things, these will increase acceptance for the reduction of influxes of nutrients and pesticides into waters. Successful examples include sprayer cleaning sites set up for winemakers and farmers to reduce the entry of PPPs into the waters. The wastewater created here is treated with a special cleaning technique.

In the sphere of awareness campaigns, "Pesticide-Free City"[17] can be highlighted as a positive example.

The Luxembourg Plant Protection Products Act[18] regulates the distribution and use of plant protection products. For example, the application of pesticides in public spaces has been banned since 1 January 2016. The Act also provides for the establishment of a national action plan to reduce the use of plant protection products. Measures to reduce the use of plant protection products are also included within the framework of the agri-environmental climate measures under the rural development plan[19] .

The Luxembourg Government's coalition agreement for the period 2018-2023[20] has laid down further measures that will reduce the use of plant protection products and lead to improved ecological management. In this way, by 2025, the proportion of organically farmed land within the total agricultural area used should be at least 20%. This currently lies at 4%. There are also plans in place, for example, to stop the use of glyphosate from 31 December 2020.

The website for the national campaign "Without-Pesticides"[21], which draws attention to the harmful effects of pesticides on nature and health and demonstrates alternative cultivation methods for public and private land in the settlement area, contains varied information relating to the handling and hazards of pesticides.

In France, the Ecophyto Plan initiated in 2008 showed that a lower dependency on PPPs due to agri-structural measures could be reconciled with the economic returns of the farms. Nevertheless, it is noted that necessary but not yet sufficient conditions have been created to achieve the goal of reducing the use of PPPs in France. The plan Ecophyto-II was therefore developed, aiming to reduce PPP use by 50% by 2025.

In 2018 the Dutch Ministry of Agriculture, Nature and Food Quality published its vision "Agriculture, Nature and Nutrition: Valuable and Connected", which describes the transition toward circular farming in 2030, a concept that involves the production of as little waste as possible, minimising the emission of pollutants and using raw materials and end products with as little loss as possible. The Dutch Federation of Agriculture and Horticulture (LTO) is working towards the overriding objective that plant protection products will no longer have a negative impact on waters by 2030. Farmers must adapt their farming methods accordingly. In addition, there is an initiative that aims for no

[17] https://www.bund.net/umweltgifte/pestizide/pestizidfreie-kommune/
[18] Loi du 19 décembre 2014 relative aux produits phytopharmaceutiques
[19] http://www.ma.public.lu/actualites/communiques/2015/07/031/
[20] https://gouvernement.lu/de/publications/accord-coalition/2018-2023.html
[21] http://www.ounipestiziden.lu/

more PPPs to be used in the flood areas of the main stream of the Rhine (Rheinaue wetlands).

3.5 Recommendations

Especially with regard to agriculture, the ICPR recommends that there should be regular communication in the Rhine catchment area about the possible measures mentioned above, the other approaches otherwise intended in the states, the experience gained so far and information on local initiatives.

The ICPR recommends that the measures taken at national level should not focus solely on individual active substances. These may change depending on the approval of substances (c.f. isoproturon), and substitutes are also often equally problematic. In addition, the metabolites of authorised substances are relevant to the quality of the water, so they should also be taken into account. A consistent chain of measures is to be considered from the source to the disposal of products for the substances relevant to water (cf. Chapter 3.3 and ICPR Technical Report No. 240). In order to improve the process, it is recommended that the (states of the) ICPR address problems more proactively with the agricultural industry and the European regulatory authorities. The measures intended to facilitate water-friendly agriculture must be expanded (inter alia) to reduce the influxes from plant protection products. The acceptance of farmers, winemakers and horticulturalists should be further increased through awareness campaigns.

The measures set out in the action plans must be consistently implemented in constructive cooperation with agriculture.

The promotion of environmentally and water-friendly agriculture (especially organic farming) is recommended by the ICPR.

4. Industry and trade

4.1 Main pollution

Industrial and commercial discharges cover a wide range of substances and substance groups. In terms of the industrial chemicals (in particular flame retardants, diglyme and PFC) selected and evaluated as examples by the ICPR, these exceed both existing environmental quality standards (EU-EQS) and drinking water target values (IAWR values).

Due to new analysis and screening techniques (e.g. non-target analysis) and the consistent development of new substances, substances are increasingly being detected in waters for which there are no (legal) standards. There is no internationally coordinated management of newly occurring and not legally standardised substances.

4.2 Challenges

The Rhine catchment has a high industrial density and numerous international industrial companies.

An assessment therefore needs to be made as to which additional measures could be useful at international or at least EU level.

Due to the large variety of industrial and commercial sectors in the Rhine catchment and the associated diverse substance groups, prioritisation and an intensive dialogue with industry and trade seem to be a significant (first) step. Such discussions, which are expedient both internationally, nationally and regionally, can improve the knowledge of wastewater constituents, for example through a substance inventory, as well as knowledge regarding possibilities for reduction.

4.3 Measures

Measures at source include the selection of input substances - also in environmental terms, as well as process optimisation and the closure of material cycles, in order to avoid emissions as far as possible. For existing residual discharges, an assessment must be made as to the significance of these for water quality target setting. For poorly degradable substances it must be examined, e.g. on a case-by-case basis, whether the amount of these substances in (waste)water-relevant processes (purification, rinsing) can be significantly reduced or whether these substances can be replaced by less problematic ones. Similarly, production and processing operations, for example, can be adapted so that as few problematic substances as possible enter the wastewater.

The ICPR Technical Report No. 202 also showed that with regard to specific impurities e.g. PFC in individual wastewater flows, these can usually be treated more efficiently at the company itself than as mixed wastewater at a municipal wastewater treatment plant. The pretreatment of wastewater flows in these cases is therefore useful and efficient at company level.

The specifications for Best Available Techniques (BAT) for EU countries are set out in the Best Available Techniques Reference Documents (BREFs) by the Industrial Emissions Directive (Directive 2010/75/EC). However, these requirements are sometimes insufficient to minimise micropollutants. Additional emission-reducing measures may be required in some states if the situation on the immission side of things, or other protection goals or uses require them. Additions to the specifications would be desirable.

An additional measure is building awareness among the professional public, for example with further education provisions and guidelines.

4.4 Practical examples from the different states

In addition to REACH and the Industrial Emissions Directive at EU level, several international agreements have already been developed for individual groups of substances, such as the Stockholm Convention on Persistent Organic Pollutants, which came into force in 2004, and the Minamata Convention on Mercury, which came into force in 2017. The EU has implemented both conventions through directives.

In Switzerland, wastewater from industry and commerce may fundamentally only be discharged into a body of water or into the sewage system where a permit is present. Those draining off industrial water must take the necessary measures in accordance with the latest technology in terms of production processes and wastewater treatment, in order to avoid polluting the waters. A situation analysis of the substance discharges from industry and commerce is currently being carried out in Switzerland. Further measures can potentially be developed based on this analysis.

Regional measures are being taken that focus, for example, on increased and cooperative communication with the industrial sphere. Such a communication model has been successfully applied in Switzerland for some time.

In the Principality of Liechtenstein, wastewater from industry and commerce may fundamentally only be discharged into a body of water or into the sewage system where a permit is present. The different industries are monitored periodically or within the framework of campaigns. In this way, e.g. within the context of a campaign, all public petrol stations nationwide are checked and technically upgraded for water pollution control.

In Austria, every direct discharge of wastewater from industry and commerce requires a permit under the Water Act. Indirect discharges of wastewater from certain source areas or from wastewater in which specified load thresholds of hazardous wastewater substances are exceeded are also subject to authorisation. 61 specific wastewater emission regulations form the basis for the prescription of limit values for wastewater properties and constituents in the Water Act assessment on discharge into surface waters. They contain emission limits based on state of the art technical knowledge for the typical wastewater characteristics and constituents of the respective source area, the associated monitoring requirements and methods as well as assessment criteria with regard to compliance with emission limits. These legally binding specifications are complemented by state-of-the-art technical recommendations for avoidance, retention and cleaning techniques for the respective industry. The wastewater emission regulations are constantly adapted in line with state of the art technical knowledge. The implementation of Best Available Technique conclusions on the basis of the EU Industrial Emissions Directive applies to requirements relating to wastewater, in a similar vein.

In Germany, the requirements regarding the discharge of wastewater are implemented in the Waste Water Ordinance, which contains a general section as well as a specific annex for municipal wastewater and 56 branch-specific annexes for industrial and commercial wastewater[22]:

- state of the art technology generally applies regardless of the size of the plant,
- certain requirements also for indirect influxes (pretreatment of wastewater),
- imperatives for minimisation e.g. for chelating agents, PFC,
- for some sectors also impact-related requirements (e.g. toxicity to fish eggs, daphnia, algae or luminescent bacteria as well as the Umu test for mutagenic potential),
- further requirements with regard to the influx in accordance with the German Federal Water Act are possible if this is necessary on the immission side of things for the protection of the water body or due to further protection goals or uses.

[22] http://www.gesetze-im-internet.de/abwv/AbwV.pdf

The German Federal Environment Agency is currently working on a concept to identify persistent and mobile (PM) as well as persistent, mobile and toxic (PMT) substances within the context of REACH, in order to better protect drinking water resources against the influx of chemicals in the long term.[23]

In France, direct or indirect discharges are regulated by the requirements for plants that are subject to licensing, which are classified as environmentally hazardous, or by water law. Non-household discharges into public sewerage networks must be the subject of an agreement between the company and the network operator. Industry-specific studies have been carried out on certain industry spheres where hazardous substances are emitted, to better describe the pollutants, identify their origin and to plan reduction and disposal techniques (the substitution of products, specific wastewater treatment, new techniques, etc.). The associated emission limits will be adjusted as part of the revision of the relevant general ministerial decree, and specific sectoral decrees.

With regard to small and medium-sized enterprises (SMEs), the LUMIEAU project in Strasbourg sets out a specific section covering around ten manual trades. This refers to the section "Supporting the Revision of Practices" by volunteer professional demonstration personnel. The clean technologies offered are evaluated in terms of their effectiveness, limitations, cost and acceptance.

In Luxembourg, for direct and indirect dischargers in industry and manual trade, the limit values and discharge conditions are established within the framework of the processing of a license application under the Luxembourg Water Act[24] , taking into account BREF and BAT documents. This also applies to micropollutants as far as the information is available. Where there are any suspicions, information is requested or investigations are carried out. In essence, the current limit values relate to heavy metals, for historical reasons.

In the Netherlands, the evaluation of discharges involves three steps. Companies must specify which (auxiliary) substances could enter the water cycle, and assess the hazard of these substances for the water, using the General Assessment Methodology (GAM)[25]. On the basis of categorisation into water hazard classes, the right level of attention can be given to purification technology. Drawing upon this information and information from BREF documents or national BAT documents, it is possible to check whether a discharge corresponds with the BAT. A check must then be made that the residual discharge does not lead to the applicable water quality thresholds being exceeded. This evaluation is carried out with the help of the immission test (www.immissietoets.nl). Failure to comply with the immission test will mean that locally, the water quality standard(s) for (a) given substance(s) cannot be met, which will consequently pose a risk to aquatic ecology, to achieving the WFD targets or to drinking water quality. In these cases additional efforts are required to reduce emissions. This is referred to as BAT+.

In the Netherlands, the guidelines issued for the granting of authorisations have been adjusted since 2016, in order to better meet the REACH requirements for substances of very high concern. In addition, the requirements that apply for discharges near drinking water abstraction points were formulated more explicitly, including (inter alia) the integration of a drinking water test for relevant newly emerging substances.

Within the context of the water quality Delta Approach, all relevant entities (Rijkswaterstaat, water boards, provinces and municipalities) will come to an agreement to review all authorisations in the coming years, in the light of the new requirements for substances of very high concern, substances potentially of very high concern (national precaution list) and newly emerging substances.

[23] https://www.umweltbundesamt.de/reach-leitlinien-schutz-des-rohwassers
[24] Amended Water Act of 19 December 2008
[25] https://www.helpdeskwater.nl/onderwerpen/applicaties-modellen/applicaties-per/vergunningverlening/vergunningverlening/abm-algemene/general-assessment/

4.5 Recommendations

For industrial or commercial sites where the pre-treatment of wastewater streams could achieve an efficient reduction of micropollutants, the ICPR recommends discussing and regulating such pretreatment at a national level.

For precautionary reasons, the ICPR recommends that the states in the Rhine catchment examine a reduction requirement for persistent and/or persistent and mobile substances, which initially seem less ecotoxicologically relevant, but which are discharged in large quantities into waters e.g. polymers as an additive in cooling water, benzotriazole, dioxane and diglyme.

Particular attention should be given to substances classified as substances of very high concern (REACH Regulation (EC) No 1907/2006).

The ICPR recommends that states in the Rhine catchment area engage in a stronger dialogue with industry and commerce on measures and projects at a national level. The ICPR should regularly discuss these dialogues and their results.

The ICPR pursues analytical developments and promotes the exchange and potential harmonisation of analytical methods in the Rhine catchment. In addition, it regularly reports on newly occurring or newly detected substances and, where necessary, includes them in the list of Rhine substances.

In some sectors, many industrial chemicals may be present in the wastewater. In addition to the sum parameters COD and TOC (which in particular illustrates poorly degradable organic substances better than the sum parameter COD), in such cases specific requirements for individual substances and, where applicable, also impact-related requirements must be taken into account (biological test methods for the summary capture of effects). The ICPR recommends an exchange of knowledge regarding existing test systems.

The ICPR sees the development of international agreements, such as the Stockholm Convention and the Minamata Convention, as a practical solution for individual, particularly hazardous substances and/or groups of substances with a worldwide distribution pattern, in order to tackle water pollution.

5. Synthesis of recommendations

Micropollutants can have a negative impact on both the ecology of waters as well as the production of drinking water.

Essentially, with regard to the reduction of micropollutants, measures at source come into consideration, in terms of their application, as well as centralised and decentralised measures. In addition, improvements in monitoring/evaluation and public awareness should be taken into account.

ICPR recommendations for the areas considered here (municipal sewage collection and treatment systems, agriculture and industry):

(1) Where possible, measures at source are generally to be given preference. These measures help to prevent and/or reduce the amount of micropollutants entering the waters. These measures will only be able to partially solve the problem, in particular for wastewater from settlement areas, so that often a combination of measures from source to final (partial) purification is required.

(2) For **municipal sewage collection and treatment systems**, based on prioritisation criteria, accumulated experience and other aspects, the ICPR recommends that a selection of eligible wastewater treatment plants should be equipped with an additional purification stage.
The prioritisation criteria for selection are:
- Discharge with a high proportion of pollution in the water into which the discharge is made;
- Discharge into ecologically sensitive waters;
- Discharge into waters used for the production of drinking water.

When developing the criteria, different approaches can be used.
In addition, regular communication in the Rhine catchment as well as mutual consultation and support are recommended.

(3) For the **handling of X-ray contrast media**, the ICPR recommends that tests are carried out as to whether and how the separate collection of XCM in hospitals and x-ray practices can be applied or expanded, including accompanying awareness campaigns. In addition, further pilot projects for additional measures are to be tested.

(4) For the **agriculture** sector, in addition to a regular international exchange of knowledge in the Rhine catchment area, the ICPR recommends that the focus is not only on individual active substances. Metabolites are also to be assessed. Furthermore, the measures set out in the action plans (chain of measures from source to disposal of products) must be consistently implemented in constructive cooperation with agriculture, retailers and consumer organisations. The promotion of environmentally and water-friendly agriculture (especially organic farming) is also recommended.

(5) For the **industry and trade** sector, the ICPR recommends that the pretreatment of wastewater streams be discussed and regulated nationally. For persistent and/or persistent and mobile substances it is recommended that a requirement for the reduction of these is examined. Particular attention should be given to substances[26] classified as being of very high concern.
A stronger dialogue with industry and commerce is recommended. In addition to the sum parameters COD and/or TOC, specific requirements for individual substances and also impact-related requirements must be considered. The ICPR recommends an exchange of knowledge regarding the existing test systems.

[26] REACH Regulation (EC) No. 1907/2006