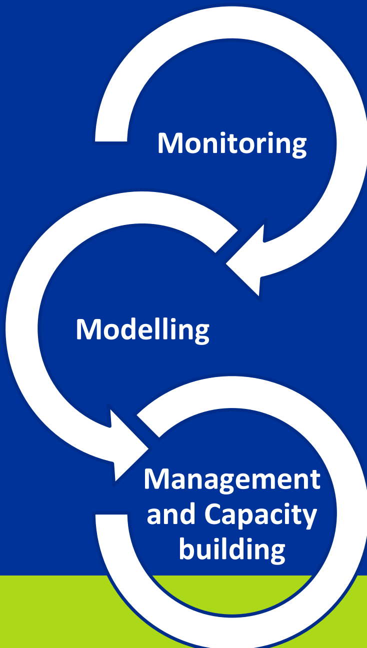
Interreg
EUROPEAN UNION
Danube Transnational Programme
Danube Hazard m³c

TACKLING HAZARDOUS SUBSTANCES POLLUTION IN THE DANUBE RIVER BASIN BY MEASURING, MODELLING-BASED MANAGEMENT AND CAPACITY BUILDING

DH m³c layman's report



Project co-funded by European Union funds (ERDF, IPA, ENI) and National Funds of the participating countries

ICPDR IKSD
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau
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DANUBE HAZARD M³C - KEY FACTS

Funding instrument: Danube Transnational Programme (3rd Call), Priority: Environment and culture responsible Danube region, Specific objective: Strengthen transnational water management and flood risk prevention.

Project duration:
01.07.2020. – 31. 03. 2023.
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Overall Budget: € 2,597,483.94
ERDF Contribution: € 2,114,973.33
IPA Contribution: € 33,094.32
ENI Contribution: € 59,793.67

Partners:
- **Lead partner:** TU Wien, Austria
- National Administration „Romanian Waters" (NARW), Romania
- Bulgarian Water Association (BWA), Bulgaria
- Umweltbundesamt - Environment Agency Austria (UBA), Austria
- International Commission for the Protection of the Danube River (ICPDR), Austria
- Budapest University of Technology and Economics (BME), Hungary
- University of Zagreb, Faculty of Chemical Engineering and Technology (FCET), Croatia
- Water Research Institute (WRI), Slovakia
- Jozef Stefan Institute (JSI), Slovenia
- Center for Ecotoxicological Research Podgorica (CETI), Montenegro
- Institute of Chemistry, Moldova

Associated Strategic Partners:
- Ukrainian Hydrometeorological Institute State Service on Emergencies and National Academy of Sciences, Ukraine
- Public Institution "Waters of Srpska", Bosnia & Herzegovina
- Ministry of Environmental Protection, Serbia
- General Directorate of Water Management, Hungary
- German Environment Agency, Germany
- Institute of hydrometeorology and Seismology, Montenegro
- International Association of Water Service Companies in the Danube River Catchment Area, Austria
- Ministry of Foreign Affairs and Trade, Hungary
- Ministry of the Environment and Spatial Planning, Slovenia
- International Sava River Basin Commission, Croatia
- Ministry of the Environment of the Czech Republic, Czech Republic
- Federal Ministry of Agriculture, Regions and Tourism, Austria
- Ministry of Economy and Sustainable Development, Croatia

Further information on the project, partnership and the Danube Transnational Programme:
http://www.interreg-danube.eu/approved-projects/danube-hazard-m3c

1. BACKGROUND AND CHALLENGE

Chemical compounds are an indispensable part of our life. They are contained in all consumer products, used by industry in production processes, in agriculture as pesticides, or in human and animal medicine. Some of these compounds are persistent to degradation, toxic and bioaccumulative and when released into the environment they may endanger aquatic life and the safe consumption of fish and drinking water. These so-called Hazardous Substances (HS), polluting the Danube river, are in the focus of this project.

Figure 1.
Danube Transnational Program area

The EU environmental laws, with the Water Framework Directive (2000/60/EU directive, WFD) as the main regulatory instrument for water protection, consider pollution with HS a major water quality issue. As rivers have no borders, these substances are transported across countries. This is why dealing with HS requires cooperation at the international level, also beyond the EU borders, as non-EU countries in the Danube River Basin (DRB) face this major issue too.

Despite the efforts made by the international community, reflected in the Danube River Basin District Management Plans (DRBMP) and national plans, there is a significant risk of failing to achieve the goals of the directive. This is mostly due to substantial knowledge gaps and a lack of institutional capacity in monitoring and modelling HS emissions and selecting the most effective management options. More focus must be thus put on the HS in the future in order to take effective steps towards achieving the goal of a healthy aquatic environment for all.

2. OBJECTIVES AND OVERALL CONCEPT

The project Danube Hazard m^{3}c (DH m^{3}c) aimed to pave the path towards a durable and effective transnational control and reduction of HS water pollution in one of the most important rivers in Europe, the Danube.

The project builds on the three elements of water governance:

- monitoring and data inventorying,
- modelling and management,
- complemented by capacity building.

Objectives of the DH m³c project:

- improving baseline knowledge on the fate of HS and the relevance of different emission sources affecting the status quo of water pollution,
- bridging the gap between science and policy by elaborating policy recommendations based on profound system analyses.

Project outcomes feed directly into the work of the International Commission for the Protection of the Danube River (ICPDR) and the national administrations within the partnership.

3. MONITORING AND MODELLING AS TOOLS PROVIDING A NECESSARY KNOWLEDGE BASE

HS released into the environment as a consequence of human activities, can be transported into surface and ground water from numerous point and diffuse sources via different pathways, as shown in Figure 2.

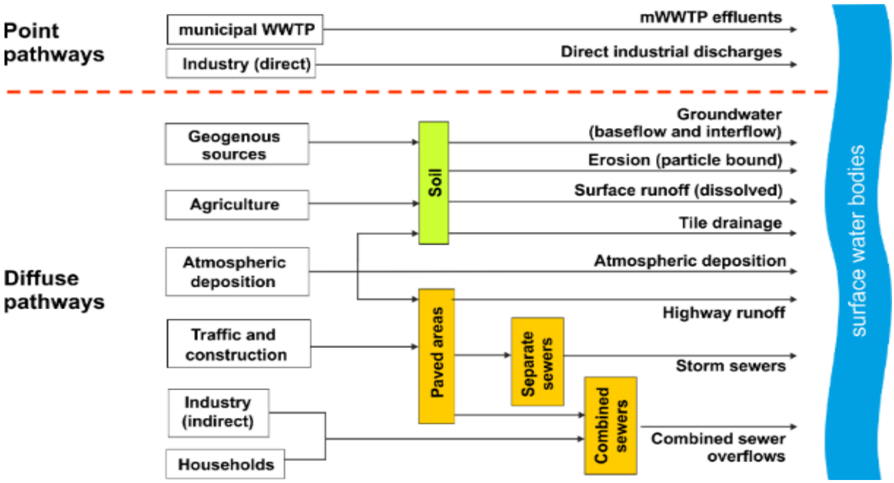

Figure 2. Sources and pathways of HS into the aquatic environment (S. Kittlaus CC-BY-SA 4.0)

A sound understanding of how this transport works is an indispensable foundation for developing policies and strategies serving the efficient management of HS. In order to make the best use of the limited resources, which authorities have available for managing water pollution, it is necessary to prioritize the identified problems according to their relevance and to select the most effective intervention points and methods (e.g. source control). The basis for obtaining the necessary information for this process is a target-oriented monitoring complemented by environmental modelling, which both make possible adequate characterization of pollutants transport routes.

The DH m³c project logic followed these steps:

1. Problem identification: Monitoring provides data on concentrations of the substances of interest in different emission pathways and environmental compartments (e.g. in atmospheric deposition, soils, wastewater, ground- and surface water). Surface and groundwater data were first used to check compliance with environmental quality standards (i.e. the regulatory thresholds set for specific compounds).

2. Build the models and validate: Secondly, combining the data on emissions pathways with cross-sectoral information on infrastructure (e.g. municipal and industrial water management), hydrology (e.g. river net, river flow), land use (agriculture, mining) and landscape morphology lead to establishing a pollution inventory (an extensive database).

3. Extrapolation: Collected data feed into emission models which then allow for instance extrapolating from a local to a regional or catchment scale, assessing the relevance of different sources and pathways of water pollution, predicting the concentration of HS in unmonitored rivers and evaluating scenarios of potential future developments regarding effects of management strategies.

3.1. Inventorying and monitoring results

PROJECT ACHIEVEMENT: DHm³c inventory database of HS concentrations has been established. DHm3c online database is available to everyone.

- The project team collected, merged and harmonized the fragmented and dispersed available information on the concentration of HS in rivers, soils, wastewater treatment effluents and groundwater from different countries of the Danube Basin into one comprehensive inventory database (Figure 3). This database also includes all DH m³c project measurement results.

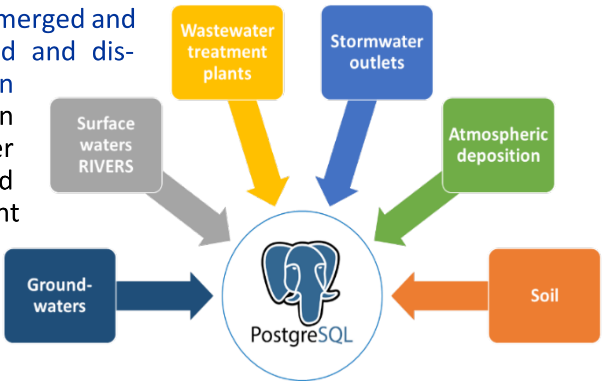

Figure 3. Structure of the DH m³c inventory database

- The DHm³c database establishes a valuable basis for assessing pollution levels in different compartments, deriving emission factors, identifying trends and generating consistent datasets for basin-wide modelling.

- Data collection provided an overview of the data availability and coverage of the measurements, which highlighted some important monitoring gaps and certain differences between partner countries (missing monitored pathways, lack of harmonization of methods, and data collection).

PROJECT ACHIEVEMENT: Targeted monitoring programme

- To fill critical information gaps and to demonstrate alternative and cost-efficient monitoring approaches, targeted monitoring campaigns were carried out in seven pre-selected Danube pilot regions located in Austria, Bulgaria Hungary and Romania (Figure 4). The regions have been selected to reflect distinctive traits with respect to climate, hydrology, land-use and pollution pressure.

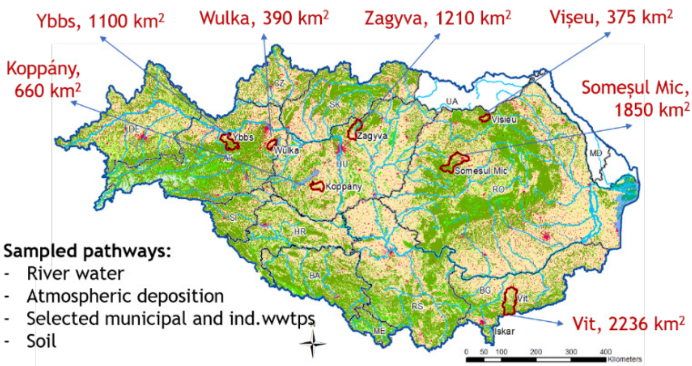

Figure 4. Pilot regions in the project

- Bearing in mind the large number of HS present in the water bodies, the project focused on 46 indicator substances from 5 different substance groups of high relevance in the Danube River Basin, which are representative for different major sources and emission pathways. These include pharmaceuticals, industrial chemicals, pesticides, combustion products and potentially toxic metals.
- The monitoring concept covered measuring concentrations and calculating loads in different pathways (as shown in Figure 5). In this way, significant transport routes could be identified the relevance of point and diffuse pollution sources, or the role of high flow events (linked to heavy rainfalls) in the contaminant transport in rivers could be understood better. The data collected during monitoring is a vital source of information for substance balances and input for modelling activities.

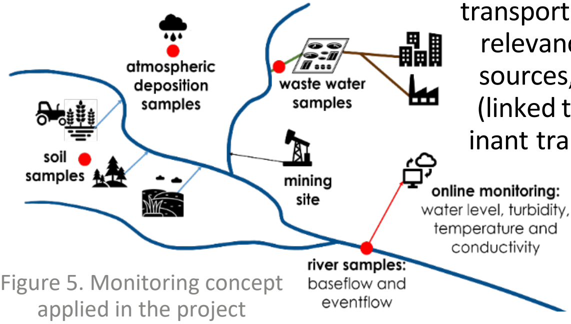

Figure 5. Monitoring concept applied in the project

Figure 6. Devices, probes and monitoring stations for online-measurements

Figure 6 offers a few impressions from the monitoring activities.

Measurements evaluation and risk assessment results

The monitoring was conducted at 20 surface water monitoring sites in seven pilot regions in four countries (RO, BG, HU, AT). Based on one-year weekly surface water monitoring covering mostly low and mean flow conditions, two-monthly composite samples (i.e. mixtures of individual samples collected over this period) were produced and analyzed. Event flow sampling with autosampler was performed for the proper representation of the flow conditions in rivers.

From the results of this high-frequency monitoring, a mean annual concentration was calculated, which should be comparable to the regular monthly (12 samples) monitoring results, often used for risk assessment under the Water Framework Directive.

The risk assessment covered the following inorganic and organic substances and substance groups.

Industrial chemicals: Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA), 4-tert-Octylphenol, Nonylphenol, and Bisphenol A.

Industrial chemicals and combustion by-products: 16 EPA Polycyclic aromatic hydrocarbons (PAHs).

Metals: Mercury (Hg), Cadmium (Cd), Copper (Cu), Nickel (Ni), Lead (Pb), Zinc (Zn), Chrome (Cr) and Arsenic (As).

Pharmaceuticals: Diclofenac and Carbamazepine.

Pesticides: S-Metolachlor (herbicide) including Metolachlor-ESA and Metolachlor-OA (metabolites), and Tebuconazole (fungicide).

Monitoring results from all monitoring stations were compared to the environmental quality standards (EQS) of Directive 2008/105/EU amended by Directive 2013/39/EU (on Priority Substances) and to the substances enacted on the national level (National Substance List). The number of sites and pilot regions, where exceedance of the EQSs was determined for certain compounds is shown in the table below.

Substance > EQS	Substance Group	No of monitoring sites	No of pilot regions	Countries	Regulation
PFOS	Industrial chemical	9	5	All	Directive 2013/39/EU
Cu	Heavy Metals	2	1	RO	National Substance List
Cd	Heavy Metals	2	1	RO	Directive 2013/39/EU
Zn	Heavy Metals	2	1	RO	National Substance List
s-Metolachlor	Pesticides	2	1	HU	National Substance List
Diclofenac	Pharma-ceutical	11	4	AT, HU, RO	New proposal of the revised Priority Substance List
Bisphenol-A	Industrial chemicals	20	7	All	New proposal of the revised Priority Substance List

In a second step, for each of these “risk” substances, dominant pathways were evaluated for each catchment with the aid of emission modelling. Considering the dominant pathways, scenarios are formulated, which enable assessing the potential effectiveness of a specific measure to mitigate pollution.

Note: *The new proposals of the revised Priority Substance List were also assessed, but do not form a legal basis for the designation of measures at the present time.-In addition, no assessment was performed for Benzo(a)pyrene (PAH) either. All measured values were below the limit of quantification, which, however, is clearly above the EQS.*

3.2. Modelling results

PROJECT ACHIEVEMENT: Two models have been applied and further developed to comprehensively estimate and visualise HS contamination of the Danube River Basin.

In the project, two complementary modelling approaches were used:

- The Modelling of Regionalized Emissions model[1] (MoRE) was applied to the seven pilot regions to quantify emission loads into surface waters via point and diffuse emission pathways.

[1] https://isww.iwg.kit.edu/english/MoRE.php

- Building on the increased system understanding thanks to this detailed analysis, the Danube Hazardous Substances Model (DHSM) was used to identify and estimate sources and emissions of HS for the whole Danube River Basin.

Monitoring results based on a stratified sampling of low flow periods and flood events were used to calculate annual substance loads and concentrations, even useful to validate model results. Uncertainties of input data and model approaches are taken into account by modelling base, minimum and maximum variants (Figure 7).

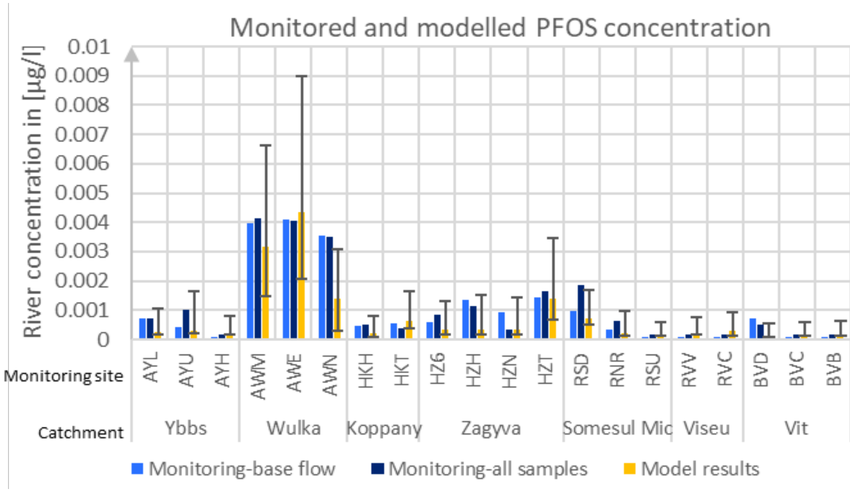

Figure 7. Monitored and modelled (MoRE)river concentration of PFOS at the outlets of the pilot regions and outlets of monitored sub-catchments

Modelling results, obtained with both approaches, show the contribution of single pathways (Figure 8) as well as regional hot spots for the substances of interest (see Figure 9 for PFOS example).

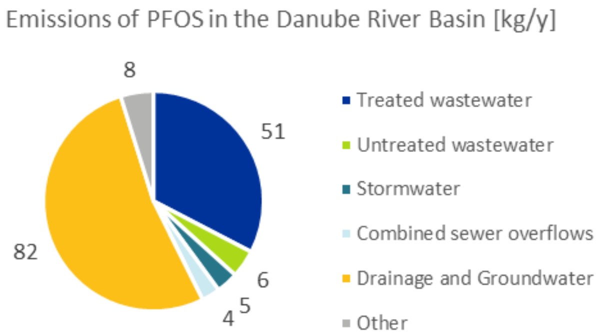

Figure 8. The relative share of simulated pathways of PFOS (DHSM)

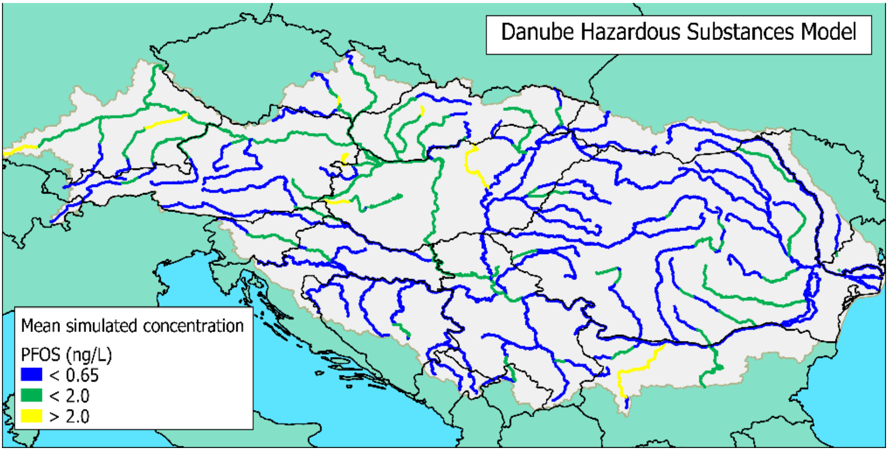

Figure 9. Estimated concentrations of PFOS at DRB scale
(values below EQS are displayed in blue)

Substance specific conclusions

Carbamazepine (Car) and Diclofenac (Dic) are pharmaceuticals: These two chemicals are mainly used in human medicine and therefore are mainly emitted to natural water systems via municipal wastewater. As they have poor adsorbability and poor degradability, they are hardly removed by biological wastewater treatment and the main emission pathway is direct emissions from sewer systems without wastewater treatment or treatment plant effluents. Pharmaceuticals used in veterinary medicine may take more diffuse emission pathways (e.g. surface runoff, groundwater) partly included in the modelling approaches, nevertheless they were not investigated in the project.

Perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), bisphenol A (BPA), nonylphenol (NP), 4-tert-octylphenol (4tO) are industrial chemicals: They differ widely in application and in chemical-physical properties. They enter the water systems via multiple pathways. Due to their mobility and high persistence, PFOS and PFOA and other „new" substances of the large group of Per- and Polyfluoroalkyl Substances (PFAS) are of major emerging environmental concern.

Metolachlor (Met) and Tebuconazole (Teb) are pesticides used in agriculture: Therefore, emissions from agricultural areas directly via surface runoff and erosion or indirectly via groundwater runoff are the main inputs into surface water. Additionally, due to applications in urban settlements (facades or roofs), urban areas may locally contribute to surface water pollution as well.

Benzo(a)pyren (BaP) is a PAH compound: PAHs such as BaP or fluoranthene are produced as side products of combustion processes, but are contained in some products (e.g. tires) as well. The main emission pathways are via air leading to accumulation in soils and making soil erosion the main emission pathway to surface water on a regional scale. Locally runoff from roads may also contribute to water pollution in relevant shares.

Cadmium (Cd), lead (Pb), copper (Cu), nickel (Ni), mercury (Hg), and zinc (Zn) are metals and arsenic (As) is a metalloid: They naturally occur in the environment. Some (Cu, Zn) are essential nutrients. However, if their safe thresholds in the environment are exceeded, they may adversely affect aquatic life and humans. Different activities (traffic, impurities in fertilizers, air emissions from heating, corrosion) lead to their enhanced distribution into the environment and enrichment in soils. Thus, soil erosion is the main direct input pathway to water bodies. For effective policies one needs to know, that (1) in many cases the soil is contaminated historically; and (2) the atmospheric transport can be significant, i.e. pollution transport over long distances (e.g. mercury). In addition, specific pollution hotspots from some industrial activities (e.g. metallurgy or combustion plants) and mining may lead to high levels of local to regional pollution.

4. POLICY RECOMMENDATIONS

The main EU water regulatory instrument, the Water Framework Directive (WFD 2000/60/EC), with its related acts, addresses management of HS pollution in water and constitutes the backbone of the relevant national water policies. It aims to set framework conditions for a harmonised implementation of various measures at the national level, e.g. the list of priority substances to be controlled or phased out, rules for controlling specific industrial emissions, or rules on pesticide application.

PROJECT ACHIEVEMENT: Comparative assessment of the existing policies
The national legislations are facing challenges since many of the water management related EU legislations have been revised in line with the EU Green Deal and its related strategies such as the Farm to Fork Strategy, the Biodiversity Strategy and the Zero Pollution Action Plan. While keeping the environmental and climate objectives ambitious, the revision process will likely bring challenges for water management by tightening the requirements and/or extending the scope of numerous water-related regulations for urban wastewater treatment, industrial technology implementation and pollution control, integrated pest management, agricultural measures, chemical monitoring and reaching good chemical status.

Moreover, in some Danube countries, substantial lack of institutional capacity, unclear responsibilities, insufficient intersectoral dialogue and knowledge gaps regarding monitoring data and chemical emissions hinder the establishment of an efficient management. On the top of this, climate change could exacerbate the impact of HS pollution, in particular the heavy rainfall events and the prolonged droughts with low flow conditions, causing high river loads and increased in-stream concentrations, respectively.

PROJECT ACHIEVEMENT: The policy guidance

In the frame of the project a guidance document recommending sound policy instruments and effective measures for managing HS pollution has been developed. The target audience of the document is decision-makers in the water management policy field. It offers Danube countries support for the preparation and implementation of tailor-made national water management policies. Selected recommendations worked out in the framework of the guidance and the proposed way forward are presented here.

The guidance and the first ideas for recommendations were presented at the 25th International River Symposium, where experts representing various countries and sectors discussed the policy aspects of HS pollution control. This exchange substantially helped the elaboration of the guidance.

1. Need for harmonization

Monitoring approaches of the Danube countries and the evaluation of the measurements need to be better harmonized.

- Danube countries should designate together an updated list of river basin specific pollutants (RBSPs) for the DRB, which are intensively used and problematic for the waters in the basin. This list should be determined by harmonizing the existing lists of potential Danube RBSPs derived by the Joint Danube Surveys (JDS) and national lists of RBSPs. The list is to be subject to regular updates based on future scientific investigations.

- Danube countries may consider harmonizing the immission[2] and emission[3] targeted monitoring programs as appropriate. In the first step, detailed descriptions are required for each type of monitoring programs, indicating the aim of the programs and number of HSs, why certain priority substances are missing, where the sampling points are, what the monitoring frequency is, etc. This information should be then shared and discussed with the Danube countries.

- Danube countries are advised to harmonize the sampling and analytical methods towards using standardized methods for the common parameters and including wider application of methods for assessing the impacts of mixtures of HS on water bodies and ecosystems.

[2] Amount (concentration) of a pollutant present in the environmental compartment.
[3] Amount (flux) of a pollutant that is actually emitted from the source.

- It is suggested to harmonize the Environmental Quality Standards (EQS) of the compounds of transboundary importance based on total or bioavailable concentration values in water as well as concentrations in sediment and biota, as appropriate.
- It is recommended to harmonize the respective emission standards for urban and industrial wastewater discharges as well as to incorporate the evaluation and control of the discharges from combined sewer overflows[4] into the regulations.

The adequate answer to these needs will contribute to establishing an enabling regulatory framework and to more effectively control and reduce HSs pollution in the DRB.

2. Towards a sound knowledge base: emission inventory

Developing a comprehensive and sound knowledge base is a prerequisite towards an effective control of HS pollution. On one hand, it should include consistent emission inventories for indicator substances, especially targeting the major emitters such as industrial facilities and urban wastewater treatment plants but also diffuse sources that are difficult to monitor. Diffuse emission inventories should be based on catchment-scale water quality models with appropriate emission factors, representing all relevant pathways, while maintaining the link to sources. These models are able to trace back water emissions to pathways and sources and can assess the impact of measures on water status and their efficiency to reduce emissions.

In addition, there is a strong need for well-designed and targeted monitoring efforts throughout the DRB over longer periods, focusing on a limited number of substances. Well-designed investigative monitoring programs for establishing an emission inventory should be started at least where there is already an identified problem or pollution risk is relevant. It is recommended to develop and use a harmonized, comprehensive transboundary database including HS concentrations in all relevant environmental media and emission pathways, taking into account that relevant pollution sources could be located beyond national borders. In addition, the database should contain certain spatial, statistical and environmental data that are of high importance for the inventory development and interpretation (e.g. landuse, population, river discharge).

These data would provide a good empirical basis and system understanding for the modelling, for identifying the emission sources but also for the selection of the most-effective combination of measures. A list of indicator

[4] Combined sewer systems - that carry wastewater and stormwater in one pipe - become overwhelmed by excess stormwater and overflow into streams.

substances for emission inventories has to be carefully selected and established at the basin-wide level based on thorough discussions and consensus. All relevant pollutant groups should be represented in the inventory.

Application of modelling-based risk assessment at river basin scale can help optimizing the overall surface water monitoring process. Emission monitoring, modelling and inventory development can reduce the immission monitoring costs by orienting surface water monitoring to those water bodies where the pollution pressure is significant. They can also help focusing monitoring efforts on new and problematic compounds for which little knowledge is available. Importantly, better or even free access to the monitoring and inventory data as well as on registered emitters should be provided.

Action plan to develop a comprehensive emission inventory

Suggested actions to develop an emission inventory are as follows (Figure 10):

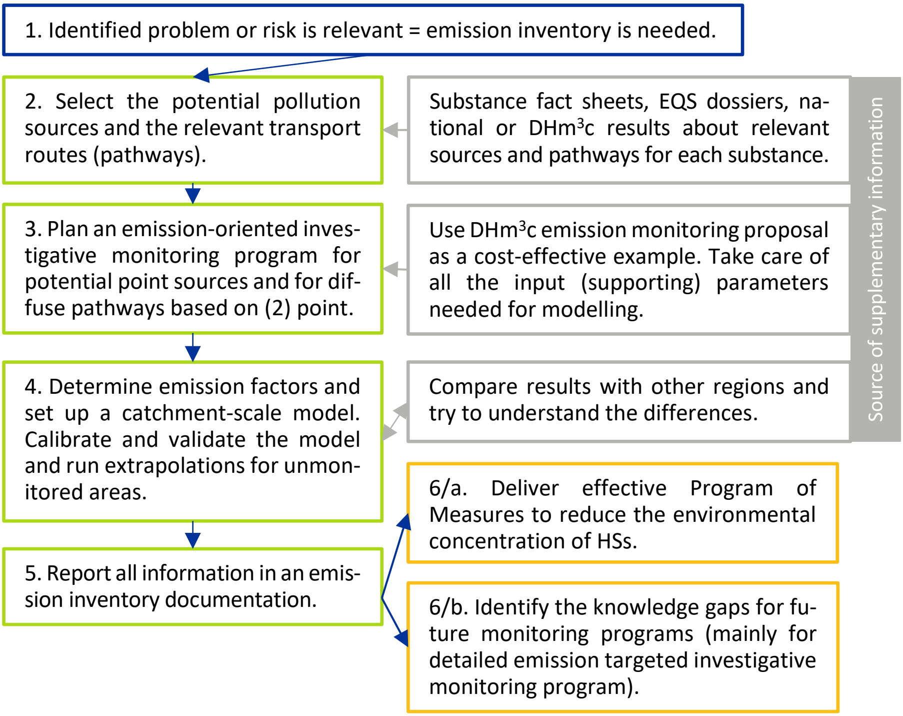

Figure 10. Development of emission inventories

3. Towards an efficient management: Program of Measures

Future water management efforts on HS pollution should change the paradigm by shifting the focus from substances to pathways through:

- defining "priority pathways" instead of priority pollutants because water management interventions are directed at some critical pathways and have less impact on regulatory frameworks related to chemicals' admission or use;
- defining "marker substances" for these priority pathways since too many substances are in use to monitor all of them.

Program of Measures on controlling HS pollution should address the following aspects:

- Designing and implementing pollution control measures in all relevant sectors, in a harmonized and coordinated way and in line with the pollution control hierarchy (Figure 11).
- Providing regulatory incentives to the emitters to substantially reduce the discharge of HS through limiting or banning the use of certain persistent substances or setting appropriate pollution fees.
- Considering the extended producer responsibility approach targeting the main polluters responsible for the emissions and shifting economic responsibility towards producers, along with strengthening the inspection mechanism over the production chain.
- Providing economic incentives for developing and implementing up-to-date technologies and substituting harmful substances.
- Raising awareness on the negative effects of chemicals on the environment and provision of information and facilities for safe disposal of harmful substances at the local level.

Action plan to implement efficient measures

Measures should be implemented in accordance with the pollution control hierarchy, represented by an inverse pyramid (Figure 11).

- Priority should be given to prevention at the source to avoid the unnecessary release of harmful chemicals. This can be ensured by banning or limiting the production and market placing of certain hazardous chemicals but also improved waste and pest management can play an important role to reduce the release of these substances. Moreover, behavioural change of people, education and awareness raising in society are also crucial to ensure the reasonable and responsible use of chemicals in daily life.
- Since many of the chemicals are widely used and their presence cannot be prevented, measures controlling the emission pathways and the mobilization of pollutants are of utmost importance for water management. Appropriate treatment of municipal and industrial wastewater, best available techniques at industrial sites, controlling combined sewer overflows and rainwater inlets, water retention in urban areas, reducing runoff and soil loss from the field by constructional measures and best management practices are the most important interventions.
- Finally, the chemical fluxes can be further retained by applying retention measures both on the field and in the river, for example, buffer zones, green infrastructure measures, wetlands and floodplains are great examples of these measures, which have other positive impacts on the water status such as water retention, flood mitigation, climate change adaptation and preserving biodiversity. Nevertheless, they should not be considered as primary nature-based treatment facilities replacing source or pathway control measures.

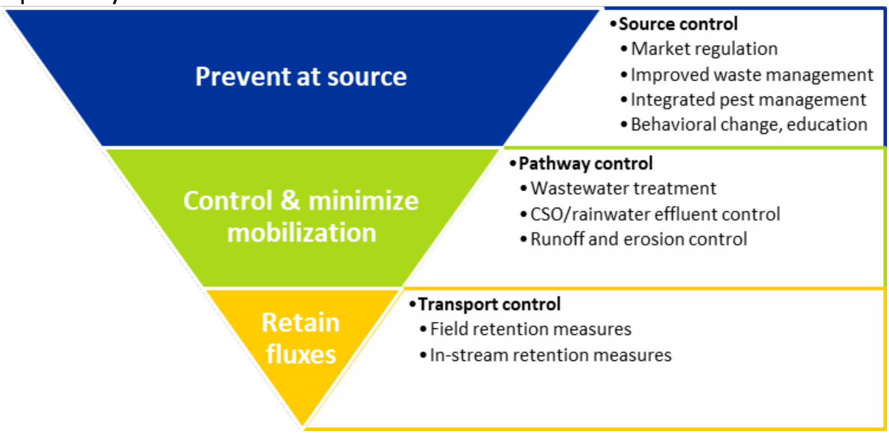

Figure 11. Pollution control hierarchy

5. CAPACITY BUILDING

There is a strong need to further develop and better harmonize the regulatory framework of the Danube countries and increase institutional capacities in inventorying, monitoring and modelling to address the HS pollution of the Danube effectively. Therefore, the project included a tailor-made program of capacity building activities. Through national and transnational trainings, a final workshop, and a set of new tools that are made available DHm^{3}c strives, among others, to achieve progress in the harmonization of data and methods used for pollution control among all DRB countries. Having comparable results at the basin level requires common methodological approaches for HS measurements and modelling. All this is very important for developing effective transboundary HS pollution management strategies. How to best achieve these goals was the leading subject discussed during these events.

PROJECT ACHIEVEMENT:
8 national training courses on monitoring and inventorying

The main purpose of the national training courses held in eight Danube River Basin countries was to improve the knowledge and skills of experts working in the field of water management. It focused especially on innovative smart monitoring strategies for the effective assessment of concentrations and loads through different emissions pathways and in rivers, as well as on the assessment of the chemical status of water bodies. In Figure 12 you can see some photos from those lively events, where more than 400 participants were trained, and represented the relevant stakeholders from pilot regions and not only (water users, sector agencies, interest groups from industry, agriculture, environmental protection and researchers). During all national training courses, some useful lessons were learned and recommendations for future developments were formulated. One of the important achievements of the national training events was the improvement of the understanding of the concepts, approaches and methodologies for developing harmonized inventories for HS emissions, including their relevance for HS modelling.

PROJECT ACHIEVEMENT: 3 transnational training courses on modelling

A more in-depth insight into the HS modelling was the main topic of the e transnational trainings held in Bucharest, Budapest and Vienna. It was clear from the beginning that HS modelling is a new approach, very modestly implemented in the countries of the DRB. The goal of this event was to share knowledge and improve relevant skills and competencies of the participants from the Danube region regarding HS modelling, and to present modelling potential to improve future HS pollution control and management. On Figure

13 you can see a sew suggestive images from those trainings, that represented a great opportunity to share valuable information, knowledge, experiences, and approaches related to modelling topics on HS emissions.

PROJECT ACHIEVEMENT: Technical Guidance Manual

Based on the overall activities carried out in the frame of the project a "Technical Guidance Manual with best practices on hazardous substances pollution management" has been developed to provide a practical support in monitoring and modelling of HS pollution for practitioners. It is considered an important instrument for stakeholders of the project.

PROJECT ACHIEVEMENT: An international final DHm^{3}c workshop

The final results of the project were presented and discussed with international experts in the framework of a conference and a workshop in Vienna, both embedded into the **25th International River Symposium** (Figure 14). In total, 40 participants, representing 13 countries, attended the workshop.

Figure 12. National trainings on monitoring: presentations and field trips
upper left: Balatonszárszó, HU; right: Zagreb, CR;
middle left: Colibita Lake, RO; right: Vienna, AT;
lower right: Koppány catchment, HU; right: Bratislava, SK)

Figure 13. Transnational trainings on modelling
left: Budapest, HU; and right: Vienna, AT

Figure 14. Presentation of the results at the 25th International River Symposium (left) and the participants of the final project meeting (right) in Vienna

PROJECT ACHIEVEMENT: Training packages

In line with the project aims, the project partners jointly developed learning packages that covered the main topics addressed in the frame of the project. These packages were used in training courses held at the national and transnational level, mentioned above.

The need for close cooperation, the exchange of knowledge both at the national and regional level, as well as the need to strengthen technical and professional capacities, were highlighted in all training events. By raising awareness among different institutions at the national, regional, and transnational levels on critical aspects of data collection, data management, and monitoring, the dialogue focusing on different goals and perspectives related to monitoring and inventorying, further capacity development should be continued in the future to aid a reliable and robust assessment of emissions and their potential reduction.

6. PROJECT ACHIEVEMENTS

DH m^{3}c

The main outputs and deliverables of the Danube Hazard m^{3}c project are as follows:

- Inventory database of concentrations of hazardous substances in the DRB
- Demonstration of a harmonized and cost-effective measurement concept for the monitoring of HS river pollution and of HS emission pathways in 7 pilot regions
- Harmonized MoRE model adapted to specific territorial characteristics within the DRB
- Report on improved system understanding as basis for adapted transnational emission modelling at DRB scale
- Demonstration of the management plan development process at watershed level for HS pollution based on detailed emission modelling in 7 pilot regions
- Report on existing policies and management plans regarding HS water pollution in the DRB
- Upgraded version of the Danube Hazardous Substances Model (DHSM) adapted to territorial needs for transnational modelling of HS emissions in the DRB
- Policy guidance document for improved representation of HS in the DRBMP and national RBMPs
- Technical guidance manual on HS management for stakeholders
- National trainings on monitoring and inventorying of HS pollution and Training material packages, available in English and in 9 official languages of the DRB
- Three transnational trainings on modelling and scenario evaluation and Training material package, available in English
- International workshop on management of HS pollution

Impressum
Published by Budapest University of Technology and Economics, Department of Sanitary and Environmental Engineering
H-1111 Budapest, Műegyetem rkp. 3.
www.vkkt.bme.hu

Edited by Katalin Mária Dudás
English version is based on project status at 14.03.2023.
National translation created by Adrienne Clement
Printed by BME