Managing an International River Basin Towards Water Quality Protection: The Danube Case

Igor Liska

Abstract Nineteen countries share the Danube catchment area, making it the world's most international river basin. Given the number of the countries and the diversity of social, political and economic conditions, the transboundary river basin management is of supreme importance in the Danube River Basin. The Danube River Protection Convention signed in 1994 is the legal instrument for cooperation and transboundary water management, and it led into establishing the International Commission for the Protection of the Danube River (ICPDR). In reaction to the requirements of the EU Water Framework Directive and of the EU Floods Directive, the Contracting Parties of the ICPDR committed themselves to use the ICPDR as a platform for implementing these directives in the Danube River Basin District and for coping on a basin-wide level with the key pressures related to organic pollution, pollution by nutrients and hazardous substances, hydromorphological alterations, flood protection, navigation, hydropower, sediment management and groundwater management. The ICPDR established the Transnational Monitoring Network which regularly monitors water quality in the Danube River Basin as well as the Danube Accident Emergency Warning System which alerts the Danube countries in case of transboundary pollution accidents. The first Danube River Basin Management Plan was published in 2009, and it set the programme of measures with the view of reducing the pressures on the surface and groundwater. At present the first Danube Flood Risk Management Plan is under finalization focusing on flood prevention, protection and preparedness taking into account the environmental objectives of the EU Water Framework Directive. Of high importance is also the cooperation with the other sectors such as navigation and hydropower aiming at sustainable economic development while avoiding the adverse

I. Liska (✉)
International Commission for the Protection of the Danube River, Vienna International Centre, D0445, Wagramer Strasse 5, 1220 Vienna, Austria
e-mail: Igor.Liska@unvienna.org

I. Liska (ed.), *The Danube River Basin*, Hdb Env Chem (2015) 39: 1–20,
DOI 10.1007/698_2015_388, © Springer-Verlag Berlin Heidelberg 2015,
Published online: 9 July 2015

effects on the water status. Using a synergy between implementing the Convention and the current EU legislation, a significant progress has been achieved in ensuring the protection and improving water quality in the Danube River Basin.

Keywords Programme of measures, River basin management, The Danube, Water quality monitoring

Contents

Abbreviations

AEWS	Accident Emergency Warning System
BAT	Best available technologies
BOD_5	Biochemical oxygen demand
COD	Chemical oxygen demand
DEFF	Data exchange file format
DRB	Danube River Basin
DRBD	Danube River Basin District
DRBMP	Danube River Basin District Management Plan
DRPC	Danube River Protection Convention
EU MS	Member State of the European Union
FD	EU Floods Directive
ICPDR	International Commission for the Protection of the Danube River

JDS	Joint Danube Survey
NGO	Non-governmental organization
PAH	Polycyclic aromatic hydrocarbons
PRTR	Pollutant Release and Transfer Register
SPM	Suspended particulate material
TNMN	Transnational Monitoring Network
UWWTD	Urban Wastewater Treatment Directive
WFD	Water Framework Directive
WWTP	Wastewater treatment plant

1 Introduction

The Danube River Basin is Europe's second largest river basin, with a total area of 801,463 km^2. More than 80 million people from 19 countries share the Danube catchment area, making it the world's most international river basin [1]. The map of the Danube River Basin District is shown in the Fig. 1.

Given the complexity of the basin, the transboundary river basin management has been considered for decades as a top priority in the Danube River Basin. The official start of the joint cooperation of the Danube countries in water quality protection dates back to 1985 when the Bucharest Declaration was signed giving the way to 'cooperation on questions concerning the water management of the Danube'. However, there was still a need to develop an international strategy for the protection of water resources in the Danube catchment area. Therefore, on the basis of the UNECE Convention on the Protection and Use of Transboundary Waters (Helsinki Convention), a corresponding agreement relating to the international law for the Danube River Basin was developed. The Convention on the Protection and Sustainable Use of the Danube River (Danube River Protection Convention, DRPC) was signed in June 1994 in Sofia [2]. The DRPC was designed to encourage the Contracting Parties to intensify their water management cooperation in the field of water protection and use. With its entry into force on 22 October 1998, the DRPC became the overall legal instrument for cooperation and transboundary water management in the Danube River Basin.

The objectives of the Danube River Protection Convention are as follows:

- Ensuring sustainable and equitable water management
- Conservation, improvement and the rational use of surface waters and groundwater
- Controlling discharge of wastewaters as well as of the inputs of nutrients and hazardous substances from point and non-point emission sources
- Controlling floods and ice hazards
- Controlling hazards originating from accidents (warning and preventive measures)
- Reducing pollution loads entering the Black Sea from sources in the Danube catchment area

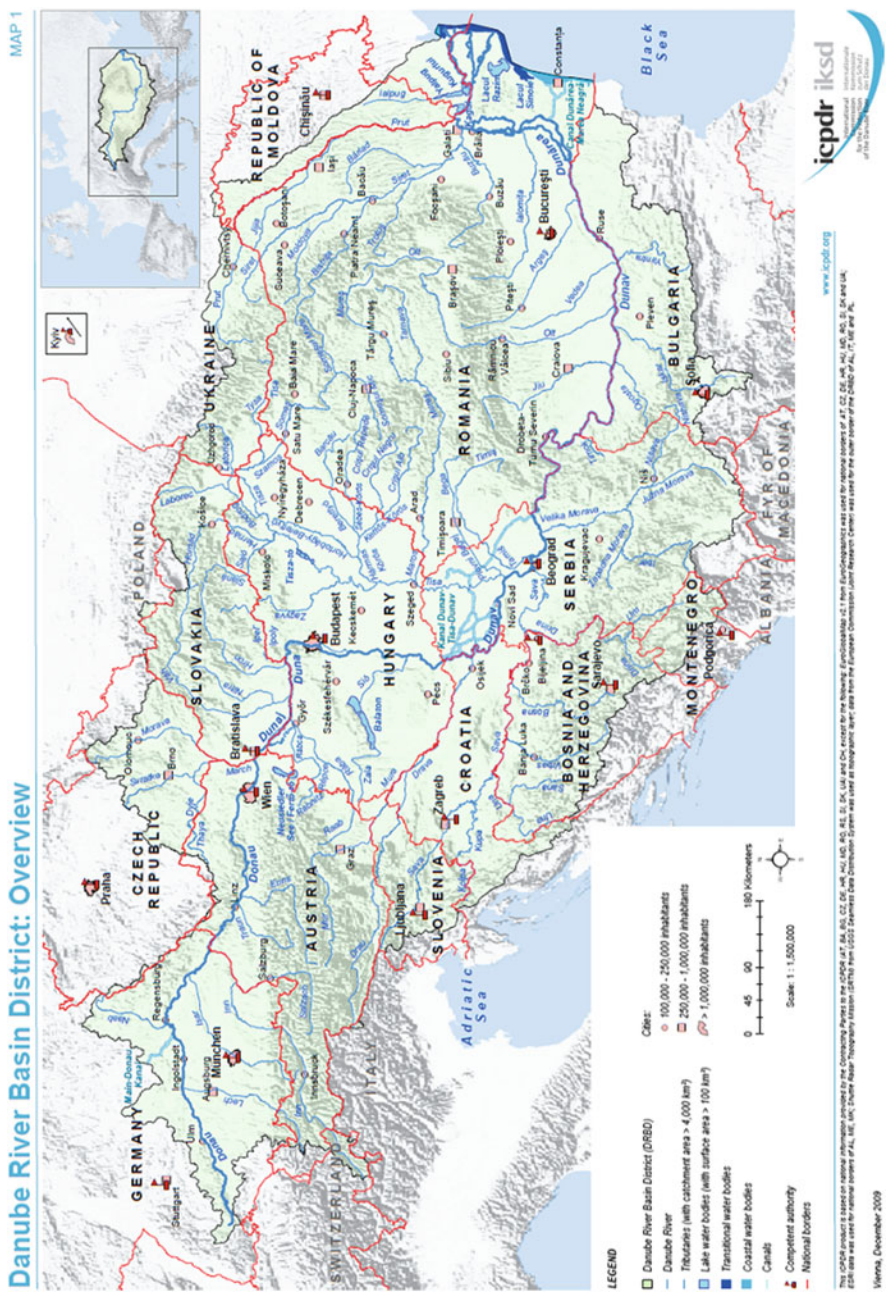

Fig. 1 Danube River Basin District

Responding to the obligations of the Convention, the Danube countries have established the International Commission for the Protection of the Danube River (ICPDR) to strengthen regional and transboundary cooperation.

2 Major Pressures to Water Quality in the Danube River Basin

2.1 Organic Pollution

Organic pollution is mainly caused by the emission of partially treated or untreated wastewater from agglomerations, industry and agriculture. Many agglomerations in the Danube River Basin still have no, or insufficient, wastewater treatment and are therefore key contributors to organic pollution. According to the Danube River Basin Management Plan [3], a total of 6,224 agglomerations $\geq$2,000 PE are located in the DRBD, and wastewaters are not collected at all in more than 2,900 agglomerations (12.6% of the total generated load). Approximately 1,000 further agglomerations have collection systems that require more stringent treatment. A preliminary analysis on industrial and food industrial sources of organic pollution identified a total number of 173 facilities emitting directly into the DRBD and 189 facilities with indirect emissions to water through urban sewers [3].

2.2 Nutrient Pollution

Nitrogen and phosphorus emissions cause eutrophication in many surface waters of the Danube River Basin and contribute to eutrophication in the Black Sea North Western shelf. For the period 1988–2005, the Danube, as one of the major rivers discharging into the Black Sea, was estimated to introduce on average about 35,000 tonnes of phosphorus and 400,000 tonnes of inorganic nitrogen into the Black Sea each year [3].The main sources of nutrients in the Danube are agriculture (50%), municipal wastewater (25%) and industry (25%). The legal limit for nutrient content in groundwater is often exceeded throughout the whole basin [1].

Nutrient pollution from point sources is mainly caused by emissions from insufficiently or untreated wastewater into surface waters (from agglomerations, industry and agriculture). Diffuse source pollution is caused by widespread activities such as agriculture. The levels of diffuse pollution are not only dependent on anthropogenic factors such as land use, and land use intensity, but also on natural factors such as climate, flow conditions and soil properties. These factors influence pathways that are significantly different. For nitrogen, the major pathway of diffuse pollution is groundwater, while for phosphorus, it is erosion.

2.3 Hazardous Substances

The major sources of hazardous substances in the Danube River Basin are industrial effluents, storm water overflow, pesticides and other chemicals applied in agriculture as well as discharges from mining operations and accidental pollution.

Information about the emissions of hazardous substances into water in the Danube River Basin was collected through the ICPDR emissions inventories; nowadays, it is brought together in PRTR.

Data on occurrence of hazardous substances in water are collected by the national monitoring programmes; the key attention is given to the priority substances according to the Directive 2008/105/EC [4] amended by the Directive 2013/39/EC [5] and to other specific substances determining the ecological status according to EU WFD [6]. Hazardous substances are also addressed in the ICPDR monitoring activities: few priority substances are annually analyzed within the Transnational Monitoring Network, while a wide range of hazardous substances is monitored during Joint Danube Surveys

2.4 Hydromorphological Alterations

Anthropogenic pressures resulting from various hydro-engineering measures can significantly alter the natural structure of surface waters. This can have negative effects on aquatic populations and result in the deterioration of the status of surface waters. Hydropower generation, navigation and flood protection are the key water uses causing hydromorphological alterations. The Danube River Basin Management Plan identified three key hydromorphological pressures of basin-wide importance: interruption of river and habitat continuity, disconnection of adjacent wetlands and floodplains and hydrological alterations. Attention has to be given also to the planned and ongoing infrastructure projects in the Danube River Basin as they may impact the river hydromorphology adversely.

2.5 Sediment Management

According to the Danube River Basin Management Plan, the sediment balance of most large rivers in the Danube River Basin is considered as disturbed or severely altered. River engineering works, dredging, torrent control, hydropower development and the reduction of adjacent floodplains are the most significant pressures to sediment management. Hydropower plants in the upper Danube catchments trap almost 80–90% of the sediment bed load. In the lower Danube, the transport of suspended load currently reaches only 30% of the original amount recorded, due to abundant anti-erosion and hydro-technical works throughout the entire Danube

River Basin and significant sediment settling in the Iron Gate 1 reservoir. Quality of sediments suffers from emissions of persistent and toxic substances. While recent results for the organochlorinated compounds in sediments and suspended particulate material (SPM) indicated relatively low concentration profiles of these contaminants in the Danube, concentrations of PAHs have been occasionally found at elevated levels. Contamination of sediments by heavy metals (in particular by lead, cadmium, mercury and nickel) is also of concern [3].

2.6 Invasive Alien Species

The Danube River Basin is very vulnerable to invasive species given its direct linkages with other large water bodies. The Danube is a part of the Southern Invasive Corridor (Black Sea–Danube-Main/Danube Canal–Main-Rhine–North Sea waterway), one of Europe's four most important routes for invasive species, and therefore exposed to intensive colonization by invasive species. Results of the second Joint Danube Survey [7] revealed that invasive species have become a major concern for the Danube and that their further classification and analysis are vital for effective river basin management and, especially, for the correct assessment of the ecological status of surface waters.

2.7 Flood Protection

The Danube River Basin suffered from numerous floods in the past; only in the last decades, massive flood events occurred in 2002, 2006, 2010, 2013 and 2014. Despite floods being natural phenomena, the impact of floods has considerable environmental and health consequences. Storage of hazardous substances inside the flood risk areas may result in harmful impacts of water pollution on ecosystems during minor and major floods. Therefore, the Directive 2007/60/EC [8] requires to provide for the establishing of flood hazard maps and flood risk maps including information on potential sources of environmental pollution as a consequence of floods and to develop flood risk management plans listing measures addressing flood-related pollution. It is however to be stressed that structural flood protection measures have a potential to affect water quality significantly, and therefore, their implementation has to respect the environmental objectives of Article 4 of the Directive 2000/60/EC. Therefore, EU environmental legislation asks for the evaluation of better, feasible environmental options to the proposed structural changes to rivers if these changes could lead to a deterioration of the status of these waters. The Water Framework Directive sets out such requirements and strives to balance maintaining human needs while protecting the environment with the ultimate goal of achieving a sustainable approach to water management. Natural flood management considers the hydrological processes across the whole catchment of a river to

identify where measures can best be applied, with a focus on increasing water retention capacities.

2.8 Navigation

Historically, the Danube and some of its tributaries have formed important trade routes across Europe. The harnessing of these rivers to facilitate navigation has radically changed their physical and ecological characteristics, while pollution from ships and boats is also a problem. Navigation is a pressure which can potentially affect the ecological and chemical status of large river systems. The major pressures resulting from navigation are changes of the natural river structure and to river course (such as the blocking of connections to separate channels, tributaries and wetlands), disruption of natural flow patterns by hydromorphological alterations, hindering fish migration due to sluices, engineering works designed to remove sediments and clear channels, accidental pollution involving oil or hazardous substances, pollution by discharged bilge water and by wastewater from tank washings and sewage from passenger boats and inadvertent introduction of invasive species (http://www.icpdr.org/main/issues/navigation).

Navigation requirements can result in a stabilized, single thread, ecologically uniform river channel, lacking both natural in-stream structures with their gentle gradients and connectivity with the adjacent floodplains. In addition to other hydromorphological alterations, this might lead to the loss of species [9].

2.9 Hydropower

The increased use of energy from renewable sources, together with energy savings and increased energy efficiency, is an important step towards reduction of greenhouse gas emissions to comply with international climate protection agreements. This development represents a significant driver for the future development of hydropower generation in the countries of the Danube River Basin. The most serious problems resulting from the construction of hydropower facilities are the disruption of the longitudinal continuity of the rivers and dramatic changes in the rivers' hydrological characteristics.

2.10 Groundwater Management

Groundwater should not only be viewed as a key source of drinking water, but it has to be protected for its environmental value as well. Due to slow groundwater flows, the impacts of anthropogenic activities may be detected with a substantial delay.

The overall assessment of pressures on the quality of major transboundary groundwater bodies in the Danube River Basin showed that pollution by nitrates from diffuse sources is the key factor affecting the chemical status of these groundwaters. The major sources of this diffuse pollution are agricultural activities, non-sewered population and urban land use. Groundwater quantity in the Danube River Basin is affected by groundwater abstraction for drinking water supply and for industrial and agricultural use.

3 Major Achievements in Protecting and Improving the Water Quality

3.1 Cooperation in Implementing WFD in the Danube River Basin

In 2000, EU adopted the Water Framework Directive (WFD) to bring together and integrate work on water resource management. The basis for the WFD-related activities is the river basin. The directive's environmental objective is to restore every surface and groundwater body across the EU to a 'good status' by 2015. This includes a good ecological and chemical status for surface waters and a good chemical and quantitative status for groundwater. With the coming into the force of the EU Water Framework Directive in December 2000, the countries of the Danube committed to use this legislation to assist in meeting the goals of the Convention. The commitment to use the methods and meet the goals of the Directive was made by all countries, i.e. not only EU Member States but also accession countries and countries not in the EU (such as Serbia or Moldova). The ICPDR plays a coordinating role in ensuring that a river basin management plan for the entire basin is prepared [10]. The key component in the process of the WFD implementation was the preparation of the Danube River Basin District Management Plan (DRBMP). The key elements of the plan are the analysis of significant pressures in the Danube River Basin, description of monitoring networks and overview of the status of water bodies, economic analysis of water uses and Joint Programme of Measures that were planned to meet the WFD environmental objectives. An important issue in preparation of the Plan was the work of the Danube experts towards the evaluation of pressures on the water bodies, including pollution by organic substances, nutrients and hazardous substances. A comprehensive set of emission data that enabled application of models (just to mention the most important one – MONERIS – which was applied for the assessment of diffuse pollution on a basin-wide scale (http://moneris.igb-berlin.de/) provided the necessary data for preparation of scenarios being an essential foundation for setting the measures.

3.2 Joint Programme of Measures

The Danube Joint Programme of Measures outlines specific actions and scenarios at the basin-wide scale and their likely outcomes by 2015 and beyond. It is firmly based on the national programme of measures of each Danube country, which shall be implemented at the latest by 2012. The Plan also indicates where the proposed measures remain insufficient to meet the WFD requirements on a basin-wide scale and proposes additional actions. It indicates where action is needed and also where further monitoring effort is required. The Plan focuses on the main transboundary problems, the Significant Water Management Issues, that can directly or indirectly affect the quality of rivers and lakes as well as transboundary groundwater bodies. For the Danube River Basin, these were identified as pollution by organic substances, pollution by nutrients, pollution by hazardous substances and hydromorphological alterations or changes to the natural character and structure of the water body. Based on the detailed picture we now have of the Danube Basin waters, the DRBM Plan outlines visions for each issue to achieve an improved and sustainable water environment [11].

Measures identified in the Joint Programme of Measures for organic pollution will result in a considerable reduction of BOD_5 and COD loads. However, following the baseline scenario will still not ensure the achievement of the WFD environmental objectives on the basin-wide scale by 2015. Significant further efforts for the next RBM cycles will still be necessary to ensure this. In the long run, the technical implementation of the UWWTD requirements [12] as well as the IPPC Directive [13] by EU MS and an equal level of measures in non-EU MS would be sufficient to solve the problem of organic pollution.

The planned measures will decrease nitrogen and phosphorus emissions to surface waters in 2015 by 12% and 21%, respectively. This will remarkably improve the situation in the Danube River Basin and the Black Sea, but it will still not be enough for achieving the management objectives of the DRBMP and the WFD environmental objectives on the basin-wide scale. Reductions in nutrient pollution will be achieved as soon as more stringent UWWT obligations with N and P removal for agglomerations >10,000 PE are applied for EU MS. The commitment of the ICPDR of banning phosphorus in laundry detergents in 2012 and in dishwasher detergents in 2015 is seen as a cost-effective and necessary measure to complement the efforts of implementing urban wastewater treatment.

The implementation of the Dangerous Substances Directive, the IPPC Directive, the UWWT Directive and the widespread application of BAT will improve but not solve the problem of hazardous substances. It is estimated that the management objectives and WFD environmental objectives will not be achieved in 2015 regarding hazardous substances; however, there is a need for more monitoring data on hazardous substances, as well as information on sources and relevant pathways. Further measures are the appropriate treatment of priority substances from industrial discharges and further strengthening of prevention and safety measures at contaminated sites. In addition, the continued upgrade of WWTPs with biological

treatment (which results in some hazardous substances accumulating in the sewage sludge) as well as increases in the number of WWTPs will contribute to reduce the load of hazardous substances. Finally, additional reduction through product-related measures should be considered.

Measures will be taken to improve river continuity, reconnection of floodplains/wetlands and hydrological alterations by 2015. However, a significant number of respective pressures will still remain in 2015, and good ecological status/ecological potential will not be achieved by 2015. By 2015, it is expected that 108 barriers will be made passable for fish, whereas 824 river and habitat continuity interruptions will remain. This means that the self-sustainability of sturgeon species and other migratory species in the DRB will be enhanced, but impacts will remain. Remaining continuity interruptions will be addressed by 2021 and 2027. By 2015, 62,300 ha of adjacent floodplains/wetlands will be reconnected and/or the hydrological regime improved, and additional restoration efforts will be taken beyond 2015. Although there is a positive cumulative effect of connected wetlands/floodplains and improvement of the water regime to adjacent water bodies, further investigation is required as to the extent that these reconnections will improve the water status at the basin-wide level, in order to better target measures.

3.3 Basin-Wide Monitoring and Assessment of the Water Status

An essential prerequisite of the assessment of the water status was availability of reliable and harmonized information on water quality. The Danube countries have been actively engaged in a long-term process of ensuring mutual understanding and cooperation in water quality monitoring.

This process started in 1985 with the monitoring of transboundary river sections of the Danube under the Bucharest Declaration and has been boosted since 1996 when yearly status of water quality has been published based upon the Transnational Monitoring Network (TNMN) developed by the Danube countries in response to the Danube River Protection Convention. This monitoring activity provides the necessary basis for a harmonized water quality assessment throughout the whole basin, which not only gives an overview of water quality trends in the basin and of loads of substances discharged into the Black Sea but also fosters achieving of compatibility between water assessment approaches in the Danube River Basin.

The TNMN laboratories in the Danube countries have a free choice of analytical methods they use for the analysis of the agreed set of physicochemical quality elements and priority substances, provided they are able to demonstrate that the methods in use meet the required performance criteria. Therefore, the minimum concentrations expected and the tolerance required of actual measurements have been defined for each determinand so that the method compliance can be checked.

Table 1 Number of surface water bodies in the Danube River Basin District failing to achieve the good chemical status due to particular priority substances defined by the Directive 2008/105/EC

	Danube	Tributaries	Lakes	Coastal waters
Heavy metals				
Cadmium	8	33	1	6
Lead	1	25	1	4
Mercury	6	33		
Nickel		15	1	3
Pesticides				
Trifluralin		3		
Atrazine		1		
Diuron		1		
Isoproturon		2		
Hexachlorocyclohexane	1	1		
Industrial pollutants				
Anthracene		1		4
Octylphenol		6		
Tetrachloroethylene		1		
Trichloroethylene		1		
Trichloromethane		3		
Brominated diphenylether		1		
1,2-Dichloroethane		1		
Di(2-ethylhexyl)phthalate		13		
Naphthalene				4
Other pollutants				
Aldrin	3			6
Pentachlorophenol		2		
Benzo(*a*)pyrene				4
Benzo(*b*)fluoranthene		7		4
Benzo(*k*)fluoranthene		7		4
Benzo(*g*,*h*,*i*)perylene	3	2		3
Indeno(1,2,3-cd)pyrene		2		
Tributyltin compounds		1		
Dieldrin				6
Endrin				6
para–para-DDT	4	10		6
Fluoranthene				4
Hexachlorobenzene				5

To ensure the quality of collected data, a basin-wide Analytical Quality Control programme is annually organized by the ICPDR. For storage of TNMN data, a relational database has been developed by the ICPDR. The TNMN data collection is carried out at the national level by the National Information Managers who receive the data from the national laboratories. After collection, the data are checked and converted into an agreed data exchange file format (DEFF). The

national DEFF files are submitted to the TNMN data centre in Slovakia for additional checking and final processing. Having obtained the formal approval by the ICPDR, the data are uploaded into the website.

Agreed and organized data is essential in being able to generate the political will to take actions to address problems. The yearly assessment of water quality has been supplemented by periodic Joint Danube Surveys with the view of providing a comprehensive picture of the status of the river ecosystem based on a wide range of monitoring variables covering biology, chemistry, microbiology, hydromorphology, isotope analysis and toxicology. The scientific contribution of these special monitoring exercises was enormous but similarly important were the aspects of training and methodological harmonization as well as public awareness rising.

The first Joint Danube Survey was carried out in 2001. For the first time, comparable data about the entire course of the river have been provided covering over 140 different biological, chemical and bacteriological parameters. These data were used as an essential information source for the first analysis of the Danube River Basin District according to WFD Article 5. Six years later, the second Joint Danube Survey has created a comprehensive and homogeneous database on the status of the aquatic ecosystem of the Danube and its major tributaries. For the first time, the fish survey on the whole Danube was carried out bringing a unique dataset and contributing also to methodological harmonization between EU and non-EU countries. JDS2 also introduced the first ever systematic survey of hydromorphological parameters in the entire navigable longitudinal Danube stretch using a single method. The survey confirmed earlier ICPDR conclusions of a generally improving trend for water quality along the main Danube River. It also reinforced specific problems, especially at a number of tributaries and downstream of large cities. It appeared as well that a number of specific problem areas such as pollution by WFD priority substances as well as the newly emerging contaminants need further more extensive examination, particularly in some tributaries [7]. JDS2 has proved to be a valuable tool for improving the databases for water quality assessments, and it has confirmed the need to carry out such investigative monitoring exercise on a regular basis. Information produced by the two Joint Danube Surveys helped the ICPDR Contracting Parties to implement the Danube River Protection Convention and the EU Water Framework Directive, and the concept of JDS has become an integral part of TNMN. The data from the two surveys are also an essential source of information used in most of the chapters in this book. The sampling stations of JDS2 are shown in Fig. 2.

The general objective of the WFD is to achieve both 'good ecological status' and 'good chemical status' of surface waters. The first Danube River Basin Management Plan included information on water status in all surface water bodies in catchments larger than 4,000 km^2. Altogether, 681 river water bodies were evaluated. Out of these, 193 achieved good ecological status or ecological potential (28%) and 437 river water bodies achieved good chemical status (64%). Out of a 25,117 rkm network in the DRBD, good ecological status or ecological potential is achieved for 5,494 rkm (22%) and good chemical status for 11,180 rkm (45%).

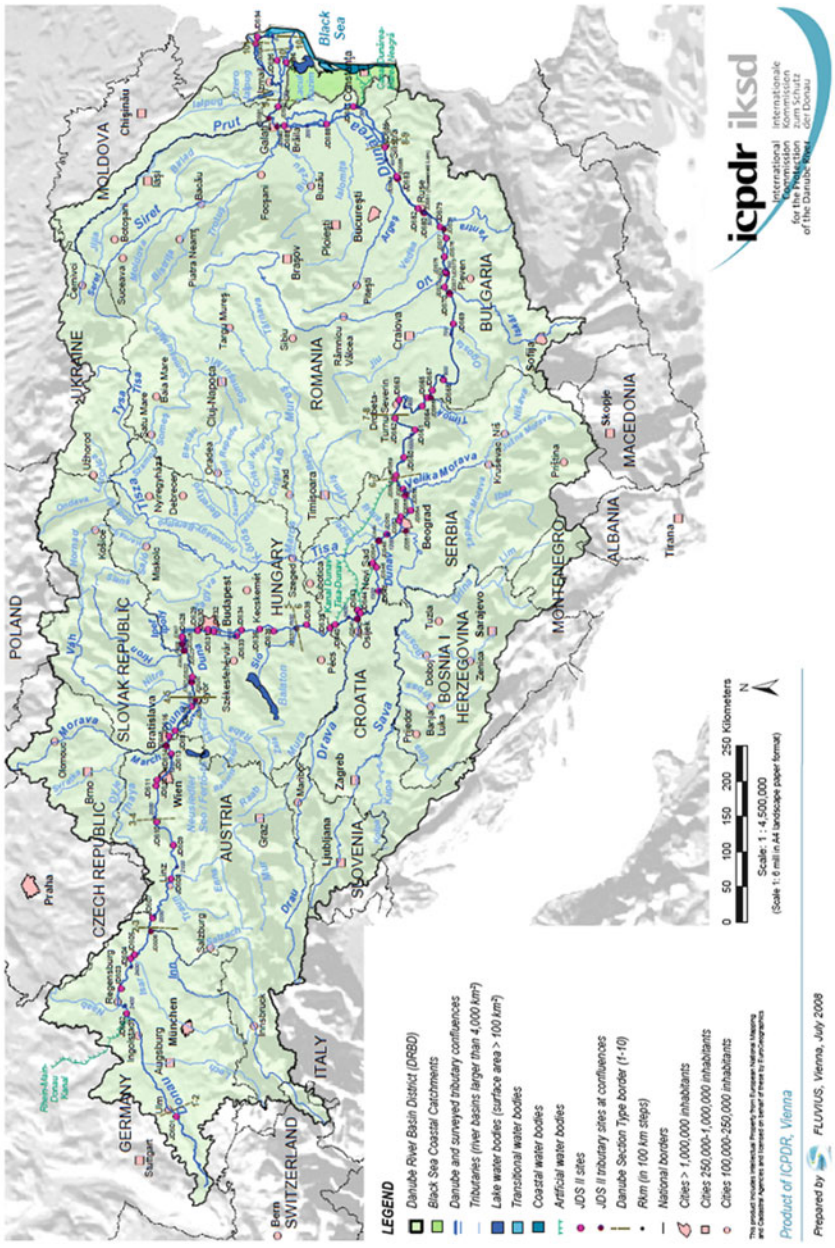

Fig. 2 Sampling sites of the Joint Danube Survey 2

Although many gaps and uncertainties in the assessment of the surface water status still exist, the river basin managers and stakeholders now have a good picture of the condition of the entire Danube Basin for the first time, based on national data, the ICPDR's Transnational Monitoring Network and the two Joint Danube Surveys. Assessment of the chemical status managed to provide the first ever comprehensive overview of contamination of surface waters in the Danube River Basin by WFD priority substances. The priority substances causing poor chemical status in the surface water bodies in catchments larger than 4,000 km^2 are listed in Table 1. From this table, it is apparent that heavy metals, DEHP and *p*,*p*-DDT are priority substances hindering achieving of WFD environmental objectives at most.

At this stage, the status assessment of water bodies is not yet directly linked to the measures and the effects of the measures at the basin-wide scale. A follow-up is therefore needed in order to better understand the linkage between the effects of the measures and the water status at the basin-wide scale [3].

3.4 The Danube Accident Emergency Warning System

The Accident Emergency Warning System (AEWS) of the Danube River Basin is activated whenever there is a risk of transboundary water pollution, or threshold danger levels of certain hazardous substances are exceeded. The AEWS sends out international warning messages to countries downstream to help the authorities put environmental protection and public safety measures into action. Thanks to this system, the adverse consequences of numerous transboundary pollution accidents that occurred during last two decades in the Danube River Basin could be timely and efficiently mitigated.

3.5 Flood Protection

In response to the danger of flooding, the ICPDR adopted the Action Programme for Sustainable Flood Prevention in the Danube River Basin in 2004. The overall goal of this Action Programme is to achieve a long-term and sustainable approach for managing the risks of floods to protect human life and property, while encouraging conservation and improvement of water-related ecosystems. In 2009, in line with the Action Programme, 17 flood action plans for the subbasins of the Danube were adopted by the ICPDR.

At the ICPDR Ministerial Meeting in 2010, the Contracting Parties committed themselves to make all efforts to implement the EU Floods Directive throughout the whole Danube River Basin and to develop an international flood risk management plan. The first milestone in the FD implementation under ICPDR was carrying out a preliminary flood risk assessment and identification of those areas for which it has been concluded that potential significant flood risks exist or might be considered

likely to occur. This was followed by the preparation of flood risk and flood hazard maps leading to the elaboration of flood risk management plans. The general objectives of flood maps are to increase public awareness of the areas at risk from flooding, to provide information of areas at risk to give input to spatial planning and to support management and reduction of the risk to people, property and the environment. Flood risk management plans shall address all aspects of flood risk management focusing on prevention, protection and preparedness, including flood forecasts and early warning systems, and taking into account the characteristics of the particular river basin or subbasin. The Danube Flood Risk Management Plan will also include the promotion of sustainable land use practices and improvement of water retention focusing especially on natural water retention measures. These measures aim to safeguard and enhance the water storage potential of landscape, soil and aquifers, by restoring ecosystems, natural features and characteristics of water courses and using natural processes. They support Green Infrastructure by contributing to integrated goals dealing with nature and biodiversity conservation and restoration and provide multiple benefits, including flood protection, water quality and habitat improvement.

Next to developing action programmes and management plans, which create a framework for an effective management of flood risks, the ICPDR elaborated an inventory of contaminated sites in flood-prone areas listing potential pollution threats in case of flood events. This inventory is a basic prerequisite to setting prevention measures minimizing adverse impacts of floods on water quality.

3.6 Navigation

To address the adverse impacts from navigation to water ecology, the ICPDR linked up with the Danube Commission and the International Commission for the Protection of the Sava River to execute in 2007 an intense, cross-sectoral discussion process, which has lead to the adoption of 'Joint Statement on Inland Navigation and Environmental Sustainability in the Danube River Basin'. The Joint Statement provides principles and criteria for environmentally sustainable inland navigation on the Danube and its tributaries, including the maintenance of existing waterways and the development of future waterway infrastructure. All key stakeholders from the basin such as the representatives of navigation authorities, environmental protection authorities, industries and environmental organizations throughout the basin have been involved in this process. The Joint Statement provides also an overview on the legal background regarding both Inland Waterway Transport and environmental issues. The Joint Statement and its practical implementation will ensure the integration of economic development and environmental standards during the planning/implementation of new navigation infrastructure projects. It provides the basis for potential win-win situations for the navigation sector and the environment [9].

To provide further guidance to the Joint Statement, the EU PLATINA project developed a Manual on Good Practices in Sustainable Waterway Planning, which is designed for use in the Danube River Basin. The manual offers general advice on organizing and implementing a balanced and integrated planning process. Thereby, project developers must also consider national, regional and local aspects and requirements when developing an inland waterway transport project. The early integration of stakeholders (including those representing environmental interests) and of environmental objectives and wide communication are essential for successful planning process [14].

3.7 Hydropower

The ICPDR responded to the need of sustainable development of hydropower with minimum effects on the water status by producing in close cooperation with the hydropower sector and all relevant stakeholders the guiding principles on hydropower development. The key element of these principles is a holistic assessment based on a strategic planning approach and being fully in line with the requirements of the WFD, which needs to be carried out for the development of new hydropower plants. The environmentally sound hydropower facilities should fully respect a number of environmental requirements such as minimum ecological flow, upstream and downstream continuity, hydropeaking and sediment/bedload transport. While many Danube countries reported to have environmental requirements in relation to ensuring river continuity and ecological flow requirements included in their existing national legislation, technical guidelines as well as clear criteria, standards and definitions are not always in place yet causing difficulties in the practical implementation. Therefore, the dialogue between water managers and hydropower sector is essential for finding win-win solutions for a sustainable development of hydropower in the Danube River Basin.

Aware of the fact that hydropower plants offer an additional reduction potential for greenhouse gases but recognizing as well their negative impacts on the riverine ecology, the Ministerial Declaration asked in 2010 for the development of Guiding Principles on integrating environmental aspects in the use of hydropower in order to ensure a balanced and integrated development, dealing with the potential conflict of interest from the beginning.

In the frame of a broad participative process launched in 2011, with the involvement of representatives from administrations (energy and environment), the hydropower sector, NGOs and the scientific community, first an 'Assessment Report on Hydropower Generation in the Danube Basin' has been elaborated [15]. The report provides information on a variety of issues, including information on the current situation regarding existing hydropower plants in the DRB. As a second step, the 'Guiding Principles on Sustainable Hydropower Development in the Danube Basin' have been elaborated [16]. Besides outlining background information on the

relevant legal framework and statistical data, the Guiding Principles are addressing the following key elements for the sustainability of hydropower:

1. General principles and considerations (the principle of sustainability, holistic approach in the field of energy policies, weighing of public interests, etc.)
2. Technical upgrading of existing hydropower plants and ecological restoration measures
3. Strategic planning approach for new hydropower development
4. Mitigation measures

The Guiding Principles were adopted by the ICPDR in June 2013 and recommended for application by the Danube countries, what is planned to be further facilitated via an exchange of experiences on the application in the frame of a follow-up process.

4 Conclusions

Numerous pressures stemming from anthropogenic activities affect the water quality in the Danube River Basin. To address these pressures, the Danube countries established a platform for cooperation in transboundary river basin management: the International Commission for the Protection of the Danube River founded under the Danube River Protection Convention. Using a synergy between implementing the Convention and the current EU legislation such as WFD and FD, a significant progress has been achieved in ensuring the protection and/or improving water quality in the Danube River Basin. Few examples of actions taken towards water quality protection and of water status-related problems in the basin are provided in this chapter, but they are complemented by additional information in the other chapters of this book highlighting biological, chemical and hydromorphological situation as well as the status of sediments and groundwater.

References

1. ICPDR (2009) The Danube River Basin (facts and Figures). ICPDR, Vienna
2. ICPDR (1998) Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention). ICPDR, Vienna. http://www.icpdr.org/main/publications/legal-documents
3. ICPDR (2009) Danube River Basin District Management Plan. ICPDR Publication IC/151, Vienna. http://www.icpdr.org/main/activities-projects/danube-river-basin-management-plan-2009
4. Directive 2008/105/EC of the European parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy. Offic J Eur Communities L348:84

5. Directive 2013/39/EC of the European parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy. Offic J Eur Communities L226:1
6. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Offic J Eur Communities L 327, p 1.
7. Liska I, Wagner F, Slobodnik J (2008) Joint Danube Survey 2, Final Scientific Report. ICPDR. http://www.icpdr.org/main/activities-projects/joint-danube-survey-2
8. Directive 2007/60/EC of the European parliament and of the Council of 23 October 2007 on the assessment and management of flood risks. Offic J Eur Communities L288:27
9. ICPDR (2008) Development of inland navigation and environmental protection in the Danube River Basin. Joint Statement on Guiding Principles. ICPDR, Vienna. http://www.icpdr.org/main/activities-projects/joint-statement-navigation-environment
10. Liska I (2011) Water threats at river basin scale. In: Quevauviller P, Borchers U, Thompson KC, Simonart T (eds) The water framework directive – action programmes and adaptation to climate change. RSC Publishing, p 62
11. Weller P, Liska I (2011) A river basin management plan for the Danube River. Water Res Manag 1(1):6
12. Council Directive of 21 May 1991 concerning urban waste water treatment (91 /271 /EEC), Offic J Eur Communities L135:40
13. Directive 2008/1/EC of the European parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control. Offic J Eur Communities L24:8
14. ICPDR (2010) Manual on good practices in sustainable waterway planning. ICPDR, Vienna. http://www.icpdr.org/main/activities-projects/joint-statement-navigation-environment
15. ICPDR (2013) Assessment report on hydropower generation in the Danube Basin. ICPDR, Vienna. http://www.icpdr.org/main/activities-projects/hydropower
16. ICPDR (2013) Guiding principles on sustainable hydropower development in the Danube Basin. ICPDR, Vienna. http://www.icpdr.org/main/activities-projects/hydropower