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WATER RESOURCES DEVELOPMENT: ECONOMIC AND LEGAL ASPECTS

Water Resources Management Issues in the Danube River Basin District—Examples from Serbia[1]

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Abstract—This paper aims to present water resources management problems in Serbia and recommend possible solutions. Key issues involve water quality and water quantity. Water quality is endangered by organic pollution from different sources and low degree of waste water treatment. Incomplete exploration of water resources availability as well as their inadequate exploitation are the biggest problems related to water quantity. Other problems involve lack of harmonized legislation, insufficient investments in water resources management, inadequate water price, low level of services, the lack of an effective integral water management system, illegal construction in the areas of water sources and potentially floodplains as well as lack of monitoring. In order to deal with these problems and overcome or mitigate their consequences, complex of measures should be implemented in the frame of interdisciplinary and transdisciplinary national and international projects.

Keywords: water resources management, water quality and quantity, measures, Danube River Basin District, Serbia

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INTRODUCTION

Water resources management in Serbia is the part of integrated management system of great international rivers: Danube, Sava and Tisza. International Commission for the Protection of the Danube River in which scope is Tisza Group (ICPDR) and International Sava River Basin Commission (ISRBC) deal with the main water management issues. ICPDR consists of all Danube countries with territories >2000 km^2: Austria (AT), Bosnia and Herzegovina (BA), Bulgaria (BG), Croatia (HR), the Czech Republic (CZ), Germany (DE), Hungary (HU), Moldova (MD), Montenegro (ME), Romania (RO), the Republic of Serbia (RS), the Slovak Republic (SK), Slovenia (SI) and Ukraine (UA), while the ISRBC consists of the following countries: Slovenia, Bosnia and Herzegovina, Croatia and the Republic of Serbia. "Significant Water Management Issues" (SWMI) include surface water pollution by organic substances, nutrients, hazardous substances and hydromorphological alteration, as well as alteration of groundwater quality and quantity [22, 29, 30].

[1] The article is published in the original.

SIGNIFICANT WATER MANAGEMENT ISSUES IN SERBIA

Key issues related to water management in Serbia involve water quality, water quantity and water regime. These problems involve: lack of harmonized legislation, insufficient investments in water resources management, inadequate water price, low level of services, irrational water exploitation, low degree of waste water treatment, poor surface water quality, the lack of an effective integral water management system, illegal construction in the areas of water sources and potentially floodplains etc. [26].

Water quality is endangered by organic pollution, nutrient pollution and pollution by hazardous substances. Organic pollution generates from urban waste water, industry and agricultural point sources. According to the total population equivalent (PE) 65% of waste water are collected with no treatment, and only 2% were collected with tertiary treatment in the period 2011–2012. According to the total organic pollution (t/year biological oxygen demand (BOD)) of the surface waters via urban waste water 88% were collected but not treated for the same year [30]. Besides this, many problems in waste water treatment plants functioning occur: insufficient capacity, technical outdated systems, the impossibility of integration in

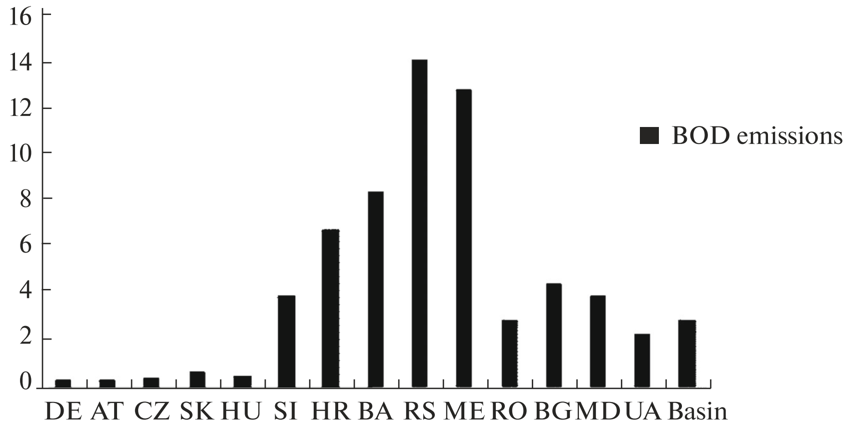

Fig. 1. Specific organic pollution (kg/year BOD) of the surface waters via urban waste water in DRBD in 2011/2012 [30].

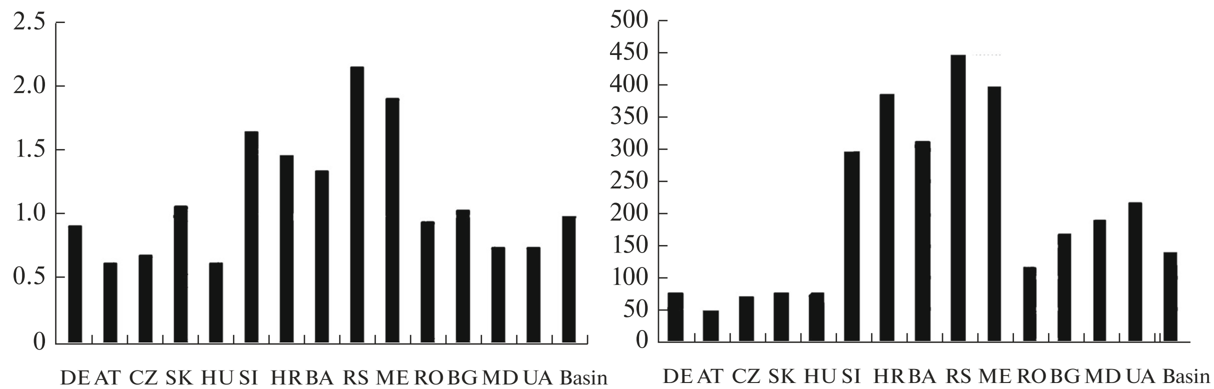

Fig. 2. Specific nutrient pollution (g/PE/year) of TN (left) and TP (right) via urban waste water in the DRBD in 2011/2012 [30].

future solutions, irregular maintenance, low efficiency, the instability [5, 6, 9]. All these problems have caused that total and specific organic pollution of the surface waters via urban waste waters were the highest in Serbia comparing with all other countries in the DRBD. Total organic pollution amounted 106211 t/year BOD, while the value for the whole DRBD was 256282 t/year BOD. Specific organic pollution (Fig. 1) amounted 14 kg/PE/year BOD, while the average value for whole DRBD was 3 t/year BOD during the 2011–2012. The biggest share of the industrial sectors in the total organic pollution via industrial discharge had the products from the food and beverage sector (65%), while the rest consisted of intensive livestock production and aquaculture and energy production [30].

Nutrient pollution also generates from urban water, industry and agricultural point sources, as well as diffuse inputs. Problems related to nutrient pollution in Serbia are similar to those relating to organic pollution. According to the total nutrient pollution (tons Total Nitrogen (TN) and Total Phosphorus (TP) per year) of the surface waters via urban waste water, 82% were collected but not treated in the period 2011–2012. Specific nutrient pollution via urban waste waters was the highest in Serbia comparing with all other countries in the DRBD and amounted 2200 g/PE/year TN (average value for the whole DRBD was 1000 g/PE/year TN) and 450 g/PE/year TP (average value was 140 g/PE/year TP for the whole DRBD) per PE in the same period. TN via direct industrial waste water discharges was also highest in Serbia and amounted 4340 t TN in 2012 (Fig. 2).

According to the TN the biggest share of the industrial sectors in the total nutrient pollution via industrial discharge had the energy sector (62%), chemical industry (32%), while the rest consisted of products from the food and beverage sector as well as intensive livestock production and aquaculture. According to the TP the biggest share of the industrial sectors in the total nutrient pollution via industrial discharge had the energy sector (68%) and the rest consisted of products from the food and beverage sector (32%) [30]. As Urošev et al. [31] point out, the results of calculations annual biogenic loads (inorganic nitrogen (DIN), phosphate (PO_4) and TP in the Serbian sector of the

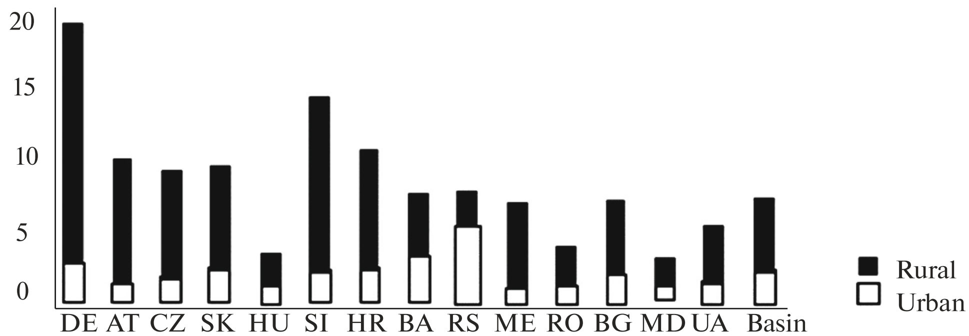

Fig. 3. Rural and urban specific TN emission (kg/ha/year) in the DRBD for the period 2009–2012 [30].

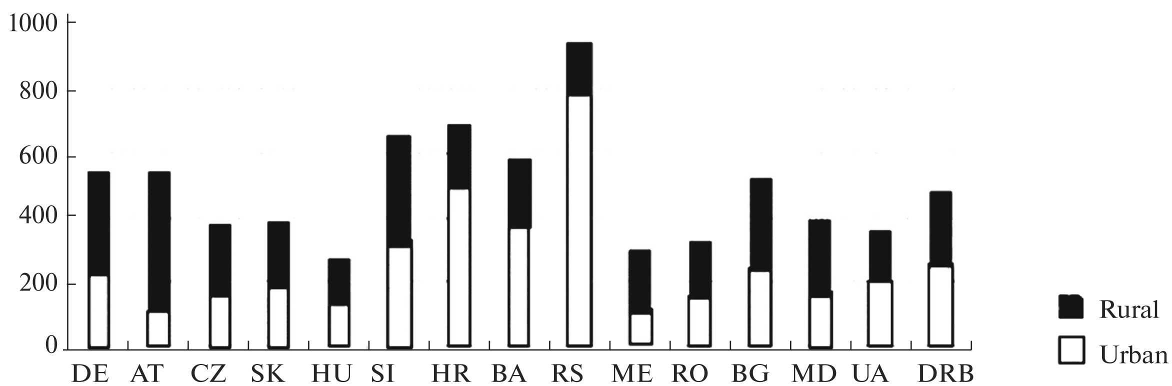

Fig. 4. Rural and urban specific TP emission (g/ha/year) in the DRBD for the period 2009–2012 [30].

Danube for the period 2001–2009 indicate their independence of water flow, t.e. the load and increase with the expenditure biogenic substances. The minimum nutrient loads in the Serbian sector of the Danube is observed at the station Bezdan (153200 t/year DIN, 3021 t/year PO_4, 9070 t/year TP), while the maximum is calculated for Smederevo (205350 t/year DIN, 9638 t/year PO_4, 16529 t/year TP) in the period 2001–2009. The calculated nutrient loads to the Serbian part Danube (1426–1116 river km) and its main tributaries compared to stations of other Danube countries, basically coincide with the general trend of increasing downstream [31].

Unlike all the other countries in DRBD, diffuse urban specific TN emissions in Serbia were higher in urban than rural areas (Fig. 3) in the period 2009–2012 and amounted 6 kg/ha/year N, which was the highest value in the DRBD (average value for the whole DRBD was 2 kg/ha/year N).

The main source in the overall TN emissions was urban water management (68%), while other sources were other areas (16%), agriculture (10%) and natural sources (6%). The big share of the pathways in the overall TN emissions had urban runoff (36%), point sources (34%), and groundwater flow (22%), while the rest consisted of overland flow (5%) and erosion (3%). Serbia also generates the highest area-specific P emission rates (Fig. 4). Total sum of urban and rural specific TP emissions was the highest in DRBD and amounted 950 g/ha/year P in the period 2009–2012 (average value for whole DRBD was 490 g/ha/year P).

This was caused by high emissions from urban areas (780 g/ha/year P), which was higher than sum of urban and rural emissions in other countries. The main source in the overall TP emissions was also urban water management (81%), while the other sources were agriculture (14%), natural sources (3%) and other areas (2%). The overall TP emission was also highest in Serbia and amounted 933 g/ha/year P, while the average value for the whole DRBD was 477 g/ha/year P. The biggest share of the pathways also had point sources (45%) and urban runoff (37%), while the other pathways were erosion (15%) and groundwater flow (3%) [30].

Official methodology for water quality assessment, Serbian Water Quality Index (SWQI), based on the following ten parameters: oxygen saturation, BOD, ammonium, pH, total nitrogen oxides, orthophosphate, suspended solids, temperature, conductivity and most probable number of Coliform bacteria (*E. coli*/MPN) has many disadvantages. Main limitation for SWQI is relative small number of parameters.

Used parameters give information about organic and nutrient loading, but not about heavy metal and pollution by hazardous substances. Also SWQI can be computed even in a case of missing some values. Practically, it means that SWQI can be calculated on the basis of just one parameter [12].

In addition, for determining the water pollution levels in several Serbian rivers and canals is used Water Pollution Index (WPI). This is a combined physical-chemical index which makes it possible to compare the water quality of various water bodies, independent of the presence of pollutants [10]. The WPI represents the sum of ratios between the observed parameters and prescribed standard values, and its value determines one of the six classes of water pollution. For WPI determining following parameters were taken into account: dissolved O_2, O_2 saturation, pH, suspended sediments, BOD, chemical oxygen demand (COD_{Mn}), nitrites, ammonium, saprobes index, metals (Fe, Mn, Ni, Hg), sulphates and Coliform bacteria. According to the results of Milanović et al. [18] the WPI values in six-year period (2004–2009) in the canal network of the Hydrosystem Danube-Tisza-Danube (north part of Serbia, Vojvodina province) indicate that the canal water is mostly moderately polluted or polluted, i.e. III or IV pollution class, respectively. The profile Vrbas II has the highest mean WPI value, which classifies the canal water at this section as classless watercourses. The lowest mean WPI value for analyzed period was registered at profiles Sombor and Vrbas I, where the canal network starts. General conclusion is that the values of the parameters indicators of organic pollution (BOD, ammonium, Coliform bacteria etc.) are far above limits, indicating the predominance of organic pollution in this area. This is a consequence of the activities of food industry, agricultural production and household sewage waters [18].

Similar analyses are made for Timok River (Danube River basin) in east part of Central Serbia. Combined physical-chemical Water Pollution Index (WPI) calculated for two periods—1993–1996 and 2006–2009 at four hydrological stations in Timok River basin have shown that the pollution rate increased downstream. According to the WPI values, the water of Timok River, after receiving the Borska Reka, indicated Class IV (polluted) in the 1993–1996 period, whereas after 2006, the increased pollution rate was observed and the river water has been classified as Class V (impure) in recent years [4]. The Borska Reka River and wastewater of the Municipality of Zaječar have the greatest impact on the high WPI values. According to the calculated WPI values, the Borska Reka is classified into Class VI (heavily polluted) [19]. The general conclusion is that the values of some parameters which indicate organic pollution (BOD, amonium, Coliform bacteria, etc.) and the presence of metals (Fe, Mn, Cu) are far above the permitted limits, indicating severe organic and inorganic pollution in this area. The main sources of Timok River Basin pollution are untreated communal wastewater (from Knjaževac, Zaječar, Bor) and the wastewater from the Bor mining industrial complex [4].

The following three key hydromorphological pressure components of basin wide importance have been identified in the DRBD: interruption of longitudinal river continuity and morphological alteration; disconnection of adjacent wetlands/floodplains, and; hydrological alterations, provoking changes in the quantity and conditions of flow. Number of barriers in the Serbian part of DRBD is 17, which is not significant comparing with majority DRBD countries. These barriers are mainly used for hydropower and water supply. At the other hand, Iron Gate Dams 1 & 2 and Djerdap reservoir between Serbia and Romania remain significant river and habitat continuity interruptions for the Danube River posing problems for long and medium distance migratory fish species. The well-known migratory sturgeon species (Danube sturgeon, bastard sturgeon, starry sturgeon and beluga), which used to come upstream along the Danube to Hungary and Slovakia prior to the formation of the Djerdap reservoir, can no longer be found in the Djerdap reservoir because Iron Gate Dam 1 (Hydroelectric Power Plant Djerdap I) interrupts their migratory path [24].

Construction of Iron Gate Dams 1 & 2 causes the great impacts on water quality. This may lead to changes in the physical, chemical and biological characteristics, degradation of water quality in a reservoir, and changes in the thermal regime, the process in thermopeaking (short-term temperature fluctuation in the river reach below dams), is causally linked to hydropeaking, ice jam formation on rivers. As Babić Mladenović et al. [2] point out forest of the deterioration of water quality of Iron Gate 1 reservoir due to high water levels and low velocities reducing the streams self-purification potential resulting in increasing eutrophication effects as well as accumulation of hazardous and harmful substances in sediment, has not be fulfilled [2]. Also, dam on the enter of Djerdap Gorge is considered to be ecological black spot due to the formation of deposits and accumulation of toxic sediments. According to the sediment size in Djerdap reservoir is allocated Donji Milanovac, where is deposited materials from 0.4 to 50 μm, or fine particles of clay and plankton masses with high absorption capacity and the content of toxic substances, which contributes to the high pollution of the system. Periodic water quality analyses of the Djerdap reservoir in period 2001–2005 indicate that changes in water quality are caused by: expressed sedimentation, biochemical decomposition, organic substances, primary production decrease, accumulation of toxic substances (primarily heavy metals, Cd and Hg) [16]. These deposited sediments could cause big ecological problems in the future.

Based on all physical and chemical parameters, the water quality of Djerdap reservoir corresponds to the specified Class II according to Serbian classification [21] which is still satifactory. According to the biological parameters (phytoplankton and zooplankton) the water quality corresponds to the Class II, while macroinvertebrate species indicate Class III of water quality [21]. There is no temperature stratification and stable oxygen stratification and there is a lack of an intensive eutrophication potentials.

As Milanović et al. [17] pointed out dominated registered pollutants in the Serbian sector of DRBD are: industry, agriculture, settlements, energy and other pollutants. In this last group are the medical facilities (spa), users of thermal waters, factories for transport equipment repair etc. DRBD in Serbia is the main industrial development axis with a number of industrial centers. Unfortunately, the industries that dominate this area are mostly inflexible located as follows: inorganic chemistry in Novi Sad; basic organic chemistry in Pančevo, Novi Sad, Belgrade; steel industry in Smederevo; exploitation and processing of nonmetals in Pančevo; building materials production—in several location of Vojvodina province [17].

Wetlands in Serbia with an area larger than 500 ha cover the total area of 25790 ha, and they are partially reconnected. Comparing with majority of DRBD countries, this situation is favorable for Serbia. Hydrological alterations include impoundments, water abstraction and hydropeaking in the DRBD. The impoundment upstream of the Iron Gate Dam 1 affects the flow of the Danube River over of 310 km length up to Novi Sad (11% of the entire length of the Danube River) and represents a significant pressure [30].

According to the World Water Development Report 4 [15], Serbia is classified in the category Little or no water scarcity. However, many problems related to water quantity could be identified: incomplete exploration of water resources, insufficient specific availability of domicile surface waters, unequal spatial distribution of waters, and unfavorable water regimes [26].

The big problem in the field of water quantity is incomplete exploration of water resources (especially ground water). Due to this problem, assessments of ground water capacity are different and rang from 678 m^3/year (according to the Serbian Environmental Protection Agency) to 725.3 m^3/year [26]. Ground waters have the biggest share in water supply (70%), while the surface waters share is 30% (21% of watercourses and 9% of accumulation). Due to the overexploitation of ground water resources in some regions (Bačka and Banat in Vojvodina province), water-table is significantly decreased, which have negative implications in long-term water supply [26].

Specific availability of own surface waters is 1500 m^3 per inhabitant per year, approximately. According to this parameter, Serbia is in the poorer areas in Europe. Low limit for long-term self-sufficiency of domestic waters of one country is 2500 m^3 per inhabitant per year. Large water-stressed areas (such as Šumadija, Vojvodina province, and Province Kosovo and Metohija) have specific availability of domestic water less than 500 m^3 per inhabitant per year [26].

Spatial unequal distribution of waters is very unfavorable. Average specific runoff in Serbia is 5.7 L/s/km^2, but these values vary from 30 L/s/km^2 (mountains such as Šara, Prokletije) to less than 1 L/s/km^2 (Bačka). Water shortage is the most expressed in the densely populated lowlands with the best quality of land cover (Pomoravlje, Kolubara Basin, Šumadija, Vojvodina, Kosovo and Metohija, south Serbia) where the specific runoff declines under the 2–4 L/s/km^2 [26].

One of the most significant problems related to both water quality and water quantity is inadequate monitoring (especially ground waters and accumulations). Surface and ground water hydrological stations network (approximately 500) under the authority of Republic Hydrometeorological Service of Serbia was established for continuous monitoring of surface water quality and quantity as well as ground water regime. Observation network is divided on observation areas on the basis of major river basins. Systematical monitoring of karst and neogene aquifers have not still established. Water level and discharge are monitored only on one karst spring – Mlava spring. Ground water quality monitoring is based on the water sampling, which is conducted only once per year. Due to unequal covering by the observation network of ground waters and insufficient number of measurements, information about ground water quality and quantity status are inadequate or completely lack. This is the main obstacle for accurate estimation of ground water status of many ground water bodies, so that risk assessment according to the Water Framework Directive is not feasible [23].

Monitoring of accumulation is also weak. Parameters of water quality are measured only in five accumulations (Gradsko jezero—Bela Crkva, Sjenica, Barje, Prvonek and Zobnatica) two or three times per year during the 2013 [8]. Taking into account great importance of accumulations in water supply of settlements and industry, as well as other roles of accumulations such as mitigation of flood waves, it is necessary to establish continuous monitoring of accumulation status. One of the most drastic ecological accidents, as a consequence of monitoring lack was the pollution by cyanobacteria of accumulation Vrutci which is used for water supply of Užice municipality, when 70000 inhabitants were without water during two months in 2014.

INTEGRATED SYSTEM OF MEASURES AND POSSIBLE SOLUTIONS

In order to overcome problems related to water resources management and consequences caused by these problems, integrated system of measures should be applied. These measures could be classified in two categories: regular and interventional measures. Regular measures involve: technical, legal-organizational, urban planning measures, policy instruments and creation of an information base. Interventional measures include: measures for accident pollution prevention, identifying the causes, types and degree of threat, control the spread of pollution, notification of users and prohibition of water use [5].

Technical measures consist of measures for pollution mitigation and control measures. Measures for pollution mitigation involve direct (remediation and preventive) measures, measures for decrease emission and measures for increase watercourse capacity. Control measures include: direct control of plants, emission control from point sources, and total emission control through monitoring of surface water quality [7].

Legal-organizational measures include improvement of legislation about water, which will regulate issues related to water protection, water regulation, water use in accordance with EU water legislation, Ramsar Convention and other important documents for Serbia [26, 27]. Some of the important issues is to establishment legal framework for standard regulation for effluents, organization and control point sources of pollution [5], implementation of following EU Directives: Water Framework Directive (WFD) with the main objective achievement good ecological status of all water bodies, Nitrate Directive, Urban Waste Water Treatment Directive and EU Floods Directive 2007/60/EC [30]. In order to undertake these measures it is necessary delineation of authorities in the vertical hierarchy (among local, provincial and republic level) as well as horizontal hierarchy among different services at the same rang (for example water and veterinary inspection) [3].

Urban planning measures involve plan for integral regulation, protection and use of water on territory of Republic of Serbia, treated as unique water management space [26]. These measures also involve development and application of different mathematical models for water quality. As it is mentioned above existing methodology SWQI is not sufficient for water quality assessment. Other water quality models such as Canadian Water Quality Index (CWQI) and Agri-food Water Quality Index (AFWQI) include much more parameters of water quality, such as heavy metal concentration (CWQI) and possible pollution by hazardous substances (such as pesticides) on the basis of their concentration (AFWQI). Besides overall water quality CWQI gives information about water quality for specific uses: drinking, aquatic habitat, irrigation, livestock and recreation, while AFWQI gives information about water quality for irrigation and livestock [1, 12, 13] Comparing the results of these three indices in 2013 for the 6 hydrological stations on Danube and Tisza, it was recorded different values for the same stations: SWQI was good and very good (82 and 84), CWQI ranged from poor to fair (from 37 to 66), while the AFWQI varied from fair to very good (from 73 to 94) for irrigation and excellent (from 95 to 100) for livestock [14].

Policy instruments involve economic measures, information, education, research and development. Economic measures include economic water price as a measure of rational water demand along with the principle "the user pays" and "polluter pays" [26]. Information and public consultation and participation are very important in the entire cycle of activities: from conceptualizing policies, to measures implementing and impacts evaluating. This could be realized via stakeholders dialogues on selected management issues, ad-hoc public consultation activities for the management plan development and complete transparency of the process [30]. Some of the examples of education are the project for children "Danube box" about importance and protection of Danube River and courses for farmers about nutrient implementation, both in organization of ICPDR [11]. Example of research and development is Joint Danube Survey (JDS) which was organized three times: JDS1 in 2001, JDS2 in 2007, and JDS3 in 2013 by ICPDR. Joint Danube Surveys provide an extensive homogeneous dataset which is mainly based on WFD compliant methods. These results provide an excellent reference database serving for future efforts of method harmonization in the Danube River Basin [30].

Creation of an information base involve establishment of plants cadaster, cadaster of urban and industrial pollutants, as well as cadaster of water quality with database about limits values of toxic and hazardous substances.

Measures for prevention of accident pollution include identifying and elimination the causes, continuous monitoring, prevention of the spread pollution (via buffer zones and constructed wetlands), restrictive measures (such as prohibition of construction new facilities and closing existing facilities), notification of users and prohibition of water use [7] via systems such as Accident Emergency Warning System (AEWS) developed by ICPDR.

INVOLVEMENT IN INTERNATIONAL PROJECTS RELATED TO WATER MANAGEMENT ISSUES

Many international projects and interdisciplinary research were conducted in order to deal with water management issues. As a member of ICPDR and ISCRB, Serbia is involved in most of them. One of the most important projects in Serbia was "Serbia Danube River Enterprise Pollution Reduction Project" (DREPR). This project was the part of Joint Program of Measures (JPM) in the DRBD in the period from 2005 to 2011. The project aimed to promote environmentally friendly practices by reducing nutrients being discharged into the Danube River and its tributaries from livestock farms and slaughterhouses. In this context, a package of measures has been implemented including:

—The operation of almost 120 nutrient management plans, the construction of manure tanks, the provision of technical equipment supporting appropriate manure disposal. Furthermore a Training Information Centre for farmers and administrative staff has been established;

—The accomplishment of a groundwater monitoring in order to achieve "Good Agricultural Practice." The data gained from this survey will be used for a long term monitoring researching the efficiency of the previous measures;

—The realization of the several studies (the adoption and implementation of the Nitrates Directive or measures for pollution reduction from agricultural sources).

The next specific challenge for Serbia is to re-open Iron Gate Dams 1 & 2 for free fish migration at the border between Romania and Serbia. These dams represent the first impassable obstacles for fish migration along the River Danube from the Black Sea, addressing river and habitat continuity interruptions. Restoration of river continuity at these sites would re-open a reach of more 800 km, providing access to habitats and spawning grounds along the Danube and its tributaries for sturgeons and other migratory fish species. Therefore, the reconnection of the historic migratory routes at the Iron Gate dams (via appropriate measures such as migratory fish aids) is an important step helping to restore the Danube fisheries and improving water status. Due to the very particular challenge at the Iron Gate dams (size of the structures and transboundary relevance), the ICPDR as actively facilitating to find appropriate solution. The first step should be a feasibility study of the possible measures for fish migration returning. In the second step, based on the results of the feasibility study, respective technical measures are planned to be implemented. A scoping mission to the Iron Gate dams on possibilities to ensure fish migration was performed in May 2011 with representatives from FAO, Romania, Serbia, the ICPDR and international experts [11].

With regard to accidental pollution, The Accident Emergency Warning System was established in the early 1990s as an integral part of the activities of the ICPDR and all countries in the DRBD are involved, except Montenegro. The AEWS is activated whenever a risk of transboundary water pollution exists, or threshold danger levels of hazardous substances are exceeded. The System sends out international warning messages to countries downstream. This helps national authorities to put environmental protection and public safety measures into action. Principal International Alert Centers (PIACs) in each country form the central points of basin-wide cooperation in early warning. The ICPDR Secretariat maintains the central Global System for Mobile Communication (GSM) based communication system, which is integrated within the ICPDR information system Danubis [29]. This system is very important task for Serbia, because regardless of the existing legislation for implementation PIACs in national civil/environmental protection system, the authorities on national level are not yet officially nominated [22, 28].

As it is previous mentioned, ICPDR conducted Joint Danube Survey three times. JDS3 was the world's biggest river research expedition of its kind in 2013. JDS3 catalyzed international cooperation from 14 Danube Basin countries and European Commission, cooperating through the ICPDR. This Survey pursued three main objectives:

—To collect information on parameters not covered in the ongoing monitoring;

—To have data that is readily comparable for the entire river because it comes from the single source;

—To promote the work of the ICPDR and raise awareness for water management.

JDS3 data confirmed that there is a need for appropriate measures such as:

—Preventing or limiting to minimum fresh bank revetments and reinforcements (long bank sections are not continuously fortified by riprap in Serbia, as it is a case along the Upper Danube);

—Management of sediment balance at Danube basin-wide scale. Major changes of flow dynamics and sediment continuity along the Danube are caused by the dams (Iron Gate on the Serbian-Romanian Danube);

—Further construction and upgrade of wastewater treatment plants especially in the Middle and Lower Danube area (the input of untreated wastewater from Belgrade caused the highest median concentration of caffeine in the Serbian part, while the pharmaceutical metabolite N-acetyl-sulfamethoxazole has the highest concentration in Velika Morava on the whole investigated area);

—Comprehensive and detailed investigation of the mercury occurrence in fish in the Danube River Basin;

—Implementation of effective policies addressing the emission reduction of hazardous substances;

—Further research needs of occurrence of invasive alien species (neophytes, macro invertebrates and fish species) and on development of type-specific methods for evaluation of WFD biological quality elements;

—Attention given of bank-filtered water wells used for drinking water production [30].

The Republic of Serbia has an important place within the European water network. Network of inland waterways make up natural waterways Danube, Sava, Tisza, Tamiš and Begej, as well as the channels included in the Hydrosystem Danube-Tisza-Danube. The existing waterways are located in lowland areas, mainly in the northern and northeastern part of Serbia. Length of navigable waterways for ships carrying capacity up to 1500 t in Serbia is 993 km [25].

Through our country goes Pan-European transport Corridor VII or Danube Corridor. This is one of the most important European roads, and along with Rhine and Main is the most important waterway of the continent. Corridor VII is defined in the framework of the United Nations (UN/ECE) (European Agreement on Main Inland Waterways of International Importance—AGN). This corridor is the Danube River with a system of natural and man-made waterways.

The main objectives of the development of waterways in Serbia are: the inclusion of domestic waterways in the European network, the modernization of the fleet, ports and other supporting facilities and the expansion of domestic navigable river networks with the simultaneous construction of accompanying infrastructure facilities.

Project entitled "Rehabilitation and Development of the Navigation and Transport on the Sava River Waterway" will be undertaken among Croatia, Bosnia and Herzegovina and Serbia. The aim of the project is improvement of navigation condition. Activities include preliminary design addressing training works, dredging, river bend improvements, bridges and River Information Services. Other actions involve establishment of project committee for Joint Statement implementation including representatives of competent authorities for water management, nature conservation, environmental protection and navigation next to representatives from ISRBC, ICPDR, Danube Commission, Non-governmental organizations (NGOs) and navigation sector representatives. The project is in the phase of preparation [30].

Serbia conducts the project entitled "Preparation of necessary documentation for river training and dredging works on selected locations along the Danube River in Serbia." Activities include designs and tender documentation for river training works on six critical sections for navigation on the Danube in order to start river training works and improve navigation safety conditions. Other actions include the establishment of a transparent and interdisciplinary planning process involving key stakeholders and investigations of alternatives. The project is under implementation [30].

GLOBAQUA is one of the newest international projects, which evaluates the effects of water scarcity in six river basins, among which is Sava River Basin. This project is active since February 2014 and comprises 9 EU countries, Serbia, Morocco and Canada. The project includes experts in hydrology, chemistry, biology, geomorphology, modelling, socio-economics, and policy advocacy. GLOBAQUA aims at identifying the prevalence, interaction and linkages between stressors, and to assess their effects on the chemical and ecological status of freshwater ecosystems in order to improve water management policies and practices. Basic structure of the project consists of five modules: stressors, receptors, implications, environmental management and project coordination and dissemination. Module Stressors analyses the effects of water scarcity on the impacts of multiple stressors occurring in each study river basin, and forecasts the consequences of future scenarios for global change. It especially considers surface and groundwater hydrology, sediment transport, physical habitat, water quality, organic and inorganic pollutants, and the consequences of different climatic, socio–economic and land-uses scenarios. Module Receptors analyses the consequences of water scarcity and multiple stressors on biodiversity and ecosystem functioning. Research is based on field studies and laboratory experiments, measurements and surveys to understand the effects of stressors at different scales, as well as modelling to forecast future scenarios. Module Implications analyses the socio-economic implication of the effects of impacts on water quality and availability, as well as biodiversity and system functioning. Module Environmental Management integrates the results of the other modules to define a manageable perspective of water scarcity for the studied river basins. Module Project Coordination and Dissemination is devoted to the communication of the results to target groups (researches, policy makers, water managers, land planners, etc.), and aims to stimulate the use of results through relations with stakeholders and end-users, as well as to coordinate project activities. Sava River Basin is affected by hydromorphological pressures in the upper part, by agricultural activities and eutrophication in the middle part, and by industrial and urban pollution in the lower (Serbian) part [20].

CONCLUSIONS

Serbia is faced by numerous problems related to water resources management. In order to deal with water quality, quantity and regimes, to mitigate and prevent consequences caused by them, complex of measures should be undertaken. These measures should be implemented via interdisciplinary and multidisciplinary research as well as involvement in international projects. Continuous monitoring and integral management plans must be key steps to overcome these problems.

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