INVESTIGATION OF MONITORING SYSTEMS FOR WATER QUALITY OF THE DANUBE RIVER IN THE BORDER REGION ROMANIA – BULGARIA

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Abstract

The good coordination between all Danube countries, environmental understanding between them and their joint efforts in the global European policy for the river Danube will help to restore the purity of the river. Danube catchment is extremely large and diverse. It supports a variety of eco-systems (karst caves, alpine steppe lakes, floodplain forests, delta) and various wetlands of European significance.

Keywords: environmental monitoring, ecological balance, pollutants

Introduction

The operational European Cross Border Cooperation (CBC) program Romania - Bulgaria for the period 2007-2013 includes the border areas of both countries [1]. This program creates a bond between the two countries Romania and Bulgaria and aims to promote and support the development of the regions situated on both banks of the Danube. This program provides Romania and Bulgaria with European funding. It covers nine areas of Bulgaria: Vidin, Vratsa, Montana, Pleven, Veliko Tarnovo, Ruse, Razgrad Silistra, Dobrich, and seven counties of Romania: Mehedinti (with center city Drobeta - Turnu Severin) , Dolj (with center city Craiova), Olt (with center city Slatina), Teleorman (with center city Alexandria), Giurgiu, Calarasi and Constanta.

The population of this cross-border region is about 5 million citizens. The percentage allocated to Romania is about 64% and in Bulgaria is about 36%, which represents 17.34% of the population of the two countries.

An exception in this program as a contiguous area of Rousse and Silistra is included Razgrad , although not in the border area , but is just 10 km. distance from the border - the Danube.

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Danube river area is a unique ecosystem with a length of 3000 km and 80 million people from Europe live in its valley. Although the extinction of many species of flora and fauna (caused by their uncontrolled destruction and the river area pollution) in the river area it is still possible to find over 100 fish species, 300 bird species and 400 tree species. In the Danube basin there is a highly developed agriculture, the river water are used for irrigation and for electricity production. Danube is an important transportation and communication corridor. In the area tourism and fishing are also well developed.

Contamination of Danube river water resources is a serious threat to the ecological balance in nature. A typical example of exploitative and unreasonable man attitude to the water resources is one of the largest rivers - the Danube, in its section between Bulgaria and Romania. In the river swell sewage thousands of settlements, industrial plants and agricultural areas.

The amount of nutrients (from agricultural fertilizers and manure and household waste) that fall into the waters of the Danube and its tributaries is very large. Contamination usually occurs as a result of human activities and its sources are: "point", such as municipal wastewater treatment plants and industries (as for food production) that discharge wastewater and "not as a point", such as the agricultural land treatment with fertilizers and manure where nutrients seep into groundwater or fall with rain water in streams, lakes and rivers. Often water pollution is with dangerous substances that have toxic, carcinogenic, mutagenic and teratogenic or bio accumulative effect. Some of them degrade very slowly or are persistent, and have a significant adverse impact on living organisms. Heavy metals such as copper, iron, manganese, cobalt, zinc, cadmium, mercury, nickel and lead are toxic (emitted mainly from mining and metallurgy) and accumulate in the nutritional chain and pose a high risk to aquatic and human life. Numerous other hazardous compounds that cause toxic and / or chronic contamination are of organic origin, and are produced by the chemical, pharmaceutical and paper industries.

Monitoring of the Danube river on the border Bulgaria - Romania

Biological research in the Bulgarian section of the Danube / 399 km / shows alarming results: - recreational opportunities of the river are weakened to the limit. The water quality is getting worse and it becomes dangerous for human health. The overall river pollution with mineral substances - hydrogen carbonates, sulphates and chlorides - is growing by at about 1% per year in recent years. The nutrient pollution (nitrates, nitrites, ammonia, phosphorus) threaten water quality, biomass decreases and in some benthic places the fauna is completely destroyed (in the sections below major industrial centers).The bacteriological load increases, particularly worrying is the increase of salmonellosis causes; outflow of household waste seriously aggravates the ecological imbalance in the region.

In recent years, the efforts of local authorities and the governments of our two countries, Romania and Bulgaria are aimed to improve the water quality. This however is not sufficient to achieve and provide good quality of the water in all areas. A large part of the population still lives in areas where water quality significantly deviates from the limits set by the European Union (EU) provided for the human health protection. Water quality in watersheds of the cross border region Romania – Bulgaria depends on the climatic factors impact and on the harmful substance emissions.

Basic document for evaluation and quality control of water resources in the European Union is Directive 2000/60CEE [3] , also known as the Water Framework Directive (WFD). The main objective of the WFD is to achieve "good status" for all water bodies, both for the surface and underground. The good water management is particularly important for our two countries, considering

that our water resources are relatively insufficient: in Romania around 1700 m3 of water, while in Bulgaria, only 700 to 800 m3 of water per citizen per year, while in other European countries, these quantities are 2.5 - 3 times larger.

The directive introduces an innovative approach to water management, which is based on river basins, natural geographical and hydrological characteristics. It requires the development of plans with deadlines for the protection of aquatic ecosystems. This Directive covers inland surface waters, transitional waters, coastal waters and ground waters. The Directive has required, since December 2006 all Member States to develop their own monitoring programs that will allow assessments of the ecosystem states. The monitoring allows the human impact on water body assessments - water intakes, adjustments of rivers, dams and other. In order to obtain a comprehensive state of water assessment the analysis of the chemical composition of the water, some basic biological properties, hydrological and morphological characteristics of water bodies is included in the surface water monitoring. Groundwater monitoring, of course, examines the quality and quantity of groundwater.

There are three types of surface water monitoring introduced by the Directive:

• ***Control monitoring*** - allows to obtain data on the status of water bodies for an extended period of time and to study the changes caused by climate change. This monitoring program is focused on those water bodies that are initially designated as risk-free and for which there is not enough information. This monitoring should provide sufficient information to make a comprehensive assessment of the status of these water bodies;

• ***Operational monitoring*** - it is focused on bodies of water that are exposed to pollution, disruption of the flow when the watershed, and for which there are certain risks and problems. The main objective of this monitoring is to establish and monitor the status of those water bodies that are designated as bodies at risk. Water bodies for which there is evidence of human impact are included in operational monitoring programs;

• ***Investigative monitoring*** - monitoring that is used when more information for surface water bodies is needed and which can not be obtained with operational monitoring . For ***groundwater*** is envisaged only two types of monitoring, control and operational. Water monitoring in Bulgaria is a part of the National Environmental Monitoring System (NEMS) and includes programs for control and operational monitoring. Monitoring networks and the measuring performance are regulated by the Minister of Environment and Water (MEW). Control and the monitoring in Bulgaria is entrusted to the four Regional Basein Directorates (RBD). Bulgarian Danube Border is within the Danube River Basin Directorate in the city of Pleven. This section has got 134 points (93 for rivers and 41 for lakes) defined for control monitoring. 54 points are for operational monitoring only for rivers. In Pleven RBD all cross-border co-operation areas are included with the exception of Dobrich, which is included in the Black Sea Basin Directorate area. The region there are 161 water bodies recorded such as rivers are 120, 41 are referred to the category Lakes. The main rivers that flow through the Danube basin by regions are as follows (Table 1):

Table 1. Rivers in the Danube basin in Bulgaria

Region	***Crossing rivers***	***Rivers, directly flowing into the Danube river (numbers mean at which kilometer of Danube the river flows)***
Vidin and Montana	Topolovets, Voynishka, Vidbol, Archar Skomlya, Lom, Tsiritsa Ogosta, Timok	Topolovets - 785 km, Soldier 783 km, Vidbol - 784 km, Archar - 769 km, Skomlya , 763 km and Timok - 846 km
Montana	Lom, Tsibritsa, Prevalska, Ribene, Shutovitsa, Botunya, Barziya, Dalgoteska, Zlatitsa, Dushilnitsa Tsibar , Nechinska bara	Lom - 742 km , Tsibritsa - 716 км
Vratsa	Ogosta, Iskar (with a tributary Gostilya), Botunya (with a tributary Vartenitsa), Skat (with a tributary Speed), Ribinya	Ogosta - 685 km
Pleven	Iskar, Vit , Osam, Gostilya , Gold panega, Tuchenitsa, Chernalka, Lomya	Iskar, 637 km, 609 km , Vit , Osam , 599 km
Veliko Tarnovo	Yantra, Rosica , Belica , Dryanovska Veselina, Lefedzha, Big River , Dzhulyunishka Reka, Cold River , Old River , Eliyska River	Barata - 555 km Барата- 555 км
Ruse	Ruse Lom , Beli Lom, Cherni Lom , Malki Lom , Lom Baniski , Dolapdere, Yantra, Tochiyska	Ruse Lom - 498 km , Yantra , 536 km , 458 km Tochiyska
Razgrad	Beli Lom Malki Lom , Dolapdere , Topchiyska river Tsaratsar , War , Chairlak , Senkovets , Kerizbunar	Topchiyska River , 458 km Топчийска река- 458 км
Dobrich	Suha Reka, Dobrichka, Karandere, Shablenska Reka, Harsovska Reka	
Silistra	Kanagyol, Dry River, Senkovets , Tsaratsar	Senkovets -405 km Tsaratsar - 435 км

The major rivers of the territory of Bulgaria with catchment area larger than 4000 km2, flowing into the Danube River are Ogosta, Iskar and Yantra. For these three basins there are 63 monitoring points - 31 points of them are included in both monitoring programs - control and operational..The basin of the rivers Vit, Osam, Ruse Lom, Dobrudza rivers for which there is not enough available data were evaluated as possible risk pollutants. There are 6 cross border monitoring points in the program. With the established traditions the monitoring program of the Danube River has 5 points - Novo Selo, Baikal, Svishtov, Ruse and Silistra. The other three rivers (Timok Erma and Nishava) which are crossing the border of the Republic of Bulgaria and the Republic of Serbia are also included in the cross-border control points and Timok is included in the operational monitoring program. To assess the pollution of the Danube, which is transported through the state borders, a point at Novo Selo where the Danube river enters tn Bulgaria is established and another point is established in Silistra , where the Danube leaves the country.

The monitoring program of the Danube River Basin includes also dams - 41 pieces: and 5 of them are used for drinking water supplement. For these water dams additional monitoring requirements are included in the monitoring program. Information about the environmental potential of the remaining 36 water bodies is not available. These water bodies are therefore assessed as possible risk and are included in the program for surveillance monitoring .

In Romania the water management monitoring is entrusted to the National Administration "Apele Române" and it includes 11 Basin administrations which directly conduct monitoring control. Monitoring stations are part of the "National Integrated System for Water Monitoring ". This system includes six subsystems, namely subsystem "rivers", "lakes" subsystem, subsystem "transitional waters", "coastal" waters subsystem, subsystem "groundwater" and "wastewater" subsystem–which controls effluents discharged into natural receivers. In Romanian trans border section there are 5 administrations of the Danube River Basin:

• ***Basin Administration Jiu*** - this administration covers the following counties: Mehadintsi, Dolj and Gorj and independent hydraulic unit "Petrosani". The total area of this basin administration is 18975 km2 and river network length is 5,884 km. The main rivers in Mehadintsi County are tributaries of the Danube. They are: Black, Topolnitsa Blatnitsa, Druncha, Bahna, Ponikova and on the East - river Motru , which is the largest tributary of the river Jiu. The river Jiu is passing trough the territory of Dolj County and it is 140 km long. Beside it, other tributaries of the Danube River are rivers Barboya, Desnatsuy, Chutura, and tributaries of the river Jiu – Amaradaya, Ploska, Raznik , Dzhilort , Mereshel and Mascot. . Here goes Tesluy River, a tributary of the river Olt. In this administration there are 68 rivers, which are distributed according their eco conditions as follows: 28 rivers in very good condition, 26 in good, 13 medium and 1 river in poor environmental condition. In this administration there are also 12 natural rivers that run through the Danube River Basin, and 5 rivers of them are in good and 7 are in moderate ecological status.

• ***Basin Administration Olt*** - in this administration there are 6 counties of which only Olt county is included in the cross section and only the river Olt

crosses this county. In this area it is 100 km length. Its main tributary is the river Oltets. In this basin there are some crossing rivers - Vedya , Plapcha , Tesluy and other smaller. In this basin administration there are 187 flowing water bodies - rivers, 2 of them are of very good environmental conditions, 125 - good, 50 - moderate ecological condition, 7 - poor condition and 3 bodies are of very poor condition;

• ***Basin Administration Arges-Vedea*** - it includes 4 counties from which only Teleorman and Giurgiu counties are in the cross border section. Three major tributaries of the Danube - rivers Olt, Kalmatsui and Vedya pass this county. Other three rivers Dambovnik , Glavachok and Kalnitsa pass through the county They are tributaries of the river Nyazhlov. Rivers Teleorman , Burda Kaneluy and others pass this county. In Giurgiu County river Neajlov (Nyazhlov) passes with its tributaries - Kalnitsa , Dambovnik and Sabar. In the basin of river Arzhes there are 83 rivers. 55 are in good condition and 25 are in average condition. In the basin of river Wedel there are 21 rivers. 9 of them are in good ecological condition and 9 - in medium;

• ***Basin Administration Buzău -Ialomina*** – the cross-border Calarasi county is involved in this administration. This basin administration covers an area of 22289 km2 and river network - 5,424 km. There are 17 dams, 4 water treatment plants at a rate of 4.4 m3 /s, 9 pump stations at a rate of 111.7 m3 / s, 44 hydrological stations 49 hydrometric stations and 110 rainfall stations. Main rivers are Ialomita (Ialomita), Bukau (Buzau), Prahova (Prahova), Kalmatio (Calmatui) and (Mostistca), which is formed by a series of lakes. In the Lalomita River Basin there are 50 bodies and 33 of them are in good ecological condition, 15 in medium and 2 rivers in poor ecological condition. In Buzau River Basin there are 35 water sites, and 34 are in good ecological condition and 1 water body is of moderate ecological status;

• ***Basin Administration Dobrogea Litoral*** - this administrative center covers 4 counties and has an area of 16501 km2. From the border region is Constanta County. The rivers Almalau, Urluya, Topog, Tsibrin Candy pass this Basin. They are tributaries of the river Danube. The river Casimcea also passes through this region and flows into the Black Sea. In this administration there are 11 water bodies with average ecological condition.

Indicators of the chemical status of surface waters are examined in the monitoring stations. Also hydro-biological and hydro morphological monitoring is provided in the stations.

Indicators for the chemical status of surface waters monitoring are divided into three groups:

-***Basic physicochemical parameters*** - temperature, pH, suspended solids, conductivity, nutrients (NH4-N, NO3-N, PO4), dissolved oxygen, oxygen saturation, Mn, , ammonia nitrogen nitrate nitrogen, iron, manganese, sulfates, chlorides ;

- ***Priority substances*** - that are highly toxic, persistent and easily bio-accumulate substances. The number of these substances is 33. 16 of them may be analyzed, for three of them there is not methodology and reference material

- ***Specific pollutants*** - they are divided into three more groups:

a) Organic compounds: phenols, oil, Aldrin, Dieldrin, Endrin, Izodrin and others (total 43 organic substances);

b) Heavy metals (zinc, copper, chromium-6, and chromium-3, arsenic, selenium, and others (total 18 elements);

c) Others - cyanides, carbonates, sulfides, hydrogen carbonates, vegetable oils and fats, etc. (totally 10) .

The monitoring frequency of the various parameters can be varied depending on the result values

Hydrobiological monitoring indicators are:

- *Fito plankton* (only for Danube River, lakes and dams), macrophytes, phytobenthos, bottom invertebrates and fish. Hydro biological monitoring of superficial waters is provided by the 9 laboratories which belong to the Executive Agency for the Environment (EAE). The number of points of hydro-biological monitoring of category "river" is 1461, for category "lake / dam" is 99 and for category "coastal waters" is 21. Implementation of the monitoring programs is distributed in the period 2010 – 201. Each year between 500 and 600 points are serviced, depending on the capacity of analytical laboratories and programs planned by the Basin Directorates. The minimum frequency of the monitoring is once a year, with the exception of the phytoplankton monitoring, for which the minimum frequency is twice a year.

Hydro morphological monitoring indicators are:

- Continuity of the river, hydrological regime, quantity and dynamics of flow and connection with underground water bodies; morphological status - for rivers - varying depth and width of rivers, substrate structure of the riverbed and structure of the coastal zone, for lakes - varying depth, quantity, structure and substrate of the lake bottom and cost structure .

Groundwater Monitoring

In the Danube Basin 48 groundwater bodies are registered. They are: 35 are digging, 12 are karsts and 1 is crack. In terms of hydrological conditions 43 are unconfined and 5 units are pressurized. Groundwater monitoring network is determined by the Minister of Environment and Water. It includes:

- ***A network of stations for quantitative monitoring***. It allows to characterize and to assess the risks in terms of quantitative water body state. According to this indicator in the Danube region 44 groundwater bodies are to be monitored, 4 are not to be monitored as there is no risk of significant changes. In the region there are 86points, 63 of them are for the water level control, 20 units are for flow control and one is for surface water drainage.

- ***A network of stations for surveillance monitoring***. That validates the procedure for characterization and risk assessment of the chemical status of groundwater and provides information about the pollutants in groundwater bodies..

- ***A network of stations for operational monitoring***. That determines the status of all groundwater bodies at risk of not achieving the objectives set out in Art.4 of the WFD and to detect the presence of significant and sustained upward trend in the concentration of pollutants. They consist of points of control and operational monitoring of the chemical status of groundwater and stations for the groundwater quantitative status (water level measurement in wells and springs flow). In the Danube Basin there are 98 control points and 24

operational points for monitoring. Also there are 82 monitoring stations of water protection in the area, some of them are overlap with the control points of monitoring.

Monitoring stations of the quantitative status of groundwater include: 282 points for water level measurement, 112 points are for flow rates measurement, 69 points are for surveillance monitoring and 8 points are for control and operational monitoring

Groundwater samples were taken and analyzed by the laboratories of the EEA.

Measured parameters are divided into four groups:

• ***Basic physicochemical parameters*** - dissolved oxygen, pH, conductivity, nitrate ions NO3, ammonium NN4, temperature, Mn, total hardness, calcium, magnesium, chloride, sodium, potassium, sulfates, hydrocarbons, carbonates solids ;

• ***Additional physicochemical parameters*** - nitrite ions, phosphates, total iron, manganese;

• ***Specific pollutants of groundwater*** - Metals and metalloids - lead, cadmium, arsenic, mercury, copper, zinc, nickel, chromium - trivalent, chromium - hexavalent, strontium (of natural origin), α - activity , β - activity ;

• ***Specific pollutants of groundwater*** - organic compounds - trichlorethylene, tetrachlorethylene , aldrin , atrazine , DDT / DDD / DDE, dieldrin, drin, endosulfan, endrin, methoxychlor, HCH - compounds propazine, simazine, heptachlor, chlordane, 2,4 D - acetochlor , pendimethalin, flutriaflor, triadimenol .

The sampling rate for the control monitoring is 2 or 4 times a year, for the main physical and chemical parameters the frequency is - 2 or 4 times per year, for additional physicochemical parameters frequency is - 1 to 4 times / year, for metal and metalloid 1-2 times and for the organic matter - 1 time / year. For the 82 points, established for protection zones of water monitoring in the Danube Basin, the sampling frequency of monitoring does not coincide with the time of sampling for the control and operational monitoring. For the main physicochemical parameters the frequency is 1 time per year, for the additional physicochemical parameters the frequency is 2 times a year for metal and metalloid - also 2 times a year. The operational monitoring is only for the stations where the poor ecological condition of groundwater bodies is known.

In the Danube Basin there are 21 groundwater bodies (20 non-pressure and pressure 1) with reliable proven risk and for them the operational monitoring have to be made At risk in terms of the quantitative status are 4 of them and the rest are at risk in terms of dry conditions. Chemical pollution is mainly with NO3, PO4, NO2, and primarily is due to agriculture in areas of groundwater bodies. Two water bodies are contaminated with other activities – they are with body code BG1G0000Qa1005, located in Kozloduy valley - contamination with Fe and Cl, and the second BG1G0000Qa1008 in Belene - Svishtov valley – contamination with NH4, Fe and Mn. It is proven that 25 groundwater bodies are not at risk. The Danube Basin has 12 groundwater bodies and for them there are 43 monitoring stations for control monitoring and 20 stations for operational monitoring. .

For the trans border groundwater bodies there is a consistency with Romania - for groundwater bodies in the Danube area and in Black Sea Basin areas. For the Danube region there is only one water body with a code BG1G0000J3K048 - karsts water in Malm - Valazhkiya basin. This body of water is deep, there is a monitoring point and there is not enough data for valuation.

In Romania in 2011 a change was made in order to optimize the monitoring network. The specified stations and frequency of monitoring for the different basin administrations are as follows:

- ***Basin Administration Jiu*** – It controls 8 underground water bodies. In 2010 a new monitoring network has developed. It consists of 108 monitoring stations. The old network contains 235 points. Monitoring frequency is twice a year;

- ***Basin Administration Olt*** - in this territory of administration 14 groundwater station are included. 7 of them have a greater pollution vulnerability. This group includes units ROOT01-Ciucului, ROOT02-Brasov, ROOT05-Sibiu, ROOT06-Hârtibaciu, ROOT07-Făgăras, ROOT08-Oltului, and ROOT09 - the lower terraces of the Danube Valley - Beckett - Turnu Magurele;

- ***Basin Administration Arges-Vedea***. This administration has 11 groundwater bodies and there are 172 points established as a monitoring network. The frequency of monitoring is once per year. The groundwater bodies at risk are ROAG02-Câmpia Titu, ROAG03-Colentina, ROAG05 - lower terrace of the river Arges, ROAG07- terrace of the Danube, near Giurgiu-OlteniŃa, ROAG08 - Pitesti, ROAG09 - terrace on the river Vedea, Teleorman and CălmăŃui water body ROAG10 - terrace of the Danube, near Tr. Măgurele. The frequency of monitoring is 2 times a year ;

- ***Basin Administration Buzău -Ialomina***. In this administration area 18 groundwater bodies are included and the monitoring network consists of 163 monitoring points. The frequency of monitoring is twice a year;

- ***Basin Administration Dobrogea Litoral***. This administration includes 10 groundwater bodies and has a network of 101 monitoring points. For the main water bodies monitoring is planned to take place once per year. For underwater objects RODL01-Tulcea, RODL02 - Babadag, RODL05 - Central Dobruzha, RODL07 - terrace of the Danube near Hârsova - Brăila, RODL08 - Casimcea, RODL09 - North Dobruzha and RODL10 - southern Dobrogea monitoring is carried out twice a year.

Control and information system for waste water

Control and information system functions under Article 171, paragraph 1 of the Water Act, Section IV of Ordinance № 1/11.04.2011 [2] for water monitoring [2] and in connection with the Order № 382 / 4.20. 2010 the Minister of Environment and Water

According to the above mentioned ordinance all facilities that discharge to surface waters, all subjects under the Water Act, as well as those that require a permit under the Act for the protection of the environment are subjects for mandatory control Sampling is carried out 2 times a year / first and second half of the year / for each discharge from an object, and for urban sewage systems - once a year.

Conclusion

Pollution of the river Danube water is a serious threat for the ecological balance in the border region Bulgaria - Romania. River water may be contaminated with many substances, organic and inorganic origin, some of which may be toxic, carcinogenic and mutagenic. Some of them could additionally react and to produce new toxic products. Monitoring systems of the two countries work well individually, but it is needed to harmonize methods of sampling and analysis of contaminants for better comparability of results and joint pollution prevention in the future. Reporting of existing contamination is now not enough but strict control of businesses that generate pollutants and discharging them into the river and its tributaries has to be performed by both states.

All this provides scope for cooperation and strong collaboration between the research institutes of the two countries, and this should happen as soon as possible. Condition for this is also the joint implementation and harmonization of all regulations, measurements and processes, joint monitoring and assessment of risks to the environment and health of the population on both sides of the river and its tributaries.

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