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The main factors of water pollution in Danube River basin

Carmen GASPAROTTI[1]

[1] *University "Dunarea de Jos" of Galati, Naval Architecture Faculty*, carmen.gasparotti@ugal.ro

Abstract. The paper proposed herewith aims to give an overview on the pollution along the Danube River. Water quality in Danube River basin (DRB) is under a great pressure due to the diverse range of the human activities including large urban center, industrial, agriculture, transport and mining activities. The most important aspects of the water pollution are: organic, nutrient and microbial pollution, , hazardous substances, and hydro-morphological alteration. Analysis of the pressures on the Danube River showed that a large part of the Danube River is subject to multiple pressures and there are important risks for not reaching good ecological status and good chemical status of the water in the foreseeable future. In 2009, the evaluation based on the results of the Trans National Monitoring Network showed for the length of water bodies from the Danube River basin that 22% achieved good ecological status or ecological potential and 45% river water bodies achieved good chemical status. Another important issue is related to the policy of water pollution.

Keywords: Danube River, hazardous substances, microbiological pollution, water quality, hydro-morphological alteration

1 Introduction

The Danube River is an important international river in the world. Originating in the Black Forest region of Germany, only 40 km from the Rhine, it flows 2,857 km to its mouths at a delta in Romania and Ukraine, discharging into the Black Sea via the Danube Delta at a rate of about 6,500 m^3/s. The extreme values of the river flow are ranging from: 15,540 m^3/s, for peak discharges, to 1,610 m^3/s, for low flow. The hydrologic regime of the Danube River is influenced by the regional precipitation pattern (Gasparotti C. *et all*. 2013).

The Danube River Basin (DRB) covers an area of 801,463 km^2 that represents 10% from the surface of Europe and including 19 states (ICPDR 2005c).

The Danube has about 300 tributaries. The Danube River and its tributaries impact the lives of over 80 million people and Romania contributes by far with the largest population (more than 26%).

The DRB is conveniently divided into an upper (Black Forest region -Vienna), middle (Vienna-Iron Gates) and lower (Iron Gates - Black Sea) regions and the Danube Delta.

The Danube River and its tributary rivers provide a vital resource for water supply, sustaining biodiversity, agriculture, industry, transport, fishing, recreation, tourism, power generation and navigation. All of which are heavily dependent on the rational use and sustainable management of the river and it's related with ecosystems.

The Danube is navigable by ocean ships from the Black Sea to Brăila in Romania and by river ships to Kelheim, Bavaria; smaller craft can navigate further upstream to Ulm, in Germany. About 60 of its tributaries are also navigable. Since the completion of the German Rhine–Main–Danube Canal in 1992, the river has been part of a trans-European waterway from Rotterdam on the North Sea to Sulina on the Black Sea (3500 km). In 1994 the Danube was declared one of ten Pan-European transport corridors (corridor VII). The waterway is designed for large scale inland vessels (110×11.45 m) but it can carry much larger vessels on most of its course (Nachtnebel 1997).

The purpose of the present work is to perform a brief analysis of the sources and nature of the water pollution in the basin of the Danube River, quantifying the way how they affect the water quality, the policies to control the water pollution and the importance of implementing of WFD (Water Framework Directive) for the water quality in DRB.

2 Main factors of pollution in the Danube River basin

The Danube River is permanently subjected to both natural and anthropogenic pressures. The quality of the river water is under a great pressure from these activities with the participation of over 80 million people, which generate large quantities of pollutants and which the Danube River collects and transports them until the mouth in the Black Sea.

In DRB economic activities are very diverse including numerous large urban centers and industrial, agriculture, forestry and mining activities. The navigation is an important factor of pollution (Gasparotti C. *et all*. 2008).

Increasing of the industrial activities, intensive farming and growing of human populations imply even greater risks of pollution by nutrients and toxins. The water quality has steadily declined due to high pollution inputs from tributaries, poor pollution control and industrial inputs. Agricultural runoff is also a source of pollution and the dams have reduced the sediment and suspended solids carried down by the river, which has affected the Delta.

The most significant factors that affecting water quality of the Danube River basin are: organic pollution, nutrient pollution, hazardous substances pollution, microbial pollution (contamination), alterations due to the hydro morphological pressure (Gasparotti C. *et all*. 2013).

The pollution along the Danube is caused mainly by the following factors (ICPDR 2005c):

- point sources (municipal, industrial and agricultural);
- diffuse sources (agricultural, agglomerations);
- effects of modifying the flow regime through abstraction or regulation;
- morphological alteration.

Table 1 Overview of the most significant point sources of pollution in the Danube River District (reference 2002)

	DE	AT	CZ	SK	HU	SI	HR	BA	CS	BG	RO	MD	UA
Municipal point sources:													
WWTPs	2	5	1	9	11	3	10	3	4	6	45	0	1

Untreated wastewater	0	0	0	2	1	3	16	15	14	31	14	0	0
Industrial point sources	5	10	10	6	24	2	10	5	14	4	49	0	5
Agricultural point sources	0	0	0	0	0	1	0	0	0	0	17	0	0
Total	7	15	11	17	36	9	36	23	32	41	125	0	6

** Two of these bodies are shared by SK and HU. Where: DE-Germania; AT-Austria; CZ-Czech Republic; SK-Slovakia; HU-Hungary; SI-Slovenia; HR-Croatia; BA-Bosnia Herzegovina; CS-Serbia-Montenegro; BG-Bulgaria; RO-Romania; MD-Moldova; UA-Ukraine.*

Thus, a very important contribution to the pollution of the Danube River basin has the point sources. The inventory for the reference year 2002 includes 987 municipal, 306 industrial and 62 agro industrial points, including the significant point sources. A quantification of the most significant point sources and their repartition in each DRB country is presented in Table 1 (ICPDR 2005c).

As reflected by the above table within the upper Danube region, the point source discharges are considerably lower to those of the middle and lower Danube. Most point sources from the basin are found in Romania (125), followed at long distance by Bulgaria (41), Hungary (36) and Croatia (36). For these countries there is a large potential for reduction of the point sources discharges.

2.1 Organic pollution

The organic pollution is produced by the discharge of wastewater from point or/and diffuse sources. Organic materials are found in untreated municipal sewages, and in agricultural sources and food processing industries.

The main contributors to the organic pollution are the agglomerations which have no or insufficient wastewater treatment.

Figure 1 (ICPDR 2009a) provides an overview of the existing wastewater treatment plant, the existing treatment levels and the degree of connection to wastewater treatment throughout the entire DRB per country (reference year 2005/2006).

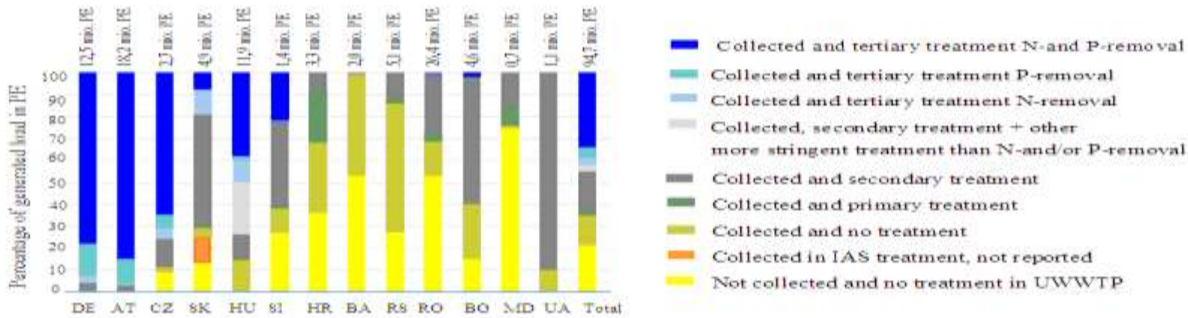

Figure 1 Wastewater treatment of the generated load from agglomerations ≥ 2,000 PE (population equivalent)-reference year 2005/2006 (existing wastewater treatment plants; existing treatment levels and degree of connection to wastewater treatment for the entire DRB by country) (from ICPDR 2009a)

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Figure 1 indicates that in the Middle and Lower Danube countries, including Romania there are not tertiary stations of wastewater treatment and predominate the nonexistence of the collection systems or there are collection systems without treatment plants or at most with primary treatment plants.

The quantities of COD (Chemical Oxygen Demand) and BOD_5 (Biochemical Oxygen Demand) emission from large agglomeration (≥10,000 PE) in the DRB are respectively 922 kt/a and 412 kt/a. The total emission, including emission from agglomerations ≥ 10,000 PE are 1,511 kt/a for COD and 737 for BOD_5 for 2000 (Table2) (ICPDR 2009a, ICPDR 2009b).

Table 2 COD and BOD_5 emissions from agglomerations ≥ 2,000 PE for each Danube country and the entire DRBD emitted through all pathways (reference year 2005/2006)

	DE	AT	CZ	S K	HU	SI	HR	BA	CS	BG	RO	MD	UA	Total
Emission COD (kt/a)	31.7	30.5	17.0	74.0	87.6	26.3	144.6	87.5	191.3	727.1	62.3	22.0	8.8	1,511
Emission BOD_5 (kt/a)	5.9	6.2	7.1	34.6	45.8	12.7	68.0	47.0	95.4	366.6	31.1	11.5	4.7	737

The discharges of industrial wastewaters are important because very often these industrial wastewaters are insufficiently treated or are not treated at all before being discharged into surface waters or public sewer systems (ICPDR 2009a, ICPDR 2009b). Figure 2 illustrates these discharges provided in 2004 by the EU member states.

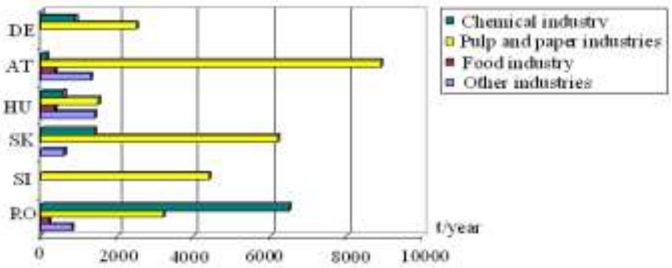

Figure 2 Direct emissions of total organic carbon per relevant types of industries in European Union Member State (2004) (from ICPDR 2009a)

The amount of pollution caused by the industrial sector varies among the countries. As a result in Figure 2, the largest emitter is the pulp and paper industry. Significant contributions have also chemical, textile and food industry.

The pressure analysis shows that the emission from industry is still lower than those from agglomerations. In agriculture, the most relevant point sources of organic pollution are animal breeding and manure disposal.

In Romania, in 1999, a statistical analysis of the main wastewater sources indicated that the highest amount of untreated waste water is generated by the municipalities (85%), chemical industry (4%), metal-processing and machine-construction industry (3%) (Ministry of Environment and Forests, National Administration „Romanian Waters” 2010).

The decomposition of organic material following extreme seasonal algae growth caused oxygen depletion in the bottom layers and reduces the diversity of the flora and fauna (Ministry of Environment and Forests, National Administration „Romanian Waters" 2008).

A significant reduction potential for organic pollution exists through the application of best available technique for wastewater treatment facilities (ICPDR 2005a). Considerable efforts as regards financial investment will be necessary to reduce organic pollution to acceptable level.

2.2 Nutrient pollution

The nutrient pollution is caused by point sources including untreated waste water discharges or inadequately treated settlements from urban, industrial, agricultural and diffuse sources. Comparatively with 1960s, in the present the level of the total nutrient load in the DRB system is considerable higher, but however is lower than in the late 1980s. The decreases from the 1980 to the present situation are due to the political as well as economic changes in the middle and lower DRB resulting in: the closure of nutrient discharging industries, significant decrease of the application of mineral fertilizer and the closure of large animal farms (ICPDR 2008a).

In 2000, the total nutrient point discharges into the Danube was about 134.2 kt/nitrogen and 22.7 kt/phosphorus.

The specific emissions of N (nitrogen) and P (phosphorus) from point sources (Figure 3 and Figure 4) show that the lowest for N discharges are in Germany, Moldova and Ukraine with 4g/(Inh.d) per connected inhabitant and for some countries this emission was higher than the assumed value of 12g/(Inh.d) (ICPDR 2005c, ICPDR 2008b).

The lowest specific P emissions from point sources was under 1g /(Inh.d) in Germany, Austria, Czech Republic, Moldova and Ukraine and biggest emissions, above 2.5g//(Inh.d) was for Slovenia, Croatia, Serbia and Montenegro.

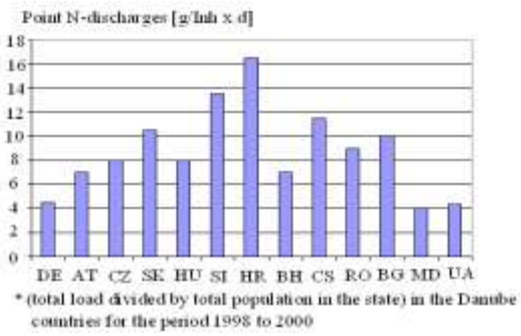

Figure 3 Inhabitant-specific N discharges from point sources* (from ICPDR 2005c)

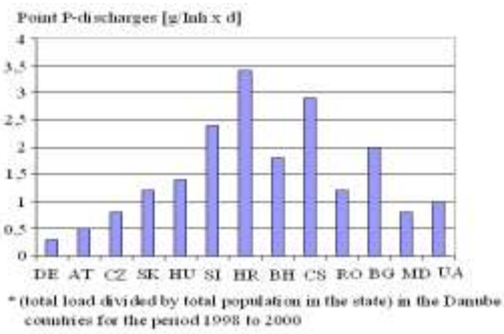

Figure 4 Inhabitant-specific P discharges from point sources* (from ICPDR 2005c)

A significant source of nutrient pollution is industrial facilities, from which the chemical and food industry sector are the most important contributors.

For the year 2005/2006, N_{tot} and P_{tot} generated load emitted from agglomerations ≥2,000 P.E. for each Danube country and for the DRB are shown in Table 3 (ICPDR 2009a).

Table 3 N_{tot} and P_{tot} emissions from agglomerations ≥ 2,000 PE for each Danube country and the entire DRBD emitted through all pathways (reference year 2005/2006)

	DE	AT	CZ	SK	HU	SI	HR	BA	RS	RO	BG	MD	UA	Total
Emission N_{tot}(kt/a)	12.3	9.5	2.8	11.4	14.7	3.2	10.9	7.3	16.6	69.3	6.5	1.9	2.1	168
Emission P_{tot} (kt/a)	1.0	0.8	0.4	1.7	2.8	0.7	2.8	1.6	2.9	11.5	1.3	0.4	0.7	28.6

Using the MONERIS model, (Schreiber H. *et all*. 2003) have found that the N emission to the river system of the Danube Basin are about 690 kt/year and the P emissions to surface waters in the Danube Basin is about 70 kt/year. The natural background (N losses without any anthropogenic influence) represents about 25% of the total N-emission and about 10% of the total P-load. Waste water discharges (mainly point sources) contributes to about 22% of total N-load and about 45% of total P-emission to the river system. The agricultural contribution is about 45% of the total and N-emission, but about 25% can probably be influenced by improved agricultural practice (e.g. reduced intensity). About 44% of total P-load stems from agricultural land and to a high existent is caused by erosion and is therefore in particle form. About 8% of the N-emission can be related to air pollution by combustion and traffic mainly with NO_x (Figure 5 and Figure 6).

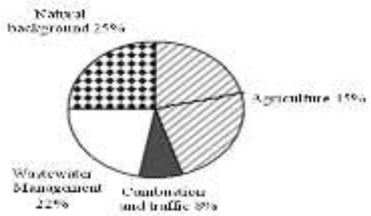

Figure 5 Sources of N emissions 1998-2000 into the river system of the Danube basin (from Schreiber H. *et all*. 2003)

Figure 6 Sources of the P emissions 1998-2000 into the river system of the Danube basin (from Schreiber H. *et all*. 2003)

About 65% (450 ktN/year) of the nitrogen emissions and 35% (25 ktP/year) of the phosphorus emission to the river system are discharged by river Danube to the Black Sea. The rest of the emissions is removed from the river system by denitrification and P-emission is stored in the river the region of the Iron Gate reservoir plays an significant role as point sink in this respect (storage of about 8-10 ktP/a) (Van Gils 2004).

Nevertheless, it has to be highlighted that the nutrient pollution in the Danube in the different countries is due to different sources. Into Hungary, Serbia and Montenegro the dominant sources for N emission are the urban settlements, whereas for Austria and Bosnia Herzegovina is mainly the atmospheric deposition of $NO_{x,}$ while for all other countries this is mainly due to the agricultural activities.

For phosphorus, the point and diffuse emission from urban settlements are the major source of pollution with the exception of Germany and Austria where agriculture shows the largest share (ICPDR 2009a).

In Romania, the Danube River carries a significant load of nitrates and phosphates that come from the countries upstream of Romania. A study in 2001 by the Economic Commission for Europe (ECE) showed that the share of nutrient pollution from abroad (at Bazias) is 84.9% for nitrogen and 70% for phosphorous. 15% of nitrogen and 30% of phosphorous pollution originate downstream from Bazias (ICPDR 2005a). In Romania, the nutrient pollution results from the discharge of wastewater into the Danube's tributaries (the Jiu, the Olt and the Argeş, the Ialomita, the Siret and the Prut rivers), direct discharges of urban waste water from the towns on the Romanian bank of the Danube (Drobeta-Turnu Severin, Braila, and Tulcea), which do not have wastewater treatment plants and a number of industries (Romag Tr.Severin, Celrom Tr. Severin, Siderca Calaraşi, Comceh Calaraşi, Celohart Braila, Alum Tulcea, Comsuin Ulmeni) also discharge their insufficiently treated waste water directly into the Danube.

The high load of nutrients (nitrogen and phosphorus) has a negative impact on water quality, caused the eutrophication of surface water that reduce fish production capacity and the water is unsuitable for recreation (Economic Commission for Europe 2001).

The nutrient load from the Danube into the delta increased several-fold for nitrogen and phosphorus from 1960 to 1990, that has caused extreme seasonal algae growth and oxygen depletion in the bottom layers and reduced the diversity of the flora and fauna (Ministry of Environment and Forests, National Administration „Romanian Waters" 2010).

Nutrient loads into the DRB have significantly decreased over the past 20 years. In the future, for this decreased the introduction of phosphate-free detergents and a drop in fertilizer use in the agriculture sector throughout the Danube basin appears to be a necessary measure.

2.3 Hazardous substances

The hazardous substances discharged in the Danube River are pesticides, ammonia, other organic micro-pollutants such as polychlorinated biphenyls (PCB) and polyaromatic hydrocarbons (PAH), heavy metals, petroleum products and pesticides. The potential health and economic risks of these pollutants are high (Gasparotti C. *et all*. 2013).

The data on contamination levels in Danube River water and sediment indicate that this is not a serious problem in its entirety, there are, however, a number of "hot spot" pollution sites. Most of the pollution sites are found in the lower reaches of the rivers (Economic Commission for Europe 2001).

The pollution with hazardous substances is produced by wastewater from point sources and diffuse emissions of pollutants (ICPDR 2005b).

The sources of pollution with hazardous substances are: industry, agriculture and transport (Gasparotti C. *et all*. 2013).

It was considered that industry and mining are responsible for most of the direct and indirect discharges of hazardous substances into the Danube basin (Administration Basin of Water Seaside Dobrogea 2010).

Industry contributes to the Danube pollution with heavy metals (extraction and processing industry, chemical industry), dangerous organic micro pollutants (organic chemical industry, pharmaceutical industry), oil product and solvent (oil refineries).

In 2004 comparatively with 2001 increase of load values of arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc. In 2004, the amount of lead directly discharged was 138 t/a, and for the zinc, 171 t/a (Administration Basin of Water Seaside Dobrogea 2010), cadmium and lead being the most heavy metals exceeding the targets values in many locations on the Lower Danube region (ICPDR 2005c).

Implementation of urban wastewater treatment contributes to the reduction of hazardous pollution from urban wastewater and from indirect industrial discharges and for the industrial sector reduction of point source emission by applying BAT (Best available technology) (ICPDR 2009a).

The intensive agricultural activities may be a source of pesticide pollution. Diffuse discharges from agriculture are important sources of micro-pollutants. About 300-500 different active agents of pesticides have been used in the basin (ICPDR 2004).

The use of the low quality phosphate fertilizer with a high content of cadmium contributes to the contamination of soil and water.

The transport activities appear to be important sources of oil pollution, and represent the main source of lead, to the Danube and its tributaries (ICPDR 2004).

Vessels have an important contribution to the oil pollution along the Danube. Ships transiting the Danube River pollute evacuating in water wastes such as: used oil, bilge oil, bilge water, wash water contaminated with oil and fuel residues. The transport and storage of oil in old tanks may produce accidental spills of petroleum products into rivers (Schreiber H. *et all.* 2003). Accidental spillages of oil are frequently encountered. In 2007, in the Romanian Danube sector five pollution incidents have occurred, some from unidentified sources and bilge water, others because of the negligence of operators and old technologies. But these sources have low potential of pollution (ICPDR 2004).

The oil pollution is a serious threat to the riverine ecosystems because the oil contains a whole series of chemical components, some of which are toxic to the micro fauna and micro flora of the aquatic ecosystems (Gasparotti C. 2010). Once introduced in the biological material, the substances may concentrate also in the food chain.

The pollution with hazardous substances affected the aquatic environment and water quality. Chronic pollution will make the water unfit for drinking, for irrigation and recreation and might also have serious effects on fish production and its suitability for human consumption (Economic Commission for Europe 2001). Moreover, many of the hazardous substances attach very easy to solid particles and are deposited not far farm the discharges points.

To increase safety and environmental protection in the event of the accidental pollutions, in the Danube basin, since 1997, the Accident Emergency Warning System –AWES is operational since 1997. This provides in real time information to the affected riparian countries. The above system is activated in the event of danger of trans boundary pollution of water or if the pollutant concentration levels were exceeded. AWES system consists of subsystems organized in the riparian countries (Ministry of Environment and Forests, National Administration „Romanian Waters" 2010; Helmer and Hespanhol 1997).

2.4 Microbial pollution

The microbiological contamination is probably the most important health-related water quality problem in the Danube region. The data available indicate that both the upstream and downstream reaches on the Danube are contaminated microbiological. The main sources affecting the microbiological water quality are raw sewage, discharges from untreated or inadequately treated municipal wastewater, impaired tributaries and impact by diffuse sources. Many of the smaller cities and villages on the tributaries have minimal wastewater treatment (ICPDR 2010).

Kavka provides data related to the content of coli-form bacteria and heterotrophic bacteria in Danube and into its main tributaries. Higher levels of faecal pollution were found in the middle part of the Danube, particularly downstream of major cities (Budapest, Beograd) as far as 1.100 river km and in the Lower Danube to the Danube Delta. The highest bacterial pollution were observed in the tributaries (Russenski Lom, Arges, Siret and Prut in particular) and in the side arms (Moson arm, Rackeve- Soroksar arm), and lower bacterial pollution in the Upper Danube reach as well as in and downstream of the Iron Gate reservoir (Kavka G. 2006).

2.5 Hydro morphological alteration

The hydro-morphological alterations on the basin wide scale are caused by the hydraulic structures such as dams, weirs, some other works, for flood defence/river regulation and navigation for the Danube and main tributaries. Gravel and water abstraction as well as outdoor recreation activities and fisheries have been identified as being of minor or local importance (ICPDR 2010).

The most important hydro morphological pressures are hydropower generation, flood protection and navigation for the Danube and main tributaries. There are over 40 hydropower stations in the upper Danube and two Iron Gate stations in the lower Danube.

Over 700 large dams/weirs have been built on the river and its tributaries, with 69 of those built in the main Danube channel. The dams have reduced the sediment and suspended solids carried down the river, which has affected the Delta (Katie R. 2010). Smaller dams, dikes, river training also have important impacts. They can have adverse impacts on recreation if the natural quality of the river is reduced.

The pressures exerted by the hydraulic structures determine interruption of river and habitat continuity, disconnection of adjacent wetland/floodplains, hydro-morphological alterations of rivers (changes in river flow patterns and sediment transport regime) influencing the state of the aquatic ecosystems (ICPDR 2009a). The fish migration, the decline of natural reproduction of fish and the biodiversity are also influenced.

The major impact is the loss of the self-purification capacity and hence of biodiversity and habitat diversity.

Possible measures to reduce the hydro-morphological alterations are: restoration water bodies with migration barriers and reconnecting of wetland/floodplains (ICPDR 2009a).

The main sources of pollution, affecting systematically the Danube, are presented in Figure 7. All these sources: agglomerations, industry, agriculture, transport, hydro morphological alteration, make pollution to be complex process and increase the to achieve a good ecological and/or chemical status of water.

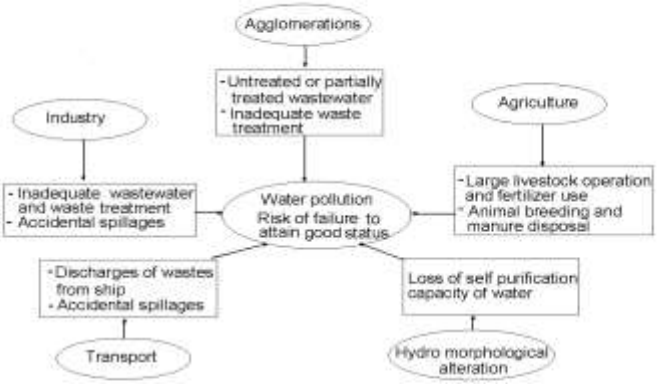

Figure 7 The main sources of pollution in the basin of the Danube River

3 Ecological and chemical status of water

After 1990, according to estimates data, the pollution of Danube decreased perceptible and a continuous improvement of the water status is noticed. These improvements are the result of the important progresses in reducing pollution achieved in countries more developed from economical point of view, (especially Germany and Austria) and the reduction of the economic activities in some of the central and eastern European countries and also due to measures for protection taken by governments (Nachtnebel H.P.1997)

Despite the fact that the actual situation shows important indicators of improvement, there are also elevated risks for not reaching good ecological status and chemical status of the water in the foreseeable future.

The evaluation based on the results of the TNMN (Trans National Monitoring Network) of the ecological status, ecological potential and chemical status of rivers from DRB in 2009 showed that from the total number of 681 river water bodies evaluated, 28% achieved good ecological status or ecological potential and 64% river water bodies achieved good chemical status (Figure 8 and Figure 9) (ICPDR 2009a; ICPDR 2009b).

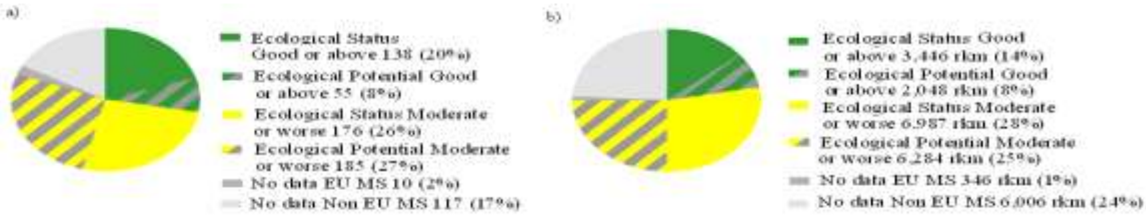

Figure 8 Ecological status and ecological potential for river water bodies in the DRBD (indicated in numbers and relation to the total number of river water bodies (a), as well as length (km) and relation to total length of river water bodies (b)) (from ICPDR 2009a)

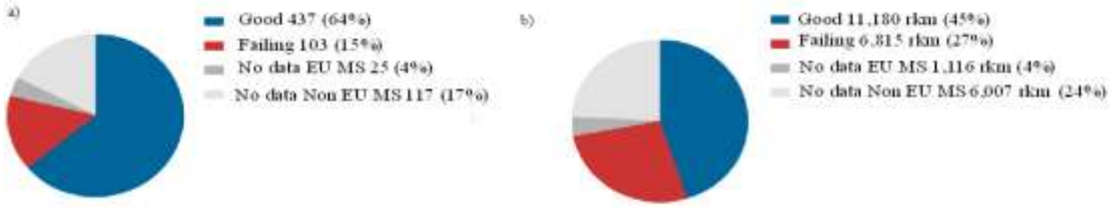

Figure 9 Chemical status of river water bodies in the DRBD (indicated in number and relation to total number of river bodies (a), as well as length (km) and relation to total length of river water bodies (b)) (from ICPDR 2009a)

According to the water quality classification on the Romanian sector of the Danube 1075 km in length, based on the global assessment of the three biological elements (macrozoobenthic, phytoplankton and aquatic macrophytes) in 2009 the water quality ranged in quality class II-good ecological state, data being provided by biological monitoring of 16 sections (ICPDR 2009a).

The water of the Danube River (including also about 20 of its affluent), in the hydrographic area corresponding to the Danube Delta and Dobrogea region, has been characterized as being 85% of moderate quality and 15% of poor quality, none of rivers having water of good or very good quality (ICPDR 2008b).

The pressure analysis along the Danube River in 2004 allowed the estimation of the main areas at risk, possibly risk or the failure to attain the good ecological and good chemical status. The results show that large parts of the Danube River are subjected to multiple pressures as it is illustrated in Figure 10 (ICPDR 2009a).

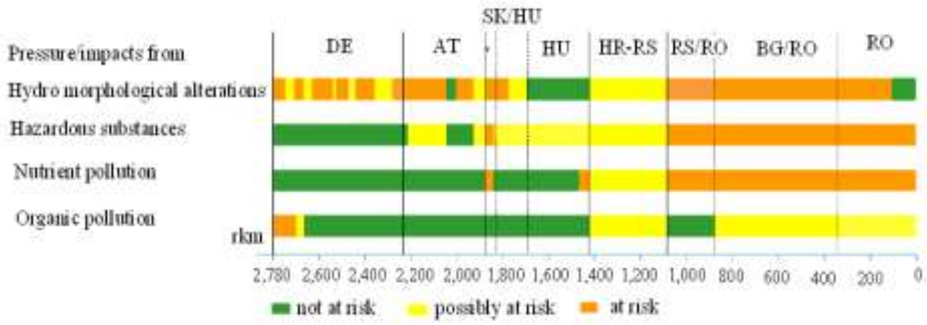

Figure 10 Results of the risk analysis for the entire Danube River length (2004) (from ICPDR 2009a)

As illustrated in Figure 10, for the entire length of the Danube River itself, 50% from its length was categorized at risk due to organic pollution, 65% due nutrient pollution and 74% due to hazardous substances. 93% of the Danube River was at risk or possibly at risk because of hydro morphological alterations.

The percentage of water bodies “at risk” or “possibly at risk” due to hydro morphological alterations is very high and reflects the level of human intervention in the Danube river basin in the past more than hundred years (ICPDR 2005c).

It consider that to reduce the risks and achieve a good status of water in the Danube River basin is possible especially by preventing and reduction pollution, this being the main objective of water management in the Danube River basin. For this purpose in many Danube countries investments have started and will to continue for another 10 to 20 years.

4 Policies to control the water pollution along the Danube River

Water quality in Danube River Basin (DRB) is significantly altered by the human activities. Water pollution has negative impacts on human health, social and economic activities, ecosystems and aquatic life.

The overall progress in improving the water quality that could be seen in the last two decades has not been sufficient, the water pollution remaining at an alarming level for the quality of life within DRB.

Policy responses to the water pollution are complex and operate within a context of local, national, regional and global policy and legal framework (Björklund *et all*. 2009).

One of political approaches concerning the water pollution is to adopt the uniform water quality standards, which serves to set realistic and achievable emission limits (Kraemer et al., 2001). Such standards are currently used in the EU. The development of a system of water classification, of the water quality objectives and of the water quality standards provides a better basis for the water management.

Implementation and enforcement of the water quality objectives and standards is another approach of the water policy. They lead to the improvement of the performances regarding the water quality protection and conservation.

The water policy also develops and implements rules and regulation and uses legal agreements to protect the waters resources (Kraemer *et all*. 2001; Björklund *et all*., 2009). The Conventions at regional and international level and the legal agreements at national level (Water Law, Water Acts, and Directives) are used to protect waters from certain pollutants and to establish regional pollution reduction strategies (Kraemer *et all*. 2001).

An important role to protect the water quality and to stop its degradation is taken by the decision of the Danube countries to cooperate in order to develop mechanisms to sustain the water resources. The Danube countries have organized a number of European conferences that have adopted principles of action, rules and programs for water quality protection. Also, they have adopted legal mechanisms and structures that facilitate the regional cooperation and the implementation of a new vision related to the water management.

The Declaration of the Danube Countries to Cooperate on Questions concerning the Water Management of the Danube (Bucharest, 1985) was established a new framework for regional cooperation (ICPDR, 2004). In 1991, the Environmental Program for the Danube River Basin was signed in Sofia, Bulgaria. This is focused on the protection and restoration of the river by supporting monitoring, data collection and assessment (ICPDR, 2004). In 1994 also in Sofia, 11 of the countries neighboring the Danube and the EU signed the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (DRPC). This Convention constitutes the legal and political framework for cooperation and water management in the Danube basin.

The development of monitoring and information systems is a condition for an effective water policy. An information base is need to develop integrated water management plans, to assess water quality, to implement and enforce laws and regulations and to inform about the state of the environment.

Water policy also includes the economic instruments such as charges, taxes, prices, tariffs for water services, economic incentives (Kraemer *et all*. 2001, Heinz *et all*. 2007). Economic and fiscal policies and introduced measures encourage water conservation and the better waste management as well as the control of the emissions from point sources.

In 2000, the EU adopts the Water Framework Directive (WFD) which provides a framework for the EU water policy, aiming the protection, improvement and the sustainable use of the water in Europe. The EU member states are obliged to fulfill this Directive.

The Directive brings major changes in water management practices. The WFD promotes a new approach of the water management. This is a modern and integrated approach for the water management, based on the concept of the river basin planning. This is one of the fundamental principles adopted by WFD (Paleari *et all*. 2005).The river basin approach requires a certain level of planning and institutional structures (Kraemer *et all*. 2001). The WFD provides the adoption of management plans and measures for each water body.

For the Danube River basin, because of its complexity, the basin-wide water management is based on three levels of coordination: the international basin-wide level; the national level and/or internationally coordinated sub-basin and finally the sub-unit level.

The WFD introduces sets of uniform standards in water policy throughout the EU (e.g. the regulations authorizing the discharge of the waste water into water courses and emissions limits for point sources) and updates of existing water legislation (Paleari *et all*. 2005).

A priority has the development of the systems of monitoring, including laboratory, data collection and assessment, harmonization of monitoring and of the methods of development of the information systems.

Also, WFD stipulates defined timeframes for the achievement of a good status of the surface water and groundwater, achievement of a good ecological status and a good chemical status of waters until 2015, this being a very ambitious task (ICPDR 2004; ICPDR 2005c).

The Directive requires an active involvement of public and of stakeholders (farms, industries, municipalities, authorities and NGOs) in taking the decisions concerning the water management. Decentralized and the transparency of decision-making systems as well as the access to information are major values of the integrated water management.

The WDF introduces economic analysis of water use in order to estimate the most cost-effective combination of measures for water uses (principle of recovery of costs) (ICPDR 2004).

The regional cooperation in managing the Danube waters was reinforced when the WFD was adopted by the European Union.

The EU water directives, including WFD, have affected considerable changes in national legislative statutes. In the EU member states, but also in the other Danube countries, these directives have been transposed into the national legislation. The main priority in relevant sectors is the implementation of the specific EC requirements to promote a sustainable water use based on long-term protection of available resources.

In Romania, the implementation of the integrated water management policy is in compliance with the EU water policy. The WFD has been transposed by the modification of the Water Law.

A fundamental document related to the water policy in Romania is the Water Management Strategy. This strategy outlines the main directions that have to be followed by the water sector (ICPDR 2004); (Ministry of Environment and Forests, National Administration „Romanian Waters" 2010).

5 Conclusions

In DRB the water quality is under great pressures from human activities to which participate over 81 million people participate.

The most important factors affecting the water quality of the Danube River are: organic pollution, nutrient pollution, hazardous substances pollution, microbial pollution, hydro-morphological alteration.

The main polluters are: agglomerations, industry, agriculture and transport. Pollution is caused by municipal and industrial wastewater discharges which are untreated or partially treated, from livestock farming and fertilizer use in agriculture, and from the hydraulic structures and navigation. For this reason an important part of the length of water bodies' networks in the Danube River basin has not achieved good ecological and chemical status of water, and the risk to not to be reached this state still remains considerably high.

The present work describes the main causes of risk pollution along the Danube River and performs a quantification of various pollution factors in different countries. Although in the last two decades the river pollution did not increase and was even diminished there is still a long way to go in order to rebuild the clean and healthy environment allover along the Danube. Nevertheless as all the factors analyzed in the present work indicate reducing the risk and achieving a good status of water in the Danube River basin is possible. This can be done by a sustained prevention and a continuous effort for reducing the pollution, and this at the present moment the main objective of water management in the DRB.

The present work describes the main causes of risk pollution along the Danube River and performs a quantification of various pollution factors in different countries.

Another important issue is related to the policy responses to water pollution, which are complex and operate within a local, national, regional and global policy context and legal framework. The policy responses make use of different types of approaches and instruments such as adopting of uniform standards for the water quality assessment; developing and enforcing the rules and regulations that govern the water use and protect the resources; developing of monitoring and information systems and also implementing of economic instruments such as charges, taxes, prices, etc.

The EU WFD adopted in 2000 provides a framework for the EU water policy and brings major changes in the water management practices. The directive promotes an integrated approach to the water management based on the concept of river basin. In addition, WFD introduces new standards, criteria, institutions, economic analysis of water use and provides active involvement of public and of stakeholders in taking decisions related to the water management. The above EU water directives, including WFD, have been transposed into national legislations of the EU member states.

The reducing of the risks and achieving a good status of water in the Danube River basin is possible by a sustained prevention and a continuous effort for reducing the pollution.

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