EUTROPHICATION IN THE YUGOSLAV PART OF THE DANUBE RIVER

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The Yugoslav part of the Danube River has become 2.5 times richer, due to its large tributaries of about 600 km in the Yugoslavian territory. The drainage of the river basin from tributaries in the upstream section of the Danube have loaded the water with nutrients, and provided favourable flow conditions in the Yugoslav section of the river, with a high level of primary production.[1,2] For example, the Hungarian section of the Danube has chlorophyll values ranging from 10-187 mg/l.[2]

The situation is similar in the upstream section of the Danube in Yugoslavia. This is the reason for the extremely high organic load[3,4] of this water, including tributaries, in the entrance of the Iron Gate I water reservoir, in spite of measures undertaken in the upstream section. The formation of the Iron Gate I reservoir and the conditions for the development of numerous other processes in the river have changed, resulting in a high degree of river water purification4 accompanied by more intensive sedimentation processes[5] with the uncertain destiny of the system as a whole.

The problem of deposits in large rivers and the transport of large amounts of detrimental and dangerous substances in suspended materials has been recognised in limnological practice for a long time. The restoration of such situations, characteristically for a chemical time bomb6 - CTB - have been solved by rigorous intervention.[7] Until now, the question of deposits accumulated in the Iron Gate I reservoir has not been expressed as a global problem of the Danube river.[8] Nevertheless, in accordance with the results of several investigations,[3,4,5,9,10] some compatible results of Cousteau's expedition11 and Muller's model,[12] this important phenomenon of the Danube has been pointed out.

Measures to protect the waters and tributaries of the Danube,13 in both national and international activities, cannot be fully recognised without realising the situation in this segment of the water course.[4,12]

Utilisation of the Danube waters

The Danube river is a large watercourse representing an extremely attractive traffic artery of high importance, especially after the regulation of waterways in Europe. The need to provide enormous amounts of water for water supply, fishing, irrigation, and various aspects of recreation and tourism, make the protection of water quality of the Danube and its tributaries a priority. The Danube watercourse presents enormous potential for complex use, if the conditions permit.

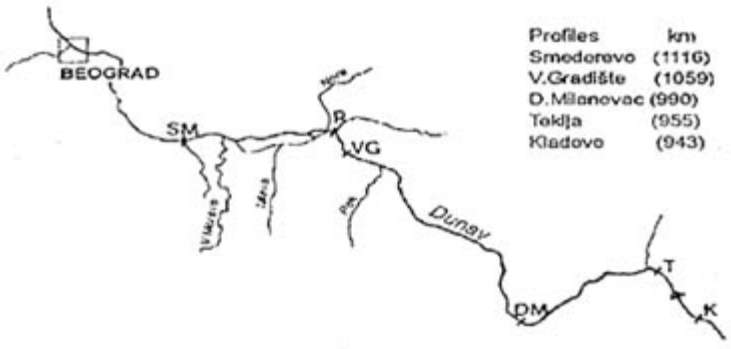

Figure 1. Section of the Danube run-of-the-river reservoir

One of the parameters determining the level of protection needed for water is its specific use or purpose. The Danube river has actually been used for drinking water and industrial use, especially in the inhabited flat part of the Federal Republic of Yugoslavia, which is a water deficient area.

The measures for protection are not compatible with this type of water use and providing the standard quality of drinking water has been extremely difficult to achieve. The protection of water quality must be solved in the future, since the Danube supplies a large number of consumers in both the upstream and downstream parts of the Yugoslav territory.

Protection of the water supply has been a priority for the Rhine valley population, and this should become a priority in the Danube region as well. To answer questions related to Danube use and protection, experience from the situation in the Netherlands was drawn[14,15] where conditions appear to be much more favourable, following exceptional activities in the area. The modern practice applied in the construction of waterworks requires the definition of its influence on the environment.

The construction of the Iron Gate I hydroelectric power plant - HPP, which would produce numerous changes over a long period of time, raised some fundamental ecological questions which have not been satisfactorily answered. One of the elementary tasks undertaken, was to realise the effects of sediment deposition, and then to analyse the effects on the water quality and the ecosystem during this deposition.

The settling of particles greater than 0.05 mm was predicted, and it was known that finer particles would be transported further over the dam. At present we know that the sediments in Iron Gate I are mainly constituted of these finer materials.5 In essence, the problem is that these materials vary and that they have different harmful and dangerous substances concentrated along the fine dust particles, and also in the plankton material deposited at this place.

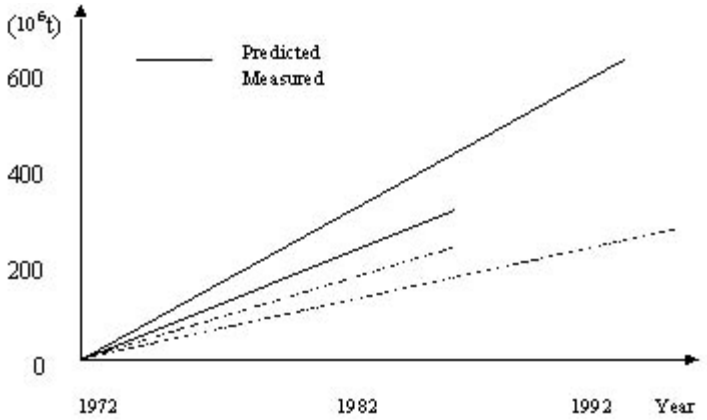

Figure 2. Predicted and measured depositional effects in the Iron Gate I HPP reservoir

The transport processes are relevant for numerous changes in the system, comprising re-aeration and changed intensity at the water/sediment layer, a process which is dependent on the flux of the water current (Table 1). The data in Table 1 and the criteria for the estimation of the system stratification are based on Freud's number.

The question is why the correct sedimentation model has not been formed in the reservoir. The reason for this is the absence of knowledge about the remarka-bly high level of organic production in the upstream section of the Danube, and its decrease in the downstream section of the reservoir. Information on the reduction of organic production in the section of the run-of-the-river reservoir has been presented at the international limnological assemblies concerning the Danube.

Table 1. Biochemical degradation and re-aeration in the studied section (characteristic discharges, water temperature about 15°C)

Section	Dischargem^3/s	BOD$_5$mg/l	DissolvedO$_2$, mg/l in/out	Mean velocityin/out	Retent.Time m/s	Krl/daydays	K2l/day
SmederevotoV. Gradiste	1850 3300 9500 11900	8.17/5.18 5.59/3.44 3.39/1.71 5.24/3.35	7.74/6.56 9.21/8.65 7.02/6.90 9.77/10.2	0.21 0.47 1.30 1.65	3.14 1.67 0.57 0.44	0.145 0.309 1.23 1.02	0.202 0.358 0.731 0.865
V. GradistetoD. Milanovac	1850 3300 9500 11900	5.18/3.15 3.44/1.87 1.71/1.52 33.35/2.62	6.56/5.11 8.65/6.82 6.90/6.86 10.2/10.4	0.18 0.22 0.65 0.80	4.44 3.99 1.32 1.10	0.112 0.162 0.189 0.224	0.111 0.128 0.274 0.317
D. Milanovac toTekija	1850 3300 9500 11900	3.15/2.26 - 1.87/1.28 1.52/1.44 2.62/2.33	5.10/4.51 6.72/6.68 6.86/6.80 10.4/10.0	0.10 0.16 0.49 0.60	4.03 2.79 0.91 0.74	0.082 0.136 0.060 0.158	0.043 0.060 1.131 0.151

On the basis of this knowledge, it has finally been possible to create a model of water quality in the Hungarian section of the Black Sea.12 It practically means that the phenomenon of deposition of large amounts of planktonic material under conditions of turbulent flow has formed conditions for co-deposition through the coagulation processes of the finest particles of allochthonous material and plankton in the Iron Gate I

reservoir. This phenomenon has produced numerous consequences, not only to the reservoir itself and the riverbank area, but also to the downstream section.

It is evident that what is missing here is qualified, co-ordinated projects of Danube Basin countries. Such co-ordination would effectuate the quantification of processes in the whole drainage basin, and would represent the basis for a model of water quality and water protection measures.

Contrary to the expected effects of eutrophication - with increased primary production as the first link of the chain - in this section of the reservoir, processes of degradation and deposition of the introduced plankton mass from the upstream section and the intensive deposition of the finest particles of allochtonous material, started from the beginning and were followed by the formation of a specific new type of sediment. The thickness of the sediment material, in the section near D. Milanovac, is currently more than 20 m.

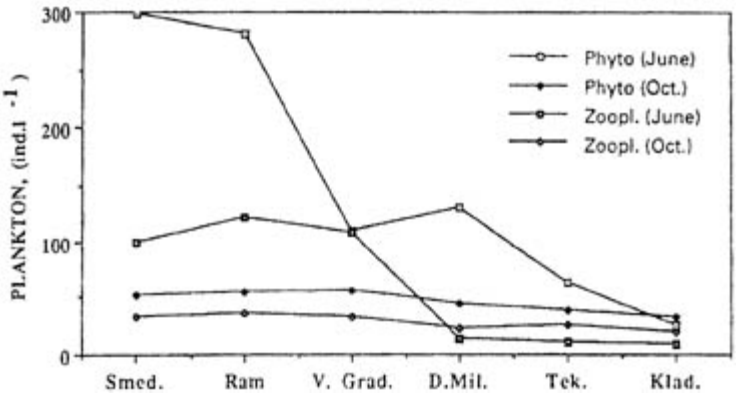

Figure 3. Reduction of the plankton content along the run-of-the-river reservoir

With sedimentation followed by the biochemical mineralisation of the introduced organic load in the limited oxygen transfer from the air, the oxygen concentration in the water has been reduced intensively.[3,4,12] This has been particularly expressed under the low flow water conditions by the increased temperature of water during the fall period. In this period, the mineralisation processes in the sediment have also been intensified, followed by a release of gases, along with the appearance of some organic and metallo-organic complexes. The intensification of deposition in the run-of-the-river zone, which spreads upstream from Belgrade, has given multiple meanings to the impacts of the groundwater in the riverbank area.[5] Along with the phenomena of the reduced yield in wells, the effects of the water composition changes have given rise to the need for new intervention, including drinking water

purification.

Activities for Danube protection

The Dutch government had protested back in 1932 to the governments of Paris and Berlin against the Rhine river pollution.15 Since that time, enormous activities in the Rhine have been realised.[12] A result of the culmination of all efforts is the return of the salmonids to the Rhine river.

It is natural that the upstream consumers use the water to the maximum degree possible. It is hard to believe that any of the upstream consumers would be concerned enough to provide the downstream consumers with satisfactory water quality. This matter has been taken care of by national and international regulations.

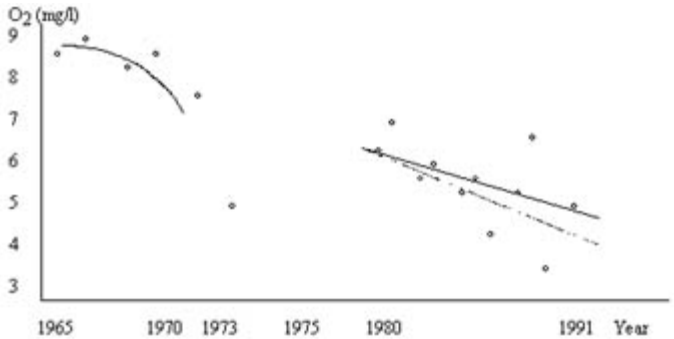

Figure 4. Degradation trend of the oxygen regime in low flow water conditions

How much is known about the quality state and problems present in the short- and long-term? Answers to these questions, which are fundamental to water protection, have yet to be found, concerning this sector of the Danube. Primary importance is given to the phenomena,

and their results, that lead to the sudden deficiency in dissolved oxygen in certain parts of the reservoir, and, then, to the generation and origin of sediments with corresponding consequences that particularly impact the downstream consumers. Previous investigations3,9,10 represent the initial work in this area, and the confirmation of its significance in the subsequently published model of quality changes in the Danube.[12]

The question of the trend of degradation of the oxygen regime, related to the influence of sediments, represents, in recent times, the central question of the survival of biota. Elution of the harmful and dangerous substances, related to processes developed in the sediments, must be taken into account when seeking solutions to the problem of protecting this part of the Danube.

The key to the solution of the protection of the Danube river is directly present here, since for only these sections of the watercourse are the measures of purification defined for upstream pollutants. Only at the level of the Iron Gate I water reservoir could the results of the activity of the drainage basin be recognised, and the future of the system is not yet known. Accordingly, along with the tasks of water quality and ecosystem protection in the Iron Gate I water reservoir, only a presumption for the real solutions is present. This is a section where numerous problems controlling the fundamental changes of the water quality and the survival of the ecosystem have been realised, where the increasing trend is the deficiency of the dissolved oxygen, and the huge deposition of sediments are seen as a chemical time bomb. All other starting points, tasks and measures are of limited domain and will not necessarily solve the problem protection of the downstream part of the Danube, or the protection of the Black Sea, as mentioned in some documents.[8]

Systematic investigations, performed by hydro-meteorology services at the borders of Danubian countries, gave us some information about the actual status of water quality. For many years, investigation methodologies and interpreta-tions of results and evaluations have been co-ordinated according to yet to be adopted methodologies and standards. In the last few years, there has been a trend to improve the methodology of estimation and the explanation of results, as a base for further protection activities. The specificity of the processes controlling changes in the water quality of the Yugoslav section of the Danube - particularly in the run-of-the-river reservoirs - have become limiting factors to the correct realisation of these tasks. This is why the study of these phenomena and their quantification has to be included in international projects on Danube research, as a base for the creation of measures to protect the river basin.

Conclusion

Water protection in the Danube river basin has been realised only partially and within limited ranges. For a quantitative advancement towards the use of these waters, an integral concept that is necessary to adopt is the equal use of water by everyone in this river basin area.

Only a clearly defined protection policy for the most endangered sections of the river basin, along with the collaboration of upstream polluters who have contributed to the problem, may lead to the improvement of river quality in the long-term. Such collaboration will lead to the adequate evaluation of all factors which are potentially present in the domain of this water flow. In this task, the Iron Gate I reservoir presents a true responsibility on the part of the entire river basin population, and everyone's participation is expected.

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