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**DEGRADATION OF THE RIVER FLOWS AND THEIR  
SURROUNDINGS UNDER BACKWATER EFFECTS  
OF THE HPP IRON GATE I  
- NECESSARY RECLAMATION AND  
REHABILITATION MEASURES**

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ABSTRACT

The paper presents an analysis of ecological problems of the river Danube under backwater effects of the hydroenergetic power plant Iron Gate I. Data collected during the period of almost two decades offer possibilities for understanding of the relevant phenomena that define the water quality changes and the state of the ecosystem in this part of the river flow, effects of water purification and consequences of this process connected to high level of anthropogenic influences. This long period enables undertaking urgent measures that are necessary for the system in the context of enormous problems that are becoming more complex as time passed by. Attempts to use analyzed information to change the attitude of the authorities which was based on incorrect prognosis and results of systematic, several decades long investigations of official organizations failed to give positive results till now. Since without adequate knowledge it is impossible to plan protection measures and rehabilitation of the system, and also estimate the damage made by NATO bombing, necessity for applying experience and results tested by relevant professionals from the Danubian and broader region is emphasized.

Key words: water quality, river flow degradation, reclamation measurements, rehabilitation measurements,

**INTRODUCTION**

Management of the water quality of large international rivers is an extremely complex problem. This problem is intensified with the increasing contamination of rivers, especially with harmful and dangerous substances that limit the use of such waters for different

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purposes. The fact that as early as in 1932 the Dutch Government started with petitions to Paris and Berlin with requests to protect the river Rhine (11) is the best example on the actuality of this problem in the last century. At the same time the fact that this river system has been rehabilitated only recently (13) is an indication of the problems and complexity that is connected with solving this in general and worldwide.

Changes in the conditions of transport that are introduced with the formation of reservoirs and demands for rational use of water for numerous purposes result in complex ecological problems. This, therefore, further complicates the problems of water protection in the analyzed region.

Up till now in many reservoir systems numerous, especially ecological, sometimes very specific problems were encountered. The problems of Asuan, reservoirs on the river Volga, etc. are well known. Hungary stopped the construction of a reservoir on the Danube due to establishing the possible negative effect on the environment.

A specific problem of river flows, especially, in the regions of high anthropogenic influence is the formation of sediments that are usually toxic, and reclamation of such systems is extremely complicated especially ecological, that are sometimes very specific. Today there are numerous examples of different interventions on such systems. Removal of sediments from the river Rhine (46) and formation of an island in the North Sea is a very efficient measure. Decontamination of sediments is also efficient, while immobilization of sediments, covering them with sterile material is far less reliable in the long run.

Analysis of the situation on the systems under intense anthropogenic influence, with an accent on water accumulation, and taking into account the international status of rivers, it is possible to understand the complexity of the problems concerning the protection of the Danube run-of-the river in the hydroenergetic power plan Djerdap I reservoir. Even in the stage of planning the system serious engagement of all professionals was necessary to solve this problem with utmost professionally.

### **Knowledge on the quality of Danube water and predictions in the phase of planning**

The Danube catchments area and tributaries that flow into the Djerdap I hydroenergetic power plant, at km 943, cover an area of 583,000 km<sup>2</sup> and drain parts or whole territories of several countries. Up to this profile over 72% of the total catchments area or 87% of the total inflow of the Danube into the Black Sea is encompassed, and those are extremely significant data for the protection of the Danube river and also of the Black Sea. The "Limnology of the Danube river", from 1966, presents basic parameters on the composition of the Danube catchments basin and its tributaries which again determines the basic mineralogical composition (14). Results of investigations of the water quality of the water flows date from the period 1960 – 1964 confirm that this was a period when the geological background was significantly altered by anthropogenic factors. This is especially relevant for the nutrients of which the most important are phosphates with a concentration in the range of 400 µg/l at km. 2320 and 530 µg/l at the profile Baja (14).

In the period before the construction of the dam the loading of the river Danube water with degradable material was greater in the sector between Hungary and Yugoslavia than the one at the Yugoslav – Bulgarian border. The consumption of KMnO<sub>4</sub> and dissolved O<sub>2</sub> content were selected as evaluation parameters since they reflect organic pollution. Besides this, they are the most suitable for direct comparison because these are relatively simple analytical methods and the probability of the correctness of the analyses is higher.

**Tab. 1 Some indicators of the Danube water composition**

Par./Prof.	Budapest	Baja	Novi Sad	Pančevo	Smederevo	Oršava
Cons. KMnO <sub>4</sub>	10.5-99.8	20.7-37.4	34-50	16-32	27-49	25.5-29.8
% saturat.	62 – 132	52 - 141	85 - 132	70 - 80	79 - 88	83 -104

The high organic loading of the Danube in the sector upstream from our country, profiles Budapest and Baja, results in large changes in saturation. This fact indicates the extreme importance for the analysis of the problem under the conditions of the free flow of the river Danube and especially in conditions under the run-of-the river reservoir.

The content of organic mater, intensity of biochemical decomposition accompanied with the consumption of dissolved O<sub>2</sub>, effects of deoxygenation with reaeration and primary organic production, with effects of deposition, elution, etc., defines the range of changes in the content of dissolved O<sub>2</sub> in the water mass. Establishment of the requested regularities enables production of prognostic models by which it is possible to define the above-described changes including situations with alteration of conditions on the system. With the use of these models, it would have been possible to foresee the state of the system and range of changes of the content of dissolved O<sub>2</sub> in the conditions of changes of the Danube flow after the construction of the reservoir. This would have been possible because the dependency between the parameters of the system that define the content of dissolved O<sub>2</sub> were determined as early content as 1952 in the study of the river Ohio that was carried out by Streeter and Phelps (45).

During its further use, this model was considerably upgraded with the introduction of a series of parameters that additionally define the process. Improvement of the model was carried out by numerous authors, especially in the domain of defining the constant for reaeration (6, 24, 25). The improvement of the model continues even today.

These laws were not used for the analysis of the changes of the content of dissolved O<sub>2</sub> in the reservoir of the HEPP Djerdap I and after these initial errors, this practice will persist up to present times. In this context the principle task today is to exclude the erroneous data of the Republic Hydro meteorological Department of Serbia (43) and the use of this data (9) in the activities concerning the protection of this river.

Special notice: The Serbian Government on the 9<sup>th</sup> of September 1977, among other things, concluded (20): - that the Republic secretariat for agriculture, forestry and water resources in cooperation with the Regional secretariat for water resources, based on the results of the program of observations and monitoring of the influence of the run-of-the river reservoir on the water regime of the Danube and protection of the riverbank zone, as well as suggestions that exist on the territory, recommends a complete program of measures for monitoring, management and use of the HEPP Djerdap I system up to the border of the retention zone.

With this, the responsibility for all the errors and everything that will take place in subsequent phases of exploitation and the resulting negative consequences, has to be ascribed to experts.

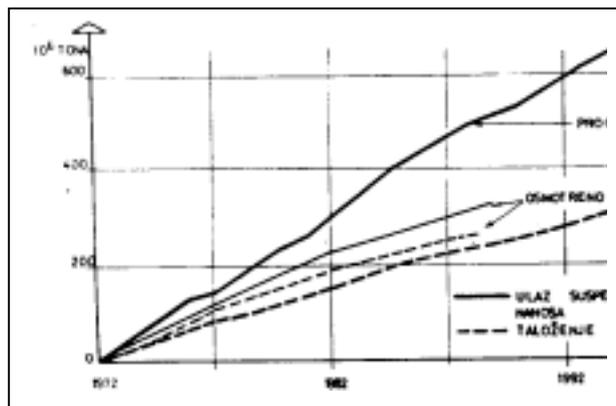
#### **Prediction of the effects of sedimentation in the reservoir**

For the purpose of planning-prediction of the effects caused by the filling of the reservoir, very extensive investigations were carried out concerning the volume and composition of

the suspended material in all flows. Determination of characteristics of suspended material serve for the elaboration of the prognostic models for deposit formation along the reservoir were carried on particles up to 0.010 mm. This means that these analyses do not include the most significant material that are relevant for the protection of the environment. The problems of suspended material in a river that are connected with the type of material and interaction of the material with the water phase but also with the surrounding area have even then drawn attention of ecologist around the world. In these analyses, done during the stage of system planning, the sediment is observed as an inert material that was significant for the planners only from the aspect of the reduction of the volume of the reservoir and generation additional retention of the flow during further exploitation.

According to data of several authors (5) the model given by Rosinsky and Kuzmin was used to calculate the effects of sedimentation which indicated the correlation between the concentration of suspended material and hydraulic parameters of the river flow.

Already in the initial phase of analysis of the validity of the model, which was presented by the authors (5), distortion of the results of prognosis and measurements was shown and that its eventual use, for such conditions of the flow, demands considerable upgrading (fig. 1). From the presented diagram a high distortion between the prediction and actually detected values, after the period of exploitation in the period 1972-1988, is evident.



**Fig. 1 The predicted and measured input and deposition of material in the accumulation**

The authors did not analyze the source of the detected disagreement, between the model and measured values. When analyzed in accordance with the model and adopted hypothesis “that the composition of the suspended material changes in such a way that the coarsest grains are deposited first” information on the size of the suspended particles that are deposited in the accumulation is obtained. According to this data in the first phase, the first 25 years, particles larger than 50  $\mu\text{m}$  will be deposited in the reservoir. In the second phase, from the 25<sup>th</sup> to the 50<sup>th</sup> year, particles larger than 65  $\mu\text{m}$  will be deposited. This conclusion masked the basic ecological problem, i.e. the fact that particles two magnitudes smaller will be deposited. These particles are those that transport and deposit the major part of pollutants in the system.

Such an approach to the problem by the planners is not in agreement with the existing knowledge from this period because at the beginning of the 30's Von Smoluhovski (50)

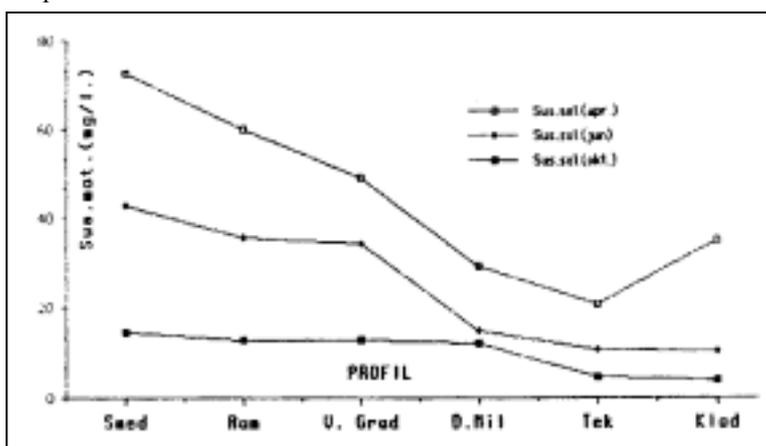
determined a model of intense coagulation in turbulent flows, which means that conditions for the correct prediction of this phenomena existed. When the quantity of sediments that are formed by a year in the reservoir 18 mill. tons order is taken into account, it is obvious how great is ecological problem.

**Investigation of the changes of the quality of water and ecosystem in the zone of the run-of-the river reservoir and the conflicts with the existing knowledge about this system**

Investigations of complex processes in the zone of the Danube, in the run-of-the river reservoir zone have been going on for almost 20 years and include processes in the water phase and in the sediments.

Yugoslav-Romanian investigations of the changes in physic-chemical and biological characteristics of the Danube water, at the border sector Ram-Radujevac (27) were carried out in the following periods: spring high waters, summer waters and autumn low waters. Investigations included measurements of the water temperature, turbidity, dissolved O<sub>2</sub>, BOD<sub>5</sub>, carbonates, contents of P (orto and tot.), nitrogen complex (NH<sub>4</sub>-N, NO<sub>2</sub>-N, NO<sub>3</sub>-N and later on Kjeldal N), organochloric pesticides, and heavy metals, later on fats and oils, and mineral oils as well as hydro biological analyses (quantitative and qualitative composition of plankton and analysis of saprobity indices of plankton with estimates of the water quality) as well as the radioactivity of water ( $\alpha$ ,  $\beta$  and total activity). The monitoring in the quality of the Danube water in the common sector, in accordance with this program, was carried out on profiles: Ram, Gradište, D. Milanovac, Tekija, Kladovo and Radujevac. Sampling of water was carried out in three points on the profiles, on the left bank, in the central part of the flow and on the right bank.

Data for the range of the detected changes and laws of these processes in the investigated sector of the Danube flow, in the run-of-the river reservoir zone are presented. The following parameters are analyzed: suspended material, i.e. seki disk, content of dissolved oxygen, content of the plankton mass and changes in the carbon system as a result of biochemical processes of mineralization and recarbonization.



**Fig. 2. Changes in the content of suspended material in the sector of the run-of-the river reservoir**

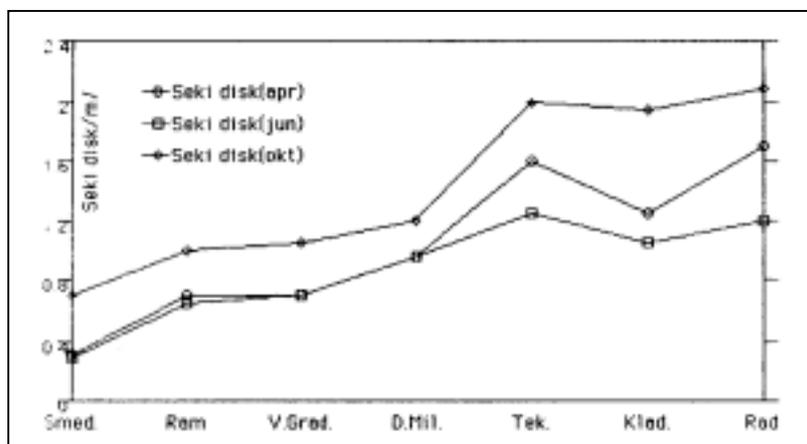


Fig. 3. Changes in the value of seki disk in the sector Smederevo-Radujevac

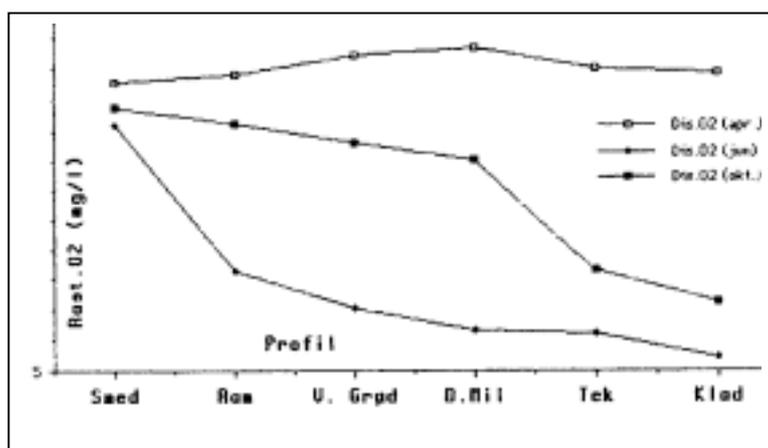


Fig. 4. Changes in the content of dissolved O<sub>2</sub> in the sector Smederevo-Radujevac