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# The Status of the Mantovo Reservoir and Management Perspectives

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## Abstract

The objective of this study is to contribute to the optimization of monitoring activities of the Mantovo Reservoir (South-Eastern part of the Republic of Macedonia), to propose effective measures to reduce the pressures and improve the status of the reservoir. Development of an effective system of water bodies status assessment in accordance with the recommendations of the EU Water Framework Directive - 2000/60/EC, which includes more frequent monitoring of physico-chemical parameters, optimization of monitoring of chemical determinants, more intensified involvement of biological monitoring and identification of basin specific pollutants were pointed out as priority activities. Regarding the optimization of the monitoring activities, our study showed that monthly monitoring of water quality determinants could be reduced to the following physico-chemical parameters: temperature, pH, transparency, DO and oxygen saturation, nutrients ( $\text{NH}_4^+$ ,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$ , TP), calcium, magnesium and metals (iron, manganese and copper), BOD and COD ( $\text{KMnO}_4$ ). Manganese, iron and copper were found to be important pollutants for the Mantovo Reservoir. Our opinion is that biological monitoring should be more frequent, but it could be limited to the survey of two dominant species *Limnodrilus hoffmeisteri* and *Chaoborus crystallinus*. A set of measures for the status improvement of the reservoir is proposed in this paper that includes: hydro-technical works at the mouth of the Kriva Lukavica River aimed at reducing the inflow of pollutants, reservoir bank stabilization, reduction of pollution caused by urban waste waters, regulation of construction activities in the area of the reservoir and proper management of sports activities.

**Keywords:** water management; impact assessment; water body status monitoring, biological monitoring, the Mantovo Reservoir.

## Introduction

Reservoirs are managed water bodies and, therefore, there is a particular need for the managers to understand their physical, chemical and biological features. This knowledge is acquired through research and assessment of water quality/status data gathered during routine monitoring programs. So, water quality in a reservoir can be maintained in the desired quality limits, only with effective monitoring of selected water quality parameters (World Lake Vision Committee, 2003), which is the base for the design of short- and long-term management plans.

More than 121 reservoirs have been built in the Republic of Macedonia (21 larger and more than 100 small reservoirs). They are used for water supply, hydro energy production, irrigation, fishing and tourism (Slavevska-Stamenković et al., 2009). In respect to water supply, the Republic of Macedonia mostly relies on surface water resources. However, not enough attention has been given to complex physical-chemical and biological investigation (Stojkovski, 1960; Smiljkov, 1996; Miljanović et al., 2004; Slavevska-Stamenković et al., 2009; Slavevska-Stamenković et al., 2012) and adequate routine monitoring, ecological protection and management are lacking.

Better understanding of the main physical and chemical processes and the ecological response may be essential for proper reservoir management. Slavevska-Stamenković et al. (2012) analyzed spatial and temporal heterogeneity of the limnological characteristics and provided more detailed information

about the limnological processes taking place in the Mantovo Reservoir (South-Eastern part of the Republic of Macedonia). The obtained data could be used to indicate possible measures to reduce the pressures and consequently, to improve the status of the reservoir, so it shall be the focus of this study.

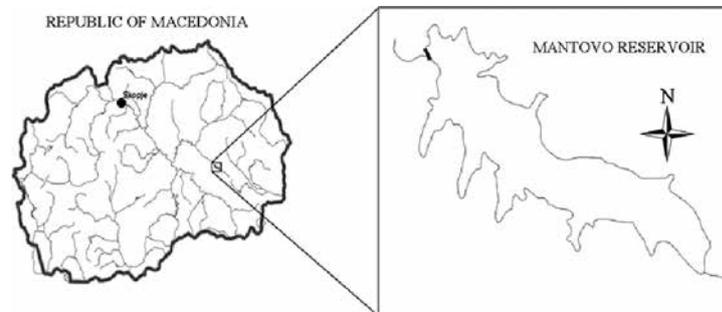


Figure 1: Map of Mantovo Reservoir.

## Study Site

The Mantovo Reservoir (41°58'32" N, 22°32'37" E) is located in the northern temperate area, in the South-Eastern part of the Republic of Macedonia at an altitude of 402.5 m (Fig. 1). The reservoir was built in 1978, by damming the Kriva Lakavica River, which belongs to temporal watercourses (Gelev, 2001). Mantovo is classified as a large reservoir (Vasilevski, 1995) having a surface area of 4.94 km<sup>2</sup> and a maximal depth of 20 m. The length of the reservoir is approximately 5.5 km and the average width is about 0.80 km. Significant water level fluctuations (3-5 m) take place in the reservoir, since water is used for irrigation of the surrounding fields (via the artificial channel Vrastica built in the foothills of Smrdes Mountain 8.26 km in length). The water regime in the reservoir is under the influence of numerous smaller inlets that are of temporal character and dried out throughout most of the year.

The geology consists primarily of limestone and igneous and metamorphic rocks rich with copper, iron and manganese (Mijalov, 1991). A recent survey of the thermal regime showed that Mantovo is a dimictic reservoir (Slavevska-Stamenković et al., 2012)

## Results and Discussion

The Mantovo Reservoir is under a strong anthropogenic influence, which is especially pronounced during the dry period of the year (Slavevska-Stamenković et al., 2012). The ecosystem is primarily under the pressure caused by recreational activities, influence of seasonal settlements (tourism) along the shore, but also with wastewater from the surrounding villages (with no sewage systems).

According to the levels of nitrogen compounds (mean conc. of 0.024 mg/l NO<sub>2</sub><sup>-</sup>), the reservoir could be

assessed as a class III-IV (Slavevska-Stamenković et al., 2009). Additionally, very high concentrations of Mn (2,819 µg/l) and Cu (147.6 µg/l) were detected in the deepest part of the lake (toxic levels) and belong to class V (Regulation for classification of water, Official Gazette 1999).

The dynamics of the reservoir and its status are strongly influenced by the Kriva Lakavica River. The long dry season of the river (August-February), as well as strong erosion of steep shores (Gorgievski et al., 1999), negatively influence the status of the Mantovo Reservoir. Moreover, the most intensive irrigation occurs in the period of the dry season, which exerts significant pressure on the stability of the lake ecosystem. Additionally, high content of silt, nutrients, suspended and dissolved matter is carried by the Kriva Lakavica River and other tributaries (Slavevska-Stamenković et al., 2009) contributing to the eutrophic condition of the reservoir.

The current study could contribute to the optimization of monitoring activities of the Mantovo Reservoir. In addition, the data presented could be used to design effective measures to reduce the pressures and, consequently, to improve the status of the reservoir. The effective management of the reservoir, with the main objective to improve water status, is of importance due to the fact that an increase in agricultural activities in the region is expected, which could influence the lake through increased irrigation levels and an increased input of nutrients as a consequence of more intensive use of fertilizers. Regarding the optimization of the monitoring activities, our study showed that monthly monitoring of water quality determinants could be reduced to the following physico-chemical parameters: temperature, pH, transparency, DO and oxygen saturation, nutrients (NH<sub>4</sub><sup>+</sup>, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, TP), calcium, magnesium and metals (iron, manganese and copper). The measurement of BOD and COD (KMnO<sub>4</sub>) should also be performed each month,

as important determinants for determining levels of organic pollution.

The following text contains a proposal for optimization of activities related to the management of the Mantovo Reservoir.

More extensive monitoring of physico-chemical (parameters supporting biological investigations in accordance with the EU Water Framework Directive - 2000/60/EC) and chemical parameters (parameters listed in the Annex II of the **Directive on Priority Substances - Directive 2008/105/EC**) should occur during critical periods - one sampling during the summer stratification and one sampling during the high water level.

Biological monitoring should also be more frequent, but could be limited to the survey of two selected dominant species *L. hoffmeisteri* and *C. crystallinus*, since dynamics of the two taxa was found to effectively reflect the phenomenon/dynamics that occurred in the reservoir.

It is optimal to accomplish more intensive biological investigations twice per year, in the period of the dry season and summer stratification, as well as in the period of high water levels. The suggested approach could be considered as screening and could optimize the monitoring - reduce costs and provide quality data for design of effective protection measures.

It is also necessary to define a set of specific pollutants (the chemical determinants that are not listed in the Directive 2008/105/EC, but are important pollutants in a particular water body) that have to be monitored in the Mantovo Reservoir. Our study indicated that manganese, iron and copper should be included on the list of specific pollutants, which could be the case with other water bodies in Macedonia. The routine monitoring data, together with data gathered from the investigation, should be used to define the list of specific pollutants for waters in Macedonia, to define the target values and status class boundaries for each type of water body.

According to the data presented, organic and nutrient pollution could be considered as significant water management issues (SWMI) for the Mantovo Reservoir (as requested in the river basing management planning approach which is in accordance with the EU Water Framework Directive (2000/60/EC)). It is essential to set up specific management objectives for each SMWI. In the case of nutrient pollution, the management objectives are reduction of nutrient load from point and diffuse source and the implementation of best environmental practices regarding agricultural activities. For organic pollution, the main management objective is step by step reduction of discharges of untreated wastewaters from settlements.

Regarding the possible measures that could contribute to the prevention of further deterioration, or even the improvement of the status of the Mantovo Reservoir, and thus contribute to the realization of management objectives, the following activities (Fig. 2) could be considered as effective and economically feasible, bearing in mind the current socio-economic situation in the Republic of Macedonia:

1. To perform the hydro-technical works in the area of the mouth of the Kriva Lakavica River and the reservoir with the aim to reduce the inflow of pollutants. The wetland area around the mouth could be broadened in order to enable outflow of the water outside the river bed, reduce the strong current in the period of high waters and consequently to reduce the inflow of suspended solids and nutrients. The macrophyte vegetation cover in the zone of the confluence could also contribute to the reduction of inflow of pollutants in the lake. Thus, the technical solution could comprise the use of aquatic macrophytes for filtration of water prior to entering the reservoir, which is of particular importance during high water levels;
2. To carry out works aimed at stabilizing the banks of the reservoir, which could contribute to the reduction of erosion and consequently prevent further loss of reservoir volume. The loss of the reservoir volume influences not only the functionality of the ecosystem, but also negatively affects the use of the reservoir. The prevention of erosion could be done by planting of the riparian vegetation zone;
3. To reduce and to prevent the inflow of untreated communal waters from seasonal settlements along the river shore and villages situated along the Kriva Lakavica River. The reduction in the amount of untreated urban waste waters could be achieved through the adoption of effective regulations and the application of strict rules regarding the use and maintenance of septic tanks in the vicinity of the lake as a first step, and in the later stages, construction of sewage systems with deposition tanks. The construction and proper maintenance of simple deposition tanks with a gravity sedimentation process within the sewage systems is a low-cost approach that could significantly reduce the input of pollutants (Cheremisinoff, 2002), in addition to other low-cost approaches such as sand filtration (slow or rapid sand filtration). The overview of available techniques of waste water treatment is provided in Cheremisinoff (2002);
4. Adoption and implementation of effective legislation related to regulation of further construction of facilities connected with seasonal touristic activities; and

5. Properly controlled sports activities in the reservoir, primarily to regulate sport fishing. The use of live bait and fish nourishment should be prevented and only artificial baits should be allowed in the reservoir. This approach could additionally limit nutrient input.

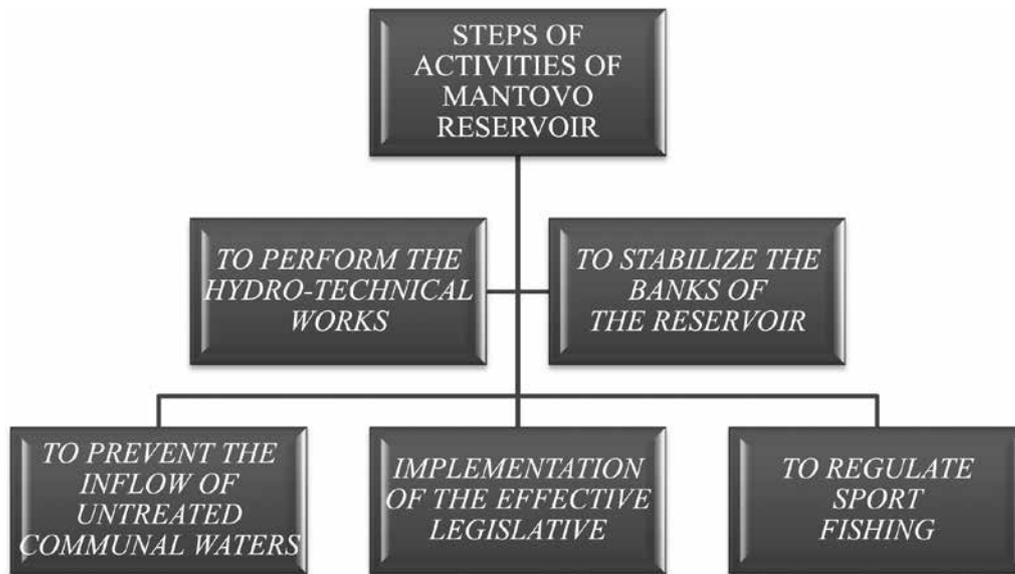


Figure 2: Activities that could contribute for improvement of the status of the Mantovo Reservoir.

Proposed measures have to be in line with the principle of sustainable development. The things that have to be understood is that sustainable development has to be implemented differently in developed countries and countries that are in the phase of development. Water management in economically less prosperous countries has to be carefully designed in order to define management priorities (significant water management issues) and to set realistic management objectives, to design a step by step approach to improvement of the water status. This approach has to be respected, not only in the case of the Mantovo Reservoir, but also in the case of other water bodies in the Republic of Macedonia, and in our opinion, throughout the Balkan region and Eastern Europe. In general, although the Republic of Macedonia is still a non EU country, it is important to implement the related EU Directives – Urban Waste Water Treatment Directive (UWWTD 91/271/EEC), EU Nitrates Directive (91/676/EEC), Sewage Sludge Directive (86/278/EEC) and the Integrated Pollution Prevention and Control Directive (2008/1/EC), in order to realize the management objectives related to the suggested SWMI. Nutrient and organic pollution are also important management issues for other water bodies in Macedonia, so the principles used in the case of the Mantovo Reservoir could be extrapolated to other waters in the country, as well as in the region.

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