REGIONAL GEOLOGY AND WATER QUALITY IN SOME STORAGE LAKES OF CENTRAL SERBIA

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Abstract

One way of providing water supply to communities is to construct dams on selected streams and thus form storage lakes. The impounded water may change in quality with the time. The changes may be natural or caused by human activities. This work is concerned with the influence of geology in the catchment area, as a major factor, on the chemical composition of lake water. It is explained on the example of a storage lake, the source of the Zaječar water supply, in which dissolved heavy metals were measured from 1991 to 2005. The explanation also applies to some other artificial lakes in central Serbia.

Keywords: *water-storage lake, geology, water quality, water supply, catchment.*

1 INTRODUCTION

The concept of the reliance on surface storage lakes for municipal water supply systems became official with the Decree on Establishing Water Management Plan of the Republic of Serbia (Off. Gaz. Republic Serbia, No 11/2002). A number of dams had already been built for the purpose, and the Plan contemplated thirty-two more storage reservoirs. Quality of water in the lakes, however, deteriorated with the time. The causes of deterioration are many, but generally are the consequence of natural processes and/or human activities in respective catchment areas. It is interesting to note that adequate exploration is lacking, which would produce parameters for reliable prediction of the water quality variation in new reservoirs.

The purpose of this work is to emphasize the need of a detailed study of the whole catchment, the complexity of background information, and the necessary target explorations at any stage of each river dam project for domestic water supply.

2 TOPICAL PROBLEMS

River water of generally good quality tends to deteriorate with the time of impoundment. The advantages of artificial lakes for water supply are a common knowledge, but the adverse effects and their repercussion on natural environment and on the lake water quality are partly overlooked in Serbia.

Information about the quality of water in artificial lakes is not always generally available to public, even to professionals. There is not an independent agency or laboratory that could deliberately sample water and silt from artificial lakes and publish the results of their analyses. This may be the inherited abstaining from "alarming the public". There were few cases of the evidently questionable water quality (impaired organileptic qualities of water, excessive chlorite content, foul odour, and the like) noted by consumers and confirmations of standard water quality in these cases (Stevanović et al., 1995).

3 FACTORS OF INFLUENCE ON THE ARTIFICIAL LAKE WATER QUALITY

Basic factors of water quality in artificial storage lakes are the following (Nikić, 1994):
I Natural (water-rock interaction) factor,
II Human activities (anthropogenic factor), and
III Physical-chemical-biological processes (lake processes factor).

Geology of a catchment is the initial natural factor of the surface and groundwater quality formation. Generally, 70 % to 80 % of the materials carried by water into a reservoir are products of rocks and soils from the catchment area (Čukić et al., 1989). Interactions of the eroded materials and water during the transport to the reservoir under particular conditions (usually turbulent flow and aerobic environment) lead to an equilibrium between the constituents in water and suspended load. The process of sedimentation results in an accumulation of mass and energy, and in a consequent change in the reduction potential and interaction with water, commonly in anaerobic environment which enhances decomposition and liberation of mobile ions of metals, gases, nutrients and organic compounds.

Research of these processes is a complex study. The study results with the reference and empirical data may be an important segment in the prediction of water quality in a future storage lake. Correlations with other storage reservoirs may be helpful, but always bearing in mind that each reservoir is specific (in geology, hydrogeology, climate, morphology, water balance and the like). Because natural factor is particular for each artificial lake, combined research will be necessary for identification and balance of the introduced ecotoxic metals that derive from rocks in the drainage area.

Artificial compounds for various uses that reach the storage lakes constitute the anthropological factor. Particularly hazardous are contaminants that reach lakes by accident or malpractice.

Many components of the mentioned factors influence the physical-chemical-biological processes evolving in the storage lake water and silt deposit. The mentioned three principal groups of factors produce components essentially affecting the quality of lake water. They are interrelated, caused by and dependent on one another. The prediction and maintenance of water quality are complex, multidisciplinary and detailed tasks. There is no concentrated knowledge within one scientific discipline, nor a generally accepted methodology of research, in predicting water quality in future.

4 GEOLOGY AND CHEMICAL COMPOSITION OF WATER IN SOME WATER-SUPPLY STORAGE LAKES OF CENTRAL SERBIA

Geology of the drainage area is a major factor of influence on the quality of water in an artificial lake. This influence on the chemical composition of water is described on the examples of several existing storage lakes.

The catchment of the Zlatibor storage lake on the Crni Rzav has an area of around 90 km^2 (Fig.1). More than 85 % of the area consists of Jurassic serpentines and harzburgite that belong to the Zlatibor peridotite massif. Serpentinites consist of reticulate bastite serpentine, accessory chromite, secondary iron oxide powder, secondary amphibole and talc. Metallic (iron, chrome, manganese) and nonmetallic (magnesite) minerals are located in Zlatibor peridotites beyond the lake catchment perimeter (Mojsilović et al., 1977).

Silt samples from the Zlatibor lake (whole in peridotites) contain heavy metals in enormous concentrations. A silt sample (1 kg) from the lake deposit near the dam contained among other constituents chrome 2.89 g, manganese 2.59 g, nickel 1.61 g, and iron 259.35 g (Collective authorship, 1989). Silt in the Crni Rzav surely had a similar chemical composition even before the dam was constructed. These findings have opened many questions. Under certain conditions, silt on the bottom of the Zlatibor lake may compromise the entire water supply system.

Figure 1. Scenery of the Zlatibor catchment and lake.

A dam constructed on the middle-lower Gruža River formed the Gruža lake. Its catchment has an area of around 319 km^2. Most of the catchment consists of Tertiary volcanic rocks (andesite, dacite, quartz latite, etc.). The characteristics of the storage lake are intensive erosion in the catchment, shallow storage basin and rapid filling with rock waste. The water quality hazards are high concentrations of ammonia, iron, manganese, sulphides, etc.

The Ćelije storage lake on the Rasina is the source of the Kruševac water supply. The catchment of this lake has an area of about 658 km^2, made up of serpentinite (18 %) and crystalline schist (16 %). There are many occurrences of mineral ores (coal, asbestos, metals). The catchment geology is probably largely responsible for the commonly high concentrations of iron, manganese, ammonia nitrogen, hydrogen sulphide, etc. Intensive erosion in the catchment and large production of waste material are limiting the useful storage of the lake.

The Grlište storage lake on the Grliška River was formed in 1990 for the municipal water supply of Zaječar and nearby communities. The surface area of its catchment is 181 km^2. There are no industrial, tourist or military establishments. Geology of the catchment is complex. Volcanic clastics and andesites of Cretaceous or Paleogene age have coverage of about 44.2 % of the area. There are several mineral occurrences of copper, iron and manganese (Veselinović et al., 1967). Two small (copper and iron) mines and a minor coalmine were operative to the late sixties of the last century.

The agency that monitors water quality in the Grlište lake from 1991 is the Hydrometeorological Institute of Serbia. Concentrations of dissolved copper, manganese and zinc in lake water (sampled in the middle of the lake from three depths: B1 surface, B2 mid-depth and B3 at the bottom) are given for the period 1991-2005 in Figs. 2, 3 and 4.

Figures 2, 3 and 4 show the growing trend of dissolved copper, zinc and manganese, which are still below the maximum allowed concentrations for drinking water. Any prediction of water quality in this lake is delicate. Heavy metals dissolved in the lake are probably genetically associated with the geology of the catchment, or part thereof made up of volcanic clastics in which these metals were found.

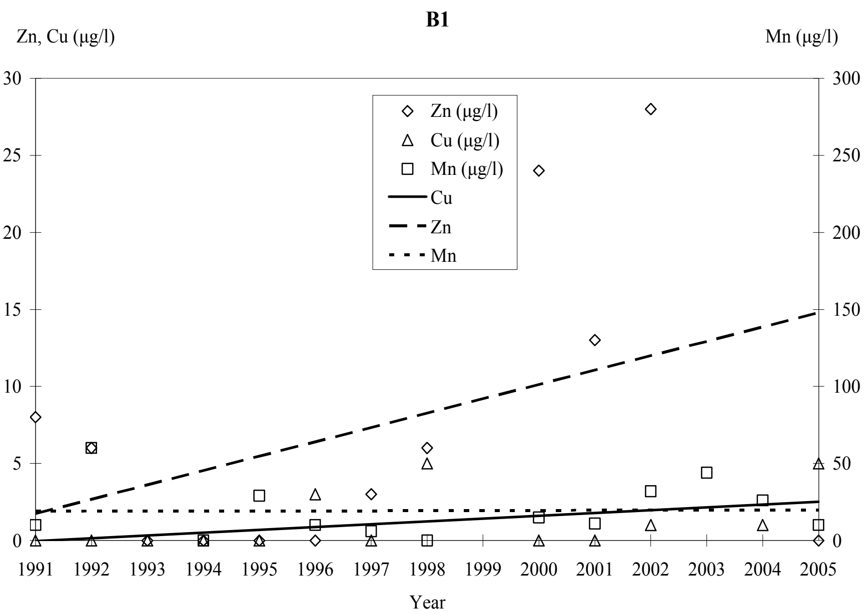

Figure 2. Copper, zinc and manganese concentrations in the Grlište reservoir point (B1) at lake surface.

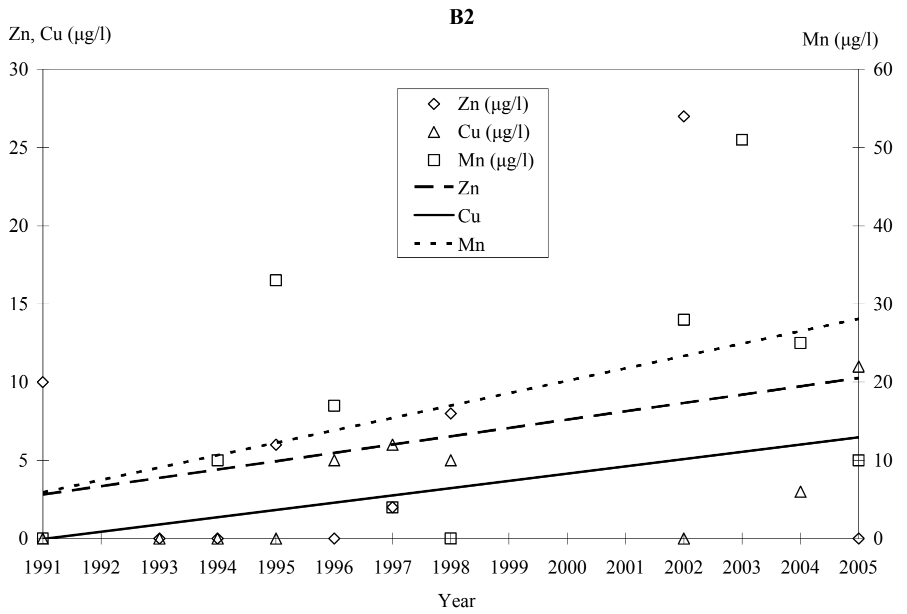

Figure 3. Copper, zinc and manganese concentrations in the Grlište reservoir point (B2) in lake mid-depth.

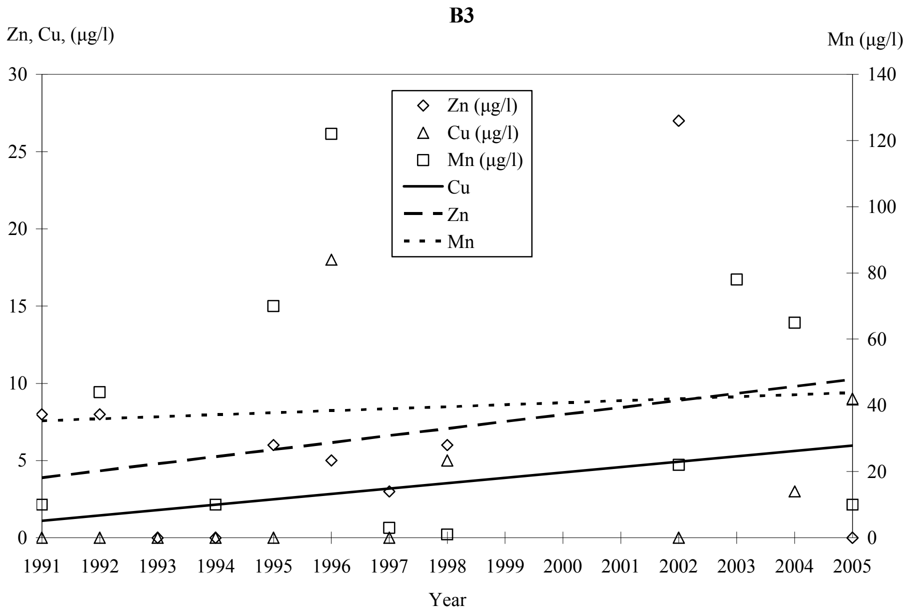

Figure 4. Copper, zinc and manganese concentrations in the Grlište reservoir point (B3) above lake bottom.

5 CONCLUSION

Vision of the prediction and control of water quality in an artificial storage lake used for drinking water supply is a scientific problem. The superficial vision to date of the water quality in future storage lakes for drinking water supply is reflected on the state of lake water in several existing reservoirs. The unsatisfactory water quality is not the result of the eutrophication alone, but also of the geology in the catchment. The problem is a lack of target exploration or disregard of indicative evidence by the decision-makers on the water supply source project in a given location.

The need of complex and multidisciplinary approach to water quality in an artificial lake for drinking water supply requires a mandatory decision on staged explorations for relevant geological data. Furthermore, the type and scope of exploration must be specified with a view to protection and maintenance of water quality in the storage lake. These two recommendations should be mandatory, because their disregard may lead to unsatisfactory water supply.

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