Water Quality Evolution in Gozna and Secu Reservoirs, Semenic Mountains, Romania

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Abstract. Knowing and tracking the evolution of water quality in reservoirs is very important, especially if one of the functions of the reservoir is to provide the water supply to the localities. The chemical, thermal and physical changes which the flowing water undergoes when it is stillled through hydrotechnical structures, like dams, can seriously contaminate water from the reservoir and the river downstream. The grade of deterioration in the water quality is in general related to the retention time of the reservoir, its storage capacity in relation to the amount of water flowing into it. The parameters of water quality determine the treatment technology and implicit, influence the cost of drinking water. Gozna and Secu reservoirs are located in the Semenic Mountains, were built as multi-purpose systems for water management. Their purpose was to produce hydropower, to supply drinking water to Resita city, mitigate flood waves and to be used as recreational areas. In this paper, the evolution of water quality on both reservoirs is analyzed based on the water samples collected over 11 years’ time period (2001 - 2011). The main water quality parameters from these reservoirs are: water transparency, temperature, pH, dissolved oxygen, CBO₅, CCOMn/O₂, total nitrogen, total phosphorous, density, suspensions.

On the base of the obtained results from the water quality evolution process analysis, the specialists in the domain can anticipate the problems, causes of water quality degradation and can establish the adequate measures for water quality conservation and improvement. Today, worldwide, is an increasing interest in the reservoir water quality since the water resources are not expanding as fast as the water demands. Because the fresh water becomes more limited (due to pollution, climate change etc.), the quality of the water becomes increasingly important.

1. Introduction

Knowing and tracking the evolution of water quality in reservoirs is very important, especially if one of the functions of the reservoir is to provide the water supply to the localities. The chemical, thermal and physical changes which flowing water undergoes when it is stillled through hydrotechnical structures, like dams, can seriously contaminate water from the reservoir and the river downstream. The grade of deterioration in water quality is in general related to the retention time of the reservoir, its storage capacity in relation to the amount of water flowing into it.

Water temperature regulates biotic growth rates, life stages and defines fishery habitat; dissolved oxygen is necessary to sustain healthy aquatic life and reservoirs ecosystem. Turbidity is influenced by the light transmission and water clarity. Nutrient enrichment fuels primary productivity that can lead to oxygen depletion and taste and odor problems. Contaminants, organic chemicals and trace metals,
are of increasing concern due to their toxicity and affinity to sediments that can accumulate in reservoir sediments. Total dissolved have interest in the water supply and other uses. Total suspended solids are a major transport mechanism for nutrients and contaminants and deposit in reservoirs, thus displacing valuable water storage. Water pH regulates aquatic chemistry and can impact water use and habitat. Dissolved iron, manganese, and sulfide, which can accumulate in reservoir hypolimnions that are low in dissolved oxygen, can lead to water quality problems within the pool and when released downstream. Iron and manganese affect water color and can lead to water treatment problems. Sulfide causes odor problems when it escapes during reaeration and can be hazardous at high atmospheric concentrations. Pathogens can present public health problems when the reservoirs are used for water supply, irrigation and recreation. [1]

Eutrophication is one of the major water quality problems of reservoirs in many parts of the world. Not only do the problems derived from eutrophication affect the quality of stored water, but they also have an adverse effect on the reservoir fauna and river in downstream of the dam. An increase in nutrients (nitrogen and phosphorus) is enhanced by temperature and light, which are the two predominant factors in biological production. Phosphorus is usually the main nutrient responsible for freshwater eutrophication, whereas nitrogen is the primary nutrient causing eutrophication of coastal areas and seas. [2]

The parameters of water quality determine the treatment technology and, implicit, influence the cost of water for different uses.

2. Study Case
Gozna and Secu reservoirs are located in the Semenic Mountains, were built as multi-purpose systems for water management. Their purpose was to produce hydropower, to supply drinking water to Resita city, mitigate flood waves and to be used as recreational areas (Figure 1 and Figure 2).

![Figure 1. Geographic location of studied reservoirs](image)
Figure 2. Localization of Gozna and Secu reservoirs

The Superior Barzava – Timis - Nera hydropower system is the oldest hydrotechnical system in Romania, early planning occurring in the early nineteenth century with a great development in the last 140 years. [3]

Gozna reservoir (Figure 3) is located on Barzava River, upstream of the Valiug village, was realized between the years 1951-1953. Gozna reservoir is the water accumulation lake with a maximum retention level at elevation 597 mdMN, with a catchment area of 80,08 km², of which 14,54 km² in the river Nera catchment (where the discharge is captured through the coast channel Nera).

Reservoir characteristics: \( V_{total} = 12 \, 053 \, 400 \, m^3 \) (between thalweg level and dam weir level) \( S_{lake} = 66,02 \, ha \) (at dam weir level).
The entire hydrographical basin is drained by a network of permanent and temporary valleys, some of which are active, favor the transport of very heterogeneous coarse silt quantities. Without manifest in depth, landslides are active in the deforested areas, the forest occupies 80% of the catchment.

Secu reservoir (Figure 4) is located on the River Barzava, about 7 km upstream from Resita, with a basin area of 165 km², of which 91.4 km² belong Gozna and Valiug reservoirs, in upstream. The lake was put in function in 1963.

Reservoir characteristics: \( V_{\text{total}} = 11\,236\,000\,\text{m}^3; \) \( S_{\text{lake}} = 105.67\,\text{ha} \) (at dam weir level).

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**Figure 3.** General scheme and capacity curve of Gozna reservoir

**Figure 4.** General scheme and capacity curve of Secu reservoir
In the catchment area meet silt and regressive erosion, collapse of banks and alluvial cones extensions, afforestation of 85%, represented by deciduous forests.

The sampling techniques, handling, transport and storage of water samples for physio-chemical and biological trials are realized according to legal standards in Romania. Sampling is realized according to the activity plan established by the Operation Manual. The Operation Manual is established by the water authorities according to provisions and requirements of the Water Framework Directive (2000/60/EC).

During the year, four sampling campaigns were conducted for data collection regarding stored water quantity and quality parameters. These periods were chosen according to the temperature, in order to measure the parameters that determine the eutrophication of the water (development stages of phytoplankton). The first campaign took place in March, during the mixing period and corresponds to the first stage of phytoplankton growth. The second campaign was in May, the period when thermocline is stabilizing, which corresponds to the growth stage of phytoplankton. The third campaign was in July, when the thermocline is well stabilized, and the second growth stage of phytoplankton takes place. The fourth campaign is in October, before temperature drops and thermocline disappears, this stage corresponds to maximum epilimnion. [3] [4]

The evolution of water quality on both reservoirs is analyzed based on water samples collected over 11 years’ time period (2001 - 2011).

3. Results and discussions
The evolution of the following parameters was analyzed: nitrogen concentration (N/NO3), total phosphorus concentration, transparency, Biochemical Oxygen Demand (BOD), water temperature and biomass. The measurements were made in the section of the dam, the middle of the lake and the tail of the lake. For biomass, we have measurements between 2001 and 2009, and for 2010 and 2011 measurements were made only in March and July, in the dam section and in the middle of the lake. The evolution of these parameters is shown in the following figures (Figure 5 – 10).

![Figure 5. Evolution of Biomass (mg/l)](image)
Figure 6. Evolution of nitrogen concentration (N/NO3) (mg/l)

Figure 7. Evolution of total phosphorus concentration (mg/l)

Figure 8. Evolution of water temperature (°C)
Analyzing the graphs, results in the following:

- The biomass concentration values are kept along the lake, the values being similar at the three water sampling points, somewhat larger variation is observed during the last part of the analyzed period; there is a slight decrease in values during the last part of the period.

- In the case of the N concentration, a decreasing tendency is observed; in the case of Gozna reservoir at the beginning of the analyzed period the concentration varies greatly along the lake, and in the case of Secu reservoir it is kept approximately constant along the lake.

- In the case of total phosphorus, a slight downward trend was observed in the last part of the analyzed period in the case of Secu reservoir; in the case of Gozna reservoir, the concentration is approximately constant along the lake, with the highest peaks in 2010 and 2011, possibly a sample analysis error.

- There is a slight tendency to increase the temperature of the water in both reservoirs.

- In the case of Gozna reservoir, there is a greater variation of BOD in the first half of the analyzed period, then a tendency to uniformity; in the case of Secu the variation is kept throughout the whole period. BOD values in Secu reservoir sounded slightly lower than in Gozna reservoir.
• Water transparency is slightly higher in Gozna reservoir than in Secu reservoir. In the last two years of the analyzed period, the water transparency in both cases decreased drastically, possibly due to the fact that samples were taken immediately after a rainy period, and the surface runoff from the neighboring hillslopes brought sediment to the lakes.

Looking at the values of analyzed parameters can observe that Gozna reservoir has a greater transparency, while temperatures and biomass are higher in Secu reservoir. Gozna reservoir is at a higher altitude than Secu reservoir.

Conclusively, it can be seen from the charts that no significant changes in the quality of the accumulation water occurred during the analyzed period.

4. Conclusions
Today, worldwide, is an increasing interest in the reservoir water quality since the water resources are not expanding as fast as the water demands. Because the fresh water becomes more limited (due to the pollution, climate change etc.), the quality of the water becomes increasingly important.

Increased attention should be paid to monitor the evolution of water quality over time. For this purpose, samples should be sampled as often as possible in areas with a high risk of degradation of water quality, in order to observe any possible negative changes and to take the necessary measures.

Managers must exploit the reservoirs so that they meet the requirements of the water users, both in terms of quantity and quality of water. Water managers are more willing today to consider the priority of maintaining and increasing the water quality, in the detriment of water volumes, to avoid costly resolution of conflicts.

If there is a need for compromise with the use of water stored in the reservoirs, cost-benefit analyzes must be made: maintaining the water quality in reservoirs and reducing the volume of water delivered to users versus delivering them the required water volumes but at a reduced quality.

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