

Water pollution in agricultural drainage area and measures for action

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Abstract: This paper deals with catchment area of zobnatica reservoir in which agricultural land takes the major portion. The actual characteristics of the catchment area, the climatic and other factors make it possible for the intensive agricultural production in the region. In that case, agriculture becomes non point source polluter of the analyzed area. Comparing the volume of use of mineral fertilizers with the contents of nitrates and phosphates in the reservoir water, their relations were observed. The prevailing climatic and pedological characteristics, in combination with the actual structure of land ownership and the exercised method of land use, make room for the occurrence of wind erosion. In the catchment area of the reservoir Zobnatica, 25-40 kg/ha of nitrogen are leached annually from arable land. An investigation showed that the rate of P₂O₅ leaching ranged from 0 to 14 kg/ha/year for light soil and from 0.3 to 8 kg/ha/year for heavy soil. A management, control and optimisation of different agricultural production processes conducted in catchment area, are the basis of all measures for the protection of soil, ground and surface water. To minimize the effect of agricultural production as source of diffuse contamination, it is necessary to choose a specific approach to each agricultural region. It is particularly important to carefully estimate natural conditions and type of agricultural production in catchment area. Complex measures for protection imply a series of synchronized activities are given in conclusions.

Key words: agriculture, irrigation, pollution, reservoir

1. INTRODUCTION

Zobnatica reservoir has been made by building earth dam. Although this reservoir are multiple purpose facilities which, according to the FAO classification, fall in the category of service reservoirs (Belic et al., 1985), the basic reason for its building in the region of northern Serbia and Montenegro was the need for irrigation. Furthermore, Zobnatica reservoir is used to variable extent for fishery and recreation activities. The reservoir has been established on water stream whose catchment area include considerable portions of agricultural land. This affects directly the mode and intensity of water quality changes. The irrigation practice which tends to intensity agricultural production and which causes considerable changes in the method of use of agricultural land, brings about still more rapid changes which may ultimately prevent the use of water for the intended purpose.

2. CHARACTERISTICS OF THE CATCHMENT

Zobnatica reservoir in northern Serbia and Montenegro has been designed to provide irrigation water for about 3,780 ha of agricultural land. Its maximum effective water storage is $5.6 \times 10^6 \text{ m}^3$. So far, about 25% of irrigation systems planned have actually been constructed. The maximum amount of accumulated water places an orientation irrigation rate about 148 mm. Since in that region plant requirements for water are larger than the calculated figures is necessary to reconsider the size of irrigation area planned. The main characteristic of the reservoir is a slow water recovery (Jankovic, 1975) and the catchment area consisting predominantly of agricultural land. The reservoir is surrounded by agricultural companies, i.e., by large plots in which mineral fertilizers and pesticides

are intensively applied, and in which corn and wheat take about 40% of the area, sugar-beet about 10% and sunflower about 5%. The predominant soil types in the catchment area are highly fertile soil types such as the calcareous hydromorphic black soil on loess plateau and the calcareous chernozem soil on loess plateau. The prevailing climatic and pedological characteristics, in combination with the actual structure of land ownership and the exercised method of land use, make room for the occurrence of wind erosion. The potential erodibility, estimated for this region after Pasak's formula (Bozinovic and Letic, 1982; Pasak, 1984), ranges around figure of 1.3 t/ha annually. The changes caused by the movement of the surface soil layer are difficult to perceive since the dominant wind in the critical period (during the sowing of spring crops, after wheat harvest) have the same bearing but the opposite direction. The largest damages are incurred when fertilizers or pesticides are transported from one plot to another and when wind drifts are disposed in canal network, water stream or reservoir. The establishment of large plots, insufficient manuring, and the use of heavy machinery for soil tillage and bedding tend to intensify the process of wind erosion which may be treated as a type of nonpoint-source pollution. According to assessment of Bozinovic and Letic (1982), wind drifts contain 8 times more humus and 10 times more nitrogen than the surface soil layer. This is why wind erosion aggravates both water quality in the accumulations as well as soil quality in the adjacent agricultural plot. The area of Zobnatica catchment is shown on Figure 1.

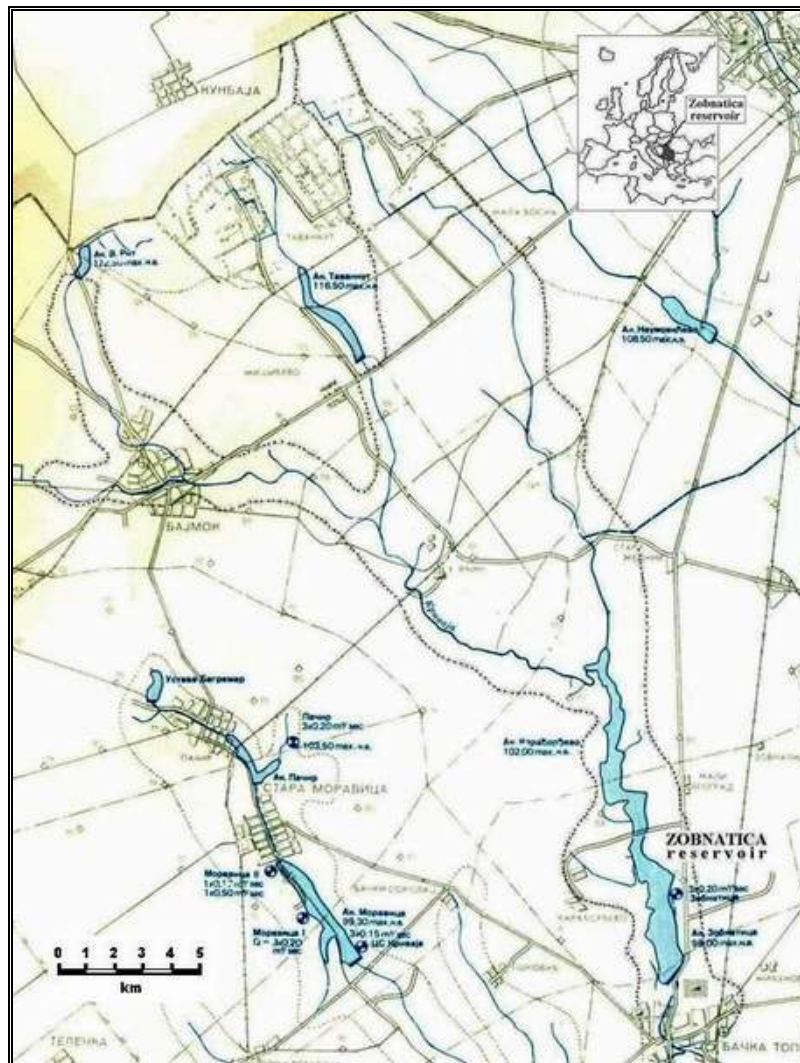


Figure 1. The area of Zobnatica catchment

3. RESULTS AND DISCUSSION

Generally, nitrogen load in a catchment area, thus, level of reservoir water pollution with nitrogen, depends primarily on method of land use, fertilization level and type, and hydrological conditions. Mineral nitrogen (ammonium and nitrate) which has not evaporated and has not been leached is taken up by plants and taken out by yield and harvest residues. In the case of wheat and corn, the amount of nitrogen take out is 2% weight for yield and 0.5% weight for harvest residues. Certain indications of possible pollution sources may be obtained using literature data (Hann, 1987) and the method of Kolenbrander adapted for the soil and climatic conditions of the northern part of Yugoslavia. In the catchment area of the reservoir Zobnatica, 25-40 kg/ha of nitrogen (ammonium especially nitrate) are leached annually from arable land. The analyses of NO_2 , NO_3 and NH_4 contents in the period 1980-2003 (Fig. 2.) showed that the amount of nitrates in reservoir water ranged to 3.5 mg/l in Zobnatica reservoir. Nevertheless, nitrate contents in this location were below the limit values prescribed by WHO (11.3 mg/l). The contents of ammonium nitrogen showed trends of increase in ammonium content, indicating the presence of polluters of organic origin. Phosphate is less migratory than nitrogen. Accordingly, it is a pollutant with a less effect to pollution. Since plant requirement for phosphate is lower than for nitrogen, considerably lower amounts of phosphate take part in the cycle. Soluble phosphate H_2PO_4 , which prevails at pH 5-7, is readily taken up by plants. At pH values below 5, phosphate tends to become fixed in combination with Fe and Al, while less soluble compound such as dicalciumphosphate and apatite prevail at higher pH values. An investigation (Stevanovic and Filipovic, 1982) showed that the rate of P_2O_5 leaching ranged from 0 to 14 kg/ha/year for light soil and from 0.3 to 8 kg/ha/year for heavy soil. Our analyses of PO_4 content in Zobnatica reservoir water conducted in the period 1980-2003 showed that the content ranged from 0 mg/l to 0.5 mg/l (Fig. 3.).

It should be added at this point that considerable amounts of pesticides, which definitely affect water quality were not analyzed within the scope of this investigation. Considering the agricultural activities practiced and the natural conditions prevailing in the analyzed catchment area, it appears practically impossible to avoid further deteriorations in water quality in the reservoirs which were the subject of this investigation.

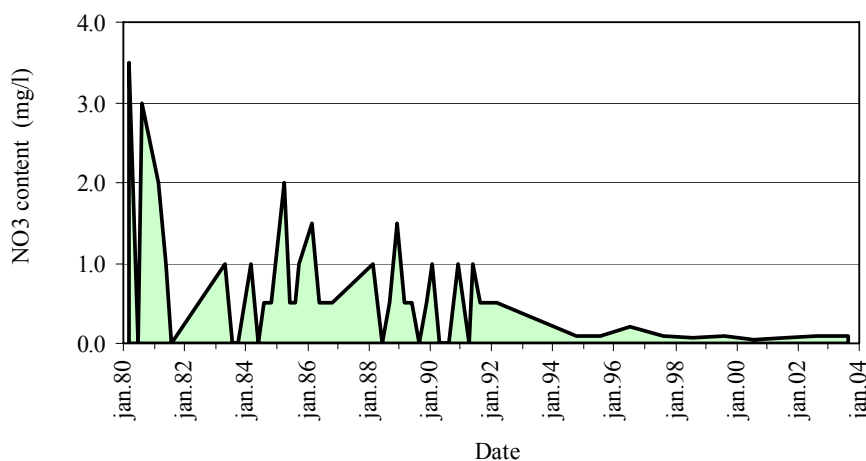


Figure 2. The NO_3 and PO_4 content in Zobnatica reservoir during observation time

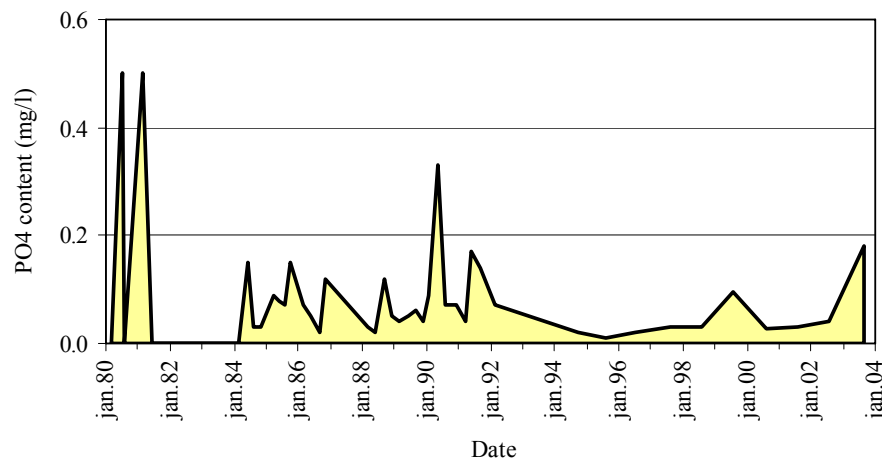


Figure 3. The NO₃ and PO₄ content in Zobnatica reservoir during observation time

3.1 Irrigation water quality

Irrigation in Vojvodina has become an indispensable and not an additional measure (Belic A. et al., 2003). Reservoir water quality in view of the irrigation needs is determined on the basis of its physical and chemical properties. The physical properties are expressed by water temperature and content of suspended matters. The fact that adding water tends to cool the soil, reducing its microbiological activity and content of nutrients in the available form, points out a necessity for soil and water temperatures to be accordant. In our case, a relatively favorable thermic regime of water in reservoir, nearing the lower limit of the optimum temperatures, makes its water applicable for irrigation. The contents of suspended matters at the period of irrigation are acceptable too. This is particularly important because sprinkling is the prevalent irrigation method in the analyzed location.

In our meliorative practice, estimates of irrigation water quality have been made on the basis of the classifications of Nejgebauer, US Salinity Laboratory, Miljkovic, FAO and Stebler's irrigation coefficient. A common point in these classifications was the degree and type of salinity of water. Extensive chemical analyses required by the classifications of FAO and Miljkovic have made these classifications less attractive to practitioners although these classification - through the analyses of water salinity and alkalinity, soil permeability, effect of specific ions on plants, environmental reaction and effect of toxic substances - offer detailed parameters of irrigation water quality.

The region of northern Serbia and Montenegro has the average annual rainfall of 610 mm and groundwater with 500-6000 mg/l dissolved salts, and also a pronounced water shortage in the course of vegetative season. These circumstances call for the use of generally accepted irrigation water classifications explanation as well as for locally adapted classifications e.g., the classification of Nejgebauer. As the region is dominated by the continental climate, the quality rating given by the classification of US Salinity Laboratory had to be moderated. However, a deterioration in irrigation water quality during the analyzed period (summer) was observed in the reservoir Zobnatica. Intensive agricultural production in the catchment area of the reservoir may be explanation for this. Particularly disadvantageous was the occurrence of classes IIIb (IVb) and C3-S1 which stand for water with unfavorable properties even for well-drained soils in catchment area. Furthermore, the ion balance of HCO₃-Na-Mg type in the analyzed water was also unfavorable. Increasing of electrical conductivity into reservoir water (Fig. 4.) is also demonstration of water quality deterioration.

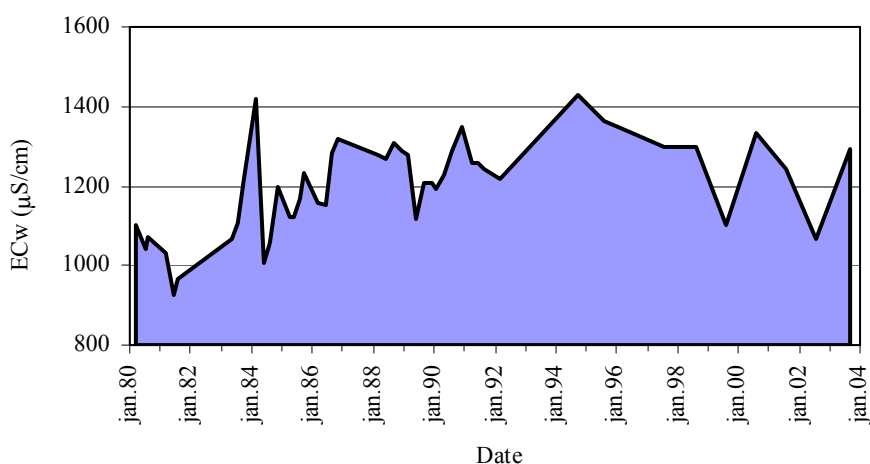


Figure 4. The electrical conductivity values in Zobnatica reservoir during observation time

3.2 Measures for protection of water quality

A management, control and optimization of the relations between different production processes conducted in catchment areas on one side and water quality in reservoirs on the other, are the basis of all measures for the protection of ecosystems (Foster and Young, 1980). To minimize the effect of agricultural production on water quality in reservoir, it is necessary to choose a specific approach to each agricultural region. It is particularly important to carefully estimate natural conditions and type of agricultural production in catchment area. Complex measures for protection of water quality in reservoir imply a series of synchronized activities, to mention the most important ones:

- Determining the catchment area of a reservoir,
- Adjusting production plans to a correct crop rotation. A five crop rotation (wheat, corn, sugar beet, sunflower, soybean) is recommended due to biological reasons as well as to mineral fertilization and its balanced influence on the potential pollution of water in reservoir,
- A study of all processes taking part in the transportation of pollutants in the ecosystem of a reservoir,
- A strict control of a preventive production technology which implies a correct use of agricultural machines for soil cultivation in order to reduce the pulverization of the surface soil layer and increase its resistance to wind erosion,
- A planned establishment of wind breakers in region endangered by wind erosion,
- A rational and restricted use of mineral fertilizers paying particular attention to kind, dose, time and method of their use. Total doses of basic and nitrogen fertilizers needed for different soil types in a catchment area should be determined on the basis of a soil fertility survey,
- An optimized use of pesticides, including certain restrictions with respect to dose, time and method of application,
- A constant supervision of catchment area, i.e., a series of perpetual operations warranting against any risk of water pollution in a reservoir.

It is thus obvious that the protection of water quality in a reservoir is designed. To foretell and prevent adverse occurrences in the designed ecosystem, it is necessary to have a team of experts of different profiles and an extensive data base capable of generating pertinent information and offering correct solutions.

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