



Evaluation of surface waters quality in Nidzica agricultural catchment area

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ABSTRACT

Nowadays, human activity has been playing an increasing role in determining the quality of surface waters. The aim of the following article is to show an influence of anthropogenic factors influencing the variability of chemical composition of river waters in a catchment area with an agricultural use of lands. The authors carried out the analysis of surface waters quality, made an inventory of pollution sources of surface waters and presented the proposal of quality improvement of surface waters in the Miechów and Kazimierz districts. Research on the concentration of biogenic compounds was conducted in the Nidzica catchment area. Data for research was obtained from the Voivodship Inspectorate for Environmental Protection, County Offices and Commune Offices. The tested area was an agricultural one. The major pollutants of the waters of catchment areas include both area and point pollution. Fertilizers and natural fertilizers are used to raise the yield and then they get into the surface waters by flushing from the fields. The main goal is to investigate the dynamics of changes in the content of nutrient compounds in surface waters during the year (seasonal changes) and in the multiannual period (multiannual changes).

Keywords: Nidzica river, seasonal changes, multiannual changes, area pollution, point pollution

1. INTRODUCTION

Nowadays, human activity has been playing an increasing role in the quality of surface waters. Nitrogen and phosphorus compounds get to surface waters from area sources (surface runoff from field crops) and point sources (discharge of household-economy waste). The high content of these substances in surface waters could lead to river eutrophication. The aim of the study was to evaluate the changes in the content of nitrogen and phosphorus compounds in the waters of rivers draining the area of Miechów and Kazimierz districts in the years 2002-2006. Data for the research was obtained in the Voivodship Inspectorate for Environmental Protection, County Offices and Commune Offices.

The analysis was conducted with reference to the status of water and wastewater infrastructure, use of the land and hydrometeorological conditions. In the first stage of work, the characteristic concentrations of analyzed compounds were determined and also their seasonal and temporal variability was determined. The obtained results show that phosphorus compounds in river waters were markedly seasonal, with the highest concentrations occurring in spring and autumn and the lowest concentrations in summer months (Fig. 1, 2, 3). Trend analysis has shown that phosphates, total phosphorus and nitric nitrogen were characterized by increasing tendency. The other compounds have shown no tendency to change. Based on the correlation analysis, it was found that there was a significant relationship between phosphate and water temperature and flow. Increased levels of nitrogen compounds may indicate the presence of contaminants from area sources, such as surface runoff from farmland, which accounts for over 70% of catchment area. In order to limit the inflow of biogenic compounds to the river waters of the Miechów district, it is necessary to rationally manage mineral fertilizers. Further coordinate actions to develop water and wastewater infrastructure and eliminate uncontrolled waste water discharges are also essential.

The purpose of this article is to show an impact of agricultural activity on the variability of the chemical composition of surface waters, with particular emphasis on nitrates, phosphates and sulphates. The authors conducted an analysis of the quality of waters in the Nidzica basin. They made an inventory of pollution sources and presented a proposal to improve the quality of surface waters in the Miechów and Kazimierz districts.

2. RESEARCH AREA

The research on the impact of agriculture on the quality of surface water was conducted in the Nidzica catchment area, which drains much of the Miechów and Kazimierz districts. Nidzica catchment area is included in areas where agriculture is the main economic sector and is the main source of subsistence for the local population.

The districts of Kazimierz and Miechow are typically agricultural regions (Table 1). The high degree of agricultural land is due to the very good soil conditions, which are necessary for plant development as well as farm livestock farming. Most of the soils of these districts are fertile agricultural soils, mainly black earth, dominated by soils of II and III classes. Large soil complexes of good and very good agricultural usefulness are used for the cultivation of the most valuable field crops such as: wheat, ground vegetables, forage and industrial crops. The decisive influence on the development of agriculture in this area is also exerted by surface formation, climate and water relations.

Table 1. Land use in Miechów and Kazimierz districts in 2012 (%).

| Land usage | Miechów district | Kazimierz district |
|---------------------------|-------------------------|---------------------------|
| Area of agricultural land | 75,6 | 90,0 |
| Arable land | 71,1 | 83,6 |
| Orchards | 0,6 | 1,7 |
| Meadows | 2,8 | 13,5 |
| Pasture | 1,2 | 1,2 |
| Forests and forest lands | 11,9 | 2,3 |
| Other lands | 12,5 | 7,7 |

Source: Own study based on GUS data.

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3. CHARACTERISTICS OF SURFACE WATERS

In hydrographic terms, the studied area borders on the west with the catchment basins of: Prądnik and Przemsza, in the north of Pilica, in the east of Nida, in the south with the lower part of Szreniawa, and the catchments of small streams passing directly to the Vistula River [3].

The area is mainly drained by Nidzica river and its tributaries. The river is a left-bank tributary of the Vistula-with a length of 51.2 km and a total catchment area of 708.4 km² [1]. The largest right-bank tributaries of Nidzica are the rivers: Kalinka, Maloszkówka and Jawornik. The most important left bank tributaries of this river are Nićka and Sancygniówka. An average volume of the annual outflow measured in cross-sections in Skalbierz and Dobiesławice amounts to 53 and 64.8 million m³/ year, respectively. Extremely small surface water resources indicate the annual outflows from the Nidzica basin, which are conducive to intensive infiltration and climatic conditions, which favor high evaporation.

The catchment of Nidzica River is poor in water down to Dobiesławice profile and the average single outflow does not exceed 4,5 dm³/s·km², which is characteristic for the lowland in central Poland. It should be emphasized that the district of Kazimierz belongs to areas

of water deficit. Precipitation deficiencies in the vegetation period are especially noticeable. The river is characterized by a large fall in the bottom of the valley, which is 1.44% . At the bottom of the river valley are ponds, marshes and drainage ditches.

Table 2. Catchment parameters.

| Features | Unit | Parameters |
|------------------------------|-----------------|-------------------|
| River length | km | 62,2 |
| Catchment area | km ² | 643 |
| Maximum catchment length | km | 51,2 |
| Average catchment width | km | 12,6 |
| Exposition of catchment area | | SE |

Source: Collective study edited by Irene Dynowska and Maciej Maciejewski [2].

In general, Nidzica has a north-easterly direction in the south-east, and the river basin is slightly elongated. Most of the watercourses in the two districts are unregulated and the bottom of the river valleys and streams are flat. Nidzica is characterized by a low density of river network, which is related to considerable permeability of partially compressed and sealed subsoil [4,5]. Nidzica has a relatively large annual amplitude of water states of 295 cm. The general tendency to such fluctuation is conditioned by the retention of the subsoil, especially the weak water-bearing nature of the rocks which are present in its subsoil. The Nidzica basin lies entirely within the Nidzińska Basin and is built of limestone and chalky marl covered with loess.

Table 3. Average annual total and underground outflow on the Nidzica River in Dobiesławice.

| River | Measuring point | Surface [km²] | Average annual total outflow [l /m³ year] | Underground power factor inflow rate [%] |
|--------------|------------------------|---------------------------------|---|---|
| Nidzica | Dobiesławice | 643 | 4,1 | 65 |

Source: According to the materials of the Institute of Hydrography and Institute of Geography Jagiellonian University.

Nidzica is characterized by a low drainage coefficient, due to the fact that its basin is located in the precipitation shadow of the Cracow-Czestochowa Upland.

4. WATER POLLUTION

The water quality of the Nidzica River and its tributaries is investigated at the measurement and control points in the Miechów district in Slaboszów and in the Kazimierz district in cities Skalbierz, Kazimierza Wielka and Piotrowice. In the initial and inlet sections of the river, water quality was at the level of the norms of II-III class of water purity, while in the middle it was below the III class of purity. Among the indicators that deteriorated the water quality of the river and were measured at the individual measurement points one should mention the color, general slurry, COD, Kjeldahl nitrogen, nitrites, phosphates, general dissolved substances and bacteriological indicators [8,9].

The quality of the Nidzica river water has remained catastrophic for many years. The poor quality of the water is largely determined by the excess of bacteriological and biogenic substances.

The main sources of surface water pollution are:

- permanent flow of sewage of social and living nature. This is evidenced by the content of nitric nitrogen and the sanitary state of the water. This situation is due to high level of dehydration of the village with simultaneous lack of a sewerage network. These factors have led to scattering the sources of pollution, which flow to the rivers all over their length and cause:
 - water pollution already in source sections,
 - high concentration of flushed slurry from unprotected farmland with dusty loess soils,
 - the increase of the content of fertilizers rinsed from the fields during the thaw period and intense rainfall.

The analysis, conducted in the years 2002 – 2006, showed that the sanitary condition of the Nidzica water, in Miechów district, was classified as II class water in the physicochemical group.

In the groups of pollutants the rating was as follows:

- concentrations of organic and inorganic substances corresponded to I class of purity,
- the suspension content was oversized,
- concentrations of biogenic compounds corresponded to II class of purity due to over 1-fold excessive concentration for both total phosphorus and nitrate phosphorus [4-9].

According to the general assessment, Nidzica is classified to the III class of purity, which was determined by bacteriological impurities. This demonstrates the improvement of water quality in Nidzica. Between 2002 and 2006, the river was classified as a leading water that did not meet standards.

In the year 2002-2006, the content of pollutants increased. There was a 4-fold increase in total phosphorus and 2-fold phosphate. High levels of total and nitric nitrogen were maintained at high levels. In 2006, Nidzica drained water of the III class of purity.

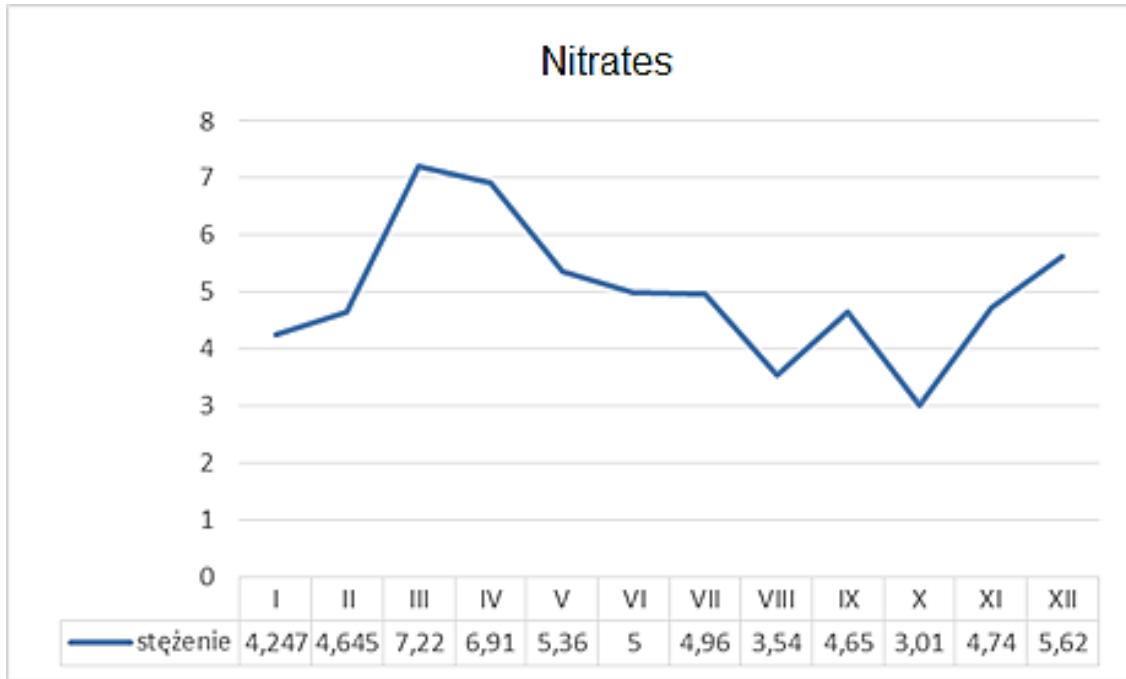


Figure 1. Average values of water pollution in Nidzica in Słaboszów in 2004 – nitrates.

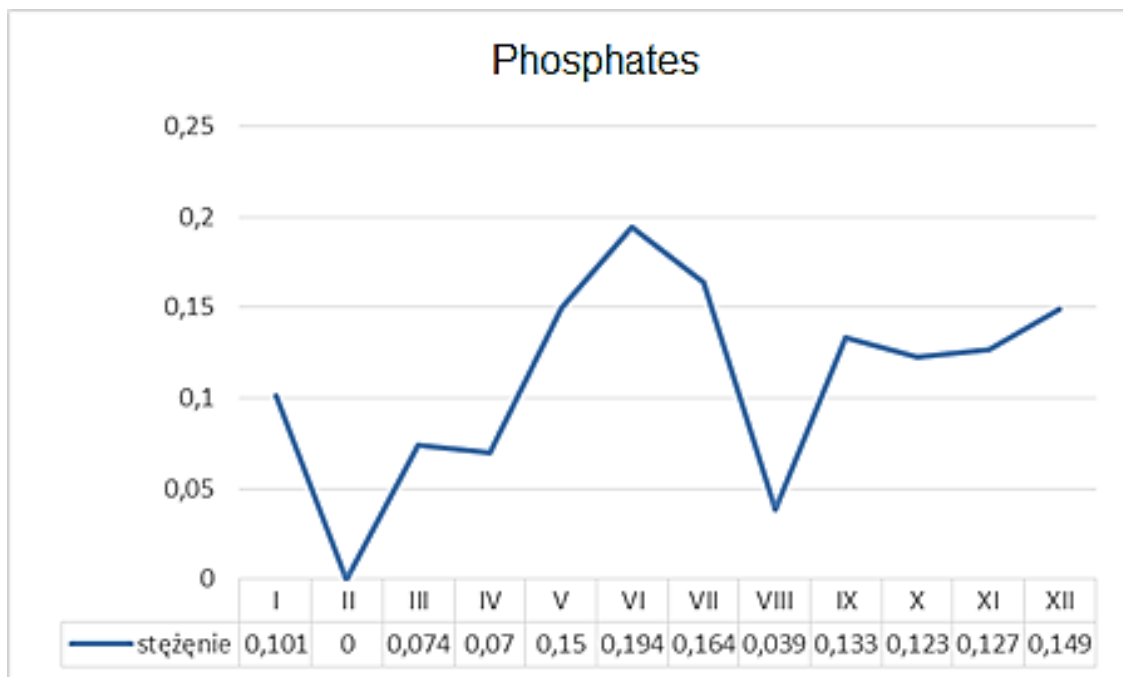


Figure 2. Average values of water pollution in Nidzica in Słaboszów in 2004 – phosphates.

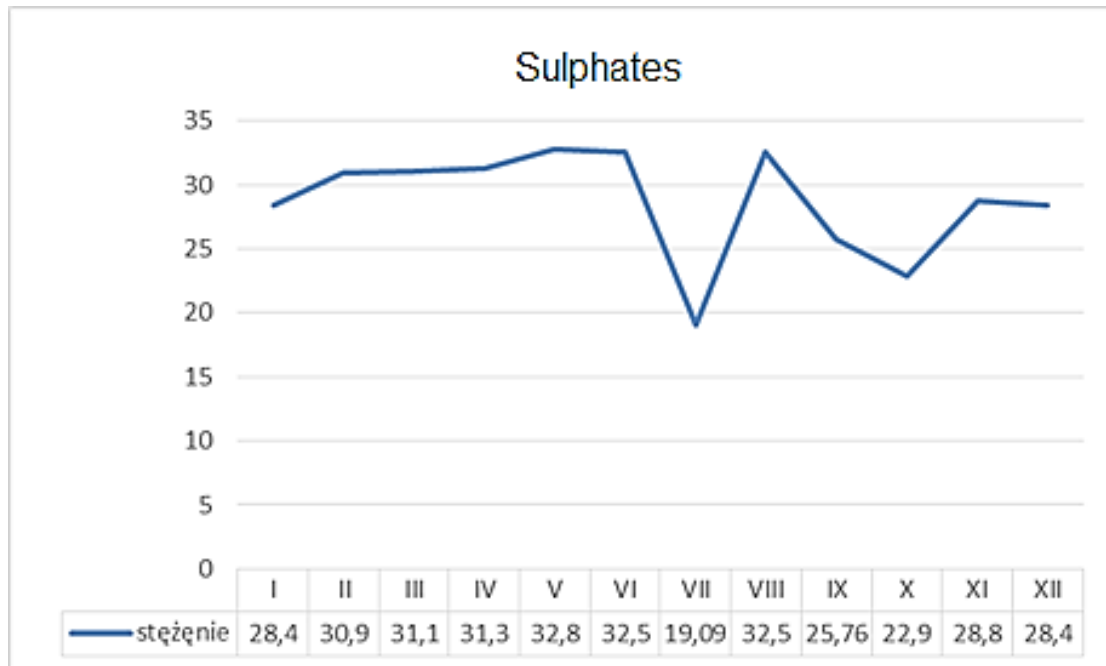


Figure 3. Average values of water pollution in Nidzica in Słaboszów in 2004 – sulphates.

Seasonal changes in chemical composition are related primarily to changes in the flow during the year. Directions for changes in particular chemical characteristics depend on the source of delivery of particular ions to the riverbed. During increasing flows in winter and spring thaw, the content of ions coming from point sources of supply, such as household sewage, decreases. During the melting period, the concentration of features associated with area sources increases.

The degree of washing of covers in the catchment area and the availability of chemicals for transport has a significant importance, in shaping chemical compounds of rivers' water during the whole year. With comparable flows, the lower concentration of most ions occurs in spring and early summer - as a result of washing away chemicals from the melt cover - than in the fall and winter, when stocks of available warm season compounds are replenished due to intense chemical weathering of the covers.

Changes of air and water temperatures during the year (seasonal factor) are mainly influenced by changes in the concentration of nutrient compounds in the water. In the summer, during vegetation season, concentration of almost all biogenic compounds is clearly increasing. Probably the cause of such changes is an intense decay of organic matter of both, natural and anthropogenic origin, in the warm season.

5. SUMMARY AND CONCLUSIONS

The Miechów and Kazimierz districts are regions where agriculture is the main economic sector and it is the main source of subsistence for the local population. It is characterized by good conditions for the development of agriculture and the agri-food

industry. Sources of pollutants are social sewage from the village along the river. There is also a significant impact on the quality of water in the river caused by area pollution. Whole length river waters have been classified as not conforming to the norms in the physicochemical group due to the concentration of biogenes. Agricultural activity, inter alia, the fertilization of arable land has an impact on the quality of the examined waters. These compounds enter the water surface and contribute to changes in the sanitary state. The phenomenon is especially noticeable after rainfalls, when the concentration of nitrate in rivers rises. It is therefore desirable to limit the use of fertilizers and plant protection products and continuously monitor waters to maintain them at a constant level of pollution/purity. It is necessary to control the intensity of agricultural production and to limit livestock farming. It is also necessary to liquidate wild dumps and to organize water and sewage management. It is essential to use plant protection products with half-decay in soil which is less than 6 months. The lack of sanitary sewage and sewage treatment plants are some of the most serious problems which should be solved in the research area. However, the implementation of a comprehensive water and sewage management program requires multi-million-dollar financing. Investments are carried out in obtaining financial support from the EU funds, which should be integrated into the interregional programs.

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