Assessment and spatial analysis of nitrate contamination in drinking water sources in the Pleven Region, Bulgaria

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INTRODUCTION

One of the major challenges facing water supply utilities in Bulgaria is ensuring compliance of drinking water with regulatory standards for nitrate concentrations. Out of the 28 administrative regions in the country, 11 are significantly affected by elevated nitrate levels in groundwater used for drinking water supply. Pleven Region is one of the affected areas. It is characterized by intensive agricultural production, which is considered one of the main causes of water resource contamination. The migration of nitrates from soil to groundwater depends on a number of factors, including seasonality, crop type, fertilizer application practices, soil granulometric composition, watershed relief, and etc.

METHODS AND MATERIALS

Laboratory analyses of drinking water conducted by the Regional Health Inspectorate (RHI) – Pleven for the period 2018–2024 were used in the present study. The obtained results were evaluated against the regulatory limit value of 50 mg/L. Statistical processing of the data included the calculation of mean values and medians for each settlement within the district. In addition, a comparative analysis was performed between the average values established for the study period (2018–2024) and those reported for the preceding period (2010–2017).

Geographic Information System (GIS) tools were used to perform comprehensive analyses of specific water sources to assess the spatial distribution and extent of nitrate pollution.

RESULTS

For the period 2018-2024, the RHI - Pleven, according to its monitoring program, tested a total of 1849 drinking water samples for nitrate content. 381 samples (21%) contained nitrates above the norm of 50 mg/l.

For each settlement in the district, maximum, minimum and average values, as well as median values for nitrate content in drinking water were found.

The obtained results demonstrate that in 15 settlements the average nitrate concentrations exceeded the regulatory threshold of 50 mg/L (Table 1). A comparative analysis with the previous study period (2010–2017) indicates a substantial increase in the number of affected settlements, from 8 to 15. During the earlier period, exceedances of the regulatory standard were reported in the village of Gigen, the village of Dragash Voyvoda, the village of Iskar, the village of Gradina, the town of Koynare, the village of Izgrev, the village of Cherkovitsa, and the village of Zgalevo. It is significant that the leading positions in nitrate pollution for both periods were occupied by the same settlements.

DISCUSSION

Pleven region includes 123 settlements and relies almost entirely on shallow groundwater from the first aquifer for public water supply, making these water sources highly vulnerable to surface contamination.

The water supply network is outdated and heavily deteriorated, which significantly reduces the quality of drinking water. The regional water utility company is currently implementing an investment project under the Environment Programme 2021–2027, focused on the large-scale replacement of deteriorated water pipelines, reduction of water losses, and modernization of water treatment facilities.

The project also includes measures to optimize the water resources management process through the upgrading of remote sensing and monitoring systems, as well as the implementation of GIS technologies.

The region is characterized by intensive agriculture, predominantly cereal and oilseed crop production, associated with regular nitrogen fertilizer application. In addition, most small settlements lack sewage systems and wastewater treatment facilities, while domestic wastewater is commonly discharged into septic tanks and soak pits. These conditions contribute to persistent nitrate contamination of shallow groundwater used for drinking water supply.

Spatial analysis (performed with GIS) of individual water sources indicates that nitrate pollution levels increase with a higher proportion of arable land within the catchment area, as well as with increasing slope gradients surrounding the water source. (Table 2)

CONCLUSIONS

Despite the implementation of legislative measures and good agricultural practices, an increasing trend in nitrate contamination has been observed in the region.

This highlights the need for stricter control over nitrogen fertilizer application in agriculture, as well as the wider use of GIS and other advanced technologies for predicting contamination levels and identifying new potential water sources.

Table 1. Settlements in Pleven region with average nitrate values in drinking water exceeding the norm for the period 2018-2024.

№	Municipality	Settlement	Avg. value [mg/L]	Min. value [mg/L]	Max. value [mg/L]	Median [mg/L]	n Number of samples
1	Gulyantsi	Gigen village	147.00	74.39	199.75	149.37	21
2	Nikopol	Dragash Voyvoda village	139.63	15.59	259.94	155.59	50
3	Gulyantsi	Iskar village	137.12	10.48	199.26	132.52	14
4	Pleven	Mechka village	86.39	5.61	128.01	97.84	24
5	Dolni Dabnik	Gradina village	83.52	41.91	121.27	85.39	22
6	Cherven Bryag	Koynare town	79.83	41.24	128.04	72.03	33
7	Levski	Izgrev village	70.30	54.90	99.12	71.34	21
8	Pordim	Borislav village	68.43	41.72	87.96	69.77	19
9	Dolna Mitropolia	Bozhuritsa village	67.18	33.18	88.53	67.48	30
10	Levski	Kozar Belene village	58.54	25.92	353.67	39.99	15
11	Nikopol	Cherventsi village	55.21	6.00	163.80	11.66	23
12	Levski	Obnova village	52.19	24.28	71.14	55.59	30
13	Pordim	Zgalevo village	51.75	22.53	68.04	52.55	29
14	Dolna Mitropolia	Bivolare village	50.85	40.83	68.43	40.83	3
15	Dolna Mitropolia	Dolna Mitropolia town	50.46	26.56	79.11	50.53	22

Table 2. Relative proportion of arable land within the catchment areas of selected settlements with the highest levels of nitrate contamination in Pleven Region.

settelment	Gigen	Gradina	Koynare
Avg. value for nitrates [mg/L]	147	83,52	79,83
Watershed (ha)	3426	21288	5174
Share of arable land	84,55%	62,54%	73,25%

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