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Review article

HEALTH HAZARDS IN THE TAP WATER IN PLOVDIV REGION

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ABSTRACT:

Introduction: Water is a precious substance that sustains life on our planet. Nowadays, the quantity and quality of this natural resource is threatened by the global warming, industrialization and urbanization.

Purpose: The aim of this study is to present the results of the research on the tap water quality and the most common hazards related to tap water consumption in Plovdiv region.

Materials and methods: A review of the official reports from the Regional Health Inspection for the period July 2021- June 2025 was performed regarding the reported tap water quality in Plovdiv region. Descriptive and comparative methods were applied for the analysis and evaluation of the systemized data.

Results: The responsible institutions report well documented decline in the quantity of the water resources but in general the water supply is sufficient. There are several populated areas with water scarcity that are in the process of search for new resources.

Urbanization, farming and global warming result in frequent microbiological contamination of water which is the most commonly reported deviation from the standards for safety. That is also the most frequently monitored parameter. Pathogenic microorganisms are eliminated by intensified water treatment resulting in high chlorine concentration in the water with possible negative health effects. Still, the necessity for this is expected to remain high in the future.

Analysis of the chemical condition of the water resources shows three most common problems – nitrate, phosphate and ammonia contamination as a result of extensive agricultural utilization of the land; uranium contamination, as well as increased alpha radioactivity, probably resulting from a combination of natural and man-made factors; manganese contamination, probably from the geological features of the region.

Conclusions: Failure to provide sufficient and clean water would have a profound negative impact on public health and wellbeing. High vigilance is necessary to mitigate health risks linked to contaminated water consumption. The preservation of currently utilized as well as potential future water resources is of highest priority.

Keywords: Environmental hazards, Water contamination, Public Health,

INTRODUCTION

Water is a precious substance that sustains life on our planet. Access to safe and clean drinking water is a universal human right, recognized by the United Nations General Assembly in its Resolution 64/292 and reaffirmed by initiatives like the European Citizens' Initiative Right2Water.[1, 2] This foundational principle places a critical obligation on governments to ensure that this essential resource is delivered to the public in a manner that is both reliable and free from health hazards.

The Plovdiv region, located in the Upper Thracian Plain in Bulgaria, is a major agricultural and industrial center in Southern Bulgaria. Its water resources are primarily defined by the Maritsa River and its tributaries. The Maritsa River is a vital artery for the region, serving as a key source of water for both irrigation and economic activities. Plovdiv Province, like the rest of Bulgaria, has a number of dams that are crucial for water supply, irrigation, and hydropower. Beyond surface waters, the region also relies on a rich network of groundwater aquifers, particularly in the broad river terraces, which are crucial for local water supply.[4] However, the abundance of these water resources is often offset by significant challenges to their management and quality. Plovdiv Region experiences growing number of water-related problems that are both multifaceted and systemic. They can be broken down into the following key issues:

1. Aging and Deteriorated Infrastructure

The primary challenge facing the water sector is a severely degraded and outdated water supply infrastructure. Decades of chronic underinvestment have resulted in a network characterized by extensive leaks and frequent failures, leading to staggering volumes of unaccounted-for water. As reported by the responsible institutions, water losses within the distribution networks exceed 60%, representing a significant waste of a critical public resource.[5] This high rate of leakage not only contributes to water scarcity and a loss of financial revenue but also creates a vulnerability to external contamination. The compromised integrity of the pipeline system facilitates the infiltration of pollutants from surrounding soil and groundwater, directly impacting the quality of the drinking water supplied to consumers.[6]

2. Water Scarcity and Management Issues

Compounding the infrastructural problems is an intensifying issue of water scarcity, which has become a persistent feature of the Bulgarian landscape. The combined effects of climate change and inefficient water management have led to critically low levels in dams and reservoirs, particularly in regions susceptible to drought. [7] The situation exacerbated as a result of the lack of management across the water sector that prioritizes public water supply over industrial. [8]

3. Water Quality and Pollution

The final critical issue is the systemic pollution of water sources, which poses direct health hazards to the public. Bulgaria has faced scrutiny from the European Union for its failure to comply with urban wastewater treatment directives, leading to its referral to the European Court of Justice. [9, 10] This non-compliance results in the discharge of untreated wastewater into rivers and other water bodies. Beyond that, agricultural and industrial runoff, particularly in key river basins like the Maritsa, introduce a range of contaminants including heavy metals and nitrates. [11] The lack of modern treatment facilities and comprehensive monitoring programs, as highlighted by the World Bank (2017), means that these pollutants may not be effectively removed before water reaches the tap. [12]

The confluence of these factors translates directly into a number of health hazards for the population.

PURPOSE

The aim of this study is to present the results of the review on tap water quality and the most common hazards related to tap water consumption in Plovdiv region.

MATERIALS AND METHODS

A review of the official reports from the Regional Health Inspection for the period July 2021- June 2025 was performed regarding reported condition of the tap water in Plovdiv region. Yearly Summary Reports since 2018 that were available online are also analyzed.

The water quality parameters examined were selected based on their inclusion in the RHI's routine monitoring schedule. These parameters were categorized into physical, chemical, and microbiological indicators. The data was collected and analyzed by the RHI according to established methodologies and standards in accordance with Bulgarian and European Union regulations.

The collected data were compiled and analyzed using Microsoft Excel. Descriptive and comparative methods were applied for the analysis and evaluation of the systemized data.

RESULTS AND DISCUSSION

In Bulgaria, the quality of drinking water is regulated by Ordinance No. 9 (2001), which establishes the mandatory parametric values and monitoring requirements. [13] The responsibility for routine monitoring lies with the local Water Supply and Sewage (WSS) companies and the Regional Health Inspection (RHI). While WSS companies are obliged to perform regular water testing, their monitoring does not always include the full range of parameters. By contrast, the RHI serves as the official public health authority, with qualified laboratory personnel and accredited methodologies that ensure compliance with national and EU standards. The RHI therefore provides the most reliable and systematically collected data. Annual summary reports on water quality are available for the period 2018–2024. [14] Since July 2021, more detailed monitoring results have been published biweekly. [15]

The results of comprehensive analyses of published reports indicate the presence of contamination with the potential to adversely affect public health.

1. Microbiological Contamination

Approximately 4,6% of all annual samples in the Plovdiv region demonstrate microbial contamination.[16] Between 2021 and 2025, out of 212 settlements in the region, 53 reported microbiological contamination of the drinking water supply, and in 21 of these, contamination was a recurrent problem.

According to official RHI reports, the leading cause of contamination is inconsistent chlorination, which is often performed manually. During the study period, only one instance of microbial growth was documented in the presence of adequate residual chlorine, underscoring the importance of proper disinfection. To address this, automated chlorination devices have been introduced and are now operational at approximately 70% of pumping stations. [16]

However, microbiological risks are compounded by structural vulnerabilities in the supply infrastructure. The aged and deteriorating pipeline network, which is responsible for an estimated 60% water loss in the region, creates multiple entry points for pathogens. Additional risk factors include poorly delineated sanitary protection zones around water catchments and unregulated livestock farming near water sources, both of which remain unresolved challenges.

Environmental conditions further exacerbate the issue. Higher contamination rates were observed during warmer months consistent with the trend of climate change increasing the risk of microbial proliferation in water supplies. In the period 2022–2024, 61% of the samples exhibiting contamination were collected between June and October (samples collected after the 2022 floods are not included). Elevated temperatures are generally linked to higher bacterial abundance in drinking water systems in other studies, although seasonal contamination patterns vary depending on disinfectant residuals, hydraulic conditions, and source water characteristics. [17]

Notably, no microbiological contamination was recorded in the larger cities, such as Plovdiv and Asenovgrad, despite these systems undergoing the most rigorous bacterial testing. This finding illustrates that effective management can largely reduce the risk of microbiological contamination.

Nevertheless, intensified disinfection practices have introduced a secondary challenge: elevated residual chlorine concentrations. While essential for microbial control, excess chlorine causes short-term effects such as eye, nose, and throat irritation, and imparts an unpleasant taste and odor to the water. More importantly, chronic exposure to chlorination by-products, including trihalomethanes, has been linked to increased risks of certain cancers and other adverse health outcomes. Instances of excessive chlorine were recorded even outside officially declared prophylactic chlorination periods, raising additional public health concerns.

Excess residual chlorine was recorded in 10 settlements during 2024.[15] Notably, notice for the mass disinfection of the water supply system was not issued on WSS website for eighter of these events. [18]

The floods of 2022, which affected several settlements in the Plovdiv region, demonstrated the vulnerability of the water supply system to major hydrological events. [19] In six of the seven most severely impacted villages, microbiological contamination of the distribution networks was promptly detected and mitigated through emergency measures, which successfully restored water quality. [20] Nonetheless, the region remains among those most frequently experiencing microbiological contamination of the central water supply. Moreover, beyond the flooded settlements, an additional eight communities in the area also reported microbiological contamination following the heavy rainfall. [15]

2. Chemical contamination

The most frequently reported chemical contaminant in the region is nitrates. This issue is largely anthropogenic, arising from the intensive use of fertilizers in agricultural fields. Leaching from soils into groundwater and shallow aquifers is the primary cause for water contamination. [14]

Nitrates pose significant health risks. They are reduced to nitrite, which can oxidize hemoglobin to methemoglobin, causing "blue baby syndrome" in infants.[21] Beyond acute toxicity, multiple large epidemiologic studies and syntheses published in the last five years link chronic, low-to-moderate nitrate exposure to adverse reproductive outcomes: higher odds of preterm birth and signals for certain congenital anomalies, sometimes at concentrations below current standards. [22, 23, 24, 25]

Evidence on cancer is evolving: a 2024 U.S. cohort associated nitrate in tap water with elevated cancer mortality even when levels were below the regulatory limit, while a 2022 meta-analysis found positive associations mainly for gastric cancer; a 2024 Cochrane protocol notes the need to update earlier conclusions that the cancer link was unclear. [26, 27] Long-term risks are biologically plausible because nitrite can form carcinogenic N-nitroso compounds and nitrate competitively inhibits the thyroid's sodium-iodide symporter—raising concern for thyroid dysfunction in susceptible individuals. [28]

A persistent nitrate problem has been documented in the villages of Tatarevo, Brestnik, Belashtitza, and Brani Pole. (Table 1) Sporadic reports also exist for several other settlements with borderline concentrations; however, the lack of regular testing data prevents a clear assessment. Even in the most affected villages, testing is typically carried out only once per year, which limits the ability to track seasonal fluctuations. [15] Notably, all reports since 2019 repeat the same statement regarding the planned resolution of this issue by the supplying company, yet the problem remains unresolved. [14]

Table 1. Nitrate concentrations (mg/L) in drinking water from settlements with recorded exceedances in Plovdiv Region, 2021–2024

	Graf Ignatievo	Belashtitza	Brestnik	Brani pole	Tatarevo	Momino selo	Markovo	„Filicon-97" Plovdiv	Tyurkmen
Year	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l	Nitrates mg/l
2021	64±3	62±2	84±3	67±3	no data	no data	53±2	70±3	50±2
2022	46±2	47±2	80±3	no data	86±3	no data	8,3±1,3	no data	no data
2023	44±2	no data	56±2	66±3	142±7	no data	no data	no data	no data
2024	no data	68±3	51±2	66±3	125±5	50±2	19,2±0,9	no data	no data
2025	47±2	no data	81±4	no data	129±6	no data	no data	no data	no data

Data source: RHI Plovdiv, 2021–2024 monitoring reports

A notable exception is the village of Graf Ignatievo, where nitrate contamination had previously been reported. According to official reports, a purification system was installed, and nitrate concentrations have remained within the permissible limits for the past four years. [14]

Beyond nitrates, phosphate contamination has been identified in the villages of Zelenikovo and Pravoslaven. This issue is attributed to the geological characteristics of the area. Although technical solutions exist, they have not been implemented, likely because phosphates in drinking water are considered to present relatively low health risks. [14]

Geological factors are also responsible for elevated manganese levels in Brestovitsa. The problem became particularly acute in 2021, when concentrations exceeded the regulatory limit by more than twentyfold. Although all tests conducted over the last three years have shown normal values, the official restriction on water consumption remains in place. [14] In addition, occasional elevations of iron, manganese, boron, and selenium have been reported in other settlements, though these are generally sporadic rather than persistent problems. [15]

1. Radiological contamination

The Plovdiv region is characterized by naturally occurring radioactive isotopes in the environment. Historically, the area was extensively exploited for uranium mining, with nine deposits actively developed in the past. [29] The natural features combined with the disturbance of geological layers and insufficient funding for mine rehabilitation has increased the risk of water contamination.[30]

Because the chemical composition of groundwater depends on the geological formations it flows through—and most of the region's drinking water supply relies on such sources—naturally occurring radioactivity is expected. Other factors like redox conditions, pH, and carbonate chemistry strongly influence uranium mobility, with oxidizing and carbonate-rich waters – which are typical for the region - enhancing transport. [31] Urbanization and over-extraction of groundwater further exacerbate the risk by drawing on deeper, older and potentially more contaminated layers.

From a health perspective, uranium and other radionuclides pose dual hazards. Alpha-particle radiation is highly ionizing and can damage cellular DNA, increasing carcinogenic potential up to twentyfold relative to equivalent gamma or beta exposure. Uranium itself is also chemically toxic: soluble compounds primarily affect the kidneys, causing nephrotoxicity, while insoluble forms may accumulate in bones, liver, and reproductive organs, disrupting renal, hepatic, neural, and endocrine functions. Recent toxicological studies have linked chronic uranium ingestion with impaired renal re-absorptive function and increased cancer risks, even at low exposure levels. [32, 33, 34, 35, 36]

International assessments assume a linear, no-threshold relationship between radiation dose and health risk. [37] The World Health Organization (WHO) has set an Individual Dose Criterion (IDC) of 0.1 mSv/year for radionuclides in drinking water, a level considered to represent very low risk. There is evidence that in practice, this IDC is not usually exceeded if the screening values of 0.5 Bq/L for gross alpha activity and 1 Bq/L for gross beta activity are met. These reference values were established to account for the most common radionuclides found in drinking water and their respective contributions to the radiation dose resulting from its consumption. [38]

Ordinance No. 9 on drinking-water quality in Bulgaria adopts the same IDC, but with slightly stricter alpha screening levels of 0.1 Bq/L that is imposed by European directives. This dose represents less vdiv region report exceeding alpha activity in the range of 0.1–0.5 Bq/L, with their number increasing each year. (Table 2) [14] It should be noted that exceeding alpha activity thresholds does not automatically render water unsuitable for consumption; a full dose assessment requires isotope-specific analysis. So far only Bryagovo has IDC exceeding 0.1 mSv/year and tap water is restricted for drinking purposes.

Table 2. Gross alpha exceedances in drinking water, Plovdiv Region (07.2021–06.2025)

	2021		2022		2023		2024		2025	
	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l
Milevo	0,40±0,04	27±3	0,48±0,05 0,23±0,020, 0,10±0,01	26±3 21±2 0,10±0,01 11±1	0,27±0,03 12±1	15±2	0.37±0.04	42,4±4,1	/	/
Tatarevo	/	/	/	/	0,44±0,04	13±1	/	/	/	/
Krushevo	/	/	/	/	0,33±0,03	28,4±2,8 37,56±0,036	/	26.96±0.5 26,9±0,5	/	/
Calapica	0,10±0,01	<3	0,080±0,008	<2	0,26±0,03	3,81±0,04	/	/	0.25 ±0.02	/
Chernichevo	/	/	/	/	0,30±0,03 0,05±0,005 /	35,10±0,045 0,93±0,0002 0,92±0,0002	/	/	<0.01	/
Vinica	/	/	/	/	/	/	0.34±0.03	42,7±4,1	/	/
Svezhen	/	/	/	/	/	/	1.46 ±0.14 0.48 ±0.05	60.0 ±5.7 32.7 ±5.7 3,277±0,085	0.098 ±0.009	1.92±0.43
Kalekovec	0,10±0,01	9±0,9	/	/	/	/	/	/	0.35 ±0.03	/
Caracovo	/	/	0,10±0,01	5±0,5	0,10±0,01	8,1±0,8	/	/	0.22 ±0.02	/

Kostievo	/	/	/	/	/	/	/	/	0.20 ±0.02	/
Orizare	/	/	0,10±0,01	10±1	/	/	/	/	1.13 ±0.11	/
Tri vodici	0,09±0,009	<3	0,034±0,003	<0,2	0,10±0,01	4,50±0,04	/	/	0.20 ±0.02	/
Perushtica	0,05±0,005	<3	0,093±0,009	8,6±0,9	0,10±0,01	3,54±0,04	/	/	0.23 ±0.02	/
Parvenec	/	/	/	/	/	/	0.090±0.009	2.38±0.07	0.25 ±0.02	/

Data source: RHI Plovdiv, 2021–2024 monitoring reports. *Some values are rounded to two decimals. **Some values are converted from mg/L to µg/L.

Bryagovo, Karadzhalovo, and Dragoynovo consistently report gross alpha activity above 0.5 Bq/L, alongside abnormal uranium concentrations in tap water. During the study period, eleven settlements were subjected to intensified monitoring due to elevated or consistently borderline uranium concentrations in tap water. Two settlements reported occasional exceedances followed by subsequent normalization. At present, water use restrictions for drinking and cooking remain in place in nine settlements. [14, 15] (Table 3)

Table 3. Radiological exceedances in drinking water, Plovdiv Region (07.2021–06.2025)

	2021		2022		2023		2024		2025	
	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l	Alpha Bq/l	Uranium ug/l
Debar	/	/	/	/	/	33,53±0,036	/	/	/	/
Parvomai	0,28±0,03	20±2	0,24±0,02 0,22±0,02	24±2 20±2	0,38±0,04	23,9±2,3 35,07±0,036	/	26.8±0.5 26,5±0,5	/	/
Karadzhalovo	0,35±0,04	28±3	0,40±0,04 0,43±0,04 0,45±0,05 0,40±0,04	28±3 29±3 25±3 23±2	0,53±0,05 / 0,55±0,06 0,52±0,05	26±3 34±4 34±3 32,8±3,2 34,2±3,4	/	/	/	/
Byala reka	0,36±0,04	22±2	0,42±0,04 0,46±0,05	28±3 27±3	/ 0,42±0,04	34±4 34±3	/	/	/	/
Dragoynovo	0,47±0,05	30±3	0,53±0,05 0,48±0,05 0,56±0,06 0,28±0,03	30±3 30±3 28±3 21±2	0,34±0,03 0,67±0,07 0,55±0,05 0,35±0,04	18±2 51±5 43±4 17,5±1,7 20,0±2,0	/	/	/	/
Bryagovo	0,57±0,06	40±4	0,81±0,08 0,84±0,08 1,13±0,11 0,83±0,08	42±4 49±5 50±5 48±5	0,66±0,07 0,60±0,06 0,78±0,08	45±5 46±5 64±6	/	/	/	/
Bolyarino	0,30±0,03	22±2	0,30±0,03 0,37±0,04 0,20±0,02 0,23±0,02	20±2 26±3 11±1 12±1	0,35±0,04 0,43±0,04 0,34±0,03	20±2 27±3 28,0±2,8 32,49±0,036	0.35±0.04	32.7 ±5.7	/	32.4±3.1
Gradina	/	/	0,44±0,04 0,24±0,02	25±3 22±2	0,35±0,04 0,40±0,04 0,35±0,04	19±2 30±3 28,0±2,8 35,20±0,036	/	24.17±0.44 27,3±0,5	/	/

Pravoslaven	/	/	0,40±0,04 0,38±0,04	27±3 25±3	0,29±0,03	25±3	/	/	/	/
Krushevo	/	/	/	/	0,33±0,03	28,4±2,8 37,56±0,036	/	26.96±0.5 26,9±0,5	/	/

Data source: RHI Plovdiv, 2021–2024 monitoring reports. *Some values are rounded to two decimals. **Some values are converted from mg/L to µg/L.

Particularly concerning are cases of sudden, unexpected elevations. In Svezhen, a single monthly sample in 2024 showed gross alpha activity of 1.46 Bq/L and uranium concentrations of 60 µg/L. A similar case occurred in Orizare, where gross alpha activity of 1.13 Bq/L was recently reported and remains under investigation. [15]

Furthermore, although Ordinance No. 9 requires monitoring of radon in groundwater-supplied public water systems, there are no available test results for this parameter.

These limitations highlight a broader challenge: the Regional Health Inspectorates (RHIs) are covering radiological analyses not only for Plovdiv but also for Haskovo, Smolyan, Pazardzhik, and Kardzhali regions. [14] Given the scope and complexity of radiological monitoring, their current resources appear overstretched.

Future efforts should prioritize the expansion of monitoring. Continuous surveillance could be beneficial in areas where contaminant levels fluctuate near regulatory thresholds. In addition, systematic investigations into parameters such as radon and tritium, which are formally regulated but remain unmeasured, are needed for a comprehensive assessment of water safety.

Another gap lies in communication. Utilizing digital tools, real-time reporting platforms, and targeted communication strategies can improve public awareness and help bridge the divide between institutional monitoring and community understanding.

Ultimately, the study reflects a broader imbalance: natural resources in the region have been extensively utilized, yet investment in preservation and monitoring has been insufficient.

CONCLUSIONS

Failure to provide sufficient and clean water would have a profound negative impact on public health and wellbeing. This study demonstrates that drinking water quality in the Plovdiv region continues to be challenged by microbiological, chemical, and radiological contaminants, with varying degrees of persistence and health relevance. While emergency measures and targeted interventions have been effective in some cases, systemic problems remain unresolved. The water supply system lags behind contemporary standards, and both infrastructure and management require significant improvement.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://www.riokozpd.com/index/377-monitoring.html and here: https://www.riokozpd.com/index/550-dokladi-piteini-vodi.html

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