NITRATES IN DRINKING WATER IN VARNA DISTRICT

Elena Valkova

Technical University Varna, Studentska str., № 1, Varna, 9010, Bulgaria

Abstract

The study determined drinking water state in Varna district, Bulgaria, with regard to presence of nitrates in it. Water supply sources of the district are studied. Nitrates presence in drinking water is investigated for period 2018-2022 in 17 critical areas and trends are determined. The highest nitrate pollution levels are found in Dobrogled (2018 – 256 mg/dm^3), Sadovo (2021 – 204 mg/dm^3) and Zdravets (2021 – 165 mg/dm^3). Drinking water in Dobrogled area is in the worst condition. Reported values are more than five times the norm. In 2018 the highest amount (256 mg/dm^3) is recorded for studied period, and lowest (206 mg/dm^3) is measured in 2021, which is more than four times exceeding the established norm (50 mg/dm^3). Measures and activities implemented by RHI-Varna and WSS - Varna are studied.

Keywords: *quality, drinking water, pollution, nitrates*

1. INTRODUCTION

Water is a basic natural resource, vital for existence of living organisms. Drinking water is used in all spheres of public life and especially for drinking and domestic needs. Protection of drinking water quality is one of the main priorities in environmental protection policies of all countries, to guarantee healthy human living conditions and a high standard of public health.

A number of legal documents at international, national and regional levels regulate the requirements regarding drinking water. Zero pollution, improved quality and access to drinking water are enshrined in the revised EU Drinking Water Directive, effective from January 2021 [7]. To ensure high quality drinking water, Directive includes updated standards for safety and risk management throughout water supply chain, as well as new particularly toxic pollutants for monitoring.

Despite introduction of new monitoring indicators, elevated levels of nitrate pollution are reported in a large part of water supply systems on a global, national and regional scale, which stands out as one of the most important problems for water quality. [3, 7, 8, 9, 12, 14, 17, 18, 19]

Nitrates are used in agriculture as highly effective fertilizers, in food industry (colorants, preservatives) and in industry for production of paints, medicines, plastics, glass, etc. [1, 2, 5, 10, 13, 14] Main sources of nitrate pollution are excessive or incorrect use of organic and mineral fertilizers in agriculture, domestic waste water in settlements without built-up sewage, from animal husbandry and from enterprises for production of fertilizers, medicines, plastics, etc. [1, 2, 5, 10, 14, 15, 19]

Nitrates enter human body through water and food. As independent substances, they are not dangerous for health, but when they get into the human body, in process of metabolism, nitrites and nitrosamines are produced, which pose a risk for consumers health. [10, 15]

According to the “World Health Organization”, nitrates harmless amount for an adult is 5 mg per kilogram of body weight per day, and permissible daily amount is up to 500 mg. When larger quantities than this permissible dose enter human body, they already represent a potential health hazard. [16]

Regarding drinking water quality in Republic of Bulgaria, nitrate pollution is reported as a major problem. In National report on state and protection of environment in Republic of Bulgaria from 2022 [12] it is reported that in last few years 2020-2022 there is a gradual improvement in quality of underground and surface water for most indicators, with exception of nitrates.

Groundwater and surface water are main sources of domestic drinking water supply for country and are one of main vectors for nitrate pollution of drinking water.

Nitrate removal from drinking water is a major challenge for most water supply systems due to technologies high cost. In this regard, alternative and adequate solutions should be sought to solve the problem of drinking water nitrate pollution.

Purpose of the present study is to analyze and evaluate nitrates state in drinking waters of Varna district for period 2018-2022.

2. MATERIALS AND METHODS

2.1. Study area

Object of study is Varna district, which includes 12 municipalities with 470,124 inhabitants: Avren, Aksakovo, Beloslav, Byala, Varna, Vetrino, Valchi dol, Devnya, Dolni Chiflik, Dalgopol, Provadia and Suvorovo.

Water supply of settlements on Varna municipality territory is carried out by “Water Supply and Sewerage - Varna” OOD - a commercial company whose main business is water supply and sewerage and wastewater treatment.

Water supply system of Varna municipality is supplied by a total of 148 water sources, of which 70 are in constant operation. Water quantities are reserved in 508 pressure tanks (PT) and extraction tanks (ET) with a total volume of 291,400 m^3. Due to varied terrain, system has 50 main pumping stations (PS) and over 616 km of water supply pipelines [6].

Underground water sources provided for maintenance and operation on Varna region territory are about 255 catchments and drains, 123 boreholes, tube and shaft wells. Only 55 of underground waters have established sanitary-protection zones (SPZ).

Varna municipality water supply is carried out exclusively from water sources located outside municipality territory, with water supply system total length - 4334 km. The larger aquifer groups serving settlements are [17]:

- Derivation “Kitka-Varna”, water source - “Kamchia” dam (located on Burgas region territory; maintained and managed by “WSS” EAD, Burgas), through pumping station (PS) “Vladislavovo”;
- Devnya-Varna 2nd and 3rd stage with “Devnya springs” water sources, through PS “Odessos” - supplies water to Devnya town and Varna town, and settlements along the way from Devnya to Varna;
- Water supply system “Batova” - includes about 50 underground water sources (catchments, drains and shaft wells). It supplies water to the high area of resort complex “Golden sands”, part of “Vinitsa” district, Varna and villages Kamenar and Kumanovo;
- Water supply system “Pasha Dere” (Priboy) - supplies water to part of “Galata” district and its adjacent villa area;
- “Tsonevo” dam - for emergency water supply of Varna and villages of district, PS “Tsonevo” was built in 2003, which is fed by “Tsonevo” dam and includes water in duiker № 15 of “Kitka-Varna”.

Table 1 presents water supply sources of each municipality. There is almost no inhabited place or locality that is not supplied with water in Varna district. Smaller towns and villages are supplied with water also from local water sources.

2.2. Research methodology

Data on the indicator “nitrates” in drinking water in Varna region for period 2018-2022 have been collected from monitoring performed by the Regional Health Inspection (RHI) - Varna. Monitoring is carried out together with “Water Supply and Sewerage - Varna” OOD, through Laboratory Testing Complex (LTC) at “WSS - Varna”.

Municipality	Main water supply
Avren	From pumping station (PS) “Avren” From derivation “Kamchiysky pyasaci” From PS “Cherven Most”
Aksakovo	From “Kitka-Varna” derivation (from “Kamchia” dam), via PS “Vladislavovo” From water supply system “Kokiche” From water supply system “Haramiyski vodoprovod”
Beloslav	From “Devnenski Izvori” water supply system
Byala	From “Kamchia” dam - along “Kamchiyski pyasaci”derivation, through PS “Marin Tepe”
Varna	From “Kamchia” dam - along “Kitka-Varna” derivation, via PS “Vladislavovo” From “Devnenski Izvori” water supply system, through PS “Odessos” (and for part of resort complexes) For part of Varna and resort complexes - from “Batova” water supply system, through PS “Batova”
Vetrino	From Zlatinska water supply system, through PS “Zlatina”
Valchi dol	From PS “Valchi dol”- 1 and 2
Devnya	From “Devnenski Izvori” water supply system, through PS “Ada”-1 and 2, and PS “Odessos” From “Kitka-Varna” derivation (from “Kamchia” dam)
Dolni Chiflik	From “Kamchia” dam - through derivation “Kamchiysky pyasaci”
Dalgopol	From “Kitka-Varna” derivation (from “Kamchia” dam)
Provadia	From Zlatinska water supply system, through PS “Zlatina” From PS “Provadia” From “Kitka-Varna” derivation (from “Kamchia” dam)
Suvorovo	From PS “Suvorovo”

Table 1. Water supply sources of municipalities in Varna district

Source: Report on drinking water quality supplied by Water Supply and Sewerage-Varna OOD in Varna District in 2022, RHI-Varna, March 2023.

LTC performs water analysis for drinking and domestic needs from taken water samples. Monitoring is performed according to requirements of Water Act regulations. Sampling is carried out jointly by employees of RHI-Varna and WSS-Varna. Samples are taken simultaneously from same points in planned settlements. Sampling points are indicated in joint monitoring program with their exact address, with name of object or company operating the object. [17]

Performance of laboratory analysis conforms to established standards. Obtained results are compared with norms specified in Regulation № 9 of March 16, 2001 on water quality intended for drinking and domestic purposes, SG № 43/16.05.2023 (the maximum permissible nitrates concentration in drinking water is 50 mg/ dm^3) [4].

An important addition is that in co-presence of nitrates and nitrites, ratios sum of analytically determined concentration to corresponding maximum value must be less than or equal to an unity, i.e. condition must be fulfilled [16, 17]: (nitrates)/50 + (nitrites)/3 <= 1, [mg/l].

3. RESULTS AND DISCUSSION

Based on the five-year monitoring of RHI - Varna and WSS- Varna, 17 critical zones in district are determined in terms of nitrate pollution. Table 2 presents recorded average and maximum values in drinking water of these critical areas. Trends in nitrate levels for study period 2018-2022 are determined and are presented in Figures from 1 to 17.

Izgrev	**2018**	**2019**	**2020**	**2021**	**2022**
average	58	57	52	56	42
maximum	83	88	85	62	59
Levski	**2018**	**2019**	**2020**	**2021**	**2022**
average	64	63	62	55	57
maximum	70	77	67	64	66
Chernook	**2018**	**2019**	**2020**	**2021**	**2022**
average	41	26	24	23	29
maximum	50	38	24	24	44
Ovchaga	**2018**	**2019**	**2020**	**2021**	**2022**
average	46	44	42	47	49
maximum	51	48	52	52	55
Snezhina	**2018**	**2019**	**2020**	**2021**	**2022**
average	60	62	46	52	58
maximum	77	68	52	56	62
Avren	**2018**	**2019**	**2020**	**2021**	**2022**
average	74	71	78	82	84
maximum	95	77	96	94	99
Zdravets	**2018**	**2019**	**2020**	**2021**	**2022**
average	101	115	75	102	78
maximum	130	145	123	165	123
Benkovski	**2018**	**2019**	**2020**	**2021**	**2022**
average	118	161	90	106	91
maximum	149	170	126	147	148
Sadovo	**2018**	**2019**	**2020**	**2021**	**2022**

average	156	143	128	168	162
maximum	189	162	164	204	173
Zasmianovo	**2018**	**2019**	**2020**	**2021**	**2022**
average	51	52	54	54	46
maximum	61	65	64	63	50
Zornitza	**2018**	**2019**	**2020**	**2021**	**2022**
average	65	63	57	59	59
maximum	78	86	64	63	65
Izvorsko	**2018**	**2019**	**2020**	**2021**	**2022**
average	62	50	57	61	62
maximum	69	64	61	64	67
Kiselovo	**2018**	**2019**	**2020**	**2021**	**2022**
average	65	61	55	51	48
maximum	76	70	63	59	54
Dobrogled	**2018**	**2019**	**2020**	**2021**	**2022**
average	216	156	208	127	175
maximum	256	217	232	206	225
Kichevo	**2018**	**2019**	**2020**	**2021**	**2022**
average	50	46	39	50	42
maximum	57	52	39	53	49
Klimentovo	**2018**	**2019**	**2020**	**2021**	**2022**
average	31	50	65	62	42
maximum	43	50	65	64	48
Vaglen	**2018**	**2019**	**2020**	**2021**	**2022**
average	54,5	55	51,6	50	43
maximum	58	62	59	52	49

Table 2. Nitrates dynamics (mg/dm^3) in drinking water of critical water supply areas of Varna district for period 2018-2022

Source: Report on drinking water quality supplied by Water Supply and Sewerage-Varna OOD in Varna District in 2022, RHI-Varna, March 2023.

Figure 1 shows that for the first critical zone - Izgrev, exceedance of norm (50 mg/dm^3) for nitrates presence in drinking water is constant for studied period (from 2018 to 2022) in relation to the maximum reported values. They ranged from 1.66 to 1.18 times the norm. From 2018 to 2020, nitrates values in waters rise from 83 mg/dm^3 to 85 mg/dm^3, but in 2021 there is a drop in their amount to 62 mg/dm^3. It continues in next analyzed year 2022 - 59 mg/dm^3. These readings indicate a downward trend in drinking water nitrate loading in this critical area.

In support of this is the average value marked with a blue line on graph. In it, a low excess of established norm is observed, and it even falls below norm in 2022 – 42 mg/dm^3.

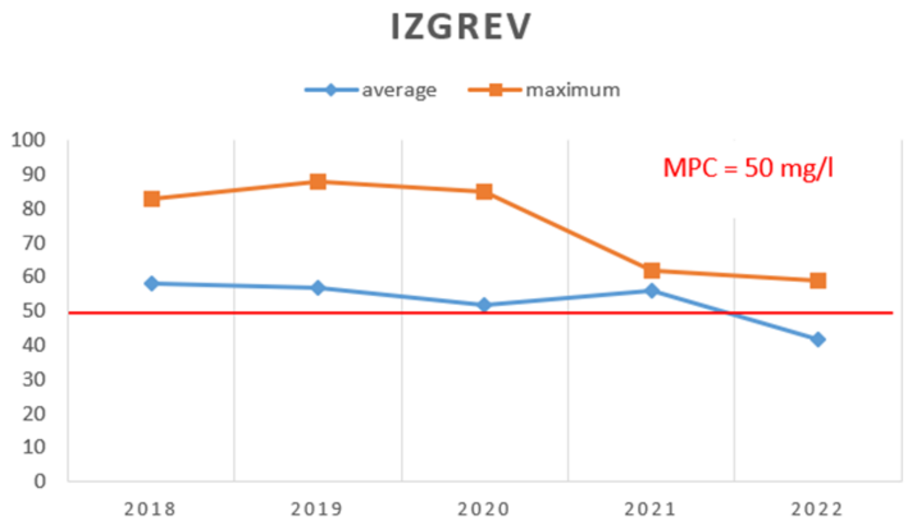

Fig. 1. Maximum and average values of nitrates in waters at critical zone Izgrev

In critical zone - Levski, for which values are graphically depicted in Figure 2, no trend can be determined, because the lowest maximum and average values are recorded in 2021, respectively: 64 mg/dm^3 and 55 mg/dm^3, and in 2022 they mark an increase - 66 mg/dm^3 and 57 mg/dm^3.

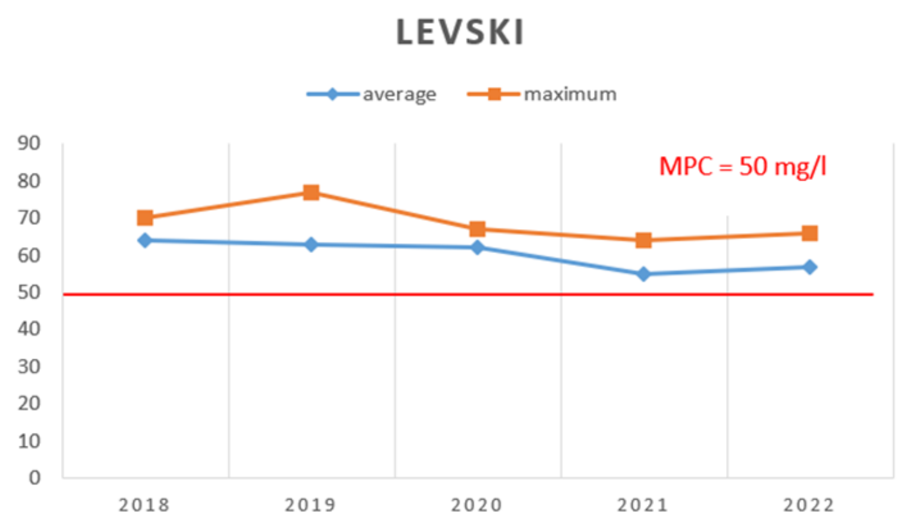

Fig. 2. Maximum and average values of nitrates in waters at critical zone Levski

Regarding the maximum values for zone, a peak is observed in 2019 - 77 mg/dm^3. Following year, measurements are 10 mg/dm^3 lower (67 mg/dm^3), which is only 1 mg/dm^3 less than results for last year of study period. At average values for first three years of analyzed period, reduction of nitrates is only by 1 mg/dm^3. Decrease that is registered in 2021 - 55 mg/dm^3 is exceeded in the last year. All readings are above normal and decline in average measured values cannot be definitively determined as downward.

Waters condition about their nitrate content is many times better in critical area - Chernook (Fig. 3).

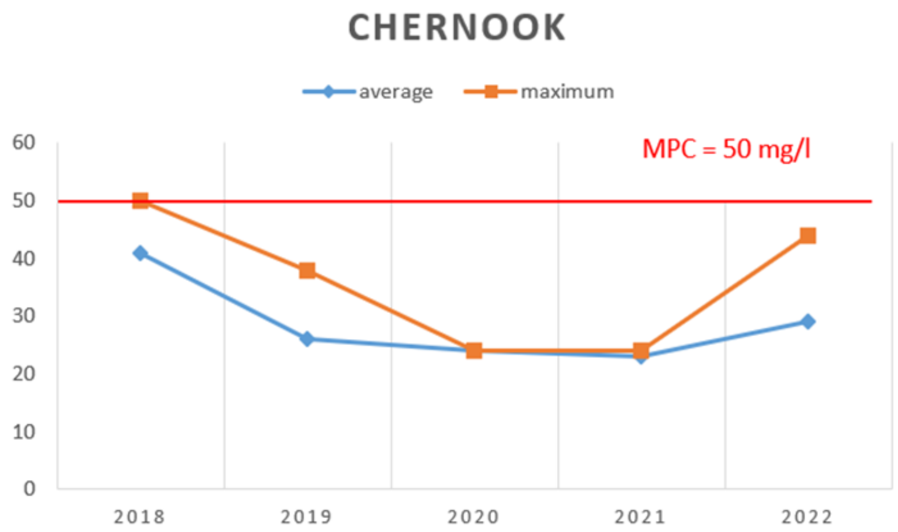

Fig. 3. Maximum and average values of nitrates in waters at critical zone Chernook

In 2018, maximum nitrates amount that is reported is 50 mg/dm^3, exactly as norm. After that, a significant decrease is registered, reaching values of 38 mg/dm^3 in 2019, and only 24 mg/dm^3 in 2020 and 2021. Downward trend, which is significantly below the norm, is compromised by increase in registered nitrates amount (44 mg/dm^3) in 2022. Although it is not possible to specify a trend even in average data, situation is better, since values from 41 mg/dm^3 in 2018 fall to 29 mg/dm^3 in 2022, with the lowest level recorded in 2021 - 23 mg/dm^3. Importantly, nitrate load for area remains 0.88 times below the norm.

It is interesting to follow future nitrates presence in waters of fourth critical zone, namely Ovchaga (Fig.4), as maximum recorded values for studied period vary around the norm, and in the first and last three years they cause an upward trend. Nitrates are 48 mg/dm^3, only in 2019, which is barely 2 mg/dm^3 less than established norm.

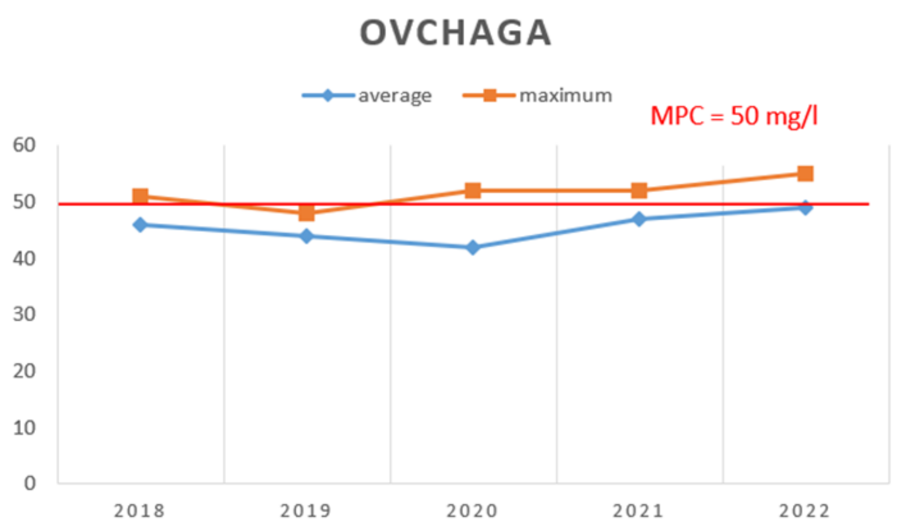

Fig. 4. Maximum and average values of nitrates in waters at critical zone Ovchaga

A better situation is ascertained from registered average values, because even in 2022 they are 49 mg/dm^3, which is below the norm. Lowest amount is reported in 2020 - 42 mg/dm^3.

In critical zone - Snezhina (Fig. 5), initially for studied period, a significant reduction in registered nitrate loads is noted. From maximum value of 77 mg/dm^3 measured in 2018, it almost reached the norm in 2020, but it is still 2 mg/dm^3 higher than it (52 mg/dm^3). Next two years it started to increase, reaching 62 mg/dm^3 for 2022.

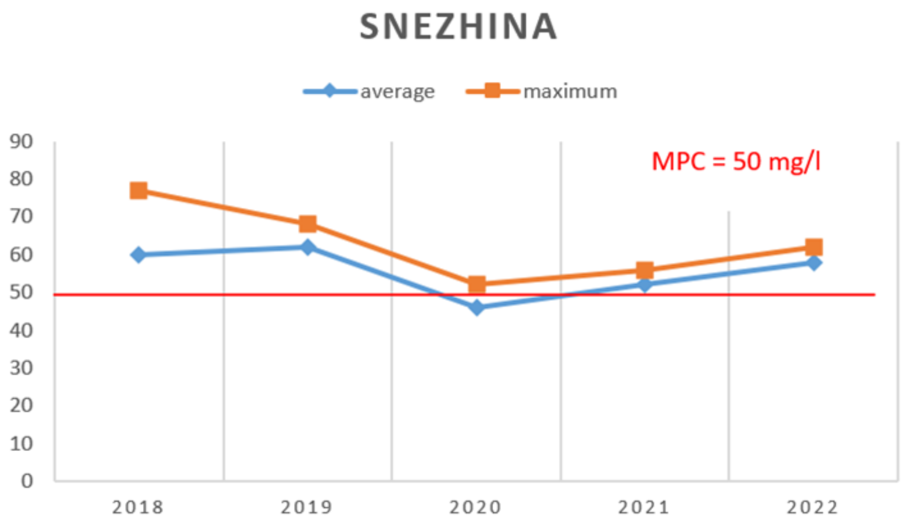

Fig. 5. Maximum and average values of nitrates in waters at critical zone Snezhina

Situation is similar with measured average values. Difference is that their data for 2020 is below the norm - 46 mg/dm^3. Trend is definitely an increasing and it is important to take more serious measures to reduce nitrate load of area waters.

A significantly deteriorated condition in terms of nitrate content is registered in a critical area - Avren (Fig. 6). Maximum measured values are almost twice the norm. Lowest maximum and average values are recorded in 2019, respectively: 77 mg/dm^3 and 71 mg/dm^3, which represent 1.54 and 1.42 times exceeding established norm.

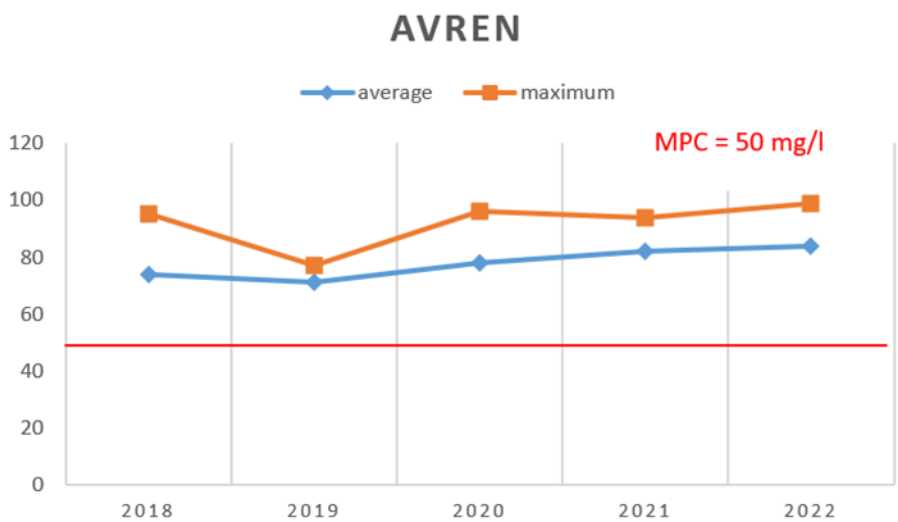

Fig. 6. Maximum and average values of nitrates in waters at critical zone Avren

Data for last three years have a slight difference, but determine an upward trend. In 2022, the maximum reported value is 99 mg/dm^3, and average - 84 mg/dm^3, which represents respectively 1.98 and 1.68 times exceeding permitted amount of drinking water nitrate content.

Situation in a critical area - Zdravets (Fig. 7) is even more serious, compared to Avren. Largest norm excess is more than three times. This maximum peak is reported in 2021 - 165 mg/dm^3. But in other years as well, maximum values are not lower than 2.52 times established norm, and they are even higher. Measured maximum values from 2018 to 2022 are respectively: 130 mg/dm^3, 145 mg/dm^3, 123 mg/dm^3, 165 mg/dm^3 and again 123 mg/dm^3.

With average values, there are only two years (2020 and 2022) in which readings are only 75 mg/dm^3 and 78 mg/dm^3, which is still allowed amount exceeding. In other years, indications are 101 mg/dm^3, 115 mg/dm^3 and 102 mg/dm^3 (2018, 2019 and 2021). Significant norm exceeding doesn't allow to specify a trend, although from 2021 to 2022 there is a registered decrease, both in maximum and in average reported value.

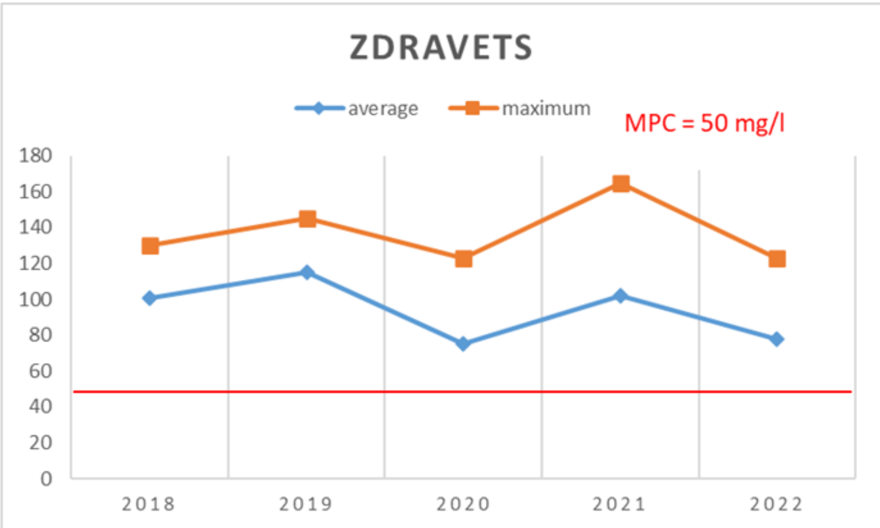

Fig. 7. Maximum and average values of nitrates in waters at critical zone Zdravets

Critical zone - Benkovski has worse drinking water quality in nitrates terms, compared to zones analyzed so far. From readings in table 2, which are graphically presented in Figure 8, it is observed that registered values are almost four times over the norm (2019 - 170 mg/dm^3); there is another decrease (126 mg/dm^3) in 2020, but then there is an increase that continues until 2022 (148 mg/dm^3), i.e. the last analyzed year of research period.

Poor waters state is also confirmed by average values, which are also above the norm: 2018 - 118 mg/dm^3 (2.36 times over norm), 2019 - 161 mg/dm^3 (3.22 times above norm), 2020 - 90 mg/dm^3 (1.8 times exceeding), 2021 - 106 mg/dm^3 (2.12 times over norm) and 2022 - 91 mg/dm^3 (1.82 times exceeding). From which it follows that highest values are reported in 2019.

Tendency is to preserve the deteriorated state of drinking water in this area.

Next critical zone, which is again one of the most problematic in terms of nitrate content, is Sadovo (Fig. 9). Levels of 204 mg/dm^3 maximum measured value in 2021 are registered for it. This is four times the norm. In previous years, data are more than three times higher than allowed, accordingly: 189 mg/dm^3, 162 mg/dm^3 and 164 mg/dm^3. They are lower than the last reported maximum value for period - 173 mg/dm^3.

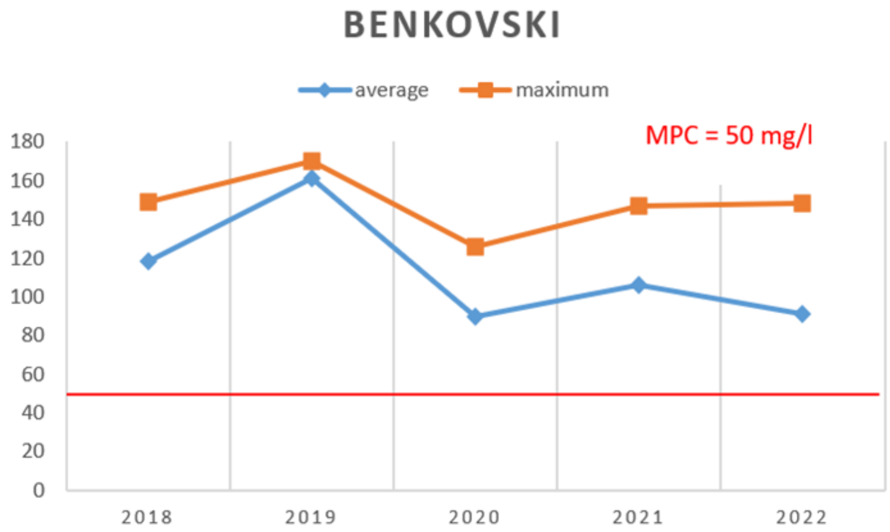

Fig. 8. Maximum and average values of nitrates in waters at critical zone Benkovski

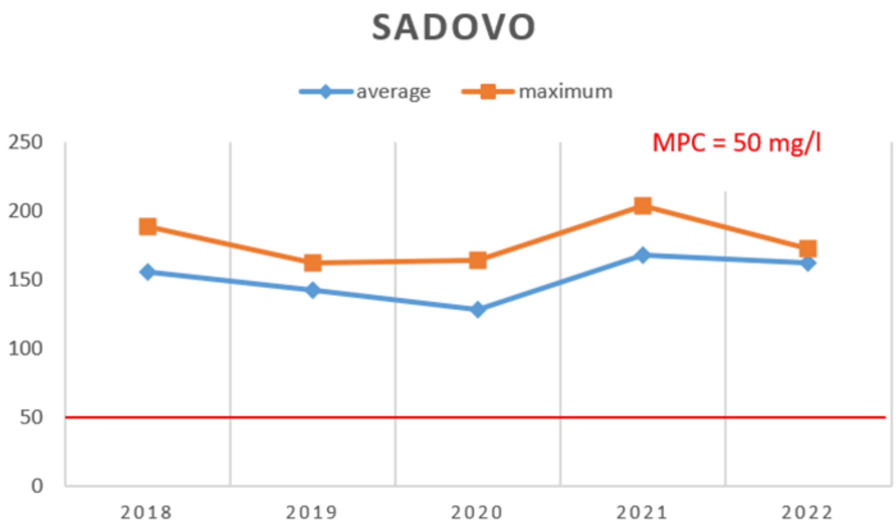

Fig. 9. Maximum and average values of nitrates in waters at critical zone Sadovo

Data for 2019 - 143 mg/dm^3 and 2020 - 128 mg/dm^3 indicated that average values are more than twice over the norm, and there is a threefold excess in 2018, 2021 and 2022.

It is not possible to determine a trend other than a future serious deterioration of drinking water state according to nitrate indicator.

Figure 10 presents data for a critical area - Zasmianovo. Drinking water state in it is almost analogous to that in Levski area, it is even better. A downward trend can be determined in nitrate loading terms, although maximum and average values are slightly above normal. Even average reported value for 2022 is 46 mg/dm^3, which is 4 mg/dm^3 lower than permissible level.

At critical zones Zornitsa and Izvorsko (Figures 11 and 12) small differences are observed. Drinking waters condition is worse than that of Zasmianovo waters. Trend for both areas is towards deterioration, i.e. increasing nitrate pollution.

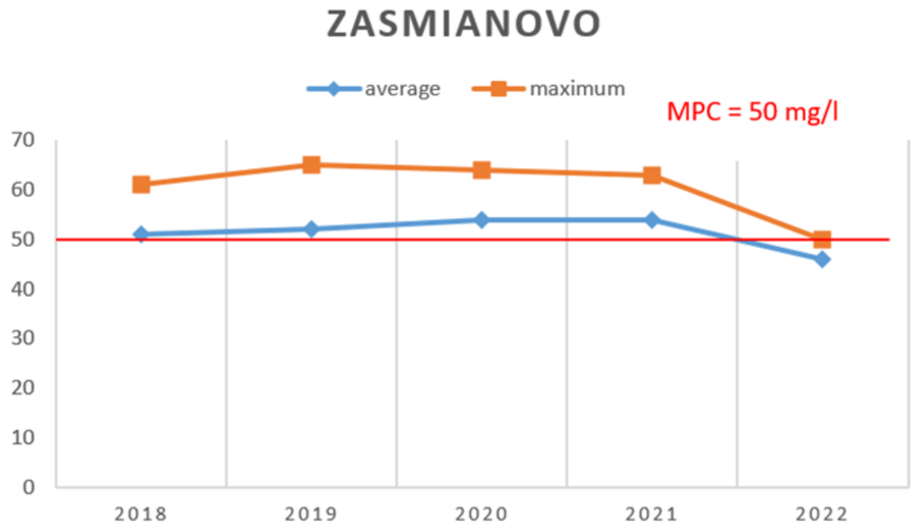

Fig. 10. Maximum and average values of nitrates in waters at critical zone Zasmianovo

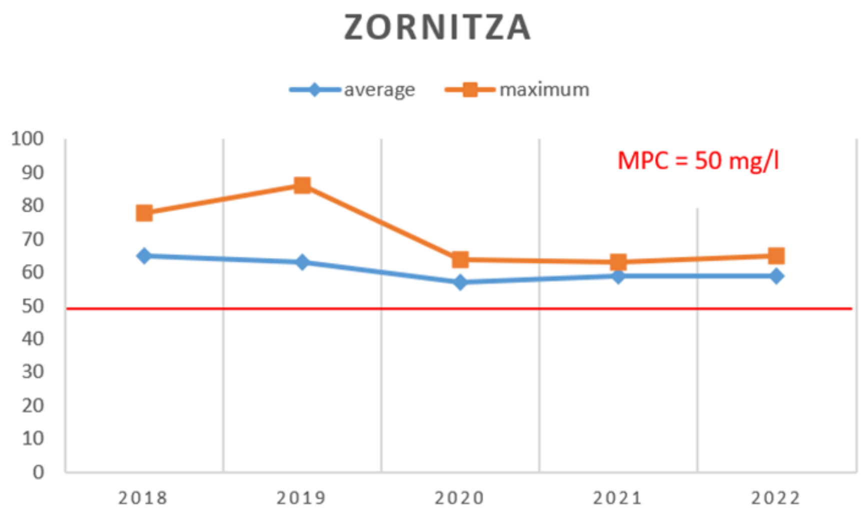

Fig. 11. Maximum and average values of nitrates in waters at critical zone Zornitza

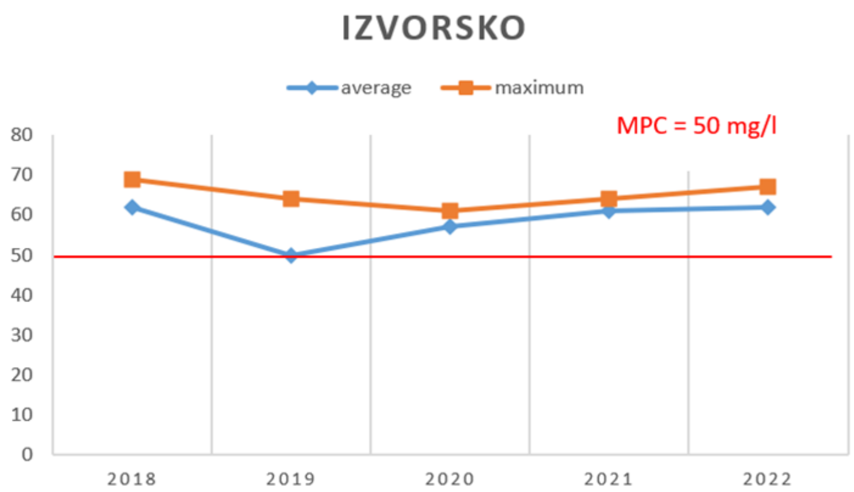

Fig. 12. Maximum and average values of nitrates in waters at critical zone Izvorsko

At critical zone - Kiselovo (Fig. 13), recorded maximum and average values are not much different from previous two analyzed zones, but at least trend in this zone is clearly visible in figure, that it is decreasing. Average reported value for last year (2022) of researched period is fell to 48 mg/dm^3, which is below the norm.

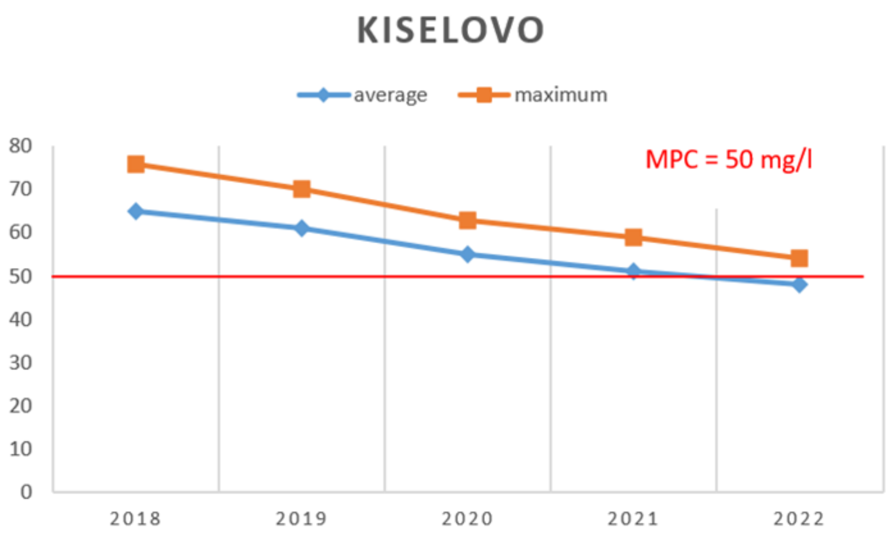

Fig. 13. Maximum and average values of nitrates in waters at critical zone Kiselovo

Of all collected data by years for seventeen critical zones of Varna district (table 2), drinking waters in Dobrogled zone (Fig. 14) are in the worst condition in nitrates terms, before Sadovo. Reported values there reached more than a five-fold excess of established norm.

Maximum values for period don't fall below 200 mg/dm^3: 2018 - 256 mg/dm^3 (5.12 times above norm), 2019 - 217 mg/dm^3 (4.34 times over norm), 2020 - 232 mg/dm^3 (4 .64 times exceeding), 2021 - 206 mg/dm^3 (4.12 times above norm) and 2022 - 225 mg/dm^3 (4.5 times exceeding).

The highest average value is reported in 2018 - 216 mg/dm^3, and lowest is 127 mg/dm^3 in 2021. Tendency is to preserve extremely high loading of drinking water in this critical zone with nitrates, which means that drastic measures and large-scale activities must be taken to improve drinking water condition in Dobrogled.

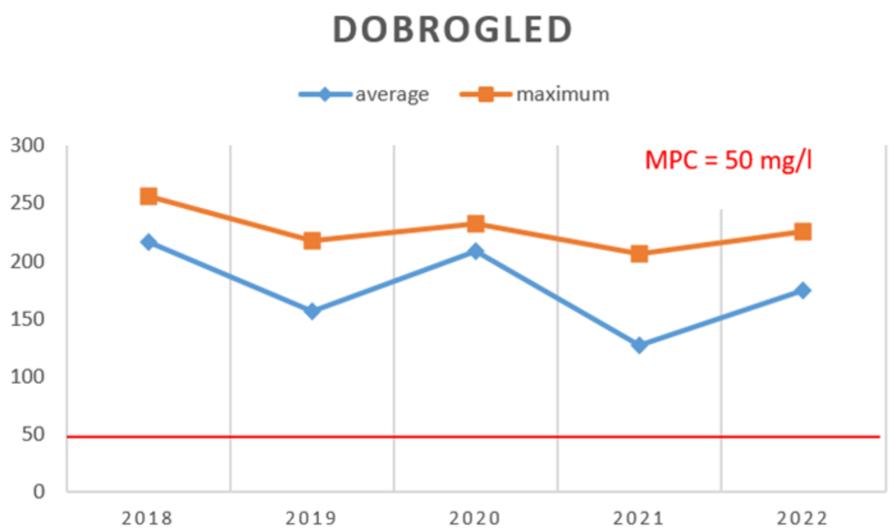

Fig. 14. Maximum and average values of nitrates in waters at critical zone Dobrogled

For a critical zone - Kichevo (Fig. 15) it can be said that it is one of less loaded areas of all seventeen zones.

The highest of maximum values is reported in 2018 - 57 mg/dm^3, which is 7 mg/dm^3 above the norm. Exceedances in 2019 and 2021 are even smaller, with 2 mg/dm^3 and 3 mg/dm^3, respectively. Lowest value is measured in 2020 - 39 mg/dm^3, which is same for maximum measured and average values. At the end of studied period, maximum reading showed 49 mg/dm^3, which is below norm. Average values vary similarly. No trend can be determined.

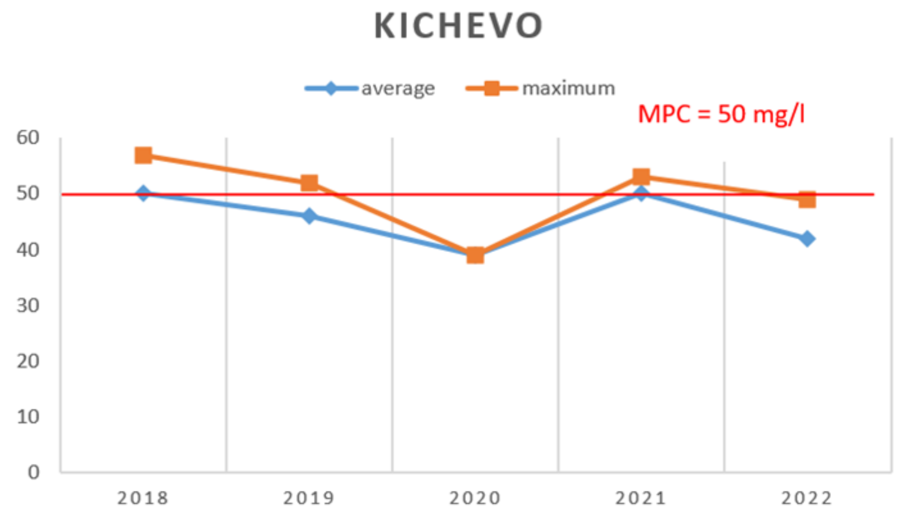

Fig. 15. Maximum and average values of nitrates in waters at critical zone Kichevo

Data for critical area - Klimentovo (Fig. 16) is interesting. In first year of period - 2018, indications for both maximum and average values are below the norm. From 2019 to 2021, however, values match almost entirely and they are above allowed. In the last year, they are back to normal. Future presence of nitrates should be monitored to determine a trend for those drinking waters belonging to specific area.

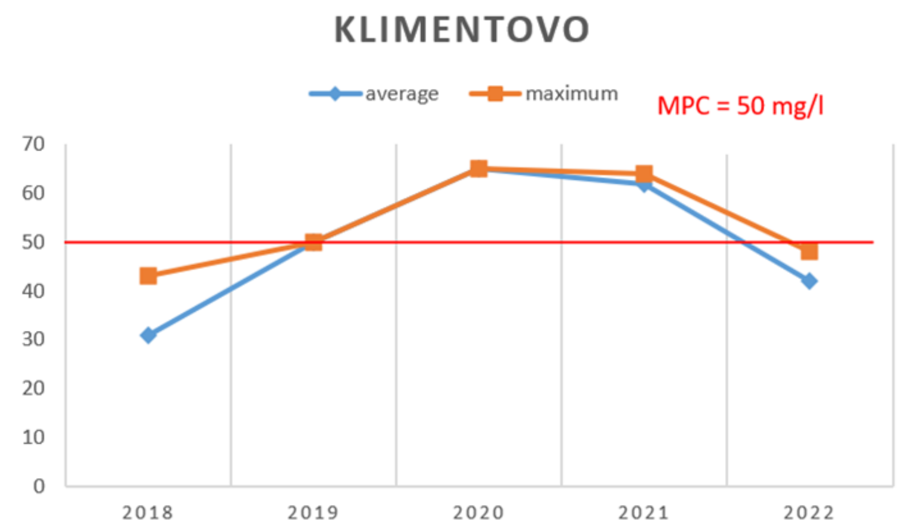

Fig. 16. Maximum and average values of nitrates in waters at critical zone Klimentovo

The last of seventeen analyzed critical zones for Varna district is Vaglen. Drinking water is not heavily loaded with nitrates, considering areas such as Dobrogled, Sadovo, Zdravets and Benkovski.

Reported values for area are close to norm, and from 2019 to 2022 they mark a permanent decrease in nitrates amount in drinking water, reaching values that are within the norm: maximum - 49 mg/dm^3 and average - 43 mg/dm^3.

This is only area for which a downward trend can be definitively determined.

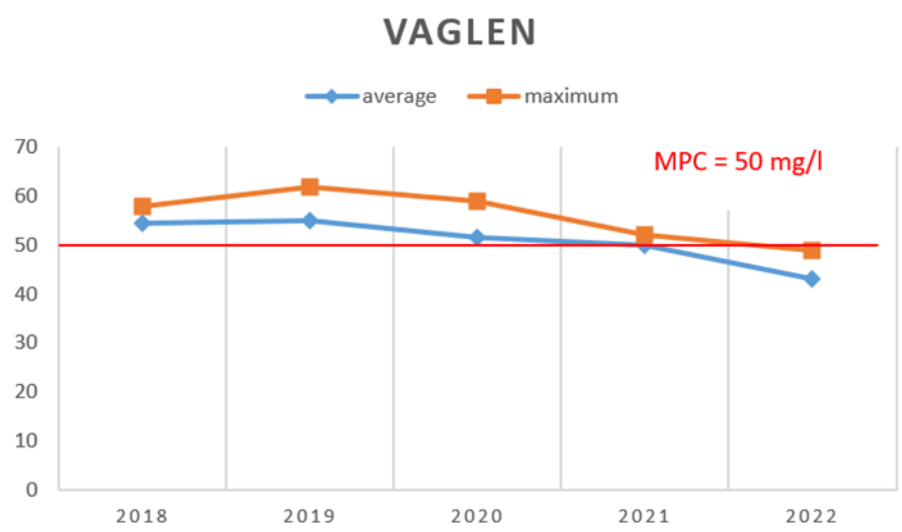

Fig. 17. Maximum and average values of nitrates in waters at critical zone Vaglen

Reasons for increased nitrates levels in considered areas can be diverse. In Varna district, especially in villages, there is no 100% constructed sewerage network. In addition, agriculture continues to develop. Climate is changing and amounts of precipitation (rain and snow) are decreasing [17]. All this helps to load water sources with nitrates. On other hand, there are arable agricultural fields in areas around catchments, drains, and boreholes from underground water sources. An important prerequisite for pollution is also lack of SPZ around a significant number of underground water sources.

4. MEASURES TO REDUCE NITRATE LEVELS IN DRINKING WATER

Measures and activities that RHI-Varna and WSS - Varna apply to supply water that meets requirements according to "nitrates" indicator are following [11, 17]:

In general, for all zones: regular nitrates monitoring is carried out - according to a schedule, Monitoring Program and control of compliance with regime of sanitary and protective zones (SPZ) is carried out - restoration of fences, marking, maintenance, etc.

Other specific measures that are applied by zones are:

- "Izgrev" water supply area - if possible, limiting water extraction from "Valchanova Cheshma" and mixing water from borehole R-162x with that from catchments;

- Zone "Ovchaga" - mixing of waters from Bulkanite catchment and shaft well (SW) is carried out;

- Zone "Sadovo" - construction of a tube well in village of Sadovo - 100 m and commissioning;

- Zone "Zasmiano" - use in full flow rate of spring "Karadaa" (by mixing in PS "Zasmiano" and as a result 10-20% above the norm of indicator "nitrates"); for months from May to October - with regular water supply for no more than 30 days, combined with notification to population; during the rest of time, use of catchment with a flow reduced by half (up to 0.2 l/s) - without increasing nitrates);

- Zone “Zornitsa” - control of compliance with regime of sanitary-protection zone SPZ-belt-I (restoration of fences, marking, maintenance, etc.); study of a constructed facility qualities - drainage in area of village with aim of including it in the zone: clarification of ownership and preparation of documents, restoration of an existing pumping station, restoration of a tube well. Construction of a water supply connection with a local reservoir in village of Zornitsa;

- Zone “Izvorsko” - Changing mixing ratio of water sources “Chair-2” and “Chair-3” and “Drainage-1” in PS “Izvorsko-2”;

- Zone “Dobrogled” - overhaul of a reservoir for village of Dobrogled; Pre-project study for provision of alternative water supply from “Kitka-Varna” derivation: construction of pumping stations, supplying water pipes, reservoirs and distribution network;

- Zone “General Kiselovo” - Control of compliance with SPZ-belt-I regime (repair of fences, marking, maintenance);

For “Ovchaga”, “Kichevo” and “Klimentovo” zones, no measures are planned to reduce nitrates, apart from more frequent monitoring, because measured values are around the norm.

Measures regarding water sources [4, 17]: all water sources have designated, marked and fenced SPZ and restrictions and rules for them are strictly observed; a Plan for actions in event of disasters and accidents, rules for informing citizens and communicating with interested parties is approved; measures are taken for additional chlorination and/or limitation of supplied water from compromised water source to water supply network, if possible, until water quality is restored; prohibition of carrying out agricultural and/or other industrial activities in SPZ-Belt I; in areas with water sources that don’t meet requirements, measures are taken to replace water source or mix water from other water sources until acceptable values of indicators are reached.

In event of emergency incidents within boundaries of SPZ, with potential to cause water pollution, persons whose activity resulted in accident perform: fencing off accident site and ensuring its security; appropriate treatment of spilled and dispersed substances with sorption materials; collecting, neutralizing or destroying spilled or dispersed substances; elimination of accident consequences.

5. CONCLUSIONS

Following conclusions can be made from research and analysis of collected information:

1. Frequency of drinking water monitoring in Varna district is carried out according to regulations;
2. The necessary indicators, according to Regulation №9 are monitored;
3. Critical areas are specified, according to reported deviations from norms for various indicators;
4. In settlements where permanent deviations are registered, RHI-Varna informs population and takes measures to limit consumption of drinking water, especially by vulnerable groups;
5. “WSS-Varna” has a developed Risk Assessment and a Water Quality Management Plan, which allows risk for drinking water to be assessed and promptly controlled with help of planned corrective measures [17];
6. 17 critical zones are specified in terms of nitrates in drinking water;
7. A greater initiative of municipalities is needed to apply for programs and to seek necessary financing of alternative water supply in settlements with permanent excesses of the maximum value according to “nitrates” indicator.

All these findings determine another extremely important problem, namely lack of water, especially for drinking purposes. This problem was felt extremely strongly in the summer of 2023 year, through water consumption regime introduced in Avren village, precisely during greatest heat and in strongest agricultural period of the year.

LIST OF ABBREVIATIONS

RHI-Varna - Regional Health Inspection -Varna

WSS - Varna - “Water Supply and Sewerage - Varna” OOD

EU - European Union

SPZ - sanitary-protection zone

PS - pumping station

REFERENCES

1. Abascal, E, Gómez-Coma, L, Ortiz, I, Ortiz, A 2022, 'Global diagnosis of nitrate pollution in groundwater and review of removal technologies', *Sci Total Environ*, 2022 Mar 1, vol. 810:152233, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/34896495/>.
2. Beeckman, F, Motte, H, Beeckman, T 2018, 'Nitrificaion in agricultural soils: impact, actors and mitigation', *Curr. Opin. Biotechnol.*, vol. 50, pp. 166-173, viewed 14 January 2024, <https://www.sciencedirect.com/science/article/abs/pii/S0958166917302239>.
3. Bishayee, B, Chatterjee, RP, Ruj, B, Chakrabortty, S, Nayak, J 2022, 'Strategic management of nitrate pollution from contaminated water using viable adsorbents: An economic assessment-based review with possible policy suggestions', *J Environ Manage.*, 2022 Feb 1, vol. 303:114081, viewed 14 January 2024, <https://www.sciencedirect.com/science/article/abs/pii/S0301479721021435?via%3Dihub>.
4. Carlstrom, M, Moretti, CH, Weitzberg, E, Lundberg, JO 2020, 'Microbiota, diet and the generation of reactive nitrogen compounds', *Free Radic. Biol. Med.*, vol. 161, pp. 321-325, viewed 14 January 2024, <https://www.sciencedirect.com/science/article/pii/S0891584920312995>.
5. Coskun, D, Britto, DT, Shi, W, Kronzucker, HJ 2017, 'Nitrogen transformations in modern agriculture and the role of biological nitrification inhibition', *Nat Plants.*, 2017 Jun 6, vol. 3:17074, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/28585561/>.
6. *Environmental Protection Program of Varna Municipality (Update) 2019-2023*, <https://www.varna.bg/upload/8773/Varna_GCAP_Report.pdf>.
7. *EU Drinking Water Directive*, effective from January 2021, <https://eur-lex.europa.eu/eli/dir/2020/2184/oj >.
8. Gatseva, PD, Argirova MD 2008, 'High-nitrate levels in drinking water may be a risk factor for thyroid dysfunction in children and pregnant women living in rural Bulgarian areas', *Int J Hyg Environ Health.*, 2008 Oct, 211(5-6):555-9, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/18164247/>.
9. Husaini, DC, Enriquez, A, Arzu, T, Miranda, K, Mossiah, D, Cardinez, C 2020, 'Nitrate Levels in Rural Drinking Water in Belize', *J Health Pollut.*, 2020 Aug 19, vol. 10(27):200904, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/32874760/>.
10. Ministry of Health, Sofia, viewed 14 January 2024, <http://www.mh.government.bg/bg/informaciya-za-grazhdani/zdravosloven-nachin-na-zhivot/hranene-i-metabolizm/nitrati/>
11. Mizuta, K, Matsumoto, T, Hatate, Y, Nishihara, K, Nakanishi, T 2004, 'Removal of nitrate-nitrogen from drinking water using bamboo powder charcoal', *Bioresource Technology*, vol. 95, Issue 3, pp. 255-257, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/15288267/>.
12. *National report on state and protection of environment in the Republic of Bulgaria,* issued in 2022, <https://eea.government.bg/bg/soer/2020>.

13. Ni, G, Leung, PM, Daebeler, A, Guo, J, Hu, S, Cook, P, Nicol, GW, Daims, H, Greening, C 2023, 'Nitrification in acidic and alkaline environments', *Essays Biochem.*, 2023 Aug 11, vol. 67(4), pp. 753-768, viewed 14 January 2024, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10427799/>.

14. Okafor, P, Ogbonna, U 2003, 'Nitrate and nitrite contamination of water sources and fruit juices marketed in South-Eastern Nigeria', *Journal of Food Composition and Analysis*, vol. 16, Issue 2, pp. 213-218, viewed 14 January 2024, <https://www.researchgate.net/publication/222073222_>.

15. Picetti, R, Deeney, M, Pastorino, S, Miller, M, Shah, A, Leon, D, c d, Dangour, A, Green, R 2022, 'Nitrate and nitrite contamination in drinking water and cancer risk: A systematic review with meta-analysis', *Environmental Research*, vol. 210, 112988, viewed 14 January 2024, <https://www.sciencedirect.com/science/article/pii/S0013935122003152>.

16. Regulation № 9 of March 16, 2001 on water quality intended for drinking and domestic purposes, amended and add. SG № 43 of May 16, 2023.

17. RHI-Varna 2023, *Report on drinking water quality supplied by Water Supply and Sewerage-Varna OOD in Varna District in 2022*.

18. Taneja, P, Labhasetwar, P, Nagarnaik, P 2019, 'Nitrate in drinking water and vegetables: intake and risk assessment in rural and urban areas of Nagpur and Bhandara districts of India', *Environ Sci Pollut Res Int.*, 2019 Jan, vol. 26(3), pp. 2026-2037, viewed 14 January 2024, <https://pubmed.ncbi.nlm.nih.gov/28589276/>.

19. Zendehbad, M, Mostaghelchi, M, Mojganfar, M, Cepuder, P, Loiskandl, W 2022, 'Nitrate in groundwater and agricultural products: intake and risk assessment in northeastern Iran', *Environ Sci Pollut Res Int.*, 2022 Nov, vol. 29(52), pp. 78603-78619, viewed 14 January 2024, <https://link.springer.com/article/10.1007/s11356-022-20831-9>.