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ECOLOGO-HYGIENIC AUDIT OF DRINKING WATER QUALITY FROM WELLS AND DAMMING OF RIVNE REGION

EKOLOGICZNA I HIGIENICZNA OCENA JAKOŚCI WODY PITNEJ W STUDNIACH I ŹRÓDŁACH W REGIONIE RÓWNE

ЭКОЛОГО-ГИГИЕНИЧЕСКАЯ ОЦЕНКА КАЧЕСТВА ПИТЬЕВОЙ ВОДЫ ИЗ КРИНИЦ И ИСТОЧНИКОВ РОВЕНЩИНЫ

Abstract

The article presents the results of ecological sanitary audit of drinking water quality from sources of decentralized water supply in Rivne region in Ukraine during 2004-2015, analyzes the dynamics of discrepancies of drinking water samples from sources of decentralized water supply according to sanitary-chemical and microbiological indicators in the context of Rivne region's districts.

Keywords: *drinking water, decentralized water supply, sanitary-chemical, microbiological indicators, water quality*

Streszczenie

W artykule przedstawiono wyniki oceny ekologicznej i higienicznej jakości wody pitnej ze źródeł zdecentralizowanego zaopatrzenia w wodę w Równem na Ukrainie w latach 2004-

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2015, przeanalizowano dynamikę rozbieżności próbek wody pitnej ze źródeł zdecentralizowanego zaopatrzenia w wodę za pomocą wskaźników sanitarno-chemicznych i mikrobiologicznych w kontekście regionów Równego.

Słowa kluczowe: woda pitna, zdecentralizowane zaopatrzenie w wodę, wskaźniki jakości wody

Аннотация

В статье представлены результаты эколого-гигиенической оценки качества питьевой воды из источников децентрализованного водоснабжения Ровенской течение 2004-2015 годов, проанализирована динамика несоответствия проб питьевой воды из источников децентрализованного водоснабжения по санитарно-химическим и микробиологическим показателям в разрезе районов Ровенской области.

Ключевые слова: питьевая вода, децентрализованное водоснабжение, санитарно-химические, микробиологические показатели, качество воды

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Statement of the problem in general outlook and its connection with important scientific and practical tasks.

The most important task of modern times is the rational use and protection of natural resources, including the provision of population with pathogen-free drinking water. Water is the most important element of the habitat of a person, without which the very existence of highly organized forms of life is impossible. Since water provides the passage of all processes in a living cell. Today, fresh water is the greatest wealth on the planet. Predictions of scientists are pessimistic: pure drinking water is already scarce for many countries, including Ukraine, and it will soon become so throughout the world [1].

According to WHO, about 80% of people's illnesses are associated with poor drinking water. Therefore, the problem of providing people with quality drinking water is relevant and extremely vivid. The world community at the beginning of the 21st century recognized the right to water and sanitation as a fundamental human right. According to

WHO, about 800 million people in the world do not have access to water of adequate quality and more than 3000 children die every day from diarrheal diseases, and around 2.5 million people die every year in the world, half of them children under 5 years old [1].

The deterioration of socioeconomic conditions, the environmental situation and, in fact, the lack of proper systemic social and sanitary monitoring of the live environment factors are real threats to the life and health of the population at the individual and population levels.

In Ukraine, the problem of water belongs to the most vivid, since the stock of local water resources (at the rate of 1 thousand m³ per inhabitant), our state belongs to the poorly watered countries of the world, it is in 15 times lower than the norm defined by The United Nations Economic Commission for Europe. Nevertheless, the use of natural water in Ukraine, as compared to advanced

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countries, is very inefficient due to the neglected technical state of the water industry and the obsolete technologies of water use and water purification, lack of a water monitoring system, effective state control over water resources protection, and imperfect water legislation.

According to experts, the current intensity of water consumption in Ukraine has

reached levels that are significantly higher than the ecological capacity of the water resources potential of Ukraine.

Therefore, in the context of developing a system of public health protection in Ukraine, the issue of providing the population with safe drinking water is extremely important for our state [2].

Analysis of latest research where the solution of the problem was initiated.

Among the specialists who studied the subject on this topic are the following scientists: A.K. Ahadzhanov, AV Vasilyuk, VA Kopilevich, N.O. Volgin, VV Medvedovsky and others. In addition, the technological aspect of purifying drinking water is highlighted in the works of O.O. Khyzhniaka, N.V. Makarova, V.V. Honcharuk, A.V. Mamchenko, N.V. Tulakina, V.F. Demchenko and others. The scientific work on environmental aspects of the assessment of drinking water have been devoted to such researches as A.V. Tulakin,

M.H. Prodanchuk, V.O. Prokopov and others, the status of water supply and drainage systems was studied by such scientists: G.M. Semchuk, M.A. Somov, A.K. Zapol'sky, V.S. Kravchenko, A.M. Tugay and others. In Poland this perspective was studied by Halicki W., Waręzak T., Jędrzejowska S., Karowicz-Bilińska A., Wiśniewska K., Kurowska E., Okręglicka K. and others. In the US, J. Braun, A. Truitt, T. Harkins made a significant contribution to the study of water use problems and relationships in the field of water management in this area.

Aims of paper.

The aim of the work is to assess the ecological and sanitary status of the drinking water quality from sources of decentralized water

supply in the Rivne region (mainly from the wells) during 2004-2015.

Materials and methods.

The data of laboratory research on sanitary-chemical, microbiological, parasitological and radiological indices of f.18 "Report on environmental factors affecting the health of the population" in the context of the region's districts for 2004-2015 [3] were used

in this work. Systematization, processing and analysis of research materials were carried out using descriptive, dynamic and comparative methods.

Exposition of main material of research with complete substantiation of obtained scientific results. Discussion.

Rivne region is one of the parts of Ukraine, where the water supply of the population with potable water is carried out exclusively from underground water levels. In

this region the number of sources of decentralized water supply decreased by 197 units, including wells from 1347 to 1147 (-

200), damming from 10 to 8 (-2) and artesian water wells from 2 to 7 (+5) from 2004 to 2015. The decrease was mainly due to the decommissioning of wells for public use. The average region indicator of non-conformity of drinking water from sources of decentralized water supply by sanitary and chemical indicators, over the period under investigation, increased more than in 2.5

times from 14.5% in 2004 to 40.0% in 2015. It should be noted that a fast growth in the percentage of non-conformity of samples over the past 2 years from 21.2% in 2013 to 40.0% in 2015 (Fig. 1). Above the average region's this indicator was in Volodymyrets, Hoshcha, Zdolbuniv, Korets, Kostopil and Radyvyliv districts (Table 1).

Table 1. Percentage of non-conformity of drinking water samples from sources of decentralized water

№	Name of districts (cities)	% of non-conformity											
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Berezne	20.8	24.28	17.8	8.6	8.5	25	26.4	54.8	37.7	70	26.1	1.9
2	Volodymyrets	20.6	24	35.6	19	16.8	31	31.0	68.1	65.2	51.7	40.9	43.8
3	Hoshcha	10.3	5.4	3.03	1.9	5.8	7.1	30.4	33.3	46.9	38.9	53.8	62.7
4	Dubno	11.2	31.2	38.2	13.6	30.8	28	3.4	35.1	33.5	35.8	34.8	27.1
5	Dubrovytsia	15.7	25	61.02	31.7	16.1	72.9	48.9	28.7	26.1	13.6	20.3	22.6
6	Zarichne	15.6	23.3	12.5	9.2	7.3	16.7	4.6	2.3	3.3	3.2	14.4	4.4
7	Zdolbuniv	12.9	11.4	16.5	35.4	9.8	15.1	24.0	21.1	34.1	18.2	0	77.8
8	Korets	9.9	8.87	9.5	11.7	10.5	3.1	17.6	14.8	7.9	2.1	49.8	68.1
9	Kostopil	22.0	16	42.42	61.5	38.2	45.5	42.4	45.4	42.4	9.3	15.8	41.3
10	Mlyniv	18.5	20	14.4	14.9	14.7	15	16.0	0	10.4	5.9	7.3	25.5
11	Ostroh	7.3	3.57	13.6	6.6	7.5	9.4	21.2	24	13.5	33.3	22.1	29.5
12	Radyvyliv	6.5	12.3	11.7	13.6	16	12.2	31.1	28.8	17.5	33.3	27.3	58.1
13	Rivne	43.7	65	26.9	45	20	26.1	38.5	42.5	31.2	100	-	-
14	Rokytne	3.9	8.33	4.8	7.4	6.5	7.7	7.1	16.7	10.2	1.5	24.7	23.3
15	Samy	23.8	56.25	28.6	61	40.8	19.2	16.8	23.9	21.8	24.2	24.8	30.3
	Total	14.5	19.8	19.98	20.5	14.3	20.3	25	28.9	26	21.2	31.4	40.0

The excess was mainly due to the content of iron, turbidity and nitrates. Analyzing the dynamics of non-conformity of drinking water samples from sources of decentralized water supply by sanitary-chemical indicators in the area of the districts, it is established that:

- In Berezne district the percentage of non-conformity dropped sharply to 26.1% and 1.9% in accordance, during 2014 and 2015. In general, in the course of 12 years, a decrease is observed in the percentage of non-conformity of drinking water samples from sources of decentralized water supply by sanitary-chemical indicators from 20.8% in 2004 to 1.9% in 2015.

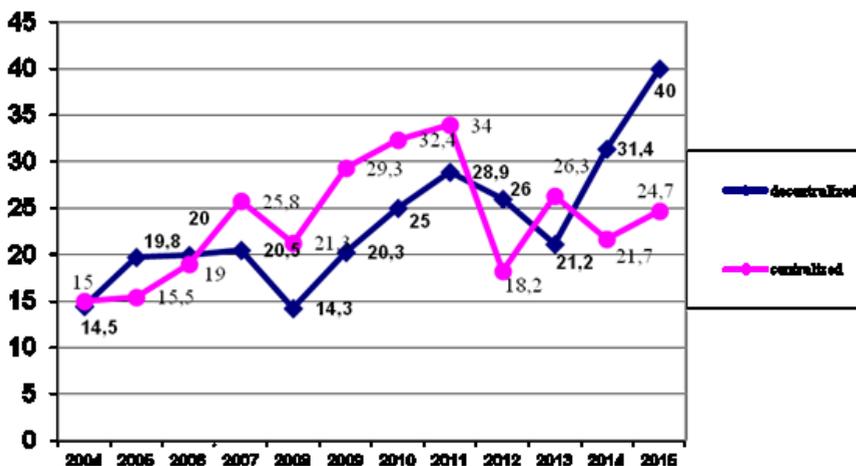
- In Volodymyrets district for the entire period of study, the percentage of non-conformity was higher than the average region indicator (with the exception of 2007). From 2004 to 2015, the indicator increased in 2.1 times from 20.6% in 2004 to 43.8% in 2015.
- In Goshcha district from 2004 to 2015, the percentage of non-conformity increased in 6 times from 10.3% to 62.7%, in accordance. Starting from 2010 there is a deterioration of drinking water samples from sources of decentralized water supply by sanitary-chemical indicators.
- In Dubno district, over 12 years, the percentage of non-conformity has grown in 2.5 times, from 11.2% in 2004 to 27.1% in 2015. It should be noted that in 2015, the percentage of mismatch of samples was significantly lower than the average.
- In Dubrovtytsia district, in general, for 12 years the percentage of non-conformity increased in 1.5 times from 15.7% in 2004 to 22.6% in 2015. However, in recent years there has been a positive trend towards a decrease in this indicator in comparison to the average region value.
- In Zarichne district from 2004 to 2015, the percentage of non-conformity of samples is reduced from 15.7% in 2004 to 4.4% in 2015, ie more than in 3 times. Since 2006, the percentage of non-conformity did not exceed the average regional indicator.
- In Zdolbuniv district over the past year, the percentage of non-conformity has sharply increased and amounted to 77.8%, which is almost in 2 times higher than the average regional indicator. At the same time, in 2014 the non-conformity of water samples with established norms was not documented.
- In the Korets district, for the entire period of study, the percentage of sample non-conformity increased in 7 times from 9.9% in 2004 to 68.1% in 2015. In the past two years, the indicator has increased dramatically, reaching 49.8% in 2014 and 68.1% in 2015, with an average value of 31.4% and 40% in accordance.
- In Kostopil district, over 12 years, the percentage of non-conformity increased almost in 2 times from 22.0% in 2004 to 41.3% in 2015. It should be noted that the percentage of samples non-conformity in the Kostopil district was almost every year higher than the average region (except for 2005, 2013-2014).
- In Mlyniv district from 2004 to 2015, the percentage of non-conformity increased in 1.3 times from 18.5% to 25.5%. Since 2009, this indicator has not exceeded the average value.
- In Ostroh district over the past 12 years, the percentage of non-conformity only once was higher than the regional average (33.3% in 2013, with an average regional 21.2%). However, it should be noted that in the dynamics the indicator has increased almost in 4 times from 7.3% in 2004 to 29.5% in 2015.
- In Radyvyliv district for 12 years, the percentage of non-conformity has grown in almost 9 times from 6.5% in 2004 to 58.1% in 2015. It should be noted that from year to year there is a significant fluctuation of this indicator.
- In Rivne district, the percentage of non-conformity each year exceeded the average region indicator. It should be noted that for 2014-2015, no researches were conducted on drinking water samples from sources of decentralized water supply by sanitary-chemical indicators.
- In Rokytno district, since 2004, the percentage of non-conformity has risen from 3.9% to 23.3% in 2015, almost in 6 times. Along with this, Rokytno district is the only one in the area where the percentage of non-conformity in the past 12 years has never exceeded the average region indicator.

• In Sarny district, the percentage of non-conformity increased in 1.3 times from 23.8% in 2004 to 30.3% in 2015 for the entire period.

When comparing the quality of drinking water from artesian boreholes of the centralized water supply systems and wells, the

excess of the average region indicator of non-conformity from the sources of centralized water supply over the indicator of wells in the period of 2006-2011 and 2013 is noted (Fig. 1).

Fig. 1 Average region indicator of drinking water non-conformity (in %) from sources of decentralized and centralized water supply for sanitary-chemical indicators in the period from 2004 till 2015.



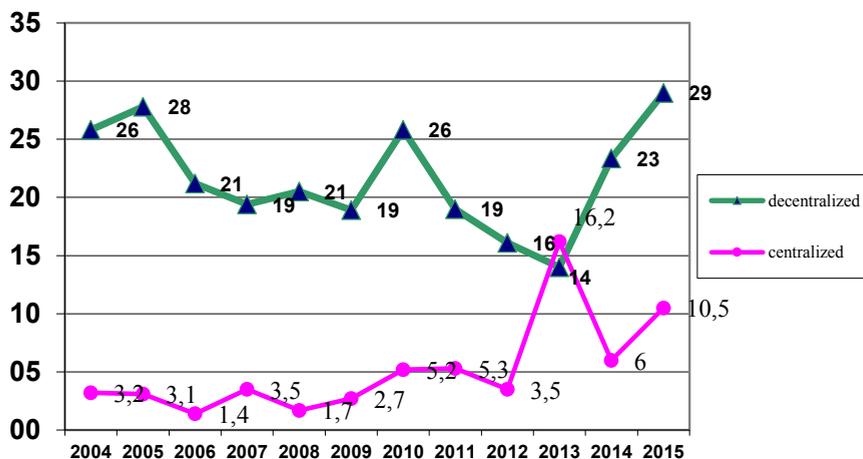
According to our research, it has been established that the non-conformity of drinking water quality with the regulatory requirements for sanitary-chemical indicators is mainly due to the excess of iron content (as a result of considerable turbidity) and nitrates. It should be noted that if the indicators of natural iron content are not critical from the point of view of toxicological effects, then excess of nitrate content is harmful, especially for children of the first years of life. Nitrates do not belong to methemoglobin producers, but reaching the stomach with water under the influence of the gut microflora are restored to nitrites with the subsequent formation of methemoglobin, which in turn blocks the ability to transfer

oxygen to the body. Methemoglobin is more stable than oxyhemoglobin for the degree of dissociation in 300, and according to some data, 500 times. If the amount of methemoglobin exceeds 50% of the total hemoglobin, the body may die from CNS hypoxia. Normally, in middle-aged children, the concentration of methemoglobin in the blood should not exceed 1-2%. The excess of nitrate content of more than 45 mg per 1 liter can cause water-nitrate methemoglobinemia, especially among children whose clinical implications is acrocyanosis (nasal, upper lip, so-called triangle, ear swab, fingertips cyanosis, tachycardia, dyspnea, cyanosis of the mucous membranes, inflammation, convulsions) [4-7].

At the same time, as recent scientific studies have shown, prolonged intake of low concentrations can cause asymptomatic methemoglobinemia among children, which is dangerous for their health, as it causes hemic and histotoxic hypoxia [8]. It should also be noted that, in combination with the combined action of other environmental pollutants, nitrate-containing compounds can cause a negative immune effect on a living organism [9].

When systematizing and analyzing data from drinking water research from sources of decentralized water supply according to microbiological indicators, it has been established that the average region indicator of non-conformity over the abovementioned period increased on 3.2% and amounted in 2015 29.0% at 25.8% in 2004 [3]. It should be noted a fast growth of the percentage of non-conformity samples in the last 2 years from 14.0% in 2013 to 29.0% in 2015 (Fig. 2).

Fig.2. Average region indicator of drinking water non-conformity (in%) from sources of decentralized and centralized water supply according to microbiological indicators in the period from 2004 till 2015.



Above the average region percentage of non-conformity of drinking water from sources of decentralized water supply according to microbiological indicators was in Volodymyrets, Goshcha, Zdolbuniv, Kostopil, Ostroh, Sarny districts and in Rivne (Table 2).

Table 2. Non-conformity percentage of drinking water samples of from sources of decentralized water supply according to microbiological indicators in dynamics for 2004-2015.

№3/n	Name of districts (cities)	% of non-conformity											
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Berezne	7.1	14.95	16.8	12.9	11.6	14.3	3.4	1.4	6.9	7.4	15	0
2	Volodymyrets	39.2	42.5	48.9	36.9	40.0	42.9	56.9	41.3	32.2	53.3	51.4	53.8
3	Hoshcha	43,3	47,2	9,4	38,9	34,5	16,4	84,1	12,1	28,6	30	44,4	58,3
4	Dubno	36,5	31,3	12,9	2,04	23,5	38	31,2	21,4	34,1	25,6	36,6	20
5	Dubrovysia	14,2	52,08	27,8	27,8	13,4	15,7	12,7	7,2	3,9	14,3	3,4	4,5
6	Zarichne	16,1	27,2	12,5	24	1,2	3,9	14,3	3,6	9,4	3	7,5	13,3
7	Zdolbuniv	48,3	74,6	46,7	43,1	53,5	44,4	26,8	42,4	37	37,5	-	62,5
8	Korets	13,2	14,3	10,2	8,9	13,3	8,96	7,6	7,6	8,2	18,3	18,7	11,1
9	Kostopil	21,5	38,2	55,9	53,8	46,0	39,4	45,4	56,2	12,1	30,8	69	83,3
10	Mlyniv	40,9	9,4	5,9	4,9	5,1	6,4	3,6	26,5	31,7	20,8	44,4	18,2
11	Ostroh	13,5	6,66	17,5	13,9	26,4	8,3	20,0	13,2	14,5	24,4	46	33,9
12	Radyvyliv	15,1	20	14,7	17,8	10,4	12,6	13,4	11,8	10	16,7	14,3	6,7
13	Rivne	22,9	42,8	39,6	26,9	34,0	38,1	40,7	45,4	53,8	81,8	-	-
14	Rokytno	36,0	26,0	16,6	19,7	17,7	17,1	14,6	11,4	4,1	0,8	11,1	8,3
15	Samy	25,4	47,6	24,1	15,6	21,8	-	62,5	22,5	19,5	5,7	30,9	66,7
	Total	25,8	27,8	21,2	19,4	20,5	18,9	25,8	19,0	16,1	14	23,4	29,0

Below there is the situation in the context of districts for non-conformity of drinking water samples from sources of decentralized water supply according to microbiological indicators:

- In Berezne district, comparing the indicators in 2004 and 2014, the percentage of non-conformity sample increased in 2 times from 7.1% to 15%, in accordance. It should be noted that in this district, the only one in the region, during the period of studying, the specified indicator did not exceed the average region indicator. In 2015, non-conformity of drinking water samples were not recorded.
- In Volodymyrets district, the percentage of non-conformity for 12 years grew in 1.2 times from 39.2% in 2004 to 53.8% in 2015. The percentage of non-conformity

each year exceeded the average region indicator.

- In Goshcha district, the percentage of non-conformity increased by 15% from 43.3% in 2004 to 58.3% in 2015.
- In Dubno district, the percentage of non-conformity varies within 30 (+ - 10)%, except for 2006-2007. As of 2015, the percentage of non-conformity decreased by 1.7 times in comparison to 2004, from 36.5% in 2004 to 20% in 2015.
- In Dubrovysia district, in recent years, the percentage of non-conformity has dropped from 14.2% in 2004 to 4.5 in 2015.
- In Zarichne district, the percentage of non-conformity declined by 2.1% from 16.1% in 2004 to 13.3% in 2015.
- In Zdolbuniv district, the percentage of non-conformity increased in 1.2 times, from

48.3% in 2004 to 62.5% in 2015. Each year this indicator exceeded the average region value.

- In Korets district, during the study period, the percentage of non-conformity decreased by 2.1% from 13.2% in 2004 to 11.1% in 2015.

- In Kostopil district, over 12 years, the percentage of non-conformity has grown almost in 4 times from 21.5% in 2004 to 83.3% in 2015.

- In Mlyniv district, sharp fluctuations in the percentage of non-conformity of drinking water samples from sources of decentralized water supply according to microbiological indicators are recorded from year to year. During the period under research, this indicator has decreased more than in 2 times from 40.9% in 2004 to 18.2% in 2015.

- In the Ostroh district, during the whole study period, the percentage of non-conformity increased in 2 times from 13.5% in 2004 to 33.9% in 2015. In the past 3 years, the percentage of non-conformity significantly exceeded the average regional indicator.

- In Radyvyliv district, the percentage of non-conformity of samples for the entire study period did not exceed 20%. Since 2004, the percentage of non-conformity has decreased by 2.5 times, from 15.2% in 2004 to 6.7% in 2015.

- In Rivne district since 2004, the percentage of non-conformity in the indicators increased in 3.8 times, from 22.9% in 2004 to 81% in 2013. This indicator exceeds the average regional value each year. In 2014-2015, no research was conducted on samples of drinking water from sources of decentralized water supply according to microbiological indicators.

- In Rokytne district, the annual percentage reduction of non-conformity is observed. During the period under investigation, the percentage of non-conformity decreased

more than in 4 times from 36.0% in 2004 to 8.3% in 2015.

- In Sarny district, this indicator increased more than in 2 times from 25.4% in 2004 to 66.7% in 2015.

- In Rivne, the research of drinking water samples from sources of decentralized water supply based on microbiological indicators was carried out only in 2014. The percentage of non-conformity was 93.7%.

- In Kuznetsovsk (now - Varash), research on samples of drinking water from sources of decentralized water supply according to microbiological indicators was carried out only in 2013. The percentage of non-conformity was 4.1%.

When comparing the average region percentage of water quality non-conformity from artesian boreholes of centralized water pipes and wells, according to microbiological indicators, there is a significant excess of its from wells than from sources of centralized water supply during the investigated period (Fig. 2).

During the investigated period in Rivne region there was no recorded radiological and parasitic contamination of drinking water, as well as epidemics outbreaks of infectious diseases with an aqueous transfer factor.

According to the results of monitoring the quality of drinking water from sources of decentralized water supply for sanitary-chemical and microbiological indicators, it should be noted the main issues that may, in one way or another, affect the state and quality of the drinking water provision to the population, in particular:

- 1) the imperfection of the legal framework, which regulates the normative and legal bases of activity in the field of drinking water supply and the effectiveness of the control mechanism over their implementation is insufficient;
- 2) unsatisfactory sanitary and ecological state of surface watercourse, which is con-

nected with the discharging of insufficiently treated waste water, contamination of coastal strips with waste, conducting anthropogenic activities in designated water area, exploitation of insufficiently protected aquifers;

3) application of imperfect technologies at water treatment plants;

4) insufficient provision of information through citizens on the quality of drinking water, recommendations and methods for its cleansing or decontamination.

In connection with this, there is a need to continue monitoring the quality of drinking water. Currently the research center "Ecology of human and public health protection" of the National University of Ostroh Academy together with specialists of the State Institution "Institute of Public Health named after O. M. Marseev National Academy of Medical Sciences of Ukraine » works on studying the correlation between the quality of drinking water and the morbidity of urban and rural population of the Rivne region.

Conclusions.

- over the last decades, the number of sources of decentralized water supply in the region has decreased by - 12%;

- the average region indicator of the non-conformity of drinking water samples from sources of decentralized water supply for sanitary-chemical characteristics over 12 years has increased more than in 2.5 times from 14.5% in 2004 to 40.0% in 2015.

- the quality of drinking water due to sanitary-chemical indicators deteriorates in sources of decentralized water supply, mainly due to high iron content, turbidity and nitrates;

- Water pollution with nitrates, which can cause water-nitrate methemoglobinemia, is especially dangerous. Above average region this indicator was in Volodymyrets, Goshcha, Zdolbuniv, Korets, Kostopil and Radyvyliv districts;

- the average region indicator of non-conformity of drinking water samples from sources of decentralized water supply according to the microbiological indicators for the period under investigation slightly

increased and amounted to 29.0% in 2015 at 25.8% in 2004;

- higher than the average region percentage of water supply non-conformity from sources of decentralized water supply according to microbiological indicators was in Volodymyrets, Goshcha, Zdolbuniv, Kostopil, Ostroh, Sarny districts and in Rivne;

- prevention of the occurrence and spread of infectious diseases, protozoiosis in the population is possible only with complex measures, which will include, in addition to sanitary-hygienic monitoring of the quality of drinking water, the state of the wells and the alertness of the population and medical staff of the health care centers in relation to diagnosis, treatment and prevention;

- in the context of the development of the public health system in Ukraine, further work is needed to determine the correlation between quality of drinking water and the state of illness of the population of the region.

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