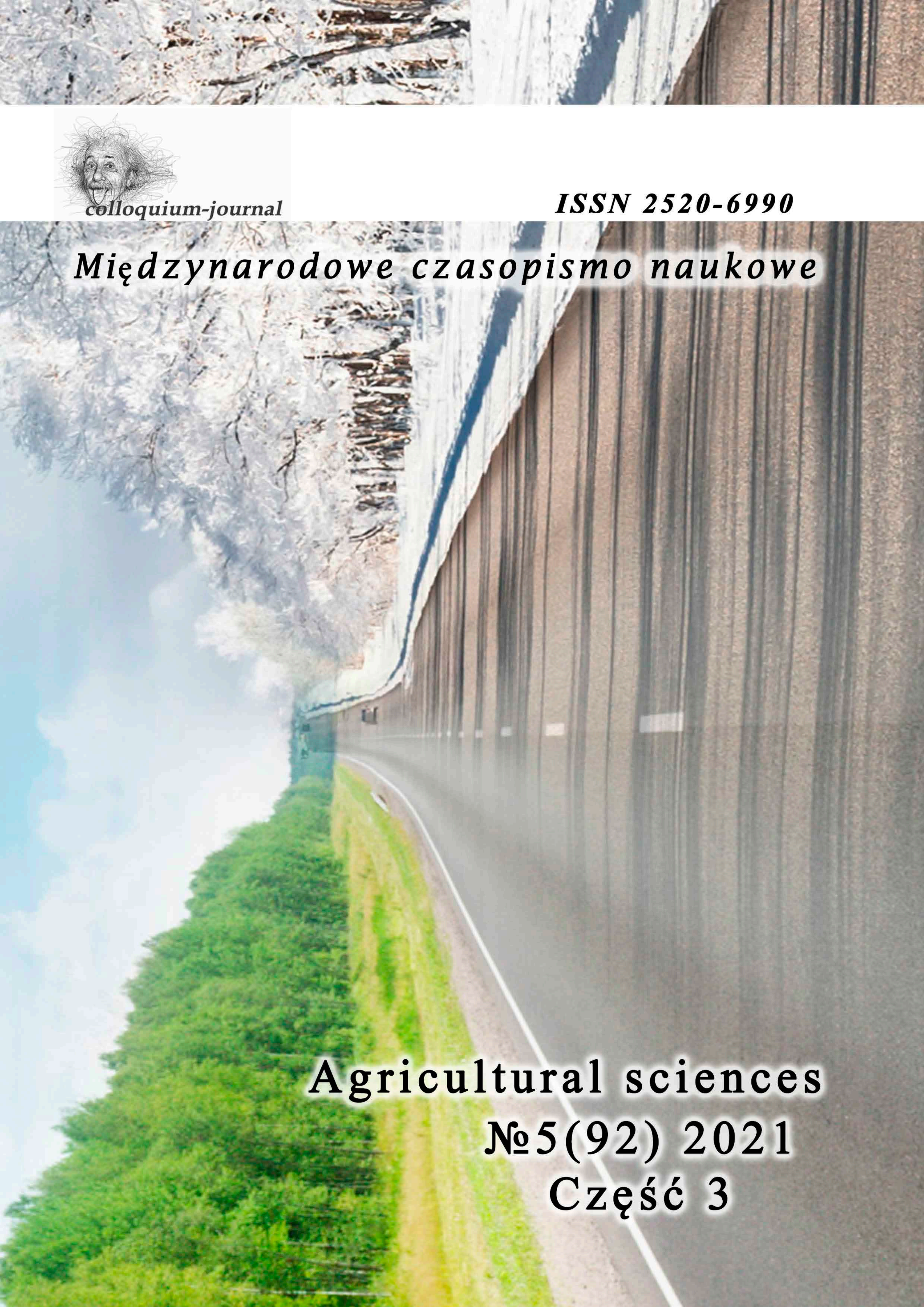

colloquium-journal

ISSN 2520-6990

Międzynarodowe czasopismo naukowe

Agricultural sciences

№5(92) 2021

Część 3

ISSN 2520-6990

ISSN 2520-2480

Colloquium-journal №5 (92), 2021

Część 3

(Warszawa, Polska)

«Colloquium-journal»
Wydrukowano w Annopol 4, 03-236 Warszawa Poland, «Interdruk»
E-mail: info@colloquium-journal.org
http://www.colloquium-journal.org/

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AGRICULTURAL SCIENCES

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ECOLOGICAL ASSESSMENT OF DRINKING WATER QUALITY BY METAL CONTENT IN VINNYTSIA

Abstract

The aim is to study the indicators of water quality from different sources of water supply in the city of Vinnytsia. In accordance with the set goal it is necessary to solve the following tasks: to select well water and tap water; determine the content of heavy metals in water samples; identify factors of water pollution and identify ways to eliminate them.

According to the results of research, it was found that the cadmium content in well water exceeds the permissible limits, 0.0024 mg / l at a rate of not more than 0.001. The rest of the studied indicators, namely: lead, zinc, copper, manganese and iron - are within acceptable limits. The content of lead (0.03 mg / l) in tap water exceeds the permissible norms (not more than 0.01 mg / l) and the content of cadmium (0.0037 mg / l) exceeds the maximum allowable concentration (not more than 0.001). Other indicators are within acceptable values. It was found that during transportation the water significantly deteriorates its quality. The content of lead increased 60 times, cadmium - 3.7 times, zinc - 17.2 times, copper - 3.1 times, manganese - 3.7 times, iron - 2 times. This increase is primarily due to the unsatisfactory condition of water transportation systems, as about 25% of the water supply network is in old condition. Household water treatment significantly improves the quality of drinking water: in pipeline water - the concentration of lead decreased by 3 times, cadmium - by 3.7 times, zinc - by 1.72 times, copper - by 3.1 times, manganese - by 2.64 times and, iron - 2.5 times. In well water, these indicators decreased by 2.5 times, 2.6, respectively; 2.3; 2.54; 2.64 and iron 2.66 times. After additional treatment, well and tap drinking water fully meets the quality requirements.

Keywords: *monitoring, water, concentration, heavy metals, quality, indicators, well, tap water.*

Water is one of the most important natural resources of mankind, without which it is impossible to imagine life. It is one of the important elements of the environment. The main problems of ecology, which are related to the hydrosphere of the planet, are the conditions of providing the population with water, its quality and opportunities to improve it. Until recently, these problems were not so acute, due to the relative purity of natural water sources and their sufficient number. But in recent decades, the situation has changed dramatically. Significant concentration of urban population, a sharp increase in industrial, transport, agricultural, energy and other anthropogenic emissions have led to deterioration of water quality, the emergence in water sources not inherent in the natural environment of chemical, radioactive and biological agents. All this makes efficient water supply the leading problem of our time.

The problem of drinking water supply in Ukraine, as in other countries, exists not in isolation, but in numerous relationships with economic, water and environmental problems. Its solution is facilitated by the Water and Land Codes of Ukraine, state standards and industry regulations governing the maintenance of drinking water sources and ensuring the proper quality of drinking water.

In this regard, the problem of providing the population with good quality drinking water is relevant.

Today, more and more attention is paid to issues related to water resources. Every year the planet becomes less and less resources suitable for human use for domestic purposes, more and more often humanity is faced with the problem of providing quality drinking water. Deterioration of water quality is due to increased water needs for domestic and industrial purposes [4].

Industrial production is very water-intensive and as a result of their activity a significant amount of pollutants enters water bodies. Therefore, the issue of the state and environmental problems of water resources in industrial regions is very relevant. All these issues have long been of concern to the scientific community, because the loss of water quality can lead to a sharp deterioration in public health, which poses a serious threat to humanity [9].

Water resources are a source of industrial and domestic water supply, and therefore play a crucial role in the development of the entire economy and in the lives of the population.

The Water Code of Ukraine defines water resources as the volume of surface, groundwater and seawater of the territory, and the water body as formed by nature or artificially created landscape object or geological structure where water is concentrated (river, lake, sea, reservoir, canal, aquifer) [2].

Water bodies of Ukraine constitute the water fund, which includes: surface waters: natural reservoirs (lakes), watercourses (rivers, streams), artificial reservoirs (reservoirs, ponds) and canals; other water bodies; groundwater and water sources; inland waters and the territorial sea.

The level of water supply in Ukraine is insufficient and is determined by the formation of river runoff, the presence of groundwater and seawater. Water resources are part of the natural reserves of water, which is directly involved or may participate in social production in specific historical conditions with a certain development of productive forces. This definition characterizes water resources not only as a natural phenomenon, but also as a socio-economic category that is closely related to the level of development of human society.

The value and importance of water for economic development, production processes and settlements, its role in the location of production is beyond doubt [1].

Now water performs a number of important functions: drinking and domestic water supply of the population and settlements; food production; production of electricity and industrial products; providing communicative functions (water transport); satisfaction of sanitary and hygienic needs.

Powerful economic complexes of metallurgical, machine-building, light, food and other industries have been formed in Ukraine. Agricultural production, construction, transport, and communications were widely developed. Agricultural production, construction, transport, and communications were widely developed. The largest volumes of water are used in the Steppe region - 37-42% of the total.

All types of water supply are divided into two categories. The first includes industries where water use is associated with the extraction of rivers, lakes, reservoirs (industry, utilities, agricultural irrigation). In this case, part of the incoming water is lost, becoming part of industrial and agricultural products, the other - evaporates. The second category includes industries that use only water resources to perform their production tasks [1].

The use of huge amounts of water by industry is one of the main causes of the problem of providing humanity with clean fresh water. This is primarily due to the exceptionally high growth rates of industrial water use in many countries over the past 20-40 years, due to the rapid development of the most water-intensive industries - heat (including nuclear power plants), petrochemical (especially man-made fibers), pulp and paper, 80 -90% of all water used by industry. Industrial water use is associated with the inflow of huge amounts of polluted wastewater into watercourses and reservoirs, which leads to high-quality depletion of water resources. Intensive use of water by thermal and nuclear power plants is accompanied by the discharge into water bodies of a significant amount of wastewater heated to 8-12 ° C, which violates their natural thermal regime and leads to thermal pollution [4].

The impact of industry on water resources is associated not only with increasing industrial water use and discharge of large amounts of wastewater, but also with changing conditions for the formation of river runoff as a result of mining, construction of industrial facilities and large groundwater intakes. Mining and abstraction of water from groundwater lead to lower groundwater levels and the formation of depression funnels in areas that sometimes reach thousands of square kilometers, which affects the circulation of natural waters in river basins [9].

Thus, the importance of water resources in human life and economic activity is very large and will increase with the further development of productive forces. However, the problem of water supply is caused not so much by an increase in the amount of water used, but by an increase in the amount of wastewater. According to modern estimates, humanity discharges more than 500 km3 of industrial and municipal wastewater into reservoirs and watercourses annually. Their neutralization requires (depending on the degree of purification) 5-12 times dilution with natural pure water. Therefore, humanity is threatened not by a lack of water in general, but by a lack of clean fresh water, not quantitative but qualitative depletion of water resources [3].

The hydrological network of the city of Vinnytsia is represented by the Southern Bug River and three small rivers - Tyazhylivka, Pyatnychanka, Vinnychka, the Bezymenny stream, ponds, lakes, streams.

The runoff of the Southern Bug within the city is regulated by the Sabariv Reservoir, a system of reservoirs and ponds. Each reservoir is characterized by its hydrological characteristics and anthropogenic load of varying intensity. Constant control over the state of water in the city is carried out by specialists of KP "Vinnytsiaoblvodokanal", the city sanitary-epidemiological station, the Southern Bug basin management of water resources. According to their water regime, the rivers of the Southern Bug basin belong to the Eastern European type of rivers with mainly snow supply. In the basin there are two hydrological areas - Podolsk and Black Sea [10].

Pollution of surface waters of the Southern Bug river basin is mainly due to point sources, which are utilities. At present, return water discharges are carried out by 49 production departments of housing and communal services, where wastewater treatment plants are pre-treated before the next discharge into the river network of the Southern Bug river basin.

The dominant share of organic matter pollution according to BOD5 is determined by MKP "Khmilnytskvodokanal" Khmelnytsky (35%), OKVP "Dnipro-Kirovograd" Kropyvnytskyi (27%), KP "Vinnytsiaoblvodokanal" Vinnytsia (15%), KP "Uman" Uman (4%). The total share of these cities among point sources reaches 81% of the total amount of discharged organic matter [10].

It is important to emphasize that the treatment facilities of most cities are in an extremely dilapidated condition. In recent years, urban development has led to an increase in the amount of wastewater, which is several times higher than the design capacity, resulting in a significant amount of insufficiently treated or untreated water enters the Southern Bug basin [6].

For a comprehensive analysis of the state of drinking water quality indicators, two sources of water sampling were identified, namely well and tap water. The selected samples of well and tap water were sent for research to the Vinnytsia branch of the State Soil Protection State Institution.

Comparing the obtained indicators with the MPC, it was found that the cadmium content exceeded - 0.0024 mg / l at a rate of not more than 0.001. The remaining indicators are within acceptable limits (table 1).

Table 1

The content of heavy metals in well water, mg / l

Element	Results of the research	State sanitary rules and regulations 2.2.4171-10
Lead	0,043	<0,1
Cadmium	0,0024	<0,001
Zinc	0,31	<5
Copper	0,056	<1
Manganese	0,037	<0,5
Iron	0,32	<1

Thus, the content of lead is 2.32 times less than the MPC, zinc - 16.12 times, copper - 17.85 times, manganese - 13.51 times, iron - 3.12 times.

To assess the hazard of the level of water pollution by heavy metals, the danger factor of the element Cd is used, which is determined by the ratio:

Cd = SI / MPC , where

SI - the actual concentration of the pollutant (substance) in the water;

MPC - the maximum allowable concentration of the pollutant (table 2).

Table 2

The coefficient of danger of the content of heavy metals in well water

Heavy metals	Research material	Actual concentration, mg / l	The norm according to State sanitary rules and regulations 2.2.4171-10	Coefficient of danger
Lead	drinking well water	0,043	0,1	0,43
Cadmium	drinking well water	0,0024	0,001	2,4
Zinc	drinking well water	0,31	5	0,062
Copper	drinking well water	0,056	1	0,056
Manganese	drinking well water	0,037	0,5	0,074
Iron	drinking well water	0,32	1	0,32

Analysis of the coefficient of danger of the content of heavy metals in well water showed that the highest rate was recorded for cadmium - 2.4, and the lowest for copper - 0.056.

Comparing the obtained indicators of the content of heavy metals in tap water with the MPC, it was found that the lead content exceeded - 0.03 mg / l at a rate of not more than 0.01 and the excess cadmium content - 0.0037 mg / l at a rate of not more than 0.001. (Table 3).

Table 3

The content of heavy metals in tap water, mg / l

Elements	Results of the research	State sanitary rules and regulations 2.2.4171-10
Lead	0,03	<0,01
Cadmium	0,0037	<0,001
Zinc	0,086	<1
Copper	0,062	<1
Manganese	0,037	<0,05
Iron	0,1	<0,2

Other indicators are within acceptable values. Thus, the lead content exceeds the MPC by 3 times and the cadmium content by 3.7 times

Analysis of the coefficient of danger of heavy metals in tap water showed that the highest rates were found for cadmium (3.7) and lead (3), and the lowest for copper (0.062) and zinc (0.086) (Table 4).

Table 4

The coefficient of danger of the content of heavy metals in tap water

Heavy metals	Research material	Actual concentration, mg /l	The norm according to State sanitary rules and regulations 2.2.4171-10	Coefficient of danger
Lead	tap drinking water	0,030	0,01	3
Cadmium	tap drinking water	0,0037	0,001	3,7
Zinc	tap drinking water	0,086	1	0,086
Copper	tap drinking water	0,062	1	0,062
Manganese	tap drinking water	0,037	0,05	0,74
Iron	tap drinking water	0,10	0,2	0,5

As you know, one of the problems of pollution of tap drinking water is the system of transportation from the place of intake to the final consumer.

Analysis of the coefficient of danger of heavy metals in tap water at the enterprise KP "Vinnytsiaoblvodokanal" showed that the highest rate was recorded in cadmium (1), and the lowest in zinc (0.005) and copper (0.02) (Table 5).

Table 5

The coefficient of danger of heavy metals in the pipeline water at the enterprise KP "Vinnytsiaoblvodokanal"

Heavy metals	Research material	Actual concentration, mg/l	The norm according to State sanitary rules and regulations 2.2.4171-10	Coefficient of danger
Lead	tap drinking water	0,0005	0,01	0,05
Cadmium	tap drinking water	0,001	0,001	1
Zinc	tap drinking water	0,005	1	0,005
Copper	tap drinking water	0,02	1	0,02
Manganese	tap drinking water	0,01	0,05	0,2
Iron	tap drinking water	0,05	0,2	0,25

Comparing the data shown in table 6, we can conclude that in the process of transporting water to the final consumer, its quality deteriorates significantly. In particular, the content of lead increased 60 times, cadmium - 3.7 times, zinc - 17.2 times, copper - 3.1 times, manganese - 3.7 times, iron - 2 times (Table 6).

Table 6

Comparison of water quality at the enterprise KP "Vinnytsiaoblvodokanal" with a prototype, mg / l

Heavy metals	Concentration at the enterprise of KP "Vinnytsiaoblvodokanal"	Concentration in the test sample	MPC
Lead	0,0005	0,03	<0,01
Cadmium	0,001	0,0037	<0,001
Zinc	0,005	0,086	<1
Copper	0,02	0,062	<1
Manganese	0,01	0,037	<0,05
Iron	0,05	0,1	<0,2

According to the results of the study of drinking water samples, it was determined that in the well water there is an excess of the maximum concentration of cadmium, and in tap water - lead and cadmium.

It is important to understand that most heavy metal salts are released into the environment as a result of human activity - mainly from emissions from mining and processing plants, as well as thermal power plants. In other words, it is anthropogenic pollution [8].

The most voluminous source of pollution is wastewater, which flows into surface water bodies with an insufficient level of treatment. Another source of heavy metals is flue gases, which settle to the surface of the earth and are washed away from it into water sources. But another, perhaps the most serious type of pollution is water, which is formed during the flooding of mine workings, in which case there is pollution of even groundwater.

It should be noted that the maximum risk of heavy metal salt poisoning increases with the use of water without further treatment from surface water and wells. In cases where groundwater is polluted, it is also not recommended to consume water from wells.

The standard of lead in drinking water for Ukraine is 0.01 mg / l, which corresponds to international standards. Dangerous dose is already 1 mg / l, lead is classified in the 2nd toxicity group.

Lead in surface waters in Ukraine is widespread almost everywhere. The degree of pollution depends on the development of industry and the saturation of traffic on highways.

For example, in large cities and towns near highways, surface waters often exceed the MPC, therefore, drinking water from wells or springs is usually risky. It should be noted that lead in small concentrations gives the water a pleasant sweet taste [8].

Among the impressive effects are lesions of the nervous and hematopoietic, cardiovascular and excretory systems, sexual dysfunction of women and men. There are also studies that confirm the carcinogenic effects of lead. It should be noted that it has the highest toxicity for small children, as they absorb it up to 40%, while adults - no more than 10%.

Lead has a dangerous effect on the nervous system, its effects primarily affect children. Lead encephalopathy is accompanied by epileptic seizures, headache and others. Depending on the degree of poisoning, the symptoms may vary and manifest with varying intensity. In children, lead poisoning can lead to a decrease in the level of mental development, as well as problems with auditory and visual response [8].

Another widespread consequence is anemia, which is typical for children and is similar to classical iron deficiency anemia. Often there are disorders in the work of the kidney.

Cadmium in water is a heavy metal that has serious side effects. In drinking water, the MPC for cadmium is 0.001 mg / L. All cadmium compounds are toxic they belong to the substances of the second class of toxicity. Its action is based on the ability to bind sulfur-containing acids and enzymes, as a result, cadmium has nephro- and hepatotoxicity. The consequences of acute poisoning can be high blood pressure, renal and pulmonary insufficiency, pathology of the cardiovascular system [8].

It should be noted that cadmium is a carcinogen and can accumulate in the human body. Unlike mercury, it is not able to penetrate the brain, so it has no neurotoxicity.

Table 6 considers changes in the quality of drinking water during its transportation from KP "Vinnytsiaoblvodokanal" to the place of sampling. The analysis of indicators showed that water quality significantly deteriorated during transportation.

The next step, considering the issue of reducing the quality of drinking water, was to analyze the state of the transportation system (table 7).

Table 7

Condition of centralized water supply and sewerage networks

Characteristic	Network type	
	Water supply	Water drainage
Total network length:	623,1 km	532,9 km
including the length of outdated networks	156,8 km	81,5 km
Term of restoration of dilapidated networks at the expense of depreciation	50 years	25 years

Analyzing the above indicators of the state of water supply and sewerage networks, it is clear that a significant part is in unsatisfactory condition.

Thus, about 25% of the water supply network is in unsatisfactory condition, which significantly negatively affects the quality of drinking water. It should also be noted that the drainage system needs to replace 81.5 km of network - about 15% of the total length. The outdated state of the drainage system causes additional danger, because when the integrity of the system is violated, there are losses of liquid household waste, which in turn creates an additional negative impact on the environment.

Thus, the replacement of obsolete networks will significantly improve the quality of drinking water for the final consumer. The system of reverse osmosis is considered to be the optimal method of household purification of drinking water from heavy metals.

Reverse osmosis is the most advanced water purification technology to perfect quality. The main element of the filter is a membrane to which water is supplied under pressure. As a result, the water is divided into purified and contaminated, which drains into the sewer. Due to the micro pores, the membrane passes only water molecules and dissolved oxygen. After the membrane, pure water enters the storage tank. In the process of purification, the water successively goes through 6 stages, for each of which a separate cartridge is provided in the filter.

The first stage is the preliminary purification of water from mechanical impurities. Water, passing through a cartridge made of porous polypropylene fiber, is cleaned of silt, sand, rust.

The second stage is purification of water from organic and organochlorine impurities, as well as chlorine. Improves taste, color and smell of water. Inside the cartridge - activated carbon in the form of granules.

The third stage is the purification of water from the smallest particles of mechanical impurities. The cartridge is made of porous polypropylene fiber of the lowest filtration rating.

The fourth stage is the main stage of filtration. Water, after pre-treatment, enters the membrane, which reliably retains 99.8% of contaminants.

Fifth stage - charcoal post filter gives purified water flavor.

Sixth degree - water is enriched with minerals.

One of the most common causes of water pollution by heavy metals in wells is a violation of the law in the arrangement and maintenance of water supply sources, namely: non-compliance with sanitary protection zones; in addition, water pollution may be affected by the uncontrolled use of mineral fertilizers in homesteads near water sources and proximity to probable sources of pollution; water pollution by surface runoff; violation of the method of cleaning wells, or violation of the frequency of this event [7].

Therefore, it is recommended to use a reverse osmosis system for domestic purification of pipeline water (Table 8).

Therefore, it is recommended to use a reverse osmosis system for domestic purification of pipeline water (Table 8).

Table 8

The efficiency of reducing the concentration of heavy metals in tap water, mg / l

Heavy metals	Concentration before purification	Concentration after purification	The norm according to State sanitary rules and regulations 2.2.4171-10
Lead	0,030	0,01	0,01
Cadmium	0,0037	0,001	0,001
Zinc	0,086	0,05	1
Copper	0,062	0,02	1
Manganese	0,037	0,014	0,05
Iron	0,10	0,04	0,2

It can be concluded that after household additional the content of heavy metals in water decreased significantly, namely: the concentration of lead decreased by 3 times (from 0.03 to 0.01), cadmium - by 3.7 times, zinc - by 1.72 times, copper - 3.1 times, manganese - 2.64 times, iron - 2.5 times.

The results shown in table 9 demonstrate that after additional purification, the water fully meets the requirements for drinking water quality.

Table 9

Efficiency of reducing the concentration of heavy metals in well water, mg / l

Elements	Concentration before purification	Concentration after purification	The norm according to State sanitary rules and regulations 2.2.4171-10
Lead	0,043	0,017	0,1
Cadmium	0,0024	0,0009	0,001
Zinc	0,31	0,13	5
Copper	0,056	0,022	1
Manganese	0,037	0,014	0,5
Iron	0,32	0,12	1

The use of well water without additional domestic treatment of heavy metals is not recommended. As noted above, reverse osmosis is recommended for efficient water purification.

Thus, after household refining, the content of heavy metals in water decreased significantly, namely: the concentration of lead decreased by 2.5 times, cadmium - 2.6 times, zinc - 2.3 times, copper - 2.54 times, manganese - 2.64 times, iron - 2.66 times.

Thus, we can conclude that after re-purification by reverse osmosis system water is fit for consumption.

Another measure aimed at reducing the cadmium content in well water is cleaning wells in accordance with the regulations of this measure.

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Colloquium-journal №5(92), 2021

Część 3

(Warszawa, Polska)

ISSN 2520-6990

ISSN 2520-2480

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Umowa z RSCI nr 118-03 / 2017 z dnia 14.03.2017.

«Colloquium-journal»
Wydrukowano w Annopol 4, 03-236 Warszawa Poland, «Interdruk»
Format 60 × 90/8. Nakład 500 egzemplarzy.

E-mail: info@colloquium-journal.org

http://www.colloquium-journal.org/