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Д.В. Сокольский атындағы «Жанармай,
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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
АО «Институт топлива, катализа и
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NAS RK is pleased to announce that News of NAS RK. Series of chemistry and technologies scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of chemistry and technologies in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of chemical sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Химия және технология сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Химия және технология сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді химиялық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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PUBLIC ENVIRONMENTAL MONITORING OF DRINKING WATER QUALITY IN THE CITY OF NORILSK

Abstract. According to UN estimates, the shortage of safe drinking water can become one of the most acute and pressing problems. The specificity of this problem for Russia is not a shortage of water resources, but their pollution and ongoing degradation of water bodies. The quality of water is understood as the totality of its properties associated with the nature and concentration of impurities in the water. Water analysis is the only tool for monitoring its condition and properties. During the experiment, a team of researchers took samples of drinking water from the water supply network in various districts of the Norilsk industrial region, studied the dependence of the quality characteristics of water on the location and sampling method. Based on the findings, conclusions on the quality of drinking water were drawn. During the experiment, the authors found that in terms of organoleptic indicators, drinking water in all areas of the NIR meets the requirements of Sanitary Rules and Regulations and GOST. Taking samples at three control points of the Norilsk industrial region, it has been proven that the water is soft and its salt content is mainly due to the presence of hardness salts. Having made the necessary analyses, the authors found that the presence of microorganisms in the water supply network of the NIR is not significant, the permanganate oxidisability indicator does not exceed the requirements of Sanitary Rules and Regulations.

Key words: ecological situation, industrial city, water supply, public utilities.

Introduction. According to UN estimates, the shortage of safe drinking water can become one of the most acute and pressing problems. The specificity of this problem for Russia is not a shortage of water resources, but their pollution and ongoing degradation of water bodies. The water quality is understood as the totality of its properties due to the nature and concentration of impurities in the water. The provision of Russian citizens with drinking water of guaranteed quality has now acquired the status of one of the most socially significant problems and has become the most important factor in the country's national security [1]. The effectiveness of its solution directly affects the health of citizens and determines the degree of environmental safety in a number of regions of the country, and sometimes contributes to the emergence of social tension in them [2].

The supply of the population with high-quality drinking water in industrial cities is a serious scientific and practical task. On the one hand, the requirements for the quality of drinking water supplied to the centralised water supply are becoming more stringent, and on the other hand, existing technologies cannot always cope with the task due to various factors: natural, environmental and technological, as well as the state of water supply networks. The practice of operating public utilities shows that violations of the normal level of water supply and environmental safety of consumers are mainly associated with accidents at pipeline sections – the most functionally significant and vulnerable elements of the life support systems in the regions [3].

Drinking water enters the water supply system – in which the biological, organoleptic indicators and indicators of toxic, chemical substances are within the limits of drinking water supply [4-7]. The quality of drinking water supplied by centralised water supply systems must comply with Sanitary Rules and Regulations 2.1.4.1074-01 “Drinking water. Hygienic requirements for water quality of centralised

drinking water supply systems. Quality control. Hygienic requirements for ensuring the safety of hot water supply systems" [8].

The purpose of the paper is the analysis of water – the only tool for monitoring its condition and properties. During the experiment, a team of researchers took samples of drinking water from the water supply network of various districts of the Norilsk industrial region (without preliminary draining and after 5 minutes of draining), studied the dependence of the quality characteristics of water on the location and sampling method, and based on the results obtained, conclusions were made about drinking water quality.

Materials and methods. During the experiment, the colour of the water was determined photometrically – by comparing samples of the test water with solutions imitating the colour of natural water. Equipment, materials, reagents that were used for testing: photocolorimeter with a blue filter (413 nm); sample cells with a thickness of the light-absorbing layer of 5-10 cm; volumetric flasks with a capacity of 1000 cm^3; volumetric pipettes, with a capacity of 1, 5, 10 cm^3 with divisions of 0.1 cm^3; potassium dichromate; cobalt sulphate; sulphuric acid, density 1.84 g/cm^3; distilled water; membrane filters. A set of Nessler tubes with a capacity of 100 cm^3 was used to prepare the colour scale. In each tube, solutions No. 1 and No. 2 in the ratio indicated on the colour scale: No. 1 – dissolve in distilled water and bring the volume of the solution to 1 dm^3 (0.0875 g of potassium dichromate ($K_2Cr_2O_7$), 2 g of cobalt sulphate ($CoSO_4 \cdot 7H_2O$) and 1 cm^3 of sulphuric acid (density 1.84 g/cm^3); No. 2 – in a flask with a capacity of 1 dm^3, place 1 cm^3 of concentrated sulfuric acid with a density of 1.84 g/cm^3 and bring to 1 dm^3 with distilled water.

The solution in each tube corresponds to a certain degree of colour. The colour scale must be stored in a dark place and replaced every 2-3 months. The calibration graph is built on the colour scale. The obtained values of optical densities and the corresponding degrees of colour are plotted on the graph. When determining the colour with a photocolorimeter, sample cells with a thickness of a light-absorbing layer of 5-10 cm were used. The control liquid is distilled water, from which suspended substances were removed by filtration through membrane filters. The optical density of the filtrate of the investigated water sample is measured in the blue part of the spectrum with a light filter at 413 nm. Colour degree is determined by a calibration chart and is expressed in degrees of colour. There are several methods for determining the pH value of solutions. The pH value is approximately estimated using indicators, accurately measured with a pH meter, or determined analytically, by conducting an acid-base titration. Necessary equipment and reagents: pH meter I-160MI, measuring combined electrode 7MA8500-8FF (LZY027Ch1138), a beaker with a capacity of 50 cm^3. An aliquot of the test water and a measuring electrode were placed in a beaker. The readings were taken after 5 minutes.

The electrometric method for determining the salinity is based on measuring the relative electrical conductivity of water using a special device – a conductometer, which makes it possible to accelerate and increase the determination accuracy in comparison with other methods. The principle of operation of the conductometer is based on the direct dependence of the electrical conductivity of water (current strength in a constant electric field created by the electrodes of the device) on the amount of compounds dissolved in water. A wide range of relevant equipment now allows measuring the conductivity of almost any water, from ultrapure (very low conductivity) to saturated with chemical compounds (high conductivity) [9-12]. Equipment and reagents used: T.D.S hold conductometer, 25 cm^3 beaker.

To determine the salinity of water, a conductometer was placed in a beaker with a test sample; readings were taken after a sound signal. To determine the total hardness of the water, the following equipment and reagents were used: burette with the volume of 25 cm^3, stand, ammonium buffer mixture ($NH_4OH + NH_4Cl$) with pH of 8-9, complexone (Trilon B) with 0.1 N, eriochrome black (sugar mixture 1 g indicator + 99 g sodium chloride), conical flasks with a capacity of 250 cm^3, measuring cylinders for 100 cm^3, 10 cm^3. A sample of 100 cm^3 was placed in a conical flask, then 10 cm^3 of an ammonium buffer mixture, 10-20 mg of eriochrome black were added, mixed and titrated with a Trilon B solution until the colour of the solution changed from wine red to blue. The total stiffness was calculated using the formula (Eq. 1):

$$dH = \frac{V \times C \times 1000}{W} mmol - \frac{eq}{dm^3}, \quad (1)$$

where V – volume of 0.1 N of Trilon B solution used for titration, C – concentration of Trilon B solution (0.1 N), W – aliquot part of the sample, cm^3.

Results and discussion**.** For drinking water supply to the city of Norilsk, water resources of the following rivers are used: Norilskaya and Ergalakh – for the Central and Oganer districts; Hayerlach – for the Talnakh district; Ambarnaya – for the Kayerkan district. Before entering the water supply network, water is treated at the treatment facilities of Norilsk and the Oganer residential area. The object of the study was the water sampled from three districts of Norilsk – Tsentralny, Talnakh, and Ograner districts. Samples were taken after a five-minute drain and without it (tables 1-2). Taking two samples from one site was done to prove or disprove the recommendation to drain the water before drinking to improve its quality. The study was conducted during the winter period (November-December).

Drinking water must have good organoleptic properties, i.e. be transparent, colourless, tasteless and odourless, at a refreshing temperature and free of visible impurities. The results of organoleptic analysis of water are presented in the table 1.

Table 1 – Organoleptic characteristics of samples

Samples	T, °C	Colour, points	Odour, points	Taste, points	Turbidity (transparency), FTU (Formazine Turbidity Units)
Before draining					
Talnakh	16.5	5	0	0	1.9
Tsentralny	17	5	1	1	2.0
Oraner	16.8	5	0	0	1.9
After draining					
Talnakh	15.5	5	0	0	1.5
Tsentralny	16	5	1	1	1.8
Oraner	15.8	5	0	0	1.6

Turbidity is a simple and irrefutable indicator of a change in water quality. A sudden change in turbidity may indicate an additional source of contamination (biological, organic or inorganic) or signal problems in the water treatment process [13,14]. An important indicator of the quality of water used for almost any purpose is the presence of mechanical impurities – suspended solids, solid particles of silt, clay, algae and other microorganisms, and other small particles [15,16]. The permissible amount of suspended solids varies widely, as does their possible content. Particulate matter suspended in water interferes with the passage of light through the water sample and creates a quantitative characteristic of the water called turbidity. Turbidity can be viewed as a measure of the relative clarity of water.

From the data in Table 1, it can be seen that the turbidity of tap water is lower than the normalised indicator (2.6) in all districts of the Norilsk industrial region (NIR). This is due to the fact that the tests were carried out in the winter. Turbidity of water increases with rains, floods, and melting of glaciers [17-19]. As a rule, in winter, the level of turbidity in water bodies is lowest, highest in spring and during summer rains. It should be noted that the water intakes in the Norilsk industrial region are organised in such a way that even during the flood period, the water entering the treatment facilities contains a minimum amount of suspended solids. River beds used for water consumption are lined with hard rocks and practically do not contain silt deposits.

Colour degree can be associated with the presence of dissolved salts, organic compounds, and iron ions in the water. High colour index (350 on the colour scale) indicates high contamination of water by foreign impurities and cannot be used for drinking purposes. From the data in table 1, it can be seen that regardless of the place of sampling, the colour of drinking water is 5 points. Visually, water is characterised by the indicator “colourless”. This indicates that no contaminants that give colour to the water have been found in drinking water. In addition, the presence of iron ions, which appear as a result of corrosion of water supply networks, affects the colour of water. Iron (II) ions can colour water greenish, and iron (III) ions give water a brownish tint. The lack of colour in drinking water indicates a good condition of the water supply networks in the areas under investigation.

The smell of water can be caused by both natural compounds and chemical ones. For the purpose of disinfection at water treatment plants, water from the water intake is chlorinated. During the passage of a portion of water from the wastewater treatment plant to the consumer, chlorine must evaporate, and the residual should be zero. According to table 1, it can be seen that a drinking water sampled in the Tsentralny district has the odour of chlorine. No chlorine odour was detected in samples taken in other areas of the NIR. Drinking water should have a pleasant, refreshing taste without any foreign aftertaste. If some kind of aftertaste is present then this may indicate an increased presence of salt and some mineral in the water. In addition, chlorinated water also has its own flavour, which vanishes with the weathering of chlorine. The taste of water depends on the mineral composition of the water, its temperature and dissolved gases. From the data in Table 1, it can be seen that water from all areas of the NIR, regardless of the time of sampling, does not have a taste, with the exception of the Tsentralny district. This is due to the presence of residual chlorine in the water.

The temperature regime of cold water in the tap is not regulated by GOST, however, these indicators directly depend on the season. This feature is associated with the temperature of the water at the source of the water intake, as well as the temperature indicators of the soil at the level of water conduct. The optimal drinking water temperature for the physiological needs of a person is 8-15°C. According to table 1, water in all areas of the NIR has a temperature of 15-17°C. Such water quenches thirst well. After 5 minutes of draining the water, the temperature drops by 1°C. Lowering the temperature of drinking water by 1-2°C improves its taste perception. Thus, to improve the organoleptic properties of water, it should be drained from the tap for 5-10 minutes.

The degree of acid-base indicators, determined by the concentration of hydrogen ions, forms the pH parameters, which are normally 6-9 units for drinking water, according to the Sanitary Rules and Regulations [20,21]. In terms of this indicator, Russian standards are almost the same from the EU directive – 6.50-9.50 and from the requirements of the US Environmental Protection Agency (USEPA) – 6.50-8.50. The data obtained analytically were subjected to statistical processing at p = 95% and the confidence interval was determined as 6.5 ± 0.8. As can be seen from table 2, the average pH of drinking water in all regions of the NIR meets the requirements of Sanitary Rules and Regulations and is equal to 6.5.

Table 2 – Findings of a study

Samples	Hardness, mmol/L	pH	Salinity, mg/L
Before draining			
Talnakh	1.53	6.5	107
Tsentralny	1.68	6.5	121
Oraner	1.47	6.5	107
After draining			
Talnakh	1.50	6.5	107
Tsentralny	1.68	6.5	119
Oraner	1.50	6.5	107

Figure 1 shows that the lowest pH value – 6.1 was in the water of the 4th microdistrict of the Talnakh district; slightly higher (pH – 6.2) – in 3rd microdistrict and Rudnaya street of Talnakh district, Metallurgov Square – Tsentralny district. The highest pH value is 6.5, observed in the Oganer and Tsentralny districts. pH values remain almost unchanged after draining.

Water hardness is caused by the presence of positive ions Ca2+ and Mg2+, and negative bicarbonate ions (HCO3-) [22-24]. The average hardness value does not depend on whether the sample is taken immediately or after a 5-minute drain and, depending on the area, is equal to from 1.47 to 1.68 (table 2). Since the NIR is located in the permafrost region, the water used for drinking purposes is soft. Differences in this indicator in the NIR districts are 0.3 mmol/L.

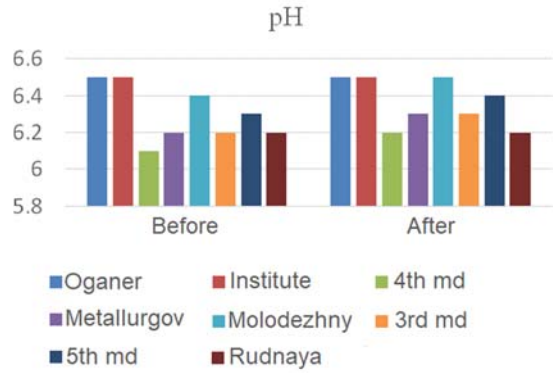

Figure 1 – The dependence of the pH of drinking water on the sampling location

Figure 2 shows that the harder water in the Tsentralny district, the softer water in the Oganer district, with the average hardness in the Talnakh district. After draining, the hardness indicators change slightly. These minor fluctuations are associated with different water sources.

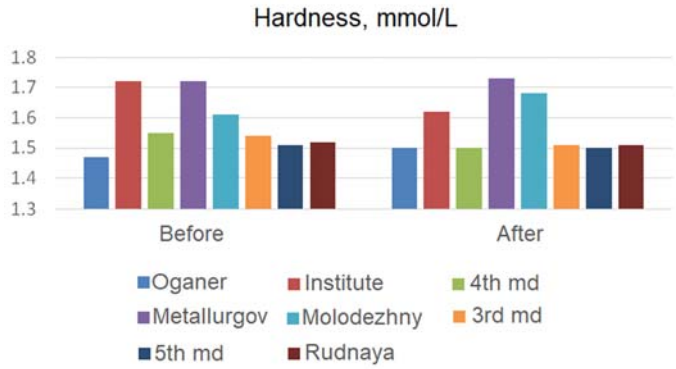

Figure 2 – The dependence of the hardness of drinking water on the sampling location

The salinity index corresponds to the stiffness index [25]. The total salt content before draining was 107 mg/L in Talnakh and Oganer districts, in the Tsentralny district – 121 mg/L; after draining in Talnakh and Oganer districts, the indicator did not change, in Tsentralny district it has decreased by 2 mg/L. Comparing the data on hardness and salt content, it can be concluded that the salt content is mainly conditioned by the presence of hardness salts [26]. Figure 3 shows that the highest indicators of salinity were noted in the Tsentralny district.

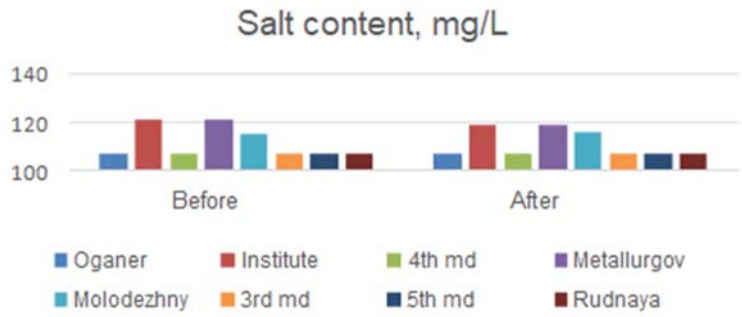

Figure 3 – The dependence of drinking water salinity on the sampling location

Oxidability is a value that characterises the content of organic and mineral substances in water, oxidised (under certain conditions) by one of the strong chemical oxidants. This indicator reflects the total concentration of organic matter in the water. The nature of organic substances can be very different –

humic acids of soils, and complex organic matter of plants, and chemical compounds of anthropogenic origin. Other methods are used to identify specific compounds. Permanganate oxidisability is a measure of the total amount of organic matter in the water. It does not show exactly which substances are present, but shows how many are in total.

These studies show that the values of permanganate oxidisability in tap water are in the range from 2.7 to 6.12 mgO/L, depending on the area in which the sample was taken. These values do not exceed the requirements of Sanitary Rules and Regulations. Higher rates were noted in the Tsentralny district: Molodezhny passway (6.12 and 4.19 mgO/L) and in the Talnakh district: Rudnaya street (5.2 and 4.7 mgO/L). This indicates the presence of microorganisms in water pipes, due to the long-term operation of water supply systems in apartment buildings.

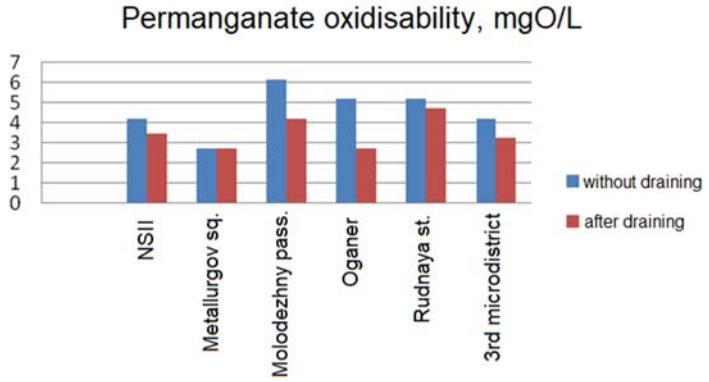

Figure 4 – Permanganate oxidisability

Figure 4 shows that before draining, water has a higher permanganate oxidisability than after. This can be explained by the fact that some of the microorganisms in the water pipes are washed off by the flow of water, and are also killed by chlorine.

Conclusions. In the course of the study, the authors found that in terms of organoleptic indicators, drinking water in all areas of the Norilsk industrial region meets the requirements of Sanitary Rules and Regulations and GOST. The authors came to the conclusion that in order to improve the taste, it is necessary to drain the water for 5 minutes, while the water temperature is reduced by 1 degree. Taking samples at three control points of the NIR, it has been proven that the water is soft and its salt content is mainly due to the presence of hardness salts. The theory that a five-minute drain of water affects indicators such as pH, hardness and salt content was also experimentally refuted. Having made the necessary analyses, the authors found that the presence of microorganisms in the water supply network of the NIR is not significant, the permanganate oxidisability indicator does not exceed the requirements of Sanitary Rules and Regulations.

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НОРИЛЬСК ҚАЛАСЫ АУЫЗ СУЫ САПАСЫНЫҢ ҚОҒАМДЫҚ ЭКОЛОГИЯЛЫҚ МОНИТОРИНГІ

Аннотация. БҰҰ-ның бағалауы бойынша таза ауыз судың жетіспеушілігі өзекті де түйткіл мәселеге айналуы мүмкін. Ресей үшін аталмыш мәселенің ерекшелігі – су ресурстарының жетіспеушілігінде емес, олардың ластануы мен су объектілері деградациясының жалғасуында болып саналады. Су сапасының астарында судағы қоспалардың қоюлануы және сипатына байланысты қасиеттерінің жиынтығы жатыр. Мақаланың мақсаты суды талдау – оның қасиеттері мен күйін бақылау.

Эксперимент жасау барысында зерттеушілер ұжымы Норильск өнеркәсіптік ауданының су жеткізу желісінен ауыз су сынамасын алды (алдын ала ағызбай және ағызғаннан кейін 5 минут өткенде), судың

сапалық сипаттамасының орналасқан жеріне тәуелділігі мен сынама алу әдісі анықталды. Судың түсі фотометриялық әдіс арқылы айқындалды, яғни зерттегелі отырған судың сынамасы табиғи су түсінің келтіріндісі болып саналатын ерітіндімен салыстырылды. Түстік шкаланы дайындау барысында Несслер түтікшелерінің жинағы пайдаланылды. Фотоколориметрмен түсті анықтау барысында жарық жұтатын қабаттың қалыңдығы 5-10 см болатын кювет-үлгілер қолданылды. Зерттеліп отырған су сынамасы сүзіндісінің оптикалық тығыздығы жарық сүзгісі арқылы спектрдің көк түсті бөлігінде өлшенеді.

Алынған деректер негізінде ауыз су сапасы туралы қорытынды жасалды. Тәжірибе барысында авторлар органолептикалық көрсеткіштер бойынша Донецк Халық Республикасының барлық аумағындағы ауыз судың санитарлық ережелер мен мемлекеттік стандарттардың талаптарына сай келетіндігін анықтады. Норильск өнеркәсіптік ауданының үш бақылау нүктесінен сынамалар алынып, судың жұмсақ екендігі және ондағы тұзмөлшер негізінен судың кермектігіне байланысты екендігі дәлелденді. Қажетті талдаулар жасалып, авторлар Норильск өнеркәсіптік ауданының сужеткізу желісіндегі микроағзалар мен перманганатты тотығушылық көрсеткіштерінің санитарлық ережелер талаптарына сай екендігін анықтады.

Түйін сөздер: экологиялық жағдай, өнеркәсіптік қала, сумен қамтамасыз ету, коммуналдық қызметтер.

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ОБЩЕСТВЕННЫЙ ЭКОЛОГИЧЕСКИЙ МОНИТОРИНГ КАЧЕСТВА ПИТЬЕВОЙ ВОДЫ ГОРОДА НОРИЛЬСКА

Аннотация. По оценкам ООН, нехватка чистой питьевой воды может стать одной из самых острых и актуальных проблем. Специфика этой проблемы для России заключается не в нехватке водных ресурсов, а в их загрязнении и продолжающейся деградации водных объектов. Под качеством воды понимается совокупность ее свойств, связанных с характером и концентрацией примесей в воде. Целью статьи является анализ воды – единственный инструмент для мониторинга ее состояния и свойств.

В ходе эксперимента коллективом исследователей были взяты пробы питьевой воды из водопроводной сети в различных районах Норильского промышленного района (без предварительного слива и после 5 минут слива), изучена зависимость качественных характеристик воды от местоположения и метод отбора проб. Цвет воды определялся фотометрически – путем сравнения проб исследуемой воды с растворами, имитирующими цвет природной воды. Для изготовления цветовой шкалы использовался набор трубок Несслера. При определении цвета фотоколориметром использовали кюветы-образцы с толщиной светопоглощающего слоя 5-10 см. Оптическая плотность фильтрата исследуемой пробы воды измеряется в синей части спектра с помощью светофильтра.

На основании полученных данных были сделаны выводы о качестве питьевой воды. В ходе эксперимента авторы установили, что по органолептическим показателям питьевая вода на всех участках ДНР соответствует требованиям санитарных правил и ГОСТов. В результате исследования проб, взятых в трех контрольных точках Норильского промышленного района, было доказано, что вода мягкая, а ее солесодержание в основном связано с наличием солей жесткости. Проведя необходимые анализы, авторы установили, что наличие микроорганизмов в водопроводной сети НИР не является значимым, показатель перманганатной окисляемости не превышает требований санитарных правил.

Ключевые слова: экологическая ситуация, промышленный город, водоснабжение, коммунальные услуги.

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