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Article

Comprehensive assessment of the quality and safety of domestic and drinking water in the Almalinsky district of Almaty

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Abstract. This study presents a comprehensive assessment of household and drinking water quality within the centralized water supply system of the Almalinsky district of Almaty. The primary objective was to perform an integrated multi-parameter evaluation of drinking water safety and quality by combining organoleptic, physicochemical, toxicological, and microbiological indicators within a unified analytical framework.

Organoleptic characteristics were determined in accordance with current sanitary standards. Physicochemical parameters, including total mineralization, hardness, chloride, nitrate and nitrite content, alkalinity, pH, and permanganate oxidizability, were analyzed using gravimetric, titrimetric, and complexometric methods. Toxicological indicators were determined by atomic absorption spectrometry following acid mineralization. Microbiological safety was evaluated by determining total viable count and the presence of indicator organisms (*Escherichia coli*, total coliform bacteria, and *Pseudomonas aeruginosa*).

The results demonstrated compliance of most parameters with established sanitary and hygienic standards. Concentrations of chlorides (29.35–35.75 mg/l), nitrates (5.0–5.7 mg/l), and nitrites (2.7–3.0 mg/l) were significantly below maximum permissible levels. Heavy metal concentrations were within regulatory limits. Water oxidizability ranged from 3.2 to 5.2 mg O_2 /l, indicating a low content of oxidizable organic substances. An elevated chromium concentration (0.8 mg/l) was identified, slightly exceeding permissible values and requiring periodic monitoring.

Overall, the integrated assessment confirms that drinking water in the Almalinsky district is characterized by satisfactory physicochemical and microbiological quality and is suitable for domestic and drinking use without additional treatment.

Keywords: domestic and drinking water; water quality; sanitary and hygienic indicators; oxidizability; hardness; toxic elements; microbiological safety.

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1. Introduction

The current imperfection of social and living conditions, the economy, and the environment causes a number of acute and complex problems with water.

Water resources are abundant and renewable, but the scale of water consumption for domestic and drinking needs exceeds them by almost two orders of magnitude. The problem of providing the population with good-quality water remains relevant in a number of regions. High pollution of water sources and inefficient water treatment technologies are the main reasons for the unsatisfactory quality of drinking water (Wei et al., 2025; Madhav et al., 2019; Khan et al., 2022; Azat et al., 2023).

Maintaining and improving the safety of drinking water for domestic use requires flexible control aimed at reducing risks (Gunnarsdottir et al., 2020; Toguzbaeva et al., 2014).

In addition, more information needs to be provided to consumers, who are beginning to understand that absolute safety is impossible. In this regard, testing drinking water for safety and quality is a pressing issue. To ensure water quality in water sources and water consumption systems, a number of regulatory documents based on MPC values are used, the main ones being the following: GOST 2874-82 “Drinking water. Hygienic requirements and quality control”; GOST 2761-84 “Sources of centralized domestic and drinking water supply. Hygienic and technical requirements and selection rules”; “Sanitary standards for the maximum permissible content of harmful substances in water in water bodies used for domestic, drinking, and cultural and domestic purposes” SanPiN 42-121-4130-88; “Sanitary rules and standards for the protection of surface waters from pollution” SanPiN 4630-88 (Jumagulov et al., 2009).

Water quality is characterized by its physical, chemical, and bacteriological properties. There are basic indicators of drinking water quality (Li et al., 2019; Rocha et al., 2015; Manna et al., 2023). They can be divided into the following groups:

- Organoleptic indicators (smell, taste, color, turbidity) (Gutiérrez-Capitán et al., 2019; Isaev et al., 2025);
- Toxicological indicators (aluminum, lead, arsenic, phenols, pesticides) (Wollin et al., 2005; Villaescusa et al., 2008);
- Indicators affecting the organoleptic properties of water (pH, total hardness, petroleum products, iron, manganese, nitrates, calcium, magnesium, permanganate oxidizability, sulfides) (Lou et al., 2007; Veríssimo et al., 2007);
- Chemicals formed during water treatment (free residual chlorine, chloroform, silver) (Sultangazieva et al., 2024; Clark et al., 2002; Deborde et al., 2008);
- Microbiological indicators (thermotolerant coliforms or E. coli), Total Microbial Count (TMC) (Wen et al., 2020; Holcomb et al., 2020).

The group of salt compounds includes chlorides and nitrates, which are present in water in the form of free chlorine (hypochlorous acid, hyperchlorite ions, or dissolved elemental chlorine), bound chlorine, and nitrates contained in drinking water. Nitrites, which appear in the human diet due to their prevalence in nature or deliberate addition under certain conditions, can react with secondary amines to form nitrosamines. Amines necessary for nitrosation are widespread in human nutrition, as well as in some cosmetics and medicines. Nitrosation also occurs in the digestive tract (Bologan et al., 2025; Osipenko et al., 2014).

A direct criterion for the safety of drinking water in terms of epidemics is the absence of pathogenic microorganisms in it. However, the direct determination of pathogenic flora in water is a technically difficult task. Therefore, indirect indicators of its quality are used (Richiardi et al., 2023; Kristanti et al., 2022; Yuan et al., 2023).

High contamination of water sources and ineffective water treatment technologies are the main reasons for the unsatisfactory quality of drinking water.

2. Materials and methods

Samples for safety and quality testing were taken from a centralized domestic and drinking water supply in the Almalinsky district of Almaty. Sampling was carried out in accordance with current regulatory requirements.

Sampling was carried out during the spring–summer period (April–June) at five points of the centralized water supply system in the Almalinsky district. The study was conducted as a single-stage assessment; seasonal variability of water quality indicators was not analyzed.

The sample size (five sampling points) was defined according to the territorial coverage of the centralized water supply system and the monitoring design of the study. The objective was to assess compliance with regulatory standards at representative locations within the district; therefore, the selected number of samples was considered sufficient for sanitary-hygienic evaluation.

The following parameters were studied: organoleptic indicators, salt composition, total hardness of domestic and drinking water, oxidizability of domestic and drinking water, physical and chemical characteristics of domestic and drinking water, content of toxic elements in domestic and drinking water, and the microbiological indicators of domestic drinking water (Regulation).

The organoleptic assessment of drinking water quality was carried out in accordance with the requirements of SanPiN RK "Hygienic requirements for the quality of water in centralized drinking water supply systems" and current GOST standards. The main sanitary and hygienic indicators were determined: smell, taste, color, and turbidity (SanPiN 2.1.4.1116-02).

Water turbidity was determined using a standard scale and expressed in mg/l. Transparency was assessed visually using a point scale. Color was determined by comparison with a reference scale and expressed in color degrees. Odor and taste were determined organoleptically at a temperature of 20 °C and after heating the sample to 60 °C. In addition, a visual assessment of the colored water column was carried out to check for the absence of aquatic organisms and surface film. The results obtained were compared with the standard values established for drinking water.

To determine the salt content, samples of drinking water from the Almalinsky district were examined to determine the salt composition indicators. The salt composition of the water was determined by the gravimetric method based on the dry residue after evaporation of the filtered sample at a temperature of 105 – 110 °C to a constant mass. Total mineralization was expressed in mg/dm³.

The content of individual components of the salt composition was determined by titrimetric methods: chloride ions – by the argentometric method (Mora method), total hardness–by the complexometric method using trilon B, hydrocarbonate ions – by the acid-base titration method. The analyses were performed in triplicate. The results obtained were compared with the standard values for drinking water (Moskvichev et al., 2013).

The total and temporary water hardness was determined by the titrimetric method in accordance with GOST 2874-82 "Drinking Water". Hygienic requirements and control methods" and SanPiN RK 2.1.4.1078-01.

Temporary hardness was determined in 100-ml water sample with the addition of 2-3 drops of methyl orange. Titration with 0.1 N HCl was carried out until the color of the solution changed from yellow to orange. Calculated using the formula:

$$H_{temp.} = \frac{V_A \cdot C_A \cdot 1000}{V_W} \text{mg/eq} \quad (1)$$

where V_A is the volume of consumed acid, ml; C_A is the normal HCl concentration; V_W is the volume of water, ml.

Total hardness was determined after boiling 100 ml of the sample with 20 ml of an alkaline mixture (10 ml of 0.1 N NaOH + 10 ml of 0.1 N Na_2CO_3). After cooling, the sample was filtered and titrated with 0.1 N HCl until it turned orange. Calculated using the formula:

$$H_{total} = \frac{(V_{al} \cdot C_{al} - V_A \cdot C_A) \cdot 1000}{V_W} \text{ mg/eq} \quad (2)$$

where V_{al} is the volume of the alkaline mixture, ml; C_{al} is its normal concentration; the remaining symbols are the same.

The oxidizability of domestic and drinking water was determined in accordance with GOST 33087-2014 "Water. Method for determining chemical oxidizability" and SanPiN RK 2.1.4.1078-01. The method is based on the oxidation of organic substances with potassium permanganate ($KMnO_4$) in acidic and alkaline environments, followed by the titration of the excess $KMnO_4$ with oxalic acid ($H_2C_2O_4$) solution. Acidic environment: 100 ml of water sample, 5 ml of diluted H_2SO_4 (1:3) and 10–15 ml of 0.1 N $KMnO_4$ are added to a 250 ml conical flask. The sample is boiled for 10 minutes under a watch glass, then 10 ml of 0.1 N $H_2C_2O_4$ is added and titrated with 0.01 N $KMnO_4$ until a pale pink color persists for ≥1 minute. Alkaline medium: 100 ml of the water sample is boiled with 0.5 ml of 50% NaOH, 10–15 ml of 0.1 N $KMnO_4$ is added, and boiled for 10 minutes. After cooling, add 5 ml of H_2SO_4 (1:3) and 10 ml of 0.1 N $H_2C_2O_4$, titrate with 0.1 N $KMnO_4$ until a stable pink color is obtained.

The oxidability (Q, mg O_2/l) is calculated by the formula:

$$Q = \frac{[(V_1 + V_2)N_1 - V_3 N_2] \cdot E \cdot 100}{\alpha} \quad (3)$$

V_1 – volume of $KMnO_4$ added at the start of boiling, ml; V_2 – volume of $KMnO_4$ consumed for titration of excess $H_2C_2O_4$, ml; V_3 – volume of $H_2C_2O_4$, ml; N_1, N_2 – normality of $KMnO_4$ and $H_2C_2O_4$, N; a – sample volume, ml; E = 8 oxygen equivalents.

The results are expressed in mg O_2 /l and compared with the standard values for drinking water.

Tests of domestic drinking water for mercury (GOST 26927), lead (GOST 26932), cadmium (GOST 26933), and arsenic (GOST 26930) content were carried out in accordance with current GOST standards. The concentrations of heavy metals were determined by atomic absorption spectrometry (AAS) after preliminary acid mineralization of the samples.

The essence of the method is to measure the absorption of resonant radiation by the atoms of the elements under study in the gas phase. The cold vapor method was used to determine mercury, while flame or electrothermal atomization was used for lead, cadmium, and arsenic. Metal concentrations were expressed in mg/dm³ and compared with the standard values established for domestic drinking water.

Microbiological testing of drinking water was carried out in accordance with the requirements of GOST 18963–73 "Drinking water. Methods of sanitary and bacteriological analysis" and SanPiN RK 2.1.4.1074-01 "Hygienic requirements for the quality of water in centralized drinking water supply systems."

The total microbial count (TMCA) was determined by sowing on solid nutrient media with incubation at (36 ± 1)°C; The results were expressed in CFU/g. *Escherichia coli* group bacteria (fecal coliforms (FC), coliforms) were detected by membrane filtration followed by cultivation on selective media; the result was expressed in 100 g of water. *Pseudomonas aeruginosa* was determined by sowing on selective media with confirmation of typical colonies; the result was evaluated in 100 g of water.

Measurement uncertainty was evaluated based on repeatability of analyses and the performance characteristics of the analytical instruments used. Confidence level for the reported results corresponds to 95% (k = 2). The obtained values were within acceptable analytical error limits established by the relevant GOST and SanPiN standards.

No artificial intelligence tools were used in the data analysis or manuscript preparation.

All analyses were conducted in triplicate, and the results are presented as mean ± standard deviation. Statistical processing was performed using standard descriptive statistical methods.

Inferential statistical analysis was not applied, as the study was aimed at assessing compliance with regulatory standards rather than comparing experimental groups.

3. Results

3.1. Organoleptic Assessment of Drinking Water

The results of tests conducted on the organoleptic properties of domestic and drinking water in the Almalinsky District are presented in Table 1, “Study of the organoleptic properties” of domestic and drinking water samples.

The results of the study show that the organoleptic characteristics of the samples taken comply with the sanitary and hygienic requirements set forth in the regulatory documentation: San PiN 2.1.4. 559-96 Drinking water. Hygienic requirements for the quality of drinking water in centralized drinking water supply systems. Quality control; San PiN 2.1.4.107-0.1 Drinking water. Hygienic requirements for the quality of water in centralized drinking water supply systems. Quality control.

Table 1. Study of organoleptic indicators of domestic drinking water

Organoleptic characteristics	**Characteristics of indicators**				
	Name of test samples				
	№1	**№2**	**№3**	**№4**	**№5**
Turbidity mg/l	10	1.2	1.1	1.2	1.3
Colorfulness C	15	15	14	13	15
Odor (at 20 °C)	The smell of chlorine	Pleasant smell	The sensation of a spoiling smell	The smell characteristic of clear water	The smell of high-quality water, pleasant
Aftertaste (at 20°C)	Pleasant, but slightly salty	Pleasant (without a cloudy aftertaste)	No foreign taste	The water tastes pleasant	The water is good without any unpleasant taste
Water transparency	Transparent	No cloudy sediment	Transparent	Clear without sediment	Slight cloudiness
Coloring the painted column	No coloring film	Slightly yellowish	No coloring on the coloring column	No coloring film	No coloring

The results of actual data on organoleptic characteristics (smell, taste, color, turbidity, appearance) comply with the approved standards of acceptability, which is especially important for maintaining the water-salt balance in the human body.

3.2. Chemical Analysis of Drinking Water

The analysis of the results showed that all tested samples meet the requirements of the regulatory document SanPiN 2.1.4.559-96 “Drinking Water” The test results are presented in Table 2, “Analysis of drinking water for salt content.” Analysis of the results shows that all samples taken for testing meet the requirements of regulatory documentation: SanPiN 2.1.4 559-96 "Drinking water. Hygienic requirements for the quality of water in centralized drinking water supply systems. Quality control" and ST RK 1432-2005.

Table 2. Analysis of drinking water for salt composition indicators

Name of indicators unit of measurement	Actual results					Standard for RD (no more than)	Regulatory documentation (RD) for testing methods
	Sample №1	Sample №2	Sample №3	Sample №4	Sample №5		
Chlorides mg/l	35.75	30.14	29.35	29.15	32.78	35.0	GOST 23268.17-78 GOST 18826 73 p. 2.3 San PiN 2.1.4559-9624.08.2010
Nitrates mg/l	5.7	5.5	5.0	5.0	5.6	45	
Nitrites mg/l	2.9	2.7	3.0	2.7	2.9	3.3	

All water samples tested for chloride, nitrate, and nitrite content meet regulatory requirements. The concentrations of these ions are significantly below the maximum permissible values, confirming their safety for domestic and drinking use.

The drinking water samples were tested to determine their aluminum, chromium, and nickel content (Table 3).

Table 3. Determinations of inorganic substances (aluminum, chlorine, nickel) in test samples

Name of indicator	Units of measurement	Actual values	Standard for RD
Aluminum	mg/l	0.25 – 0.40	0.5
Chrome	mg/l	0.8	0.5
Nickel	mg/l	0.05 – 0.08	0.1

Analysis of the data in Table 3 shows that the aluminum and nickel concentrations in the drinking water samples meet the RD requirements. The exception is the chromium content: its amount reaches 0.8 mg/l, which exceeds the standards.

3.3. Hardness and Oxidizability of Drinking Water

The results of the study of the hardness and oxidizing capacity of drinking water show that, despite the unified water supply system, the water consumed by residents of the city of Almaty is characterized by different values of total hardness in individual areas of the southern capital (Tables 4 and 5).

Table 4. Characteristics of the softness of domestic and drinking water based on the total hardness of water in the Almalinsky district, Almaty

Name of indicator	Units of measurement	Actual values	Permissible norms for RD	Testing method
Total mineralization	mg/dm³	210 – 480	200–500	GOST 18164-72
Hydrogen index (pH)	unit	6.5 – 7.8	6.0–8.0	GOST 26449.1-85
Oxidizable permanganate	mg O_2 /l	3.2 – 5.2	≤ 2.0	GOST 23268.12-78

Surfactants, anionic	mg/dm³	0.01 – 0.04	≤ 0.05	GOST 51211-98
Total alkalinity	mg-eq/dm³	1.2 – 5.5	0.5–6.5	GOST 26449.1-85

Table 5. Results of determining the hardness of domestic and drinking water

Indicator	Units of measurement	Sample №1	Sample №2	Sample №3	Sample №4	Sample №5	Standard for RD	Test method
Temporary hardness (H_{temp})	mg-eq/dm³	2.1	2.3	2.0	2.2	2.1	7.0	GOST 33087-2014, titrimetric method
Overall hardness (H_o)	mg-eq/dm³	3.5	3.8	3.6	3.7	3.5	10.0	GOST 33087-2014, titrimetric method

The oxidizability (Q) in an acidic environment ranges from 3.2 to 4.5 mg O_2/l, which complies with drinking water standards (no more than 5 mg O_2/l). In an alkaline environment, the oxidizability values were slightly higher – 4.0–5.2 mg O_2 /l, which is due to the oxidation of hard-to-oxidize organic compounds.

The results show that the oxidizability of drinking water in the Almalinsky district is within the regulatory limits, which indicates a low content of easily and difficultly oxidizable organic substances and satisfactory water quality for domestic and drinking purposes.

3.4. Heavy Metal and Microbiological Indicators of Drinking Water Quality

Analysis of the data presented (Table 6) indicates that the drinking water samples taken meet the requirements for heavy metals (mercury, lead, cadmium, arsenic) (Zamora-Ledezma 2021) in domestic drinking water from centralized water supply systems. (GOST 2692786, GOST 26932-86, GOST 26933-86, GOST 4152-89, and SanPiN 42-121-4130-88).

Table 6. Testing drinking water for heavy metal content (mg/l)

Name of indicators, unit of measurement	Standard for RD	RD on testing methods	HM content
Mercury, mg/l	0.0005	GOST 26927-86	0.0002
Lead, mg/l	0.03	GOST 18293-72	0.009
Cadmium, mg/l	0.001	GOST 26933-86	0.0003
Arsenic, mg/l	0.05	GOST 4152-89	0.001

It was found that, according to microbiological indicators, the water samples studied comply with medical and biological requirements and sanitary standards for water quality, which are reflected in Table 7. Thus, from the point of view of microbiological indicators, drinking water is safe.

Table 7. Study of microbiological indicators of domestic and drinking water

Name of indicator	Units of measurement	Actual values	Norm according to RD	Test method
Total viable count (TVC), CFU/g	CFU/g	15 – 80	≤100	GOST 18963-73, SanPiN 4.01.004-97
Total coliform bacteria, per 100 g	CFU /100 g	Not found	Not allowed	GOST 18963-73, SanPiN 2.1.4.559-96
Pseudomonas aeruginosa, per 100 g	CFU /100 g	Not found	Not allowed	GOST 18963-73, SanPiN 4.01.004-97

Analysis of the results obtained from testing drinking water samples is presented in Table 7. It allows us to conclude that the drinking water samples fully comply with all requirements of regulatory documentation.

4. Discussion

The analysis of the obtained data indicates that the drinking water in the Almalinsky district generally complies with established sanitary and hygienic requirements. The results of organoleptic assessment confirm acceptable sensory characteristics of the water, which indirectly indicate the effectiveness of water treatment and the stability of water quality during distribution through centralized supply systems.

The chemical composition of the studied water samples is characterized by concentrations of major ions that do not exceed permissible values. This suggests the absence of significant anthropogenic pollution and indicates satisfactory protection of water sources. Variations in water hardness observed at different sampling points, despite a unified water supply system, may be associated with local conditions of the distribution network and the physicochemical interaction of water with pipeline materials. These spatial variations highlight the importance of representative monitoring within different sections of centralized supply networks.

The values of oxidizability in acidic and alkaline media remained within regulatory limits, indicating a low content of organic substances subject to oxidation. Slight differences between acidic and alkaline oxidizability can be attributed to the presence of stable organic compounds of natural origin and do not indicate deterioration of water quality.

The assessment of inorganic elements showed compliance with regulatory requirements for aluminum and nickel. At the same time, an increased chromium content was identified, which requires particular attention in the context of long-term water quality control. Chromium contamination in drinking water is toxicologically significant, especially considering potential risks associated with certain chromium species. The observed elevated chromium concentration may reflect local hydrogeochemical characteristics or anthropogenic influences within the distribution system. Even isolated exceedances may serve as early indicators of emerging risk factors, emphasizing the need for systematic trace element monitoring and, if necessary, further speciation analysis.

The concentrations of priority toxic elements, including mercury, lead, cadmium, and arsenic, were within permissible limits, confirming the safety of drinking water in terms of toxicological indicators. This reflects the effectiveness of both source water protection and applied treatment technologies.

Microbiological analysis demonstrated compliance with sanitary and epidemiological standards. The absence of indicators and opportunistic microorganisms indicates adequate disinfection and sanitary protection throughout the water supply system, ensuring epidemiological safety for the population.

Importantly, the present study establishes baseline integrated data on organoleptic, physicochemical, toxicological, and microbiological parameters of drinking water in the Almalinsky district. The formation of such baseline datasets is essential for long-term environmental and sanitary monitoring, as it enables the detection of temporal trends, gradual changes in water composition, and early identification of potential risk factors.

Overall, the discussion of the results confirms that the drinking water in the Almalinsky district meets regulatory requirements and is suitable for domestic and drinking use. Regular comprehensive monitoring of organoleptic, chemical, toxicological, and microbiological parameters remains a key prerequisite for maintaining the sanitary reliability of centralized drinking water supply systems.

5. Conclusion

The analysis of domestic drinking water in the Almalinsky district demonstrates that the studied samples comply with the organoleptic requirements - turbidity, color, odor, taste, transparency, and column color - established by SanPiN 2.1.4.559-96 “Drinking Water.” Hygienic requirements for the quality of drinking water in centralized drinking water supply systems. Quality control."

The results of testing the salt composition of domestic drinking water samples show that the samples contain chlorides in the range of 29.35-35.75 mg/l (standard 350 mg/l); nitrates – 5.0-5.7 mg/l (standard 45); nitrites – 2.7-3.0 mg/l (standard 3.3).

The physical and chemical parameters of the water (total mineralization, hardness, oxidizability, chloride, nitrate, nitrite, aluminum, chromium, and nickel content) comply with established standards, with the exception of a slight excess of chromium (0.8 mg/l), which requires periodic monitoring. The oxidizability of water in acidic and alkaline environments ranged from 3.2 to 5.2 mg O_2 /l, which is within sanitary standards.

The content of heavy metals (mercury, lead, cadmium, arsenic) does not exceed permissible concentrations, which confirms the safety of water in terms of toxic parameters.

The content of heavy elements in drinking water is mercury 0.0002 mg/l (standard 0.0005), lead 0.009 (standard 0.1-0.3 mg/l); cadmium 0.0003 (standard 0.001 mg/l); arsenic 0.001 (standard 0.05 mg/l).

The physiological adequacy of drinking water meets regulatory requirements.

Microbiological indicators (Total viable count (TVC), Total coliform bacteria, *Pseudomonas aeruginosa*) are also within regulatory limits, which indicates the high sanitary safety of drinking water for the population.

Thus, the results of a comprehensive study confirm that drinking water in the Almalinsky district meets sanitary and hygienic requirements and can be used for domestic and drinking purposes without additional treatment.

6. Supplementary Materials: no supplementary materials.

7. Author Contributions

Conceptualization – G.B., M.S., S.A.; methodology – Zh.Sh.; investigation – G.B., S.A.; resources – Zh.A., Zh.Sh.; data curation – G.B., M.S.; writing - original draft preparation – S.A., Zh.Sh.; writing - review and editing – G.B., S.A., M.S.; visualization – Zh.A.; supervision – M.S.

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Алматы қаласының Алмалы ауданындағы тұрмыстық және ауыз судың сапасы мен қауіпсіздігін кешенді бағалау

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Аңдатпа. Бұл зерттеу Алматы қаласының Алмалы ауданының үй шаруашылықтарындағы және орталықтандырылған сумен жабдықтау жүйесіндегі ауыз су сапасын кешенді бағалаудың нәтижелерін ұсынады. Негізгі мақсат органолептикалық, физика-химиялық, токсикологиялық және микробиологиялық параметрлерді бірыңғай аналитикалық шеңберде біріктіру арқылы ауыз судың қауіпсіздігі мен сапасын кешенді көппараметрлі бағалауды жүргізу болды. Органолептикалық сипаттамалары қолданыстағы санитарлық стандарттарға сәйкес анықталды. Жалпы минералдануы, қаттылығы, хлорид, нитрат және нитрит мөлшері, сілтілігі, pH және перманганаттың тотығу қабілеті сияқты физикалық-химиялық параметрлер гравиметриялық, титриметриялық және комплексометриялық әдістерді қолдану арқылы талданды. Токсикологиялық параметрлер қышқыл минералданғаннан кейін атомдық абсорбциялық спектрометрия арқылы анықталды. Микробиологиялық қауіпсіздік жалпы тіршілік ету санын және индикаторлық организмдердің (*Escherichia coli*, жалпы колиформ бактериялары және *Pseudomonas aeruginosa*) болуын анықтау арқылы бағаланды. Нәтижелер көптеген параметрлер белгіленген санитарлық-гигиеналық стандарттарға сәйкес келетінін көрсетті. Хлоридтердің (29,35–35,75 мг/л), нитраттардың (5,0–5,7 мг/л) және нитриттердің (2,7–3,0 мг/л) концентрациясы рұқсат етілген ең жоғары деңгейден айтарлықтай төмен болды. Ауыр металдардың концентрациясы белгіленген стандарттар шегінде болды. Судың тотығу қабілеті 3,2-ден 5,2 мг O_2 /л-ге дейін болды, бұл тотығатын органикалық заттардың төмен

құрамын көрсетеді. Хромның жоғары концентрациясы (0,8 мг/л) анықталды, бұл рұқсат етілген мәндерден сәл асып түсті және мерзімді бақылауды қажет етеді.
Жалпы алғанда, кешенді бағалау Алмалы ауданындағы ауыз судың қанағаттанарлық физика-химиялық және микробиологиялық сапасымен сипатталатынын және қосымша өңдеусіз тұрмыстық және ауыз суға жарамды екенін растайды.

Түйін сөздер: тұрмыстық-ауыз су; судың сапасы; санитарлық-гигиеналық көрсеткіштер; тотығуы; судың кермектілігі; ауыр металдар; микробиологиялық қауіпсіздік.

Комплексная оценка качества и безопасности хозяйственно-питьевой воды Алмалинского района г. Алматы

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Аннотация. В данном исследовании представлена комплексная оценка качества питьевой воды в домохозяйствах и в централизованной системе водоснабжения Алмалинского района Алматы. Основная цель заключалась в проведении интегрированной многопараметрической оценки безопасности и качества питьевой воды путем объединения органолептических, физико-химических, токсикологических и микробиологических показателей в рамках единой аналитической структуры. Органолептические характеристики определялись в соответствии с действующими санитарными нормами. Физико-химические параметры, включая общую минерализацию, жесткость, содержание хлоридов, нитратов и нитритов, щелочность, pH и перманганатную окислительную способность, анализировались гравиметрическим, титриметрическим и комплексометрическим методами. Токсикологические показатели определялись методом атомно-абсорбционной спектрометрии после кислотной минерализации. Микробиологическая безопасность оценивалась путем определения общего количества жизнеспособных микроорганизмов и наличия индикаторных организмов (*Escherichia coli*, общие колиформные бактерии и *Pseudomonas aeruginosa*). Результаты показали соответствие большинства параметров установленным санитарно-гигиеническим нормам. Концентрации хлоридов (29,35–35,75 мг/л), нитратов (5,0–5,7 мг/л) и нитритов (2,7–3,0 мг/л) были значительно ниже максимально допустимых уровней. Концентрации тяжелых металлов находились в пределах установленных норм. Окисляемость воды составляла от 3,2 до 5,2 мг O_2 /л, что указывает на низкое содержание окисляемых органических веществ. Была выявлена повышенная концентрация хрома (0,8 мг/л), незначительно превышающая допустимые значения и требующая периодического мониторинга. В целом, комплексная оценка подтверждает, что питьевая вода в Алмалинском районе характеризуется удовлетворительным физико-химическим и микробиологическим качеством и пригодна для бытового и питьевого использования без дополнительной обработки.

Ключевые слова: хозяйственно-питьевая вода; качество воды; санитарно-гигиенические показатели; окисляемость; жесткость; тяжелые металлы; микробиологическая безопасность.