HYGIENIC FEATURES OF THE QUALITY OF DRINKING WATER FROM THE REGIONAL CENTER CENTRALIZED WATER SUPPLY SYSTEM BASED ON ORGANOLEPTIC INDICATORS

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Drinking water occupies one of the leading places among environmental factors responsible for shaping public health, so providing sanitary-and-epidemiologic wellbeing of the population cannot be considered separately from solving the hygienic problem of water supply. The study aimed to provide comparative hygienic characteristics of the quality of drinking water from the Ryazan centralized water supply system based on organoleptic indicators. Comparative assessment of the quality of drinking water was performed based on the analysis of the data of the years of research for the years 2017–2022. We performed analysis of the long-term average annual values of odor at 20 °C and 60 °C, taste, color and turbidity, share of samples non-compliant with the hygienic standards, over time. Inidicators were also assessed based on the season of the year and territorial belonging. The average indicator values were compared using analysis of variance; pairwise comparison involved the use of the Scheffe and Tamhane tests considering the Levene's test results. Confidence intervals of the relative indicators were determined based on the Wilson score. The long-term average annual values of organoleptic indicators of the quality of drinking water in Ryazan are compliant with SanPiN 1.2.3685-21. A small number of samples had odor, taste, and color exceeding the hygienic standards. Turbidity that was non-compliant with the hygienic requirements in 2.2% of samples and reached the maximum value of 16.4 mg/L (kaolin) should be considered the most challenging indicator of the quality of test drinking water.

Keywords: drinking water, centralized water supply, water quality, organoleptic indicators, regional center

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ГИГИЕНИЧЕСКИЕ ОСОБЕННОСТИ КАЧЕСТВА ПИТЬЕВОЙ ВОДЫ ЦЕНТРАЛИЗОВАННОЙ СИСТЕМЫ ВОДОСНАБЖЕНИЯ ОБЛАСТНОГО ЦЕНТРА ПО ОРГАНОЛЕПТИЧЕСКИМ ПОКАЗАТЕЛЯМ

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Питьевая вода занимает одно из главных мест среди факторов окружающей среды, ответственных за формирование здоровья населения, поэтому обеспечение санитарно-эпидемиологического благополучия населения невозможно рассматривать в отрыве от решения гигиенической проблемы водоснабжения. Целью исследования было дать сравнительную гигиеническую характеристику качества питьевой воды централизованной системы водоснабжения г. Рязани по органолептическим показателям. Сравнительная оценка качества питьевой воды проведена на основании анализа данных многолетних исследований за 2017–2022 гг. Выполнен анализ средних многолетних значений запаха при 20 °C и 60 °C, привкуса, цветности и мутности, удельного веса проб, не соответствующих гигиеническим нормативам, в динамике. Показатели также анализировали в зависимости от сезона года и территориальной принадлежности. Средние значения показателей сравнивали методом дисперсионного анализа, для парных сравнений использовали критерии Шеффе и Тамхейна с учетом результатов теста Ливиня. Доверительные интервалы относительных показателей определяли по методу Уилсона. Средние многолетние значения органолептических показателей качества питьевой воды в г. Рязани соответствовали требованиям СанПиН 1.2.3685-21. Незначительное количество проб имело запах, привкус и цветность, превышающие гигиеническую норму. Наиболее проблемным показателем качества исследуемой питьевой воды следует считать мутность, которая не соответствовала гигиеническим требованиям в 2,2% проб и достигала максимального значения 16,4 мг/л по каолину.

Ключевые слова: питьевая вода, централизованное водоснабжение, качество воды, органолептические показатели, областной центр

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Drinking water occupies one of the leading places among environmental factors responsible for shaping public health. Support of sustainable development of the State and providing sanitary-and-epidemiologic wellbeing of the population cannot be considered separately from solving the hygienic problem of water supply [1–3]. Furthermore, the drinking water organoleptic properties are sensitive markers of its quality that largely determine consumer satisfaction. Organoleptic properties can worsen due to anthropogenic pollution of water supply sources or due to natural processes related to water stagnation and blooming, as well as to eutrophication of water bodies [4]. Water treatment effectiveness and stability have a significant impact on the drinking water organoleptic properties [4, 5]. Secondary deterioration of the quality of drinking water in the water supply system is possible resulting from the reduced water demand and stagnation, increased wear of the aqueduct, high accident rate, and inadequate hygiene in the sanitary protection areas [6, 7].

High rate of the drinking water organoleptic property deterioration suggests poor reliability of the water supply system and poses considerable public health risk [8, 9]. According to a number of authors, the use of water non-compliant with the hygienic standards based on turbidity for water supply increases the risk of viral intestinal infections [10], and the aluminum ion content higher than permissible increases the risk of the central nervous system disorders [11, 12]. The increased drinking water color resulting from high iron ion (2^+) content is considered to be a risk factor of the disorders of gastrointestinal mucosa, skin, blood, immune system [8, 9].

Despite close attention of hygienists to the issue of water supply, the region-specific hygienic features of the drinking water quality are still poorly understood. Thus, the most recent research on the issue in Ryazan was conducted more than 30 years ago. Considering the importance of the problem, the study seems to be timely and relevant [13].

The study aimed to provide comparative hygienic characteristics of the quality of drinking water from the Ryazan centralized water supply system based on organoleptic indicators.

METHODS

The study was conducted in Ryazan, the center of the Ryazan Region. As for February 1, 2023, the population of the regional center was 539,000 people. Surface water of the Oka River and artesian water of the Podolsko-Myachkovsky, Kashirsky, and Oksko-Protvinsky coal system aquifers is used for water supply to the population [3]. In the overall water balance of the centralized water supply system, slight predominance of surface water (62%) was reported, except for water supply networks of the Solotcha and Stroitel area, supplied mainly by artesian water. The urban ring water distribution system consists of 143.9 km of water mains, 285.5 km of street water network, and 428.9 km of yard water distributions [3]. The average wear of water supply systems is 74% [14].

We performed analysis of organoleptic indicators of the drinking water quality (odor at 20 °C and 60 °C, taste, color, and turbidity) in control points of the Ryazan water distribution system for the years 2017–2022 based on the data provided by the sanitary and hygienic laboratory of the Center for Hygiene and Epidemiology in the Ryazan Region. A total of 3440 drinking water samples were analyzed. We calculated average values and their confidence intervals, as well as the percentage of samples non-complint with SanPiN 1.2.3685-21 [15] in certain years of the studied period, depending on the season of the year and territorial belonging.

The average indicator values were compared by analysis of variance (ANOVA) based on Fisher's exact test (F); pairwise comparison involved the use of the Scheffe and Tamhane tests considering the Levene's test results. Confidence intervals of the relative indicators were determined using the Wilson score [16]. Statistics were calculated in SPSS Statistics 19 (IBM; USA) with the target significance level set as $p < 0.05$.

RESULTS

The long-term average annual values of organoleptic indicators of the quality of drinking water in Ryazan were compliant with SanPiN 1.2.3685-21 (Table 1). However, certain values of odor at 20 °C, 60 °C and taste exceeded the hygienic standard and reached 3 points; the percentage of such samples was 0.5%, 0.9%, and 0.1%, respectively. Water color in control points of water distribution system was above normal only in 0.03% of samples. At the same time, turbidity did not meet hygienic requirements in 2.2% of samples and reached the maximum value of 16.4 mg/L (kaolin).

It should be noted that in 2018 the average values of the drinking water odor (at 20 °C/60 °C) and taste that were 0.70 ± 0.05/0.67 ± 0.06 points and 0.68 ± 0.06 points, respectively, were 1.9–2.3 times lower, than in other years ($p < 0.05$). At the same time, the highest average color and turbidity values reported in 2017 were 7.25 ± 0.07º and 0.95 mg/L, respectively, and were significantly higher, than in other years of the studied period ($p < 0.05$).

The average values of all organoleptic indicators for the studied years were compliant with SanPiN 1.2.3685-21, but in 2020 the odor (at 20 °C and 60 °C) and taste values non-compliant with the hygienic standards were reported for some points of water distribution system: in 3.5%, 6.3%, and 0.7% of samples, respectively. In 2022, the color of 0.5% of dtinking water samples was non-compliant with the hygienic standard. At the same time, the drinking water samples non-compliant with SanPiN 1.2.3685-21 based on turbidity were reported annually, and the largest share (3.0%) was reported in 2019, while the smallest was reported in 2021 (1.1%).

During the studied period the average seasonal values of all organoleptic indicators were compliant with the hygienic standards (Table 2). We revealed a considerable effect of the season on the average seasonal values of organoleptic indicators; the highest values of all organoleptic indicators were typical for winter, while the lowest values were reported for various seasons: odor and taste for summer, color for spring ($p < 0.001$), turbidity for fall ($p = 0.009$).

Drinking water samples, the odor and taste of which were non-compliant with hygienic standards, were reported in winter and spring only (Fig. 1), and in winter the percentage of those was 2.4% and 0.2%, respectively, which considerably exceeded the values reported for spring. It should be noted that the above-level drinking water color was reported in summer only in 0.1% of samples, while increased turbidity was found in all seasons of the year. Deterioration of drinking water quality based on turbidity was most often found in winter (in 3.5% of samples) and least often in spring and summer (in 1.8% of samples).

In control points of municipal water mains of the residential areas Solotcha, Dyagilevo, and Moskovsky, the long-term average annual values of odor did not exceed 1 point, while in other areas the values were significantly higher, within

Table 1. Organoleptic indicators of the quality of drinking water from the Ryazan centralized water supply system, on average for the years 2017–2022

Indicator	Units	Number of samples	Average ± 95% CI	Maximum value (characteristic)	Standard	% of samples above the hygienic standard
Odor (20 °C)	points	3408	1.35 ± 0.03	3.00 (fish)	2	0.5
Odor (60 °C)	points	3408	1.24 ± 0.03	3.00 (fish)	2	0.9
Taste	points	3407	1.29 ± 0.03	3.00 (fish)	2	0.1
Color	cs*	3407	6.56 ± 0.07	23	20	0.03
Turbidity	mg/L (kaolin)	3406	0.84 ± 0.02	16.4	1.5	2.2

Note: *cs — cobalt scale.

Table 2. Organoleptic indicators of the quality of drinking water from the Ryazan centralized water supply system, on average for seasons of the years 2017–2022

Indicator	Units	Winter	Spring	Summer	Fall	Fischer's exact test (*F*)	*P*
Odor (20 °C)	points	1.62 ± 0.07	1.32 ± 0.04	1.17 ± 0.06	1.40 ± 0.06	32.47	< 0.001
Odor (60 °C)	points	1.52 ± 0.08	1.23 ± 0.05	1.02 ± 0.07	1.27 ± 0.07	30.33	< 0.001
Taste	points	1.56 ± 0.07	1.27 ± 0.05	1.08 ± 0.06	1.35 ± 0.07	33.88	< 0.001
Color	cs*	7.00 ± 0.16	6.44 ± 0.10	6.47 ± 0.15	6.57 ± 0.15	11.84	< 0.001
Turbidity	mg/L (kaolin)	0.92 ± 0.05	0.83 ± 0.03	0.85 ± 0.04	0.82 ± 0.04	3.89	0.009

Note: *cs — cobalt scale.

the range of 1.17–1.48 points (Table 3; $p < 0.05$). The drinking water samples non-compliant with SanPiN 1.2.3685-21 based on odor at 20 °C were reported only for the residential areas Oktyabrsky, Sovetsky, and Dashkovo-Pesochnya, and the percentage of those in the total number of tests was 0.23%, 0.87%, and 1.24%, respectively. Assessment of odor at 60 °C revealed high percentage of non-standard samples in a larger number of urban areas. In Dashkovo-Pesochnya, the share of such samples was the highest 1.98%, which was followed (in a descending order) by the residential areas Sovetsky (1.22%), Kanishhevo (0.75%), Oktyabrsky (0.45%), and Zheleznodorozhny (0.37%).

Distibution of the Ryazan areas based on the average drinking water taste values showed the same features, as the distribution by odor. Furthermore, in Solotcha, Moskovsky, and Dyagilevo the average values were within the range of 0.77–0.92 points are were significantly lower, than in other areas (1.25–1.43 points) ($p < 0.05$). It should be noted that the drinking water samples, the taste of which was non-compliant with the hygienic standard, were found in the Sovetsky area and Dashkovo-Pesochnya, and the percentage of such samples was 0.17% and 0.25%, respectively.

The long-term average annual values of the drinking water color and turbidity did not exceed the hygienic standard in certain areas of Ryazan (Table 4). Furthermore, the values of the above indicators in Solotcha were significantly higher, than in the majority of the territories compared, except for the Stroitel area. These were 7.39 ± 0.49° and 1.34 ± 0.14 mg/L, respectively ($p < 0.05$). In the Stroitel area, the average drinking water turbidity was 1.01 ± 0.11 mg/L, it was 1.3 times lower, than in Solotcha, and 1.2–1.3 times higher, than in the majority of other areas ($p < 0.05$).

In the studied period the above-normal drinking water color indicators were found in the Solotcha area only (in 1.56% of samples). The largest share of water samples non-compliant with SanPiN 1.2.3685-21, the turbidity of which was 10.94% and twice exceeded the value for the Stroitel area, was typical for the same area, while in other urban territories it was between 0.75% (Kanishhevo) and 3.23% (Dyagilevo).

DISCUSSION

Based on the fact that in the 6-year period considered deterioration of the quality of drinking water from the centralized water supply system were reported only in 2020, it can be due to certain combination of factors. Such factors can include baseline water quality deterioration in the water supply source resulting from rapid production of phytoplankton in the warm period and subsequent phytoplankton mass die-off in winter [17, 18]. This suggestion is supported by predominant deterioration of the drinking water quality in winter, along with the largest share of samples non-compliant with the hygienic standards in Dashkovo-Pesochnya and Sovetsky area receiving water mainly from the Oka water supply inlet located in the Dyatkovsky backwater prone to eutrophication [19]. Certain contribution to deterioration of the drinking water organoleptic properties can be made by the decreased effectiveness of water treatment under these conditions [19]. Furthermore, secondary deterioration of water quality in the water supply system due to pronounced wear of water distribution networks and accidents cannot be ruled out [20]. The latter assumption largely explains regular registration of drinking water samples, the turbidity of which is non-compliant

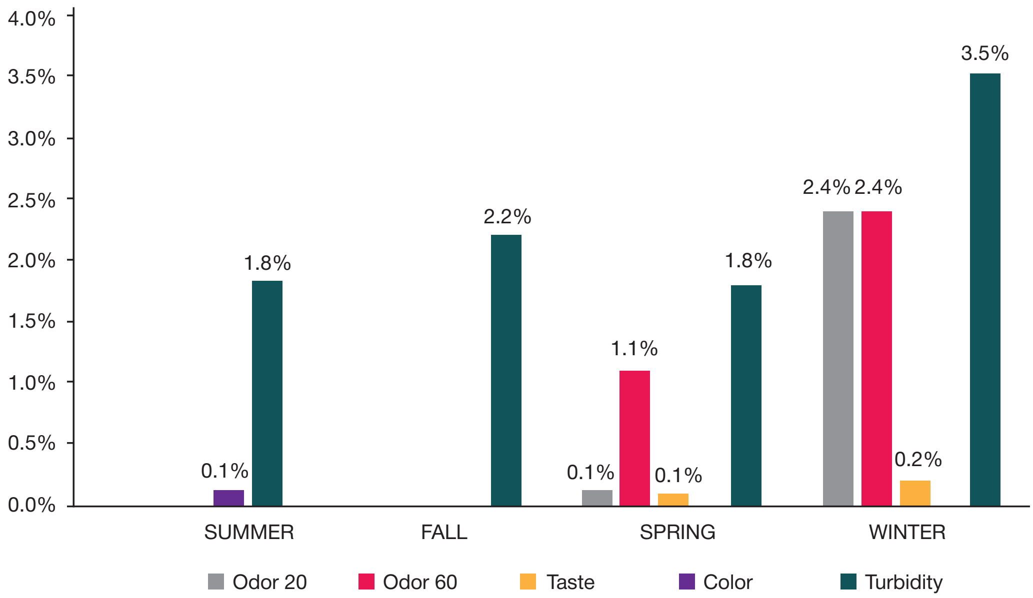

Fig. Rate of organoleptic indicator non-compliance with hygienic standards for drinking water samples by seasons of the year (%)

Table 3. Odor of drinking water from the centralized water supply system in certain areas of Ryazan, on average for the years 2017–2022

Area	Number of observations, 20 °C	Average value, points		Samples > MPC, % [95% CI]	
		20 °C	60 °C	20 °C	60 °C
Solotcha	65	0.85 ± 0.20	0.68 ± 0.23	0	0
Kanishhevo	398	1.33 ± 0.08	1.20 ± 0.09	0	0.75 [0.26–2.19]
Oktyabrsky	443	1.40 ± 0.08	1.24 ± 0.09	0.23 [0.04–1.24]	0.45 [0.12–1.63]
Dyagilevo	93	0.86 ± 0.17	0.67 ± 0.19	0	0
Moskovsky	237	1.00 ± 0.11	0.82 ± 0.12	0	0
Dashkovo-Pesochnya	404	1.41 ± 0.08	1.32 ± 0.09	1.24 [0.53–2.86]	1.98 [1.01–3.86]
Zheleznodorozhny	538	1.35 ± 0.07	1.24 ± 0.08	0	0.37 [0.10–1.35]
Sovetsky	1147	1.48 ± 0.05	1.41 ± 0.05	0.87 [0.47–1.60]	1.22 [0.73–2.04]
Stroitel	115	1.30 ± 0.15	1.17 ± 0.17	0	undefined

Table 4. Color and turbidity of drinking water from the centralized water supply system in certain areas of Ryazan, on average for the years 2017–2022

Area	Number of observations, 20 °C	Average value, points		Samples > MPC, % [95% CI]	
		Color, °	Turbidity, mg/L	Color, °	Turbidity, mg/L
Solotcha	64	7.39 ± 0.49	1.34 ± 0.14	1.56 [0.28–8.33]	10.94 [5.40–20.90]
Kanishhevo	398	6.56 ± 0.20	0.79 ± 0.06	0	0.75 [0.26–2.19]
Oktyabrsky	443	6.52 ± 0.19	0.83 ± 0.05	0	2.26 [1.23–4.10]
Dyagilevo	93	6.39 ± 0.41	0.82 ± 0.12	0	3.23 [1.10–9.06]
Moskovsky	236	6.28 ± 0.26	0.82 ± 0.12	0	3.81 [2.02–7.09]
Dashkovo-Pesochnya	404	6.38 ± 0.20	0.86 ± 0.06	0	1.24 [0.53–2.86]
Zheleznodorozhny	538	6.60 ± 0.17	0.83 ± 0.05	0	2.60 [1.56–4.32]
Sovetsky	1147	6.64 ± 0.12	0.84 ± 0.03	0	1.48 [0.93–2.36]
Stroitel	115	6.81 ± 0.37	1.01 ± 0.11	0	5.22 [2.41–10.92]

with the hygienic standard. At the same time, predominance of such samples in the residential areas Solotcha and Stroitel can result from the features of the water supply system, where artesian water predominates that is characterized by high content of hardness salts and iron (2^{+}) [20]. The excess increase in the drinking water color in Solotcha in summer was one-time; it could also result from high iron content or malfunction of the iron removal station [20].

CONCLUSIONS

The long-term average annual values of the drinking water quality organoleptic indicators in Ryazan were compliant with SanPiN 1.2.3685-21. However, a small number of samples had odor, taste, and color exceeding the hygienic standard.

Turbidity, which did not meet hygienic requirements in 2.2% of samples and reached the maximum value of 16.4 mg/L (kaolin), should be considered the most challenging indicator of the tested drinking water quality.

With relatively stable quality of drinking water, in 2020, at certain points in the water distribution network, odor (at 20 °C and 60 °C) and taste indicators were recorded that did not meet hygienic standards: in 3.5%, 6.3%, and 0.7% of samples, respectively.

Water samples with excess turbidity were reported in all areas of the city, most often in Solotcha and Stroitel (in 10.94% and 5.43% of samples, respectively), which was associated with additional supply of artesian water to the centralized water supply system. The excess increase in the drinking water color was one-time and could result from random factors.

References

1. Gorbanev SA, Eremin GB, Novikova JuA, Vyuchejskaja DS. Federal'nyj proekt "Chistaja voda". Pervye itogi. Zdorov'e — osnova chelovecheskogo potenciala: problemy i puti ih reshenija. 2019; 14 (1): 252–9 (in Rus.).
2. Valeev TK, Sulejmanov RA, Bakirov AB, Rahmatullin NR, Rahmatullina LR, Baktybaeva ZB, et al. FBUN "Ufimskij NII mediciny truda i jekologii cheloveka" v realizacii federal'nyh proektov "Chistaja voda" i "Chistyj vozduh" v Respublike Bashkortostan. Medicina truda i jekologija cheloveka. 2021; (4): 231–48 (in Rus.).
3. Litvinova AA, Dementev AA, Curgan AM, Korshunova EP, Bulycheva GN. Sravnitel'naja gigienicheskaja ocenka kachestvennogo sostava pit'evoj vody centralizovannoj sistemy vodosnabzhenija v otdel'nyh rajonah g. Rjazani. Nauka molodyh (Eruditio Juvenium). 2023; 11 (4): 505–18 (in Rus.). DOI: 10.23888/HMJ2023114505-518.
4. Hecuriani ED, Hecuriani TE, Chaplygina EV, Zhukova TV. Znachenie organolepticheskih pokazatelej pit'evoj vody Rostovskoj oblasti kak faktorov jepidemicheskoj bezopasnosti zdorov'ja naselenija. Biosfernaja sovmestimost': chelovek, region, tehnologii. 2019; 2 (26): 24–34 (in Rus.).
5. Skrjabin AJu, Popovjan GV, Tron IA. Mikrovodorosli kak faktor, vlijajushhij na organolepticheskie svojstva vody reki Don. Vodosnabzhenie i sanitarnaja tehnika. 2015; (8): 38–41 (in Rus.).
6. Prodous OA, Shlychkov DI, Spicov DV. Predotvrashhenie vtorichnogo zagrjaznenija pit'evoj vody v metallicheskih setjah vodosnabzhenija. Stroitel'stvo: nauka i obrazovanie. 2022; 12 (2): 62–71 (in Rus.). DOI: 10.22227/2305-5502.2022.2.5.
7. Vozhdaeva MJu, Holova AR, Truhanova NV, Melnickij IA, Kantor EA, Belolipcev II. Ocenka izmenchivosti himicheskogo sostava

pit'evoj vody, transportiruemoj po vodoraspredelitel'nym setjam. Vodosnabzhenie i sanitarnaja tehnika. 2020; (6): 4–13 (in Rus.). DOI: 10.35776/MNP.2020.06.01.
8. Klejn SV, Vekovshinina SA. Prioritetnye faktory riska pit'evoj vody sistem centralizovannogo pit'evogo vodosnabzhenija, formirujushhie negativnye tendencii v sostojanii zdorov'ja naselenija. Analiz riska zdorov'ju. 2020; (3): 49–60 (in Rus.). DOI: 10.21668/health.risk/2020.3.06.
9. Bogdanova VD, Kiku PF, Kislicyna LV. Gigienicheskaja ocenka pit'evoj vody iz podzemnyh istochnikov centralizovannyh sistem vodosnabzhenija ostrova Russkij. Analiz riska zdorov'ju. 2020; (2): 28–37 (in Rus.). DOI: 10.21668/health.risk/2020.2.03.
10. Ajdinov GT, Solovev MJu, Zykova TA, Govoruhina MV, Miheeva IV, Gordeev-Gavrikov VK, et al. Snizhenie mutnosti pit'evoj vody kak faktor povyshenija bar'ernoj roli vodoochistnyh sooruzhenij po otnosheniju virusnyh zagrjaznenij. Gigiena i sanitarija. 2005; (3): 55–7 (in Rus.).
11. Zemljanova MA, Koldibekova JuV. Izmenenija biohimicheskih pokazatelej nejroperedachi u detej s povyshennoj koncentraciej aljuminija v moche. Vestnik Permskogo universiteta. Ser. Biologija. 2018; (3): 308–12 (in Rus.). DOI: 10.17072/1994-9952-2018-3-308-312.
12. Zhdanova-Zaplesvichko IG, Zemljanova MA, Koldibekova JuV. Biomarkery nekancerogennyh negativnyh jeffektov so storony central'noj nervnoj sistemy u detej v zone vlijanija istochnikov vybrosov aljuminievogo proizvodstva. Gigiena i sanitarija. 2018; 97 (5): 461–9 (in Rus.). DOI: 10.18821/0016-9900-2018-97-5-461-469.
13. Zajceva NV, Sboev AS, Klejn SV, Vekovshinina SA. Kachestvo pit'evoj vody: faktory riska dlja zdorov'ja naselenija i jeffektivnost' kontrol'no-nadzornoj dejatel'nosti Rospotrebnadzora. Analiz riska zdorov'ju. 2019; (2): 44–55 (in Rus.). DOI: 10.21668/health.risk/2019.2.05.
14. Prikaz Glavnogo upravlenija "Regional'noj jenergeticheskoj komissii" Rjazanskoj oblasti ot 29 nojabrja 2018 goda № 9-ip "O vnesenii izmenenija v prikaz GU RJeK Rjazanskoj oblasti ot 25 nojabrja 2016 g. № 2-ip "Ob utverzhdenii investicionnoj programmy municipal'nogo predprijatija "Vodokanal goroda Rjazani" v sfere holodnogo vodosnabzhenija i vodootvedenija goroda Rjazani na period s 01.01.2017 po 31.12.2019" (in Rus.). URL: https://docs.cntd.ru/document/550253907.
15. SanPiN 2.1.3684-21 "Sanitarno-epidemiologicheskie trebovaniya k soderzhaniyu territorij gorodskih i sel'skih poselenij, k vodnym ob"ektam, pit'evoj vode i pit'evomu vodosnabzheniyu, atmosfernomu vozduhu, pochvam, zhilym pomeshcheniyam, ekspluatacii proizvodstvennyh, obshchestvennyh pomeshchenij, organizacii i provedeniyu sanitarno-protivoepidemicheskih (profilakticheskih) meropriyatij". (In Rus.).
16. Govorova ZhM, Govorov OB. Vlijanie fitoplanktona na formirovanie kachestva vody i metody ego udalenija. Chast' 1. Santehnika, otoplenie, kondicionirovanie. 2019; 2 (206): 32–5 (in Rus.).
17. Anciferova GA, Shevyrev SL, Kulnev VV, Rusova NI, Galkina ES. Jekologo-sanitarnoe sostojanie Voronezhskogo vodohranilishha v uslovijah «cvetenija» vod po materialam 2016–2022 godov. Izvestija Saratovskogo universiteta. Novaja serija. Serija: Nauki o Zemle. 2023; 23 (3); 147–54 (in Rus.). DOI: 10.18500/1819-7663-2023-23-3-147-154.
18. Litvinova AA, Dementev AA, Ljapkalo AA, Korshunova EP. Sravnitel'naja harakteristika pokazatelej kachestva vody reki Oki v mestah vodozaborov hozjajstvenno-pit'evoj sistemy vodosnabzhenija goroda Rjazani. Rossijskij mediko-biologicheskij vestnik imeni akademika I. P. Pavlova. 2022; 30 (4): 481–8 (in Rus.). DOI: 10.17816/PAVLOVJ89568.
19. Lonzinger TM, Brjuhov MN, Ulrih DV, Denisov SE. Optimizacija processa ochistki pit'evoj vody v period cvetenija. Vestnik Inzhenernoj shkoly Dal'nevostochnogo federal'nogo universiteta. 2023; 2 (55): 64–72 (in Rus.). DOI: https://doi.org/10.24866/2227-6858/2023-2/64-72.
20. Spravka o sostojanii i perspektivah ispol'zovanija mineral'no-syr'evoj bazy Rjazanskoj oblasti na 15.03.2021. [Internet]. Jan 2021. (In Rus.) URL: https://www.rosnedra.gov.ru/data/Fast/Files/202104/7626d1ecc0aa452bd9c3e63c6face5f0.pdf.

Литература

1. Горбанев С. А., Еремин Г. Б., Новикова Ю. А., Выучейская Д. С. Федеральный проект «Чистая вода». Первые итоги. Здоровье — основа человеческого потенциала: проблемы и пути их решения. 2019; 14 (1): 252–9.
2. Валеев Т. К., Сулейманов Р. А., Бакиров А. Б., Рахматуллин Н. Р., Рахматуллина Л. Р., Бактыбаева З. Б. и др. ФБУН «Уфимский НИИ медицины труда и экологии человека» в реализации федеральных проектов «Чистая вода» и «Чистый воздух» в Республике Башкортостан. Медицина труда и экология человека. 2021; (4): 231–48.
3. Литвинова А. А., Дементьев А. А., Цурган А. М., Коршунова Е. П., Булычева Г. Н. Сравнительная гигиеническая оценка качественного состава питьевой воды централизованной системы водоснабжения в отдельных районах г. Рязани. Наука молодых (Eruditio Juvenium). 2023; 11 (4): 505–18. DOI: 10.23888/HMJ2023114505-518.
4. Хецуриани Е. Д., Хецуриани Т. Е., Чаплыгина Е. В., Жукова Т. В. Значение органолептических показателей питьевой воды Ростовской области как факторов эпидемической безопасности здоровья населения. Биосферная совместимость: человек, регион, технологии. 2019; 2 (26): 24–34.
5. Скрябин А. Ю., Поповьян Г. В., Тронь И. А. Микроводоросли как фактор, влияющий на органолептические свойства воды реки Дон. Водоснабжение и санитарная техника. 2015; (8): 38–41.
6. Продоус О. А., Шлычков Д. И., Спицов Д. В. Предотвращение вторичного загрязнения питьевой воды в металлических сетях водоснабжения. Строительство: наука и образование. 2022; 12 (2): 62–71. DOI: 10.22227/2305-5502.2022.2.5.
7. Вождаева М. Ю., Холова А. Р., Труханова Н. В., Мельницкий И. А., Кантор Е. А., Белолипцев И. И. Оценка изменчивости химического состава питьевой воды, транспортируемой по водораспределительным сетям. Водоснабжение и санитарная техника. 2020; (6): 4–13. DOI: 10.35776/MNP.2020.06.01.
8. Клейн С. В., Вековшинина С. А. Приоритетные факторы риска питьевой воды систем централизованного питьевого водоснабжения, формирующие негативные тенденции в состоянии здоровья населения. Анализ риска здоровью. 2020; (3): 49–60. DOI: 10.21668/health.risk/2020.3.06.
9. Богданова В. Д., Кику П. Ф., Кислицына Л. В. Гигиеническая оценка питьевой воды из подземных источников централизованных систем водоснабжения острова Русский. Анализ риска здоровью. 2020; (2): 28–37. DOI: 10.21668/health.risk/2020.2.03.
10. Айдинов Г. Т., Соловьев М. Ю., Зыкова Т. А., Говорухина М. В., Михеева И. В., Гордеев-Гавриков В. К. и др. Снижение мутности питьевой воды как фактор повышения барьерной роли водоочистных сооружений по отношению вирусных загрязнений. Гигиена и санитария. 2005; (3): 55–7.
11. Землянова М. А., Кольдибекова Ю. В. Изменения биохимических показателей нейропередачи у детей с повышенной концентрацией алюминия в моче. Вестник Пермского университета. Сер. Биология. 2018; (3): 308–12. DOI: 10.17072/1994-9952-2018-3-308-312.
12. Жданова-Заплесвичко И. Г., Землянова М. А., Кольдибекова Ю. В. Биомаркеры неканцерогенных негативных эффектов со стороны центральной нервной системы у детей в зоне влияния источников выбросов алюминиевого производства. Гигиена и санитария. 2018; 97 (5): 461–9. DOI: 10.18821/0016-9900-2018-97-5-461-469.
13. Зайцева Н. В., Сбоев А. С., Клейн С. В., Вековшинина С. А. Качество питьевой воды: факторы риска для здоровья населения и эффективность контрольно-надзорной деятельности Роспотребнадзора. Анализ риска здоровью. 2019; (2): 44–55. DOI: 10.21668/health.risk/2019.2.05.
14. Приказ Главного управления «Региональной энергетической комиссии» Рязанской области от 29 ноября 2018 года № 9-ип «О внесении изменения в приказ ГУ РЭК Рязанской области

от 25 ноября 2016 г. № 2-ип «Об утверждении инвестиционной программы муниципального предприятия «Водоканал города Рязани» в сфере холодного водоснабжения и водоотведения города Рязани на период с 01.01.2017 по 31.12.2019». URL: https://docs.cntd.ru/document/550253907.

15. СанПиН 2.1.3684-21 «Санитарно-эпидемиологические требования к содержанию территорий городских и сельских поселений, к водным объектам, питьевой воде и питьевому водоснабжению, атмосферному воздуху, почвам, жилым помещениям, эксплуатации производственных, общественных помещений, организации и проведению санитарно-противоэпидемических (профилактических) мероприятий».
16. Говорова Ж. М., Говоров О. Б. Влияние фитопланктона на формирование качества воды и методы его удаления. Часть 1. Сантехника, отопление, кондиционирование. 2019; 2 (206): 32–5.
17. Анциферова Г. А., Шевырев С. Л., Кульнев В. В., Русова Н. И., Галкина Е. С. Эколого-санитарное состояние Воронежского водохранилища в условиях «цветения» вод по материалам 2016–2022 годов. Известия Саратовского университета. Новая серия. Серия: Науки о Земле. 2023; 23 (3); 147–54. DOI: 10.18500/1819-7663-2023-23-3-147-154.
18. Литвинова А. А., Дементьев А. А., Ляпкало А. А., Коршунова Е. П. Сравнительная характеристика показателей качества воды реки Оки в местах водозаборов хозяйственно-питьевой системы водоснабжения города Рязани. Российский медико-биологический вестник имени академика И. П. Павлова. 2022; 30 (4): 481–8. DOI: 10.17816/PAVLOVJ89568.
19. Лонзингер Т. М., Брюхов М. Н., Ульрих Д. В., Денисов С. Е. Оптимизация процесса очистки питьевой воды в период цветения. Вестник Инженерной школы Дальневосточного федерального университета. 2023; 2 (55): 64–72. DOI: 10.24866/2227-6858/2023-2/64-72.
20. Справка о состоянии и перспективах использования минерально-сырьевой базы Рязанской области на 15.03.2021. [Интернет]. Январь 2021 г. URL: https://www.rosnedra.gov.ru/data/Fast/Files/202104/7626d1ecc0aa452bd9c3e63c6face5f0.pdf.