ASSESSING QUALITY OF DRINKING WATER SUPPLY IN DIFFERENT REGIONS OF THE RUSSIAN FEDERATION

Sazonova OV, Tupikova DS ✉, Ryazanova TK, Gavryushin MYu, Frolova OV, Trubetskaya SR

Samara State University, Samara, Russia

The main task of any country associated with sanitary and epidemiological welfare of population is to obtain drinking water of good quality. In the majority of regions of the Russian Federation, quality of water taken from water sources and water supply systems is still unsatisfactory. As far as the extent of human impact on the environment goes, the Samara region is an ecologically unfavorable part of the Volga region. With the accession of the Republic of Crimea to the Russian Federation, the problem of water supply here has been intensified and the question of whether the drinking water corresponds to Sanitary Rules and Regulations 2.1.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 arose. The purpose of the study is to analyze quality of drinking water supply in the regions of the Russian Federation. Drinking water samples taken from the centralized domestic water supply system in the Samara urban district and Republic of Crimea were analyzed using 20 sanitary and chemical parameters. Quality of drinking water doesn't correspond to the requirements for oil products in all samples; the average value of this parameter exceeded the maximum permissible limit by 0.18 mg/dm^3 in the Samara urban district and by 0.04 mg/dm^3 in the Republic of Crimea, all the other parameters were within normal limits. However, during the comparative analysis quality of drinking water in the Republic of Crimea was insignificantly better than in the Samara urban district. Quality of drinking water is determined with the source of drinking water supply (surface and underground). Thus, to make the prepared drinking water normal, a respective water treating is necessary. Bad condition of water supply pipes can also produce a negative impact on quality of water obtained by a consumer.

Keywords: drinking water, centralized water supply, municipal hygiene

Author contribution: Sazonova OV — academic advising; Tupikova DS, Gavryushin MYu — study initiation, data collection, processing of results; Ryazanova TK, Frolova OV — design, data collection; Trubetskaya SR — analysis of sources, preparation and correction of the article.

Compliance with ethical standards: the study was approved by the Ethics Committee of the Samara State University of the Ministry of Health of the Russian Federation (protocol No. 184 as of December 21, 2021). No voluntary informed consent for every participant (authorized representative) was required.

✉ **Correspondence should be addressed:** Daria S. Tupikova
ul. Gagarina, 18, Samara, 443079, Russia; d. s.tupikova@samsmu.ru

Received: 20.04.2022 **Accepted:** 23.05.2022 **Published online:** 30.06.2022

DOI: 10.24075/rbh.2022.043

К ОЦЕНКЕ КАЧЕСТВА ПИТЬЕВОГО ВОДОСНАБЖЕНИЯ РАЗЛИЧНЫХ РЕГИОНОВ РОССИЙСКОЙ ФЕДЕРАЦИИ

О. В. Сазонова, Д. С. Тупикова ✉, Т. К. Рязанова, М. Ю. Гаврюшин, О. В. Фролова, С. Р. Трубецкая

Самарский государственный университет, Самара, Россия

Качество питьевого водоснабжения является главной задачей государства по санитарно-эпидемиологическому благополучию населения. Качество воды из источников водоснабжения и в водопроводных сетях в большинстве регионов России продолжает оставаться неудовлетворительным. По степени антропогенного воздействия на окружающую среду Самарская область является одним из экологически неблагополучных районов Поволжья. После присоединения Республики Крым к территории Российской Федерации проблема водоснабжения на этой территории усилилась, а также встал вопрос о соответствии питьевой воды нормам СанПиНа 2.1.3685–21 и СанПиНа 2.1.3684–21. Цель исследования состоит в анализе качества питьевого водоснабжения регионов Российской Федерации. Были проанализированы пробы питьевого водоснабжения из централизованной хозяйственно-питьевой сети в г. о. Самара и Республике Крым по 20 санитарно-химическим показателям. Качество питьевой воды не соответствует требованиям по нефтепродуктам во всех пробах, среднее значение этого показателя в г. о. Самара превышало уровень ПДК на 0,18 мг/дм^3, а в Республике Крым на 0,04 мг/ дм^3, все остальные показатели находились в пределах нормы, но при сравнительном анализе качество питьевой воды в Республике Крым было незначительно лучше, чем в г. о. Самара. Качество питьевой воды определяется источником питьевого водоснабжения (поверхностным и подземным). Следовательно, для достижения нормативного состава приготовленной питьевой воды необходима соответствующая водоподготовка. На качество воды у потребителя отрицательное влияние может оказывать и неблагоприятное состояние труб распределительной сети.

Ключевые слова: питьевая вода, централизованное водоснабжение, коммунальная гигиена

Вклад авторов: О. В. Сазонова — научное руководство; Д. С. Тупикова, М. Ю. Гаврюшин — инициатор исследования, сбор материала, обработка результатов; Т. К. Рязанова, О. В. Фролова — дизайн, сбор материала; С. Р. Трубецкая — анализ источников, подготовка и правка статьи.

Соблюдение этических стандартов: исследование одобрено этическим комитетом ФГБОУ ВО СамГМУ Минздрава России (протокол № 184 от 21 декабря 2021 г.). Добровольное информированное согласие для каждого участника (его законного представителя) не требовалось.

✉ **Для корреспонденции:** Дарья Сергеевна Тупикова
ул. Гагарина, д. 18, г. Самара, 443079, Россия; d. s.tupikova@samsmu.ru

Статья поступила: 20.04.2022 **Статья принята к печати:** 23.05.2022 **Опубликована онлайн:** 30.06.2022

DOI: 10.24075/rbh.2022.043

The key purpose of any community is to create a favorable living environment so that people could live a long healthy life, and the country could ensure development of human potential. One of the most important constituents of the favorable living environment is sanitary and epidemiological well-being of people as a basis of national security. Nevertheless, the issue of environmental pollution and protection in the Russian Federation is still timely and relevant in the beginning of the

third millennium. Provision of population with drinking water of good quality is one of the main tasks of epidemiological welfare and prevention of population morbidity by the country [1, 2].

In accordance with sanitary and epidemiological requirements, drinking water should have epidemiological and radiological safety, harmless chemical composition and good organoleptic properties [3, 4]. According to some authors, quality of water that comes from water supply sources and networks in the majority of regions in the Russian Federation is still bad [5–7].

In 2014, the Russian Federation gained new territories due to accession of the Crimean Peninsula, which is of an important strategic and economic value. Owing to natural and geographical peculiarities, the peninsula had the shortest water supply as compared with other regions of Russia and the USSR. In the 60s of the last century, the North Crimean Canal was built to provide drylands of Crimea with water. Dnipro water from the Kakhovka reservoir was taken to the peninsula through the Canal that had poorly coped with the task for several decades. Following accession of Crimea to Russia, Ukraine blocked the Canal, and the question of fresh water became critically acute. In the present time, hydrotechnical constructions have been built. They took water from the Belogorsk and Taygan water reservoirs to the North Crimean Canal. Three water intake areas were also created in Nizhny Gorsk and Dzhankoi Districts.

According to the Agricultural Research Institute of Crimea, over 50% water sources in Crimea do not correspond to Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 [8].

The Samara region belongs to heavily industrial, densely-populated and urbanized regions of Russia. By the extent of human impact on the environment, the Samara region is one of environmentally unfriendly regions of the Volga River basin. Motor vehicles have been playing the leading role in the creation of ecological and hygienic situation in the Samara region over the last years, as exhaust gases from these vehicles account for 60–80% of all toxic atmospheric emissions here.

The Volga River and its tributaries, that account for more than 38.5% of the total intake from all water sources in the Russian Federation, experience a great anthropogenic impact. The Samara urban area has prerequisites for a tense ecological and hygienic environmental situation. It dictates the need for constant surveillance over sanitary and hygienic condition of environmental objects, including the centralized domestic water supply system [9–11].

The sanitary and hygienic well-being of drinking water can produce both favorable and unfavorable effects on people's health. Composition of drinking water influences the total health risk. Thus, drinking water quality should be monitored on a constant basis.

MATERIALS AND METHODS

Quality of drinking water from the centralized domestic water supply system in the Samara urban area and Republic of Crimea (hereinafter referred to as the RC) was analyzed.

The samples were taken in summer 2021. The studies were conducted using 20 sanitary and chemical parameters in accordance with Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21. The studies were conducted using sanitary and chemical parameters based on health and hygiene rules and standards. Water samples were drawn in summer 2020–2021. The primary data were collected and stored using Microsoft Excel 2013 (*Microsoft*, USA).

STUDY RESULTS

As shown in table, drinking water corresponds to the requirements of Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 by many sanitary and chemical parameters.

The content of oil products was higher than MPL in all tested samples from the Samara urban area and Republic of Crimea. This can be an indicator of non-qualitative water supply.

Table. Quality of drinking water supply in the Samara urban area and Republic of Crimea

Ser. No.	Identifiable value	Units of measurement	MPL (maximum permissible limit)	Outcomes	
				Samara urban district	Republic of Crimea
1	Odour	points	no more than 2	0	0
2	Turbidity	mg/l	1.5	0.55 ± 0.06	0.93 ± 0.17
3	Color	degrees	20	15.6 ± 3.4	11.9 ± 2.4
4	pH value	pH units	20	7.42 ± 0.2	7.8 ± 0.2
5	Total hardness	° of hardness	7.0	8.2 ± 0.7	6.7 ± 0.2
6	Dry residue	mg/dm^3	1000	695 ± 32	530 ± 48
7	Permanganate index (PI)	mg/dm^3	5.0	3.48 ± 0.46	0.76 ± 0.15
8	Oil products	mg/l	0,1	0.28 ± 0.08	0.14 ± 0.07
9	Sulphates	mg/dm^3	500	116 ± 5	137 ± 15
10	Chlorides	mg/dm^3	350	75 ± 4	94 ± 2
11	Ammonia and ammonium ions	mg/dm^3	1.5	0.23 ± 0.07	< 0.1
12	Nitrites	mg/dm^3	3.0	0.014 ± 0.005	0.010 ± 0.005
13	Nitrates	mg/dm^3	45	6.2 ± 0.7	5.1 ± 0.8
14	Cadmium	mg/dm^3	0.001	< 0.001	< 0.001
15	Lead	mg/dm^3	0.01	< 0.001	< 0.001
16	Zinc	mg/dm^3	5.0	0.005 ± 0.005	< 0.010
17	Copper	mg/dm^3	1.0	0.0069 ± 0.0007	0.022 ± 0.006
18	Arsenic	mg/dm^3	0.01	0.008 ± 0.0004	< 0.002
19	Iron (in aggregate)	mg/dm^3	0.3	0.26 ± 0.06	0.29 ± 0.07
20	Anionic surfactants	mg/dm^3	0.5	0.006 ± 0.001	< 0.015

In the Samara urban area, the average value of that parameter exceeded the MPL by 0.18 mg/dm^3. It should be noted that according to the studies conducted at the department of food hygiene with a course of hygiene for children and adolescents and by Pharmatsia Research and Educational Center of the Samara State Medical University of the Ministry of Health of the Russian Federation, the content of oil products in drinking water from the centralized water supply system in the Samara urban area tends to increase.

Exceeding the maximum permissible limit of carbon compounds in surface water and groundwater is a consequence of industrial development and non-compliance with ecological standards of manufacture. Dangerous compounds seep through the soil into groundwater and contaminate the natural sources of drinking water. Water is also contaminated with oil products from transport activity and when artesian and oil-bearing layers are mixed. Consumption of water with high content of oil products increases the risk of cancer of internal organs, diseases of digestive and endocrine systems and oral cavity.

Within the Samara urban area, hardness values of groundwater samples exceeded the maximum permissible limits. Color, dry residue, permanganate index (PI), sulphates, chlorides and copper content were within normal hygienic limits. PI of drinking water in the Samara urban area was 4.5 times higher than that in the RC, whereas the average values of drinking water color and dry residue found in Samara were 1.5 times higher than the respective average values for the analyzed samples in the RC. It is worth noting that in the Samara urban district the values of dry residue were higher than normal limits (1000 mg/dm^3) in areas where drinking water is mixed with groundwater, i. e., Kuibyshevskyi district (1690.70 mg/dm^3) and Ozerny village (1435.20 mg/dm^3).

Water permanganate index is an indicative that the water contains dissolved readily oxidizable organic substances. Water color is an indirect parameter showing the presence of dissolved organic matter, in particular, humic and fulvic acids. This can also be indicative of technogenic-related contamination.

Dry residue characterizes the content of organic and inorganic matter in water. High values of dry residue influence the organoleptic indicators of water, in particular, taste. In separate areas of the Samara urban district, high values of mineralization by the dry residue are due to the values of groundwater supply sources, the Samara River impact and possible non-effective functioning of decontamination stations.

In its turn, content of sulphates and chlorides in the analyzed samples of drinking water in the RC exceeded by 1.2 times the respective values in the Samara urban area. Content of copper was 3 times lower in drinking water of the Samara urban area as compared with that of the RC.

Copper produces a negative effect on water-supply and sanitary engineering devices, as its higher water content is dangerous for human health. Professionals believe that copper is the third hazard class substance with its maximum permissible limit being 1.0 mg/l.

Nitrogenous compounds present in drinking water as nitrates, nitrites and ammonia, are indicative of contamination of water sources with sewage. No exceeded values were found in all analyzed samples by all the parameters of nitrogenous compounds.

DISCUSSION OF RESULTS

In the analyzed samples, drinking water corresponded to the requirements of Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 by many sanitary and chemical parameters. During the comparative analysis of sanitary and chemical parameters of drinking water in the Samara urban area and Republic of Crimea, higher concentrations of sulphates (mean difference of 21.5 mg/dm^3), chlorides (mean difference of 19 mg/dm^3) and copper (mean difference of 0.015 mg/dm^3) were found in water samples from the Republic of Crimea and higher values of dry residue (mean difference of 165.02 mg/dm^3), color (mean difference of 3.66 mg/dm^3) and permanganate index (mean difference of 2.72 mg/dm^3) were detected in samples of drinking water from the Samara urban area. The obtained results can demonstrate natural composition differences in the sources of central water supply, water treating and condition of water supply pipes [2, 8]. Based on the conducted analysis it was shown that quality of the analyzed samples of drinking water in the Samara urban area and Republic of Crimea does not correspond to hygienic requirements as far as oil product content goes.

Quality of drinking water is determined with a source of drinking water supply (surface and underground). Thus, respective water treatment is necessary to obtain normal composition of prepared drinking water [10, 11]. Bad condition of water supply pipes also produced an unfavorable effect on quality of water obtained by the consumer. In this case, the consumer can improve quality of drinking water by following a number of recommendations [5, 7, 10].

CONCLUSIONS

Nonconformance to hygienic requirements was reported during the conducted study estimating quality of drinking water supply in different regions of the Russian Federation. The obtained results are a testimony to the insignificant effect of cleaning with pumping and filtering units regarding organic substances which are resistant to oxidation.

References

1. Aluker NL. Innovative approaches to determining the main indicators of drinking water quality and monitoring the quality of drinking water consumed by the population. Problemy i perspektivy sovremennoj nauchnoj mysli v Rossii i za rubezhom. 2021; 3–5 s. Russian.
2. Kalacheva OA, Laboratory control — analysis of drinking water and wastewater. Estestvennye i tehnicheskie nauki. 2022; 1 (165): 282–283. Russian.
3. Berezin II, Mustafina GI. Regional features of the chemical compound of potable water from economic-drinking water supply in Samara city. Izvestiya Samarskogo nauchnogo tsentra RAN. 2011; 13 (1(8)): 1837–1840. Russian.
4. Zaytseva NV, May IV, Shur PZ. Actual problems of inhabitancy state and health of the population in Commonwealths of independent states. Izvestiya Samarskogo nauchnogo tsentra RAN. 2012; 14 (5(2)): 527–533. Russian.
5. Vorobyeva LV, Lutai GF, Kuznetsova IA, et al. The regional features of the hygienic evaluation of biological contamination of superficial waters. Gigiena i sanitariya. 2011; (1): 34–37. Russian.
6. Mysyakin AE, Korolik VV. Relationship of the quality of drinking water to its use regimens and the types of water supply pipes. Gigiena i sanitariya. 2010; (6): 31–33. Russian.
7. Sazonova OV, Suhacheva IF, Smirnova LM. and other. Features of the current state of the atmospheric air of Samara. Scientific-

methodical and legislative bases for improving the regulatory framework for the prevention health sector: problems and ways of their solution. 2012; 387–389. Russian.
8. Ivanuytin NM, Podovalova SV. Physiological usefulness of drinking water of Crimea by chemical composition. Environmental monitoring systems 2018; (13(33)): 140–146. Russian.
9. Vasilev VV, Ryabinina TV, Perekusihin MB, Vasilev EV. Providing the population of the region with high-quality drinking water as part of the implementation of the Clean Water project in the Penza region. Zdorov'e naselenija i sreda obitanija. 2021; 2 (335): 35–42. Russian.
10. Strelkov AK, Egorova IA, Bykova PG. Selection of most efficient chemicals for water treatment. Vodosnabzhenie i sanitarnaya tekhnika. 2014; (8): 5–9. Russian.
11. Sazonova OV, Isakova ON, Bedareva LI, Suhacheva IF, Vistyak LN, Tupikova DS. To the question of quality of drinking water of the centralized water supply in the city district of Samara. Ecology and health of the population. 2015; (6): 86–90. Russian.

Литература

1. Алукер Н. Л. Инновационные подходы к определению основных показателей качества питьевой воды и мониторингу качества питьевых вод, употребляемых населением. Проблемы и перспективы современной научной мысли в России и за рубежом. 2021; 3–5.
2. Калачева О. А. Лабораторный контроль — проведения анализов питьевой воды и сточных вод. Естественные и технические науки. 2022; 1 (165): 282–283.
3. Березин И. И., Мустафина Г. И. Региональные особенности химического состава питьевой воды хозяйственно-питьевого водоснабжения города Самары. Известия Самарского научного центра РАН. 2011; 13 (1(8)): 1837–1840.
4. Зайцева Н. В., Май И. В., Шур П. З. Актуальные проблемы состояния среды обитания и здоровья населения стран содружества независимых государств. Известия Самарского научного центра РАН. 2012; 14 (5(2)): 527–533.
5. Воробьёва Л. В., Лутай Г. Ф., Кузнецова И. А. и др. Региональные особенности гигиенической оценки биологического загрязнения поверхностных вод. Гигиена и санитария. 2011; 1: 34–37.
6. Мысякин А. Е., Королик В. Б. Зависимость качества питьевой воды от режимов водопользования и типов водопроводных труб. Гигиена и санитария. 2010; 6: 31–33.
7. Сазонова О. В., Сухачева И. Ф., Смирнова Л. М. и др. Особенности современного состояния атмосферного воздуха г. Самары. Научно-методические и законодательные основы совершенствования нормат.-правовой базы профилакт. здравоохр.: проблемы и пути их решения: Матер. пленума науч. Совета по экол. человека и гигиене окруж. среды РФ. М. 2012; 387–389 с.
8. Иванютин Н. М., Подовалова С. В. Физиологическая полноценность питьевых вод Крыма по химическому составу. Системы контроля окружающей среды. 2018; 13 (33): 140–146.
9. Васильев В. В., Рябинина Т. В., Перекусихин М. В., Васильев Е. В. Обеспечение населения региона качественной питьевой водой в рамках реализации проекта «Чистая вода» в Пензенской области. Здоровье населения и среда обитания. 2021; 2 (335): 35–42.
10. Стрелков А. К., Егорова Ю. А., Быков П. Г. Выбор наиболее эффективных реагентов при очистке воды. Водоснабжение и санитарная техника. 2014; 8: 5–9.
11. Сазонова О. В., Исакова О. Н., Бедарева Л. И., Сухачева И. Ф., Вистяк Л. Н., Тупикова Д. С. К вопросу о качестве питьевой воды централизованного водоснабжения в городском округе Самара. Экология и здоровье населения. 2015; 6: 86–90.