BIOLOGICAL CONTAMINATION OF WATER IN RUSSIAN WATER BODIES AND ITS EPIDEMIOLOGICAL SIGNIFICANCE

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Drinking water, household water, and recreational water can be the vehicle of infections and invasions transmitted by fecal-oral route. In this paper we studied the impact of the quality of water in water bodies on the incidence of enteric infections and invasions in the population of the Russian Federation based on the State reports "On the State of Sanitary and Epidemiological Well-Being of the Population of the Russian Federation" issued by the Federal Center of Rospotrebnadzor in 2011–2020. Based on microbiological parameters, the quality of water from the centralized sources of water supply in the Russian Federation corresponds to microbiological parameters of water in waterworks before entering the distributive pipelines (3.5 and 2.9% off-nominal tests, respectively, *Rxy* = 0.98). Giardia cysts were found in 0.06% of the assessed water samples collected from the centralized sources of water supply. This parameter correlates with the percentage of off-nominal microbiological water tests (*Rxy* = 0.84). The values of biological water contamination tend to decrease. The incidence of acute enteric infections and giardiasis shows a negative trend and correlates with the indicators of biological water contamination obtained for water from the centralized sources of water supply and grade II reservoirs. The findings, that support the literature data on the impact of biological water contamination on the incidence of enteric infections and invasions in the population, highlight the relevance of maintaining the sanitary and hygienic condition, as well as providing thorough sanitary and hygienic control of water bodies.

Keywords: water sources, drinking water, microbiological parameters, morbidity, acute enteric infections, giardiasis

Author contribution: Evtodienko AM — data acquisition and processing; Evtodienko AM, Zdolnik TD — manuscript writing; Zdolnik TD — manuscript editing and approval.

Compliance with ethical standards: the informed consent was submitted by all study participants. The study was conducted in accordance with the principles of biomedical ethics.

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БИОЛОГИЧЕСКАЯ КОНТАМИНАЦИЯ ВОДЫ ВОДНЫХ ОБЪЕКТОВ РОССИИ И ЕЕ ЭПИДЕМИОЛОГИЧЕСКОЕ ЗНАЧЕНИЕ

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Вода питьевого, хозяйственно-бытового и рекреационного водопользования может служить фактором передачи инфекций и инвазий с фекально-оральным механизмом передачи. В работе изучено влияние качества воды водных объектов на заболеваемость населения Российской Федерации кишечными инфекциями и инвазиями по материалам Государственных докладов «О состоянии санитарно-эпидемиологического благополучия населения в Российской Федерации» федерального центра Роспотребнадзора России за 2011–2020 гг. Качество воды централизованного водоснабжения в Российской Федерации по микробиологическим показателям соответствует микробиологическому состоянию воды на водопроводных сооружениях перед подачей в разводящую сеть (3,5 и 2,9% нестандартных проб соответственно, *Rxy* = 0,98). Цисты лямблий обнаруживались в 0,06% исследованных проб воды централизованного водоснабжения. Показатель коррелирует с долей нестандартных проб воды по микробиологическим показателям (*Rxy* = 0,84). Показатели биологической контаминации воды всех исследованных водных объектов имеют тенденцию к снижению. Заболеваемость острыми кишечными инфекциями и лямблиозом характеризуется отрицательным трендом, коррелирует с показателями биологического загрязнения воды централизованного водоснабжения и водоемов II категории. Результаты исследования, подтверждающие данные литературы о влиянии биологического загрязнения воды на заболеваемость населения кишечными инфекциями и инвазиями, свидетельствуют об актуальности соблюдения санитарно-гигиенических нормативов и тщательного санитарно-эпидемиологического надзора за водными объектами.

Ключевые слова: источники водоснабжения, питьевая вода, микробиологические показатели, заболеваемость населения, острые кишечные инфекции, лямблиоз

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Соблюдение этических стандартов: добровольное информированное согласие было получено для каждого участника. Проведенное исследование соответствует требованиям биомедицинской этики.

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High quality organization of water supply to the population is essential for prevention of multiple disorders, including the communicable diseases [1]. Numerous epidemiological data from both past (late 19 — early 20 century) and modern periods show the relationship between the incidence of infections and invasions transmitted by fecal-oral route and the state of water supply [2–5].

In Russia, public water supplies are a branched network of the water intake, water treatment, and water distribution facilities, some of which need repair and renovation.

According to SanPiN 2.1.3684–21 "Sanitary and Epidemiological Requirements for the Maintenance of Urban and Rural Settlements, Water Facilities, Drinking Water and Drinking Water Supply, Atmospheric Air, Soils, Living Quarters, Operation of Industrial, Public Premises, Organization and Conduct of Sanitary and Anti-Epidemic (preventive) Measures", water from the water-supply sources can be used for drinking and domestic use in case of compliance with the requirements for drinking water. In case of non-compliance with the hygienic

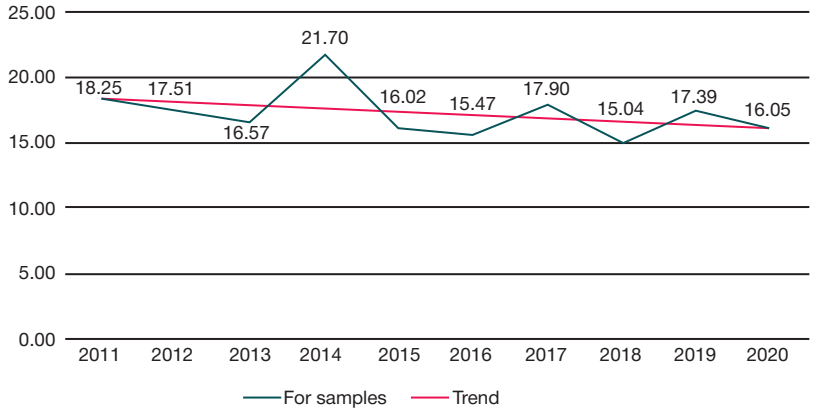

Fig. 1. Proportion of water samples from class I reservoirs that do not meet the standards by microbiological criteria in 2011-2020 (%).

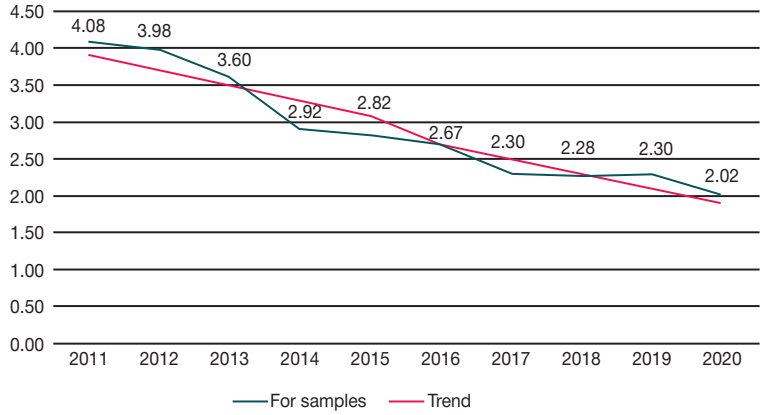

Fig. 2. Proportion of water samples from water works prior to their supply through the distribution network that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

standards of the quality of water from the water-supply sources used as public sources of drinking water supply, water treatment should be used to ensure the quality and safety of water in the distribution network in accordance with the hygienic standards [6].

The study was aimed to assess the impact of the quality of water from water bodies on morbidity in the population of the Russian Federation based on the analysis of the relationship between the microbiological and parasitological parameters of water quality and the incidence of enteric infections and invasions in the population.

The research tasks included:

- assessing microbiological parameters of the quality of water from the sources of domestic water supply (grade I reservoirs);
- assessing microbiological parameters of the quality of water in waterworks before entering the distributive pipelines;
- assessing microbiological and parasitological parameters of the quality of water from water-supply sources;
- assessing microbiological parameters of the quality of recreational water (grade II reservoirs);
- assessing the incidence of acute enteric infections and invasions (giardiasis) in the population.

METHODS

The study involved the use of data from the State reports "On the State of Sanitary and Epidemiological Well-Being of the Population of the Russian Federation" issued by the Federal Center of Rospotrebnadzor in 2011–2020. Statistical processing of the data was performed using Microsoft Excel.

RESULTS

According to the study, in 2011–2020, the average share of off-nominal tests (based on the microbiological parameters of water samples collected from grade I reservoirs) was 17.19%, and showed a moderate downward trend (Rav.gr. = –1.28%) (Fig. 1).

The percentage of off-nominal tests for water samples collected from waterworks before entering the distributive pipelines was 2.90%, and showed a pronounced downward trend (Rav.gr. = –7.02%) (Fig. 2).

The reported decline in the share of off-nominal microbiological tests of water samples collected from waterworks before entering the distributive pipelines compared to that of water from the surface water-supply sources may be interpreted as evidence of the relatively high quality water treatment in the majority of waterworks in Russia.

The percentage of positive tests of water samples collected from the centralized sources of water supply was 3.50%; a pronounced deceleration of the growth rate was observed (Rav.gr. = –5.97%) (Fig. 3). This value is marginally higher than the percentage of positive tests of water samples collected from waterworks before entering the distributive pipelines, which indicates no significant effect of the state of water distribution pipelines on the parameters of the drinking water microbiological quality.

Parameters of the microbial composition of water from the centralized sources of water supply correlate with the

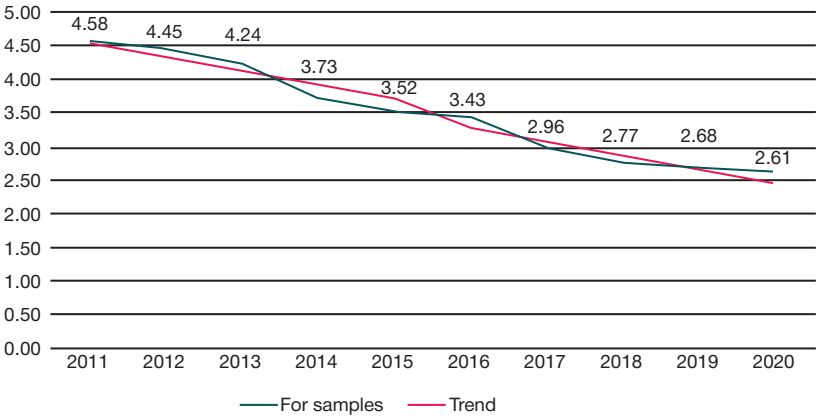

Fig. 3. Proportion of water samples from the centralized water supply system that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

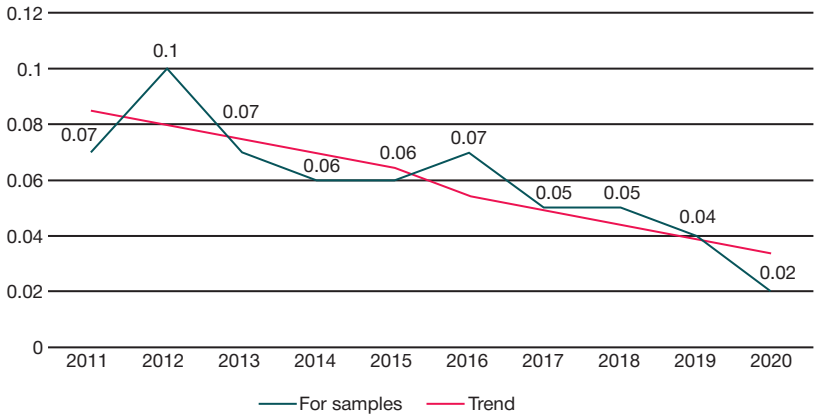

Fig. 4. Proportion of water samples from the centralized water supply system that do not meet the hygienic standards by presence of lamblia cysts in 2011-2020 (%).

microbiological quality of water in waterworks before entering the distributive pipelines (R_{xy} = 0.98).

Analysis of the dynamic changes in microbiological quality of water over the past 10 years indicates a slight decline in the share of off-nominal tests of water samples collected from grade I reservoirs during the studied period. Furthermore, a significant decrease in the number of positive tests of water samples collected before entering the distributive pipelines and from the distributive pipelines during the same time period is observed. This may be interpreted as evidence of the improvement in the quality of waterworks performance in Russia over the past few years.

According to literature, chlorination and ultraviolet light that are used to disinfect water in waterworks have a harmful effect on the bacterial flora, however, these do not provide sufficiently effective Giardia cyst inactivation [7, 8]. Considering this fact, it was interesting to analyze the data from the State reports on the content of this protozoan species in drinking water.

According to the study, the average share of off-nominal tests of water samples collected from the centralized sources of water supply (based on the presence of Giardia cysts) was 0.06%; a moderate downward trend was observed (Rav. gr. = –8.63%) (Fig. 4).

Despite the above literature data on the insufficient effect of standard water disinfection methods on Giardia cysts, our study revealed a strong correlation between the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply and the number of samples containing Giardia cysts (R_{xy} = 0.84).

The average share of off-nominal tests (based on the microbiological parameters of water samples collected from grade II reservoirs) was 22.76%, and showed a moderate downward trend (Rav.gr. = –2.25%) (Fig. 5). This indicator corresponds in some ways to the results for water from grade I reservoirs.

The average incidence of acute enteric infections (AEI) in Russia over the studied 10 years is 521.1 per 100,000 population, and shows a moderate downward trend (Rav.gr. = –2.77%) (Fig. 6).

The incidence of acute enteric infections correlates with the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply (R_{xy} = 0.49) and water samples collected from grade II reservoirs (R_{xy} = 0.56), which is in line with the literature data on the epidemiological role of water [5].

Information about the incidence of certain enteric infections and its trends is provided in Table. Analysis of this information has revealed a positive correlation between the incidence of such bacterial infections, as dysentery (R_{xy} = 0.96) and salmonellosis (R_{xy} = 0.94), hepatitis A virus (R_{xy} = 0.61) and the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply. No correlations between the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply and the incidence of viral enteric infections (except hepatitis A virus) have been revealed, possibly due to the fact that disinfectants used for water treatment mostly affect bacterial flora. This provision is also in line with literature data [5].

The average incidence of giardiasis in the Russian Federation over 10 years is 34.7 per 100,000 population; a pronounced downward trend is observed (Rav.gr. = –10.40%).

There is a strong correlation between the incidence of giardiasis and the percentage of off-nominal tests of water

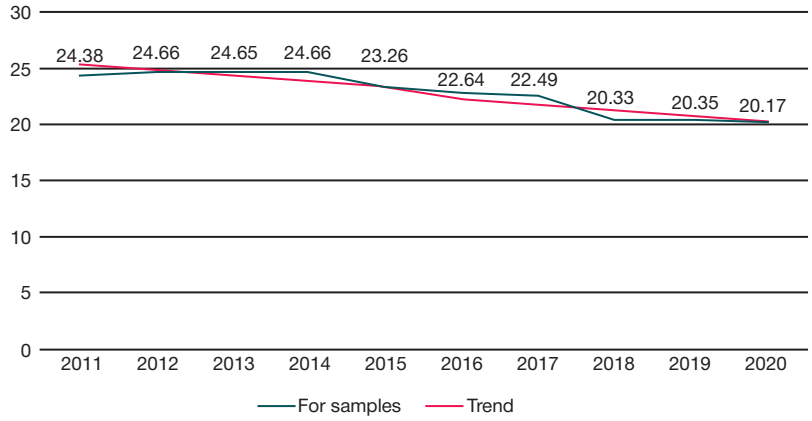

Fig. 5. Proportion of water samples from class II reservoirs that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

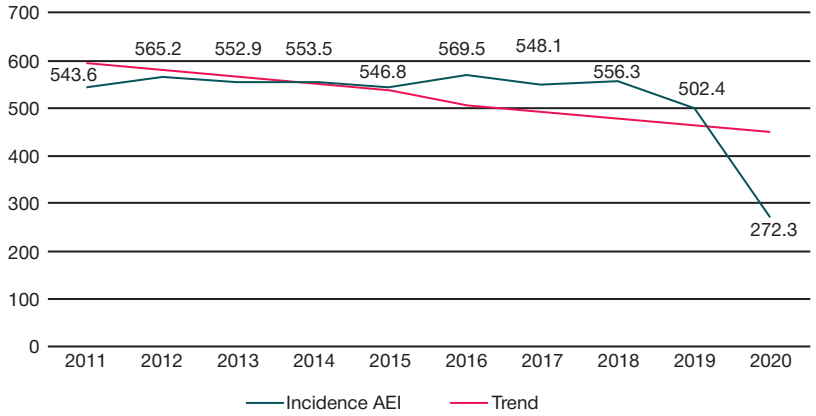

Fig. 6. The incidence of acute intestinal infections in the Russian Federation in 2011-2020 (%)

Table. Characteristics of the incidence of certain types of intestinal infections

Acute intestinal infections	Average incidence	Average growth rate
Dysentery	6.6	–10.96
Salmonellosis	27	–6.76
Viral hepatitis A	4.5	–7.02
Enterovirus infection	7.82	4.87
Norovirus infection	16.2	17.48
Rotavirus infection	72.2	–1.77

samples collected from the centralized sources of water supply based on microbiological (R_{xy} = 0.98) and parasitological (R_{xy} = 0.87) parameters.

DISCUSSION

The results obtained based on the averaged data from the large territory of the Russian Federation make it impossible to draw reliable conclusions. However, it is possible to formulate the basic provisions that arise from the findings:

- based on microbiological parameters, the quality of water from the centralized sources of water supply in the Russian Federation is generally consistent with the quality of water in waterworks before entering the distributive pipelines; this may be interpreted as evidence of the rather good state of the distributive pipelines having no sufficient effect on the quality of water supplied to the population;
- the observed correlation between the percentage of off-nominal tests of water samples collected from the centralized sources of water supply (based on the presence of Giardia cysts) with the percentage of water samples non-compliant with the hygienic standards based on microbiological parameters may be interpreted as evidence of the sufficient effect of water treatment on pathogenic protozoa in most of Russia;
- the findings confirm the literature data on the impact of biological water contamination on the incidence of enteric infections (especially bacterial) and invasions in the population.

CONCLUSION

The main provisions of the study make it possible to conclude that maintaining the sanitary and hygienic condition, as well as providing thorough sanitary and hygienic control of water bodies is relevant.

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