Microflora of drinking water distributed through decentralized supply systems (Tomsk)

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Abstract. The paper considers microbiological quality of waters from decentralized water supply systems in Tomsk. It has been proved that there are numerous microbial contaminants of different types. The authors claim that the water distributed through decentralized supply systems is not safe to drink without preliminary treatment.

1. Introduction

Tomsk oblast is the area with a plenty of fresh groundwater sources. The raw water distributed through decentralized supply systems is intensively used by individuals for drinking: streams, dug and drilled wells. People assess the quality of this water by sight and taste in the absence of experts in organoleptic properties of water. In compliance with the current national sanitary regulations [1], one of the major criteria to assess drinking water quality is its epidemiological safety. As for centralized drinking water supply, this requirement is met through preliminary treatment and monitoring microbiological quality of source waters. However, these measures are ignored in respect with streams, dug and drilled wells.

In this paper, we study the microbiological quality of waters from decentralized water supply systems in Tomsk as it is the criterion of water safety.

2. Materials and methods

The study object is waters from streams, dug and drilled wells located within Tomsk area and used for drinking and household needs. These decentralized water supply systems are based on string tapping and located in different parts of the town with different technogenic load. Most dug and shallow drilled wells are within the residential area with no centralized water supply and truck patches. The water samples were collected from most commonly used systems.

The samples were collected into sterile glass containers in compliance with procedure guideline “Sanitary Survey and Microbiological Testing of Drinking Water Quality”. In the course of the research, 77 samples were collected and investigated. In microbiological quality testing conventional microbiology methods were applied [2]. The microbiological water quality testing included data on physiological groups indicating microbial and chemical contamination, as well as those on self-purification capacity. To identify and determine the number of microorganisms, elective media were created with due regard to all physiological needs of the studied groups.

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The waters chemical composition was analyzed to determine its impact on microorganisms habitat. For this purpose, the following methods were applied: titrimetry, potentiometry, colorimetry, conductivity, stripping voltammetry, atomic absorption spectrometry, ion chromatography, and fluorometry.

3. Results and discussion

The chemical composition of the studied groundwater is mainly HCO_3-Ca-Mg or HCO_3-Mg-Ca, neutral or slightly alkaline, fresh, moderately hard. There are also waters of Cl-HCO_3 and Cl-SO_4-HCO_3 anion composition. Water salinity ranges between 0.26 g/L and 1.45 g/L. pH and hardness values in studied waters vary significantly, from 5 to 8 and from 3.6 to 11.5 mEq/L, respectively. In terms of chemical composition, some components, such as organic matter, nitrogen compounds and chloride ion, reach or even exceed MPC for drinking water [1]. Water supply sources contamination depends on ground water level and the territory anthropogenic load [3, 4].

The microflora of samples is characterized by a wide diversity of physiological groups which cause aerobic and anaerobic destruction of minerals and organic compounds. These processes have a significant impact on water quality. The number of bacteria within different physiological groups is shown in the table below while the biogeochemical characteristics and the particularities of interaction with the components of the environment were discussed in detail in our previous studies [3, 5, 6].

Table. Number of microorganisms in waters from decentralized water supply systems in Tomsk.

Physiological groups of bacteria	The number of microorganisms (cell / ml *)		
	Streams	Dug wells	Drilled wells
Mesophilic saprophytes	30-690/70	30-240/100	20-280/50
Psychrophilic saprophytes	30-43000/2830	60-6300/1670	30-1470/590
Oligotrophs	30-74100/8100	390-48050/5820	3200-920000/13500
Oil oxidizing microorganisms	30-57200/1900	30-1620/560	20-4200/730
Denitrifying bacteria	10-10000/1000	10-10000/1000	10-10000/1000
Ammonifying bacteria	10-3200/790	1020-26470/4540	10-350/120
Nitrifying bacteria	10-1000/100	10-1000/100	10-100/10
Uro-bacteria	30-5800/450	30-2340/730	0
Sulfur reducing bacteria	10-10000/1000	30-1000/100	0
Cellulose-decomposing aerobic bacteria	0-100/10	10-1000/100	0
Cellulose-decomposing anaerobic bacteria	0-100/10	10-1000/100	0
Iron bacteria	0-2000	0	0-5000

Note: The values in the table are presented as follows: minimum-maximum / average;
*cells/ml (cells per 1 ml of water).

Organic matter is one of the major factors indicating the presence of microorganisms in water. Therefore, the researchers focused on identification of psychrophilic saprophytes and oligotrophs, as the former signifies the presence of labile organic material (dissolved organic matter) while the latter determines its mineralization rate. The number of saprophytes indicates the rate of ecosystem contamination with both microbes and organic matter. In accordance with [6], the number of psychrophilic saprophytes in clean water should not exceed 100 cells per ml and should be less than the number of oligotrophs [7].

According to the research data, oligotrophs and psychrophilic saprophytes are present in all water sources. The number of psychrophilic saprophytes ranges from 30 to 43000 cells/ml, with the highest values characterizing streams and lowest drilled wells. The psychrophilic saprophytes number is particularly high in water sources located within the areas with old buildings and private houses without centralized water supply and sewerage systems. Oligotrophs are normally predominant over psychrophilic saprophytes in number, which indicates self-purification capacity of waters from the vast majority of sources.

In all studies waters, there are a great number of bacteria associated with the metabolism of nitrogen-containing organic compounds. They are ammonifying, nitrifying, denitrifying bacteria and uro-bacteria.

Ammonifying bacteria obtain carbon and energy from wide range of organic compounds, particularly, proteins, and the metabolic product is mostly ammonia [7, 9]. According to [7], the number of these bacteria in clean water should not exceed a few hundred cells per ml, or 3–5 % of total bacteria number, while in contaminated water this number can be several thousand cells per ml. In 70 % of water sources investigated in the course of the research, the number of these bacteria ranges from a few dozen to tens of thousands of cells per ml, which indicates water contamination and allochthonous (anthropogenic) organic matter presence. The greatest number of ammonifying bacteria is characteristic for dug well water (up to 26470 cells/ml), which is 7 times as many as that in stream water and 30 times as many as that in the waters from drilled wells.

Denitrifying bacteria are present in 75 % of water sources, their number ranging between 1000 and 10000 cells/ml. The greatest number of denitrifying bacteria is characteristic for the water of dug wells. These bacteria cause anaerobic destruction of organic matter obtaining oxygen from nitrates. The metabolic end product is ammonia [10].

Nitrifying bacteria, which remove ammonia through its oxidation to nitrites and nitrates, are present in almost all dug wells, 20 % of streams, and only a few drilled wells. The number of these bacteria is significantly lower than that of bacteria producing ammonia. The number of nitrifying bacteria is relatively high in old districts of the town, where the town development density is high and the layer of anthropogenic soil is thick enough, which increases the amount of carbon dioxide and ammonia in the air.

Uro-bacteria are identified in 30 % of streams and 46 % of dug wells, which are contaminated by sewage runoffs, while drilled well waters are characterized with the absence of these bacteria. The bacteria cause the destruction of carbamides, uric acid, which serve as a source of carbon and nitrogen. The metabolic end product is ammonia. More often than not, the bacteria are present in the areas contaminated by sewage and household-generated polluted runoffs.

Hydrocarbon degrading bacteria are present in 40 % of streams and 10 % of dug and drilled wells. Under favorable conditions, these bacteria destroy oil to gas and water. The great number of hydrocarbon degrading bacteria was identified in the streams which could be contaminated with petroleum: within food services area, key transit and unloading points the amount of these bacteria was more than 70 % of total number. According to previous research data [7], in raw waters clean from petroleum, the amount of hydrocarbon degrading bacteria ranges between 1 and 4 % of total bacteria number. Therefore, these data might indicate stream water contamination with oil, which can be confirmed by the high value for petroleum products in drinking-water ranging from 0.68 to 1.3 mg/l, with PMC for drinking water being 0.3 mg/l.

Sulphate reducing bacteria (SRB) are present in 50 % of streams and almost 100 % of wells. The bacteria produce hydrogen sulfide, which has a negative impact on organoleptic properties of water. However, waters from drilled wells are characterized by the absence of these bacteria.

Cellulose-decomposing bacteria, both aerobic and anaerobic ones, are present in the waters of streams equipped with wooden tapping construction and all dug wells. In summer, when the wooden construction is heated, the number of bacteria is up to thousands of cells. These bacteria presence indicates that soil has got into the water while their metabolic products can contribute to the growth of denitrifying, sulphate reducing, and methanogenic bacteria [7].

Mesophilic saprophytes, which indicate the presence of pathogenic microflora, are identified in all water sources, and their number often exceeds MPC (50 cells/ml) [1]. This means that the waters are not safe to drink.

According to the relevant classification [6], the number of psychrophilic saprophytes indicates that in 46 % of streams the water is contaminated, while in 30% – severely contaminated. The water in 50 % of dug wells is moderately contaminated and in 30 % – contaminated. More often than not, drilled well water is contaminated.

Iron bacteria identified in the studied waters are isolated instances, which are generally caused by metal tapping constructions.

In general, the present research data indicate contamination of all water samples with bacteria, ranging in number and types. In terms of total bacteria number, stream water heads the list, dug well water is ranked second, and drilled well water round out the list. The water from all sources is contaminated with organic matter, sulfur and nitrogen compounds. The contaminants get into the water due to human activities and under microbial conditions and cause the secondary microbial and chemical contamination of water, which has a negative impact on organoleptic properties of water.

4. Conclusions

Summing up the results, it can be concluded that the water from decentralized water supply systems in Tomsk is contaminated with bacteria, significant in number and ranging in types. The number of bacteria depends on the water supply system type and technogenic load of the area. Microbiological characteristics of the water indicate the high rate of contamination with bacteria, which means that the water fails to be safe to drink without preliminary treatment.

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