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Ecological Characteristics of Groundwater in Rural Areas of the Karaganda Region

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ABSTRACT
In this article, the purpose of the research was to study the ecological characteristics of groundwater and central water supply used for drinking and economic activity of the Kievka village. The hydrochemical indicators of the samples were determined with conventional methods, and performed on 16 indicators: pH, electrical conductivity, suspended solids, dry residue, chlorides, sulfates, phosphates, total hardness, sodium, ammonium nitrogen, nitrites, nitrates, chemical oxygen consumption (COD), anionic surfactants (APAS), total iron, and manganese. While assessing the hydrochemical state of drinking water in the village of Kievka, it can be noted the "Altyn-dan" kindergarten and the Kiev secondary school No. 3, exceed the MAC which is determined by certain indicators. As a result of microbiological studies of the water samples from the village of Kievka, it was revealed that the total microbial number is normal. It was determined that a different number of fungi and actinomycites were present in all samples. At the initial concentration, a large concentration of fungi was observed in all samples.

Keywords: drinking water, water quality, bacterial pollution, groundwater, environmental characteristics.

INTRODUCTION

Groundwater is usually a safe and reliable source of drinking water in many developing countries, especially in rural areas. The maintenance and protection of groundwater quality is of great importance as well as widely studied. Rural areas depend on groundwater as an important water resource. Although groundwater is less susceptible to pollution than surface water, local geology, lack of adequate sanitation and other factors can affect the water quality. Bacterial contamination raised concerns about the possibility of similar contamination in groundwater. The main processes controlling the quality of groundwater at the village level and the potential threat to human health were also studied (Brindha et al., 2017).

Groundwater depletion is a long-term decline in water levels, which is the expected result of water extraction from the country, facing depletion of groundwater throughout the world (Konikow & Kendy, 2005). The gradual deterioration of the quality of surface (river and reservoir) water caused by many anthropogenic factors, including rapid urbanization, unplanned industrialization, disposal of household waste and agricultural runoff, led to a shortage of fresh water (Mukherjee et al., 2008; Singh, Tewary & Sinha, 2011; Yadav et al., 2012; Kumar et al., 2017).

It was reported that 90% of the fresh water extracted from the underground sources is consumed in the irrigation practice; therefore, the quality of water directly affects the health of crops (Shiklomanov, 2000; Scanlon, Reedy & Tachovsky, 2007; Raju, Ram & Dey, 2009).

Groundwater is the most important because of the need for drinking water, since it is the main source of drinking water in most areas (Singh, Tewary & Sinha, 2011).

The Department of State Sanitary and Epidemiological Surveillance of the Nurinsky district conducts the planned sanitary-epidemiological control of the centralized water supply to the villages of Kievka, Karaganda oblast. Every month, a branch of the Center for Sanitary and Epidemiological Expertise of the Karaganda Region conducts the bacteriological and sanitary-chemical studies of the water in Kievka. The quality of water of the centralized water supply system in Kievka corresponds in all parameters to the Sanitary Regulations No. 554 dated July 28, 2010 "Sanitary and epidemiological requirements for water sources, household water supply and places of cultural water use and safety of water bodies".

The aim of our research was to study the ecological characteristics of groundwater and central water supply used for drinking and economic activities of the Kievka village.

MATERIALS AND METHODS

The water samples were taken from industrial and drinking water from several points of Kievka village.

For the hydrochemical and microbiological studies, the samples were taken from 6 points: No. 1 from an autonomous school well; No. 2 of the street column in the west of the village, where the beginning of the route; No. 3 from the crane of the Kiev secondary school No. 3; No. 4 from the crane of the "Altyn-dan" kindergarten; No. 5 from columns near the school from the east, at the beginning of the central water supply; Column No. 6 near the school from the west, at the end of the central water supply (see Table 1).

The hydrochemical indicators of the samples were determined with conventional methods, and performed on 16 indicators: pH, electrical conductivity, suspended matter, dry residue, chlorides, sulfates, phosphates, total hardness, sodium, ammonium nitrogen, nitrites, nitrates, chemical oxygen consumption (COD), anionic surfactants (APAS), total iron, and manganese (Decree of the Government of the Republic of Kazakhstan No. 209, 2015).

The microbiological examination of water determined the total microbial number (the number of microorganisms in 1 ml), the number of fungi and actinomycites, colonies of blue-green algae. The total microbial count (TBC) – the number of mesophilic aerobic and optional anaerobic bacteria in 1 cm^3/ml of water – is determined in all types of water. The result (TBC) is calculated by summing the arithmetic mean number of bacteria, yeast and mold fungi and expressed in colony forming units (CFU / ml). Water is considered of good quality if the number of microorganisms is less than 100 per 1 ml of water. In order to calculate the total number of microorganisms in a sample of water for planting in a nutrient medium, dilutions at different concentrations are used. The results are obtained in 3–4 days (Howle et al., 1997). The results of the experiments are statistically processed by student's criterion (Zaitsev, 1981).

RESULTS AND DISCUSSION

The results of hydrochemical studies of groundwater and the central water supply used for drinking and economic activities of the Kievka village are given in Tables 2 and 3.

As a result of the hydrochemical studies of drinking water, pH, suspended solids, chlorides, sulfates, phosphates, ammonium nitrogen,

Table 1. Water sampling points

No. points	Type of water use	Location
1	Process water	Autonomous school well
2	Underground drinking water	Street column in the west of Kievka village
3	Drinking water central water supply	Kiev secondary school №3
4	Drinking water central water supply	Kindergarten Altyn-dan
5	Drinking water	Column near the school east side, at the beginning of the center water supply
6	Drinking water	Column near the school of the western side, at the end of the center water supply

Table 2. Hydrochemical studies of drinking water of Kievka village

Name of the defined indicator	Unit of measurement	MPC	Actual value		
			Sample ID / Sampling Point Name		
			172TB-1	172TB-2	172B-4
			Kindergarten Altyn-dan	Kiev secondary school №3	Street column in the west of the village, where the beginning of the route
1	2	3	4	5	7
pH	-	6–9	7,71	7,73	7,53
Suspended substances	mg/dm^3	-	6	5	<5,0
Dry residue	mg/dm^3	1000	2900	1920	589
Chlorides	mg/dm^3	350	176,56	192,16	216,26
Sulfates	mg/dm^3	500	11,39	12,69	189,75
Phosphates	mg/dm^3	3,5	1,914	0,961	0,599
Total hardness	mg-eq/dm^3	7,0	13,2	13,8	8,93
Sodium	mg/dm^3	200	126,53	123,8	131,99
Ammonia nitrogen	mg/dm^3	2,0	<0,05	<0,05	<0,05
Nitrites	mg/dm^3	3,0	<0,002	<0,002	<0,006
Nitrates	mg/dm^3	45	0,301	0,416	0,372
COD	mg/dm^3	30	<5	<5	6,4
APAV	mg/dm^3	0,5	<0,025	0,028	0,057
Common iron	mg/dm^3	0,3	0,112	<0,1	0,180
Manganese	mg/dm^3	0,1	<0,002	<0,002	0,0037

Table 3. Hydrochemical studies of industrial water

Name of the defined indicator	Unit of measurement	Actual value
		Sample ID / Sampling Point Name
		172B-3
		Autonomous school well
1	2	6
pH	-	7,43
Electrical conductivity	ms/cm	1889
Suspended substances	mg/dm^3	12
Dry residue	mg/dm^3	944
Chlorides	mg/dm^3	271,57
Sulfates	mg/dm3	311,58
Phosphates	mg/dm3	0,899
Total hardness	mg-eqv/dm^3	16,95
Sodium	mg/dm^3	205,67
Ammonia nitrogen	mg/dm^3	<0,05
Nitrites	mg/dm^3	<0,006
Nitrates	mg/dm^3	0,350
COD	mg/dm^3	12,25
APAV	mg/dm^3	0,078
Common iron	mg/dm^3	0,233
Manganese	mg/dm^3	0,0023

Table 4. Indicators of the total microbial number of groundwater and water of the central water supply of the village Kievka

№ points / CFU / ml	1/ml	$\chi 10^{-4}$	$\chi 10^{-5}$
№5	233,67±17,65.10^2	41,33±7,42.10^5	31,33±6,46.10^6
№6	133,33±13,13.10^2	74±9.93.10^5	23,33±5,58.10^6
№3	∞∞∞	146±13,96.10^5	55±8,49.10^6
№1	182,67±15,61.10^2	154±14,33.10^5	34,33±6,77.10^6

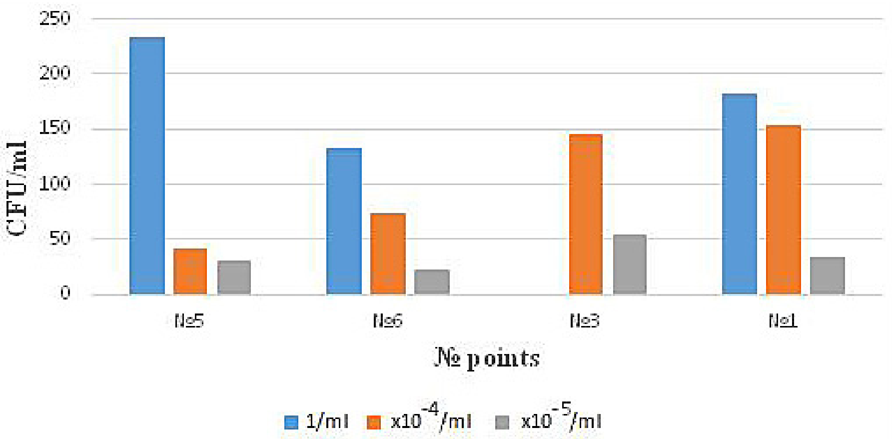


Figure 1. Indicators of the total microbial number of groundwater and the water of central water supply Kievka river

nitrites, nitrates, COD, anionic surfactants, total iron, and manganese do not exceed the MPC in all samples. The total hardness at all 3 points exceeds the MPC: at 5 points – 13.2 mg/dm^3, at 3 points – 13.8 mg/dm^3, at 2 points – 8.93 mg/dm^3, dry residue exceeds 4 points – 2900 mg/dm^3 and at 3 points – 1920 mg/dm^3.

According to the hydrochemical indicators, the technical water of an autonomous school well contains chlorides, sulfates, phosphates, ammonium nitrogen, nitrites, nitrates, total iron, and manganese. All indicators are within the norm.

According to the results of the hydrobiological studies of the samples from four sampling points, it is shown that all samples are positive in terms of the total microbial number (see Table 4).

According to the analysis of research results, it can be noted that a large number of CFUs were observed in the sample No. 1 and the sample No. 3, for example, in a sample concentration of 10–4/ml in the sample No. 3 there were 146 ± 13.96.105 CFU/ml. At the initial concentration (1 ml of the sample) the sample No. 5 was 233.67 ± 17.65.102, while the sample No. 1 reached 182.67 ± 15.61.102 CFU/ml (Figure 1).

While studying the colonies grown on different samples, the following results were obtained. In sample 5, the colonies are separated, the color of the colony is yellow, the shapes are spherical and transparent (see Figure 2).

In the water samples in which 1 ml of the sample was taken without dilution, both red and yellow colonies of microorganisms were observed.

The colonies of the sample No. 6 of different colors: yellow, pink, light yellow and purple. Some small-sized colonies are spread over the entire surface (see Figure 3).

The sample No. 3 colonies are transparent or yellow, and there are also light opaque types of microorganisms (see Figure 4).

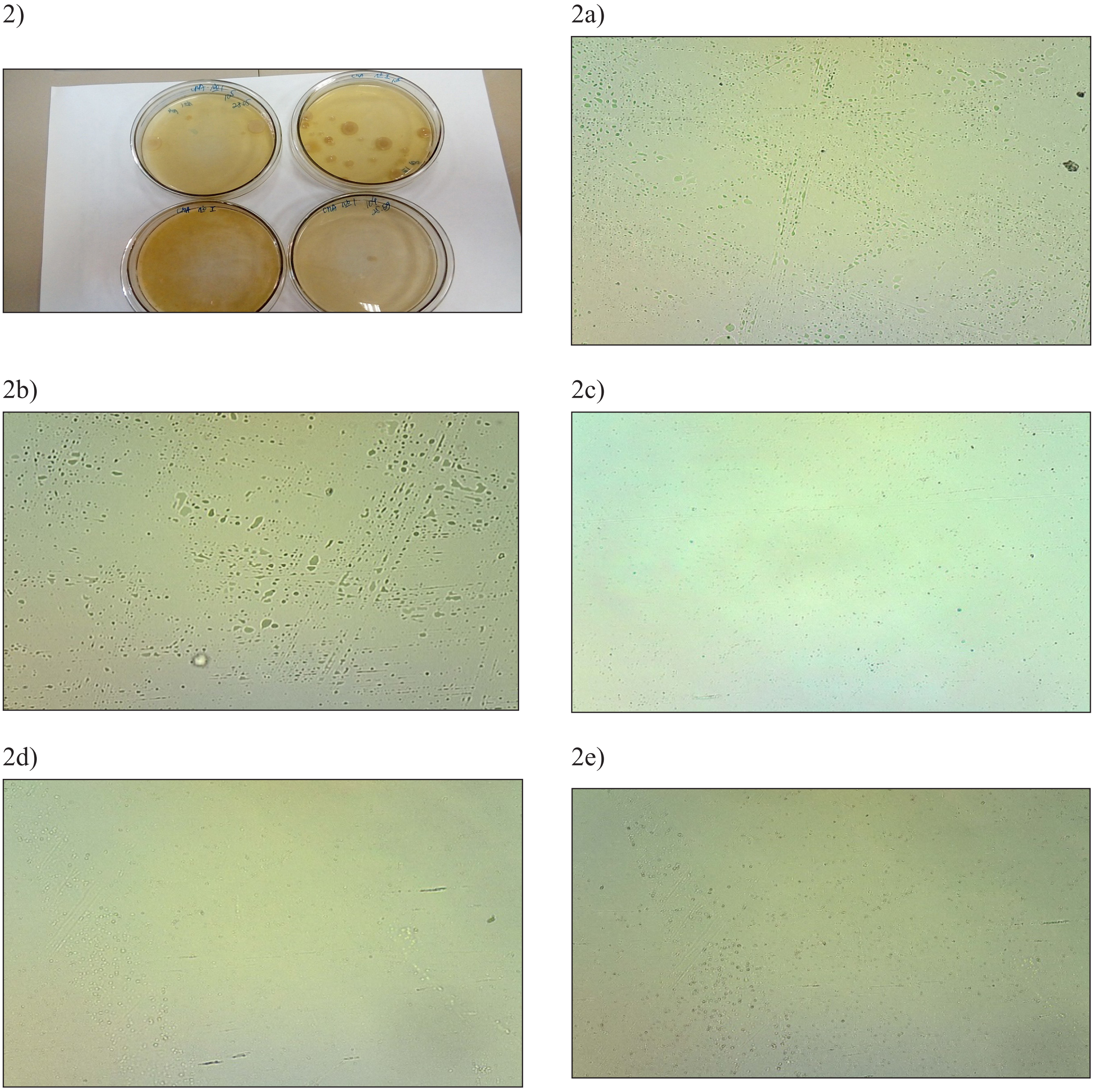


Figure 2 Colonies of water No. 5 of sample:
a), b) – original concentration,
c) 102 COE/ml, d) 103 CFU/ml, e) 104 CFU/ml

The samples of water No. 1 are small, yellowish and transparent, some colonies are large, light, transparent (see Figure 5).

According to the results of calculating the number of fungi, including actinomycetes, it can be noted that they are present in all samples (see Table 5).

In all samples, an endless growth of fungi was observed in an amount of 1 ml of water. The results of the calculation pertaining to the number of fungi showed that at the point No. 1 the largest number of fungi 46 ± 7.83.104 was observed at concentrations of 10–3/ml (see Figure 6).

While calculating the number of actinomycetes showed growth in 1 ml of the sample, an endless growth was observed in the sample No. 3, with the largest amount obtained at a concentration of 10–3/ml (see Figure 7a, 7b).

Figure 8 shows the growth of fungi and actinomycetes in all water samples taken for analysis from the Kievka village.

In the samples of all waters at the initial concentration, infinite growth of fungi was observed, and the actinomycetes in sample No. 1 was higher than the others, which is 29.33 ± 6.25.102 /ml. When the concentration of

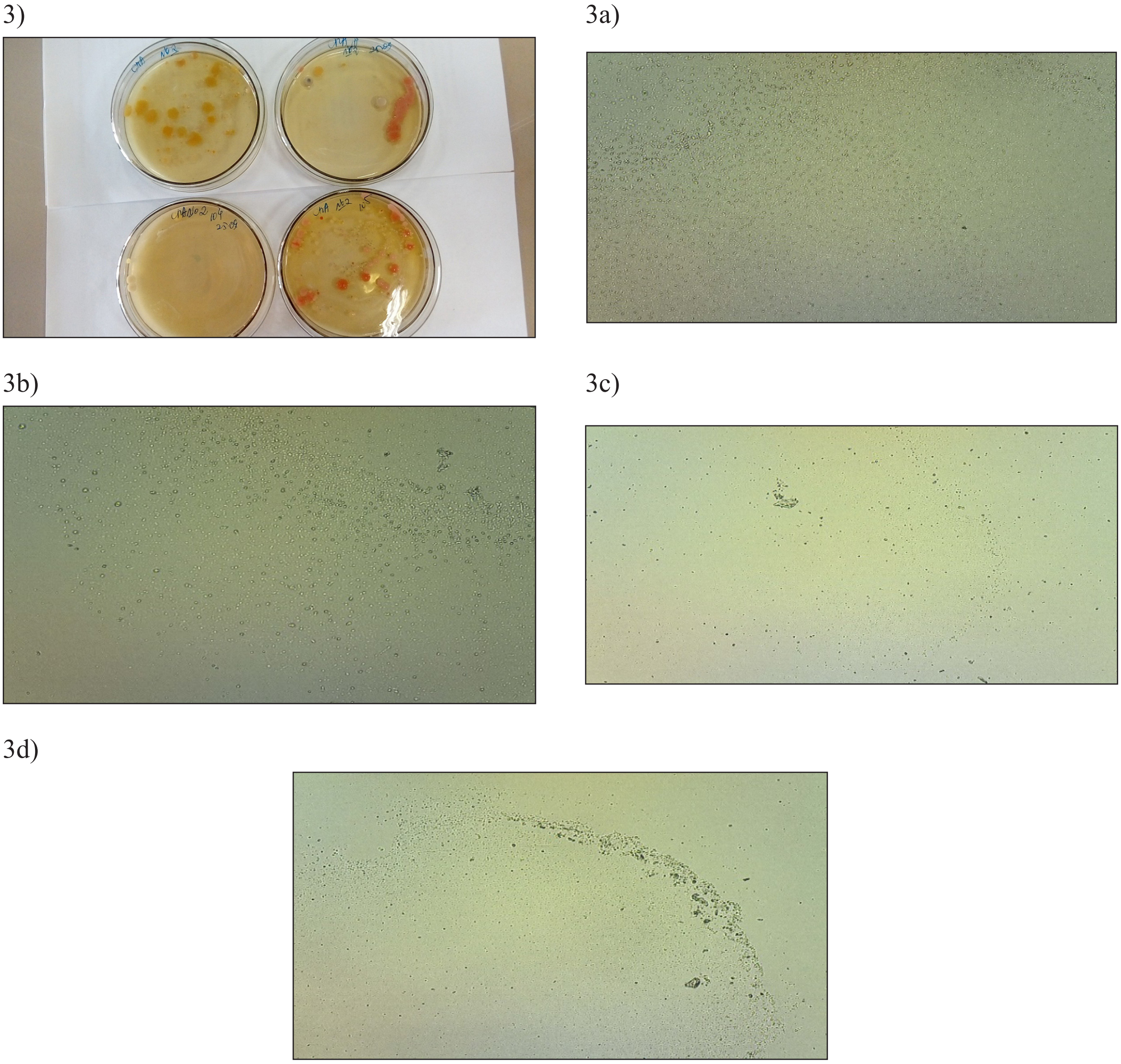


Figure 3. Colonies of water in the sample No. 6: a) the initial concentration, b) initial concentration, c) 102 KOE/ml, d) 102 CFU/ml

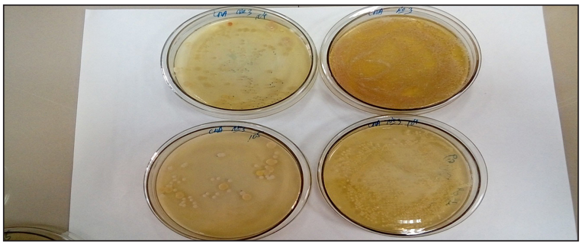
the sample is 102/ml, there are more fungi in the sample No. 1, actinomycetes in the sample No. 3, while the sample concentration is 103/ml, in the sample No. 1, actinomycetes in the sample No. 3, which is 46 ± 7.83.104/ml.

CONCLUSION

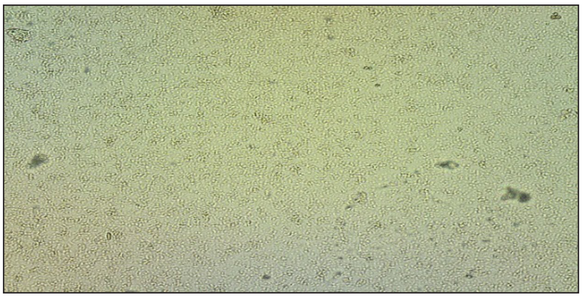
While assessing the hydrochemical state of drinking water in the village of Kievka, it can be noted that the dry residue exceeds the maximum allowable concentration in the "Altyn-dan" kindergarten – 2900 mg/dm^3; 13.2 mg/dm^3 showed a hardness in kindergarten, 13.8 mg/dm^3 at school, and a street column in the west of the village, where the start of the route was 8.93 mg/dm^3. In the autonomous school well, the highest electrical conductivity is 1889 ms/cm, chlorides – 271.57 mg/dm^3, sulfates 311.58 mg/dm^3, total hardness 16.95 mg/dm^3, sodium – 205.67 mg/dm^3.

As a result of the microbiological studies of the water samples from the village of Kievka, the following were revealed: TBC of underground water and water of the central water supply in sample No. 5 at the initial concentration of 233.67 ± 17.65.102 CFU/ml: at a concentration of 10–4/ml TBC 41.33 ± 7, 42.105 CFU/ml, No. 6 at the initial concentration 133.33 ± 13.13.102 CFU/ml, at the No. 3 sample at 10–4/ml concentration 146 ± 13.96.105 CFU/ml, 10–5/ml concentration 55 ± 8.49.106 CFU/ml, in No. 1 sample at the initial concentration of 182.67 ± 15.61.102 CFU/ml, 10–4/ml of concentration 154 ± 14.33.105 CFU/ml.

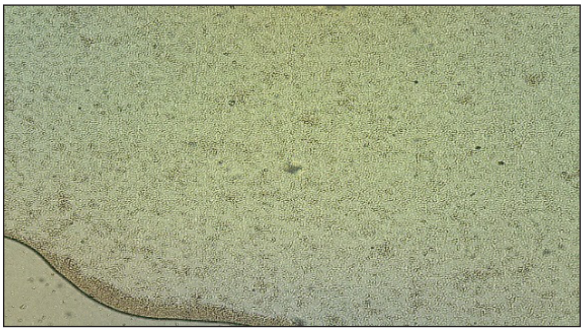
4)



4a)



4b)



4c)

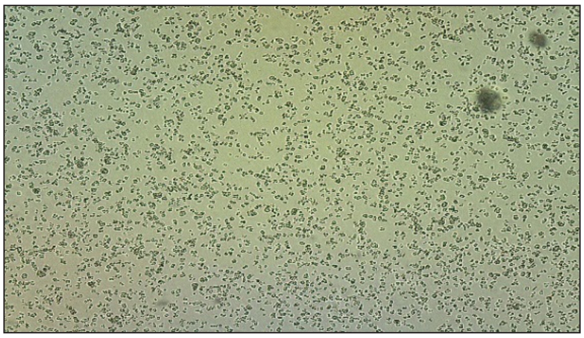
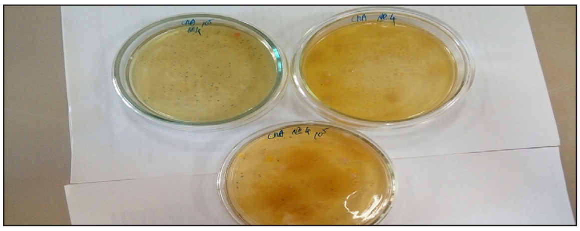
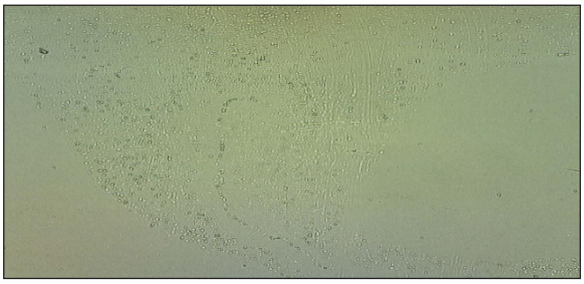


Figure 4. Colonies of the water sample No. 3: a) initial concentration, b) 1010 CFU/ml, c) initial concentration

5)



5a)



5b)

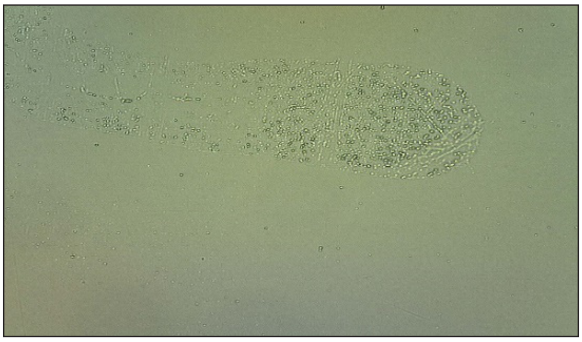


Figure 5. Colonies of water # 1 of sample: a), b) – initial concentration

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Table 5. The number of fungi and actinomycetes in the water samples of the village

№ points		1/ml	χ 10 $^{-2}$/ ml	χ 10 $^{-3}$/ml
№ 5	Fungi	∞∞∞	5±2,58.10^3	4,67±2.50.10^4
	Actinomycetes	23,67±5.62.10^2	17.33±4.81.10^3	2,0±1.63.10^4
№ 6	Fungi	∞∞∞	6.0±2,83.10^3	4,0±2.31.10^4
	Actinomycetes	15.0±4.47.10^2	7.67±3.20.10^3	5,0±2,58.10^4
№ 3	Fungi	∞∞∞	6.0±2,83.10^3	7,0±3.05.10^4
	Actinomycetes	∞∞∞	25.67±5.85.10^3	46±7.83.10^4
№ 1	Fungi	∞∞∞	6,67±2,98.10^3	14.67±4.42.10^4
	Actinomycetes	29,33±6.25.10^2	6.0±2,83.10^3	7.0±3.05.10^4

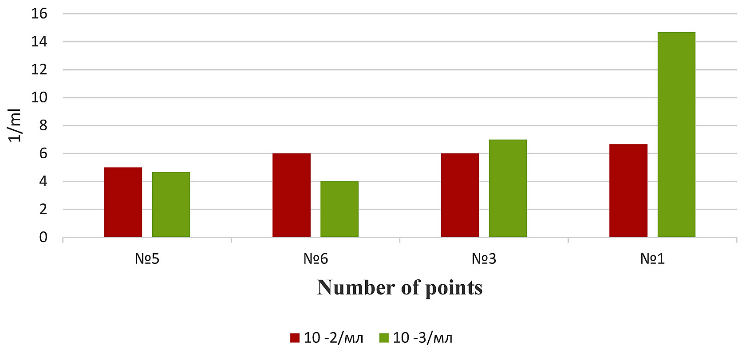

Figure 6. The results of the calculation of the number of mushrooms

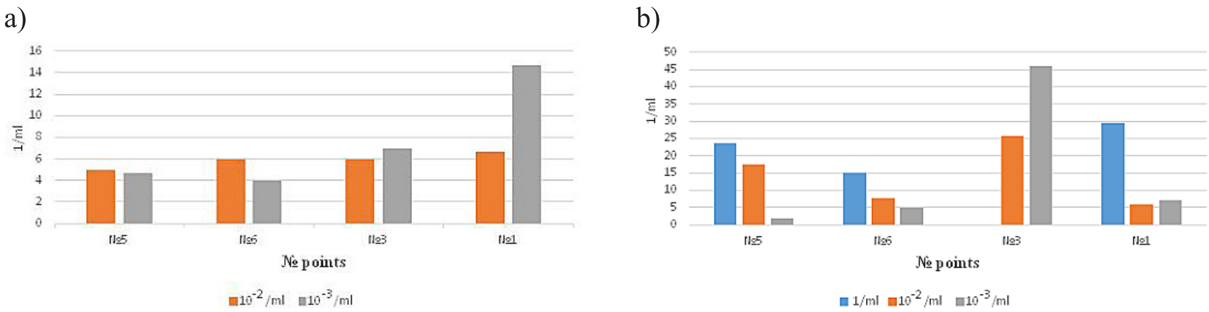

Figure 7. a) b) results of calculating the amount of actinomycetes

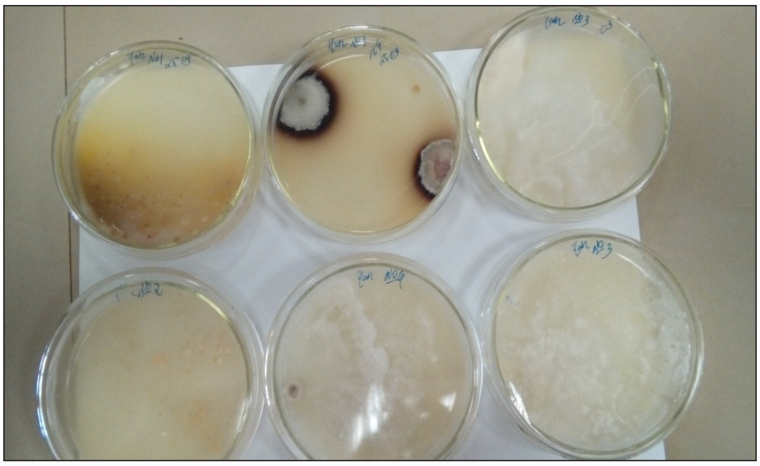

Figure 8. The growth of fungi and actinomycetes in all water samples taken for analysis from the Kievka village

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