The biota in the brine discharge area of Ludmilinskaya well (Solikamsk, Russia)

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Abstract

This paper presents results of a biota study carried out in the brine discharge area of Ludmilinskaya brine well (Solikamsk). Eight taxa of pennate diatoms and two species of invertebrates were identified during the study. Most of the identified taxa belong to cosmopolitan benthic zones with varying degrees of halobility.

Keywords: brackish water, diatoms, invertebrates

Introduction

Recently, studies of the biota of water bodies with increased salinity in areas of industrial pollution with potassium production waste have been conducted in Perm Krai (Martynenko, 2017; Martynenko et al., 2017; Khayrulina et al., 2017; Khayrulina, Baklanov, 2018). Brackish inland water bodies usually have unstable salinization conditions and vary in ecological features with a certain species composition (Hartog, 1967). In such water bodies with extreme habitats, specific biocenoses develop which may greatly differ in species composition in different areas (depending on the distance from sources of water-soluble salts in the form of salt springs and discharges of old brine wells). Human effect is usually seen as a factor contributing to biodiversity reduction although there are examples evidencing the opposite trend (Barinova et al., 2000). This paper shows the results of a preliminary study of the biotic component directly in the area of saline solution discharge.

Methods

The material for this paper was several benthic samples taken in March-April 2019 from several parts of the stream flowing from Ludmilinskaya brine well (5-10 meters far from the wooden casing pipe). Ludmilinskaya brine well (59°39’28.5”N 56°46’58.6”E) was drilled in 1906 within the Troitsky (Solikamsky) salt-making plant to determine the formation depth of rock salt and was equipped in 1910. The well was operated until 1923 when the enterprise was closed. It was not restored after the Russian civil war. Since the liquidation of the enterprise, brines from the well have moved with gravity, with their flow rate depending on the season. In 2011, the borehole environment was refurbished and the wellbore was sealed with gravel mixture for safety purposes. According to the references (Kurnakov et al., 1917), the salinity of the water pouring out of the well was 260 g/L in 1917. Water mineralization in 2017 amounted to 12 g/L (Khayrulina et al., 2017). According to our data, the mineralization of the well water has decreased to 8 g/L by mid-March 2019. The reasons for the decrease in the source mineralization remain unknown yet.

Diatoms were identified according to Zabelina et al. (1951). Environmental and geographical characteristics of algae are provided by the paper according to Barinova et al. (2000). Species of invertebrates were determined using appropriate field guides (Chekanovskaya, 1962; Key to freshwater…, 1995). The materials were examined using optical (binocular microscope МБС-10, stereomicroscope Leica MZ16) and electron probe (scanning electron microscope VEGA 3 LMH with a system of X-ray energy dispersive microanalysis Oxford Instruments INCA Energy 250/X-max 20) methods at the laboratory of the local geology of natural resources of the Mining Institute, Ural branch of the Russian Academy of Sciences.

Results

The recorded water salinity in the area of well discharge is close to the limits of salinity of 5–7 g/L, at which the minimum species diversity is observed (Remane, 1971). Only eight diatom taxa were found in the samples, including some species from different halobility categories (Tabl.).

Rapheless diatoms *Synedra pulchella* and S. tabulate dominate among the identified algae (Fig. 1, a-e). These two types were not listed among algae found in the rivers of Perm Krai (Martynenko, 2017; Belyaeva, 2013; Belyaeva, Pozdeev, 2005), but are part of some algal floras of water bodies in the Asian part of Russia. *Fragilaria pinnata* (Fig. 1, f, g) was numerous in our samples; this species predominates in the alluvial ripal zone epilithon of the Chusovaya River and samples of the upper area of the Kama Reservoir (Belyaeva, 2013; Belyaeva, Pozdeev, 2005). As the species of a single rapheless alga could not be identified, we preliminarily classified it as a teratological form of one of the species of *Tetracyclus* (given the fact that most species of this genus can exist in an acidic environment) (Fig. 1, h).

Among raphid diatoms, findings of numerous *Navicula cryptocephala* and *N. protracta* (Fig. 2, c-h) and a single finding of another species of this genus *N. peregrine* were recorded (Fig. 2, b). The latter was identified to be a variation of kefvingensis, which is characterized by closer striae (7–8 in 10 μm). All these species were found in saltwater bodies of Perm Krai (Zabelina et al., 1951; Martynenko, 2017), *N. cryptocephala* and *N. peregrina* were found in samples from the central stretch of the Kama Reservoir (Belyaeva, 2013).

Surirella striatula (Fig. 2, a) is a species of diatoms new to the algal flora of Perm Krai. According to the environmental classification of the diatoms, this species is a halophile (Barinova et al., 2000), while it is a euryhaline organism according to others (Yatsenko-Stepanova et al., 2014). In Russia, *S. striatula* was discovered at least in three modern algal floras of the Black Sea (Balycheva et al., 2017), the Tuzlukkol River (Orenburg Oblast) (Yatsenko-Stepanova et al., 2014), and the Bolshaya Smorogda River (Volgograd region) (Burkova, 2016). This species, as well as *Synedra pulchella* and *S. tabulata*, were most likely brought to the area of the northeastern part of Perm Krai by migrating waterfowl.

Eucyclops macruroides Lilljeborg, 1901 (Fig. 3, a- c), which belongs to freshwater species (Key to freshwater…, 1995), was found in the samples. However, there is evidence of this species being found in the mesohaline waters of the Danube (Zorina-Sakharova et al., 2014). Our findings also confirm that the species can live in brackish waters. Beside the copepods, oligochaete *Lumbricillus lineatus* Müller, 1771 was found in the samples (Fig. 3, d-h). This species is euryhaline, meaning it can live both in fresh waters and in extreme conditions of oceanic salinity (Chekanovskaya, 1962).

Conclusion

It is the first time that biota at the place of saline solution discharge of Ludmilinskaya well was studied, low species diversity was found in both flora and fauna. Among

***Table. Species** composition of diatoms and their ecological and geographical characteristics (by: Barinova et al., 2000). 1-habitat (B -benthic, P-B - plankton-benthic, Ep – epiphyte); 2 – temperature (C°); 3 – rheophility (ind – indifferent); 4 – salinity (hl - halophilic, mh - mesogalob, i - indifferent); 5 –ph (alf – alkaphil, alb -alkabiont, acf - acidophilus, ind - indifferent); 6 - geographic location (k - cosmopolitan, b – boreal). * for most species*

Taxon/ Environmental and geographical characteristics	1	2	3	4	5	6
Fragilaria pinnata Ehr.	P-B	10-35	ind	hl	alf	b
Navicula cryptocephala Kütz.	B	-	-	i	alb	k
Navicula peregrina (Ehr.) Kütz.	B	-	-	mh	alf	k
Navicula protracta Grun.	B	-	-	mh	ind	k
Surirella striatula Turp.	-	-	-	hl	-	-
Synedra pulchella (Ralfs) Kütz.	Ep	-	-	i	-	k
Synedra tabulata (Ag.) Kütz.	B	-	-	mh	ind	k
*Tetracyclus sp.**	B	-	-	i	acf	a-a

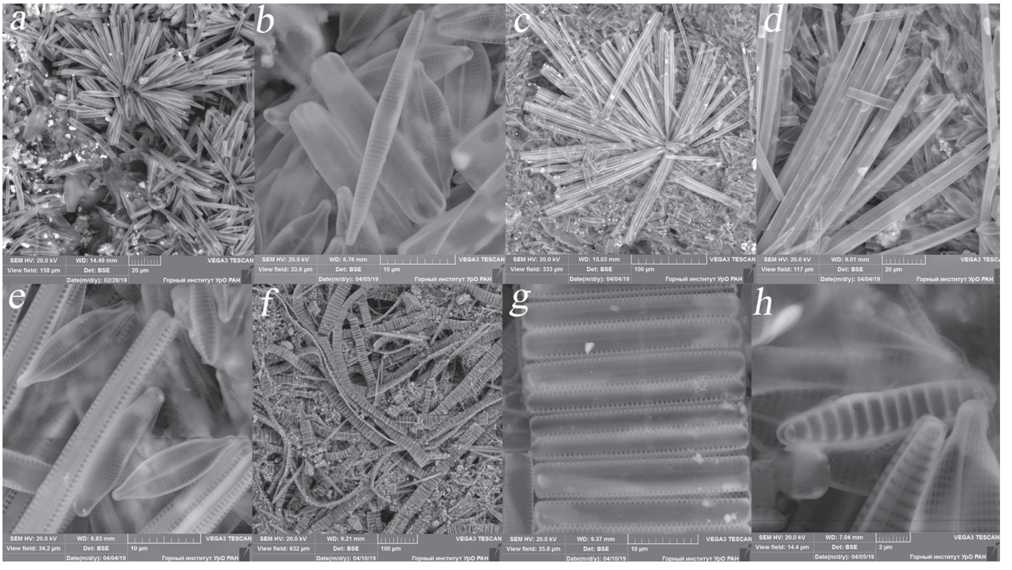

Figure 1 *The diatoms (Araphinales). Ludmiliskaya well, Solikamsk, Russia (03.-04. 2019). a, b – Synedra pulchella; c, d, e –Synedra tabulata; f, g - Fragilaria pinnata; h –Tetracyclus sp.*

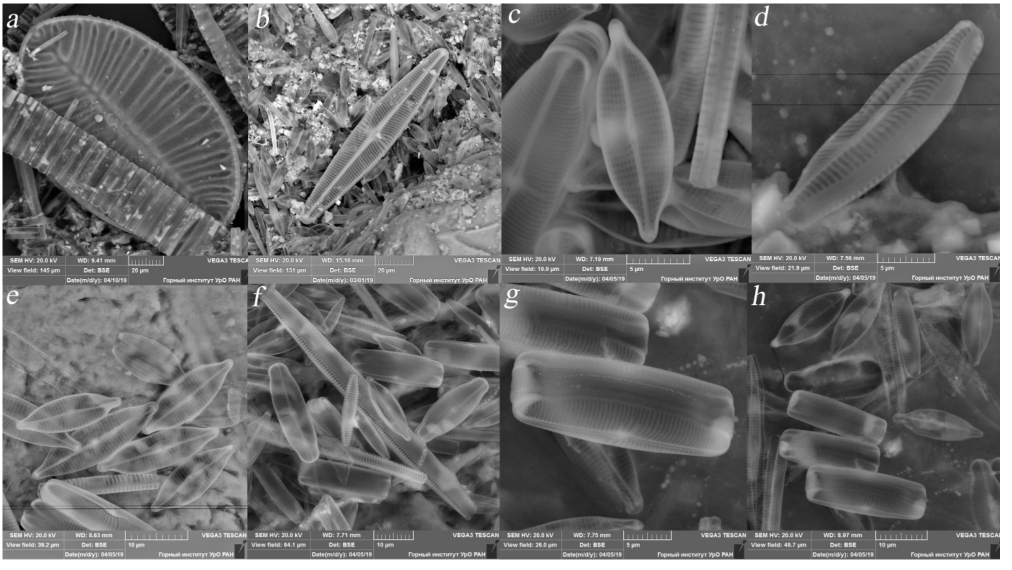

Figure 2 *The diatoms (Raphinales). Ludmiliskaya well, Solikamsk, Russia (03.-04. 2019). a - Surirella striatula; b - Navicula peregrina; c, d, e - Navicula cryptocephala; f, g, h - Navicula protracta*

the discovered diatoms, halophilic species (*Surirella striatula*), mesohalobe species (*Synedra tabulate*) and species indifferent to salinity (*S. pulchella*) were found that had not been previously recorded in the water bodies of Perm Krai. The finding of Eucyclops macruroides confirms the limits of the species tolerance with respect to salinity to be broad.

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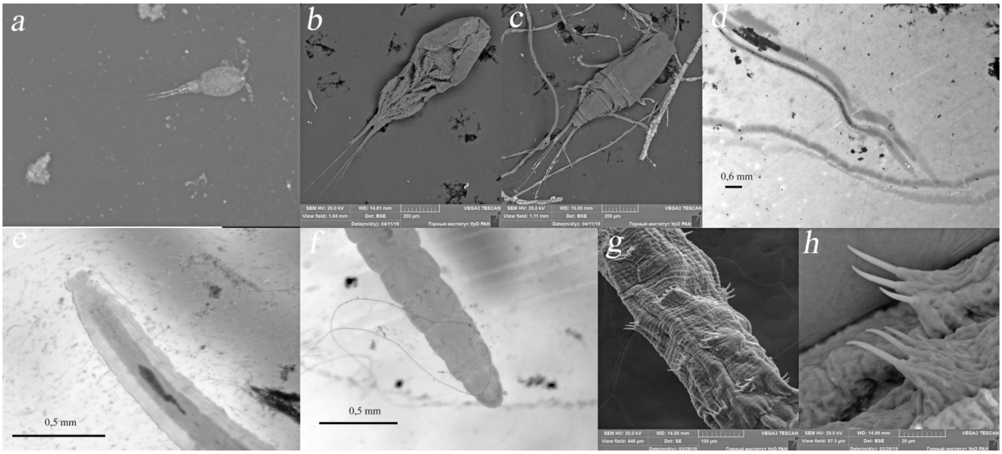

Figure 3 *Invertebrates. Ludmiliskaya well, Solikamsk, Russia (03.-04. 2019). a, b, c - Eucyclops macruroides; d, e, f, g, h - Lumbricillus lineatus s.l.*

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