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A CULTIVABLE MICROBIAL COMMUNITY IN THE LOWER YENISEI AND THE KARA SEA SHELF: DIVERSITY AND DISTRIBUTION

M.Yu. Suslova, V.V. Parfenova, O.N. Pavlova, T.Ya. Kostornova, A.P. Fedotov

Limnological Institute, Siberian Branch of the Russian Academy of Sciences, 3, Ulan-Batorskaya str., Irkutsk, 664033, Russia; suslova@lin.irk.ru

Microbial biota was studied in samples of water and bottom sediments from the Kara Sea and the Yenisei estuary collected in August through October 2009. The study included estimating the abundances of organotrophic, psychrophilic, and hydrocarbon-oxidizing bacteria, as well as spore-forming *Bacillus* genus. *Bacillus* made up 41.3 % of the total Kara Sea organotrophic community in the water and surface sediments and 54 % in the Yenisei. Hydrocarbon oxidizers isolated by filtering were the least abundant in the Yenisei estuary and the most abundant along the Dikson Village – Sibiryakov Island profile. The abundances of microorganisms in bottom sediment samples were two orders of magnitude higher than in the water, psychrophiles being the dominant group.

The necessity for studying the biogeochemical activity of microbial communities in the Kara Sea permafrost ecosystems has been increasingly evident with the progress of petroleum exploration in the Arctic shelf.

The earliest microbiological research in the Kara Sea was undertaken in 1935 by B.L. Isachenko and V.S. Butkevich [*Isachenko, 1951; Butkevich, 1958*] who revealed microorganisms in the seawater and assessed their biomass, having noted low abundances of saprophytes (10^3 to 10^4 cells/ml). Later estimates gave similar abundance values [*Kriss, 1959, 1976*]; higher numbers of bacterial cells were found in the southwestern Kara Sea in 1981 [*Teplinskaya, 1989*]. The total bacterial abundance in the Kara Sea was measured to be n10^3 to n10^4 cells per milliliter, which is an order of magnitude lower than in other Arctic seas [*Saliot et al., 1996*]. In 1993, a team from the Institute of Microbiology (Moscow) investigated the Kara Sea and the Yenisei and Ob estuaries [*Mitskevich and Namsaraev, 1994*] in terms of bacterial abundances (which was from $(2–3)\cdot10^3$ to $(250–280)\cdot10^3$ cells in a ml of seawater) and carbon and sulfur cycles. More data on bacterial abundances and production in the Kara Sea and the Yenisei and Ob estuaries collected in 2001 was reported in [*Meon and Amon, 2004*]. Hydrocarbon-oxidizing bacteria in the Central Arctic were first studied by V.V. Ilyinsky and his colleagues and were detected in very low abundances (no more than 1000 cells per liter) [*Ilyinsky, 1995*].

The objective of this study was to assess the abundances of different bacterial groups (organotrophs, psychrophiles, hydrocarbon oxidizers, and spore-forming *Bacillus* genus) in the water and surface bottom sediments of the Kara Sea shelf and the Gyda and Yenisei gulfs.

Microorganisms were studied in water and sediment samples collected during a cruise on R/V *Sovetskaya Arktika* in August through October 2009, at 13 stations on the Kara Sea shelf (Fig. 1, *a*) and 11 stations in the estuary and lower reaches of the Yenisei (Fig. 1, *b*).

The cultivable microbial community on the Kara Sea shelf (Fig. 1, *a*) sampled at stations along the profile from the Cape Kuznetsovsky to Dikson Village (W1–6) consisted mostly of psychrophiles which were four times more abundant than organotrophs. There were two distribution patterns at the six sampled stations. Psychrophiles had greater abundances in the bottom water than near the surface at stations W1–3: 113 against 17 colony-forming units (cfu) per milliliter, in spite of a small water temperature difference. At stations W4–6 located closer to Dikson they, on the contrary, decreased depthward from 191 to 34 cfu/ml as the water temperature fell to 1.5 °C and the salinity increased to 26.3 ‰ near the bottom. The abundance of organotrophic bacteria was within 45 cfu/ml. Hydrocarbon oxidizers and *Bacillus* in water samples along the Cape Kuznetsovsky – Dikson profile were, respectively, 23–600 cfu/100 ml and 3–33 cfu/ml (the greater numbers near the bottom in both groups).

A different structure of the microbial community was observed at stations W7–9, 20–22 (Kara Sea shelf) and W23 (northern end of Yenisei Gulf) (Fig. 1, *a*). Specifically, organotrophs (up to 2132 cfu/ml) were more abundant than the other microbial groups. The total bacterial abundance was the highest at W20, with dominant organotrophs, psychrophiles, and *Bacillus* (2132, 2304, and 686 cfu/ml, respectively) (Fig. 1, *a*). Hydrocarbon-oxidizing bacteria were detected in large numbers in the Kara Sea shelf seawater from stations W5, 7–9, the highest being 1200 cfu/100 ml in bottom water at W7 (Fig. 1, *a*).

Water in the lower Yenisei River contained abundant psychrophilic bacteria (Fig. 1, *b*) at all stations except W28, 29 on the Karepovsky – Cape Doro-

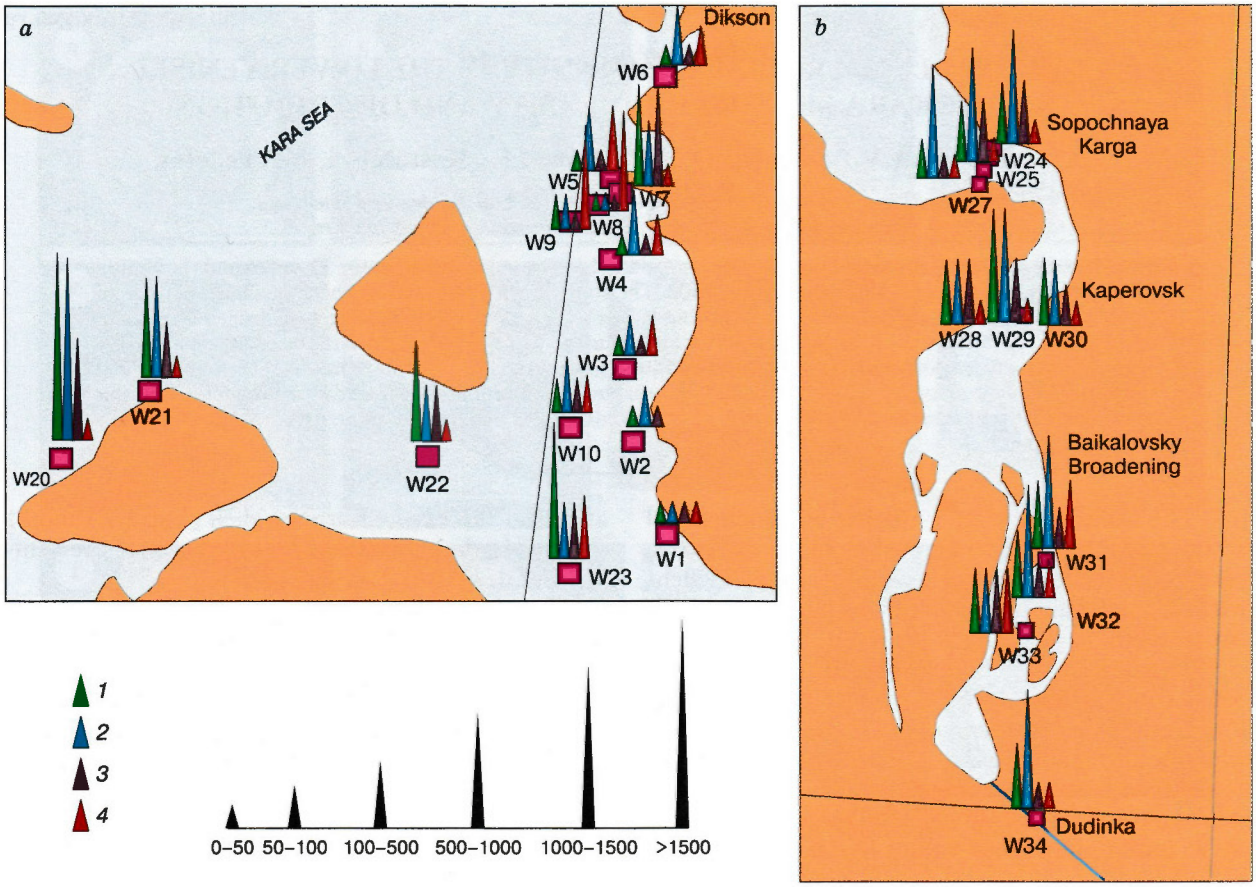

Fig. 1. Distribution of microbial groups in Kara Sea shelf (*a*) and Yenisei Gulf (*b*), in surface water.

Microorganisms: *1* – organotrophs, *2* – psychrophiles, *3* – *Bacillus* genus (cfu/ml); *4* – hydrocarbon oxidizers (cfu/100 ml). W1–W34 are station numbers.

feevsky profile where mesophile organisms had slightly greater abundances. The average abundances of organotrophs and psychrophiles were, respectively 408 cfu/ml and 550 cfu/ml. *Bacillus* genus constituted 54 % of the organotrophic community (Fig. 1, *b*). Hydrocarbon oxidizers were present in all samples of surface water in the profile across the Baikalovsky broadening (100, 200, 300 cfu/100 ml), while did not exceed 30 cfu/100 ml in all other samples (Fig. 1, *b*).

The bacterial abundances in bottom sediments were estimated in samples from five stations of the Kara Sea shelf (W7, 9, 10, 20, 22) and the Sopochnaya Karga – Cape Narzoi profile (W24–26), and were found to be two orders of magnitude higher than in the water: from $17 \cdot 10^3$ to $220 \cdot 10^3$ cfu/g. Psychrophiles were rather abundant both in the Kara shelf ($(54.5–220) \cdot 10^3$ cfu/g) and in the Yenisei ($(54–73) \cdot 10^3$ cfu/g). Hydrocarbon-oxidizing bacteria had greater abundances in the shelf than in the river sediments ($3.7 \cdot 10^3$ cfu/g against $0.45 \cdot 10^3$ cfu/g).

Generally, the microbial community was the poorest in water samples from the Yenisei Gulf – Dikson profile (W1–7), with organotrophs, psychrophiles, and *Bacillus* no greater than 45, 191, and 33 cfu/ml, respectively. The highest abundances of these groups were measured in the Kara Sea between Olenii and Sibiryakov islands. The percentages of spore-forming *Bacillus* relative to the total abundance of organotrophs were, respectively, 54 % and 45.5 % in the water and bottom sediments of the Yenisei and 41.3 and 41.1 % in the Kara Sea. The spores were 8 % in the water but as high as 74 % in the sediment, i.e. bottom sediments act as a spore-storing substrate. The highest abundances of hydrocarbon oxidizers were measured in seawater from the Kara shelf at stations of the Dikson – Sibiryakov Island profile (up to 1200 cfu/100 ml) and decreased progressively away from the open sea to no more than 30 cfu/100 ml in the Yenisei water. All analyzed microbial groups had greater bottom sediment abundances in the shelf than in the river.

Thus, an active microbial community lives in the Arctic area of the Kara Sea shelf and the Yensiei estuary. Microbes of all groups we studied have been found in all samples, the psychrophiles which grow at 4–6 °C being the most abundant. The growth of psychrophilic bacteria, both in water and in bottom sediment, is maintained by low-temperature conditions, as well as by large organic fluxes carried by the river. The shelf-estuary transition where fresh and saline water are intensely mixing is favorable for growth of microorganisms being a zone of rapid accumulation and recycling of organic carbon. This inference follows from the estimated abundances of microorganisms that can recycle both digestible (organotrophs and psychrophiles) and non-digestible (spore-forming and hydrocarbon oxidizing bacteria) organic matter. The presence of hydrocarbon oxidizers provides evidence for hydrocarbon input into the waters of the area and for self-cleaning in the ecosystem, which is also consistent with the predominance of *Bacillus* genus which participate in bacterial destruction of non-digestible organic compounds, including hydrocarbons. The abundances of hydrocarbon oxidizers are the highest especially in the water near Cape Kuznetsovsky.

The reported study has been the first step in discovering the microbial diversity in the Arctic to bridge the gap still existing in the knowledge of microbial life in the cryosphere.

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References

Butkevich V.S., 1958. Bacterial population of Arctic seas and its distribution in water and soil [in Russian]. Selected Transactions, AN SSSR, Moscow, Vol. II, pp. 77–134.

Ilyinsky V.V., 1995. Bacterial plankton of surface waters in the Central Arctic during calendar spring seasons. Mikrobiologiya, 64 (5), 696–704.

Isachenko B.L., 1951. Microbial characteristics of bottom sediment and water in the Kara Sea [in Russian]. Selected Transactions, AN SSSR, Moscow, Leningrad, pp. 334–363.

Kriss A.E., 1959. Marine (Deepwater) Microbiology [in Russian]. Izd. AN SSSR, Moscow, 455 pp.

Kriss A.E., 1976. Microbiological Oceanography [in Russian]. Nauka, Moscow, 78 pp.

Meon B., Amon R.M.W., 2004. Heterotrophic bacterial activity and fluxes of dissolved free amino acids and glucose in the Arctic rivers Ob, Yenisei and the adjacent Kara Sea. Aquat. Microb. Ecol., 37, 121–135.

Mitskevich I.N., Namsaraev B.B., 1994. Abundances and distribution of bacterial plankton in the Kara Sea in September 1993. Okeanologiya, 34 (5), 704–708.

Saliot A., Cauwet G., Cahet G., et al., 1996. Microbial activities in the Lena River delta and Laptev Sea. Mar. Chem., 53, 247–254.

Teplinskaya N.G., 1989. Bacterial plankton and benthos in the Kara Sea, in: Ecology and Biological Resources of the Kara Sea [in Russian]. Kola Science Center, AN SSSR, Apatity, pp. 29–37.

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