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RECYCLING

AIR POLLUTION & CLIMATE CHANGE

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STRATIGRAPHY OF CLADOCERA IN A CORE FROM A YAMAL PENINSULA LAKE (ARCTIC RUSSIA)

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ABSTRACT

Arctic regions are most sensitive to global climate change and Arctic waters are an excellent indicator of a current increase in air temperature on the planet. Yamal peninsula is one of a scientifically interesting part of the Arctic. It is a lake-swamp system with unique hydrological, biological, and geochemical particularities. On the one hand, the most part of water objects are under marine influence according to Yamal geographical position, at low level above the see; on the other hand, objects have a strong anthropogenic impact from oil and gas production. We studied a short sediment core from a lake in Pyasedayakha river catchment area. A total of 24 cladoceran taxa, of which 11 are in the family Chydoridae (chydorids), were identified from the 28 samples. The cladoceran stratigraphy was divided into three faunal zones and was characterized by the dominance of *Chydorus sphaericus* s.l., *Bosmina (Eubosmina)* sp., *Bosmina longirostris* and *Alona affinis*. Cladoceran assemblage changes occurred coincident with the timing of known regional warming and were strongly linked to estimated changes in primary production. Last warming has resulted in increase of the planktonic taxon *Bosmina* spp.and coincided with a decrease in the littoral taxa *Chydorus sphaericus* s.l.

Keywords: subfossil Cladocera, palaeolimnology, palaeoclimatology, Yamal peninsula, Russian Arctic

INTRODUCTION

Arctic and Subarctic regions have attracted considerable interest of researchers at the recent years. Thought to be that high-latitude regions are play a strong role in climatic forcing, and may be particularly sensitive to climate change. Climate change and active development of Far North territories lead to negative consequences and breaking of the northern ecosystems fragile balance, known as systems with a low degree of resistance to anthropogenous influence and extremely slow speed of restoration.

Cladocerans (Cladocera: Branchiopoda: Crustacea) are a key component of aquatic ecosystems, which have been used often in paleoecological reconstructions of climatic and environmental change. Their chitinous exoskeletal components (shell, head shield, postabdomen, postabdominal claws, antennal segments, and mandibles) are usually well preserved after death. Furthermore, most are identifiable to species. Ecological information exists for most species, and they are sensitive to changes in climate and environmental variables such trophic state, conductivity, saline transgressions and predation intensity [1-3].

The aim of the present investigation was to examine the taxonomic and ecological diversity of cladoceran microfossil assemblages from Lake in Pyasedayakha river catchment area (Yamal peninsula, Russia). None of the previous paleolimnological analyses examined faunal subfossil Cladocera assemblages in Yamal peninsula, Russia.

Study area

The Yamal-Nenets national district is located in the middle of northern part of Eurasia. Because of the high-altitude location of the territory, low solar radiation, considerable remoteness from warm air and water masses of the Atlantic and Pacific oceans, flat relief, open to the Arctic air masses invasion in the summertime and the overcooled continental masses in the winter, climate here is strongly continental and fierce.

Periglacial landscape is dominated by tundra and northern taiga vegetation, deep-reaching frozen ground and widespread lake districts. Most of lakes are considered to be of glacial origin. These lakes are small, rather shallow (1–3 m) and characterized by specific thermal and chemical regimes, making them sensitive to recent climate changes. The ion content in water of lakes of Yamal peninsula generally low with dominance by Mg–Ca or Ca–Mg.

The climatic conditions of the Yamal region show extreme seasonal variations. Short, cool summers (50-68 days) are followed by long (8 months) and very cold winters. The coldest month is January with an average air temperature below –25-26°C and the lowest temperatures reaching –59°C. The mean July temperatures are +4 to +15°C with maximum summer temperature + 30°C. The mean annual air temperature is negative, on Far North it reaches −10 °C [4]. Consequently, the period of open water and, respectively, vegetation period for the majority of the water organisms, such as Cladocera, is limited in the Yamal peninsula by a short temporary interval of one or two months

MATERIAL AND METHODS

Arctic and Antarctic Research Institute (Saint Petersburg State University, Russia) and Yamal region Government organized two complex expeditions in August-September 2012, 2013 to Yamal, Yavay and Gyudan peninsulas for better understanding of current environment and specific region features highlighting. Hydrological and hydroecological investigation consist river discharge, lake bathymetry, and pH, dissolved oxygen, conductivity measurements as well as water and sediment cores taken. Lake bathymetry was measured by Garmin GPSmap 178C echo sounder by small robber board. Bathymetry scheme was created in Surfer software. Geochemical analysis of water and sediment samples was carried out in the Russian-German Otto-Schmidt Laboratory for Polar and Marine Research (OSL) of AARI (St. Petersburg, Russia).

Studied lake in Pyasedayakha river catchment area (67°42'51.3" N 72°55'40.3" E) was shallow, with maximal depth 3.4 m (Figure 1, 2). A sediment sequence (57,5 cm) from the Lake in Pyasedayakha River catchments' lake was cored using either a GOIN gravity corer with a 60 cm long, 6 cm diameter metal liner and stored in plastic bags, which were transported, frozen, to the laboratory.

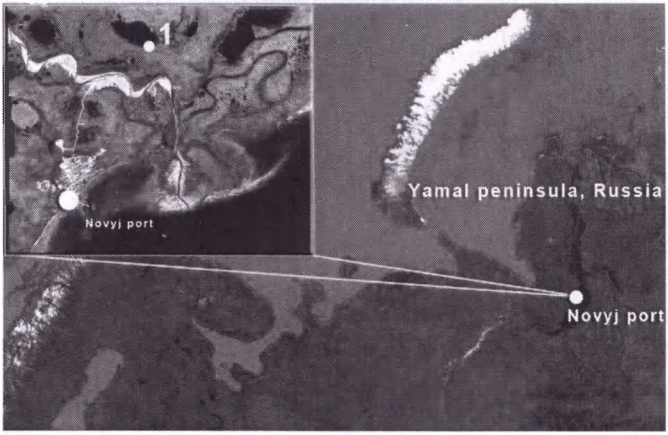

Figure 1. A map of location of Lake in Pyasedayakha river catchment area (1) (Yamal peninsula, Russia)

In laboratory sediment core was sectioned at 2-cm intervals and the subsamples were placed in small plastic bags for storage in a cold room. Handpicked, identified macrofossils were selected for AMS dating from 18-20 and 50-52 cm depth. The AMS samples were dated at the Leibniz Laboratory for Radiometric Dating and Stable Isotope, Kiel, Germany.

The cladoceran remains were prepared according to Korhola and Rautio [5]. Each sample (2 and 4 g of fresh sediments) was boiled for half an hour in a 10% solution of KOH to remove humic matter and treated with HCl to eliminate carbonates. The residue was washed and sieved using a 50 μm sieve. All remains were counted: headshields, shells, postabdomens, postabdominal claws and ephippia. The Cladocera remains were

screened using an Axiostar Plus Carl Zeiss light microscope at 100×-400× magnification. Cladocera taxonomy is followed by Kotov et.al. [6] and Flössner [7]. TILIA version 2.0.b.4 was used to generate a cladoceran percentage diagram [8]. The program CONISS was used to perform a stratigraphically constrained incremental sum-of-squares cluster analysis and identify the major groups in lake composition throughout the transect [8]. Species diversity and evenness were calculated for each sample using the Shannon Index of Diversity (H) [9].

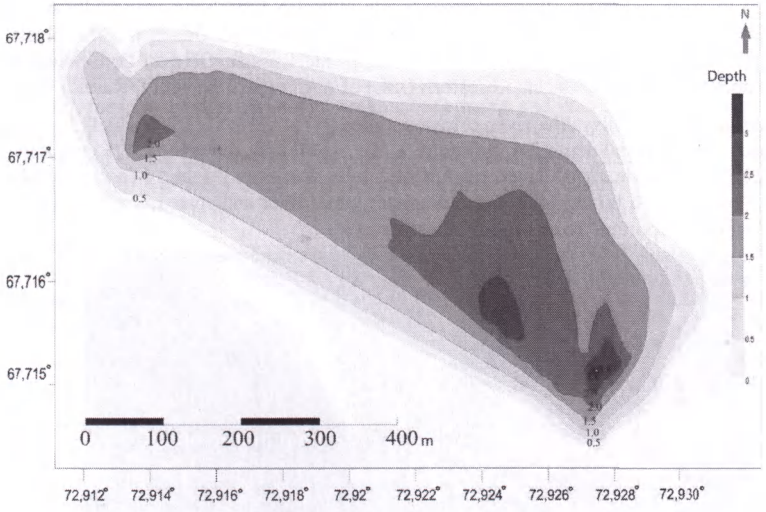

Figure 2. Bathymetry of Lake in Pyasedayakha river catchment area (Yamal peninsula, Russia)

RESULTS

During the summer period, when no ice covers the lakes and ponds, the water bodies are defined as polymictic. Because of the shallow water depth and the wind driven mixing, the water temperature is tightly correlated to the air temperature and ranged from 12.0 to 14.0 °C during the fieldwork period. The ion content in water of studied lake was low, 3 mg l^{-1}. In spite of the ration TC/TN in the studied core that has maximum 26, total carbon (TC) and total organic carbon (TOC) in suspended material was not more than 1.4 %. It means suspended supply from Yamal is not so high and mostly organic. A total organic carbon (TOC) increases markedly in the studied core towards the top.

The extreme climate of the Arctic, with a short growing season and an extended period of icecover, limits the abundance of water invertebrates and Cladocera in particularity. However, our study has shown that the subfossil cladoceran fauna of Yamal peninsula is relative rich and diverse.

A total of 24 cladocerans taxa, of which 11 are in the family Chydoridae (chydorids), were identified from the 28 samples. The relative abundances of the most common cladoceran taxa (>0.2% total abundance) are presented in Figure 3.

Shannone-Wiener Index, a measure of biodiversity and the trophic state of the ecosystem, varied very little throughout the core with minimal values of 1.96 at the top of the core and maximal values of 2.64 in the middle part of the core, averaging 2.39, characteristic for oligotrophic to β-mesotrophic conditions [10].

Species composition of Cladocera in sediments from Lake in Pyasedayakha river catchment area characteristic of its changes allowed to analyze the history of the development of the lake during the 1300 years duration and made it possible to distinguish 3 phases of its evolution (Figure 3.).

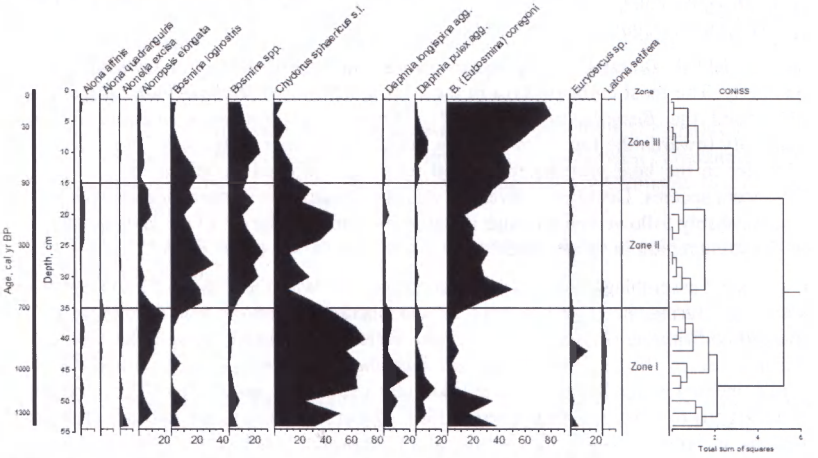

Figure 3. Relative abundances of the most common cladoceran taxa in Lake in Pyasedayakha river catchment area

The lake, during its development was with well developed pelagic zone, what is confirmed by domination of planktonic forms belonging to the family of Bosminidae. Bosminidae lived in Lake in Pyasedayakha river catchment area in all phases of its development. Relative abundance of pelagial species in core is 58.12 %. The variety of species of Cladocera belonging to Chydoridae confirms a well developed and diversificated littoral zone.

In the analyzed layer 56-58 cm of sediment core we did not find Cladocera remains. Zone I (54-35 cm) is characterized by the dominance of *Chydorus sphaericus* s.l. (23.1–71.0%). *Bosmina (Eubosmina) coregoni*, *Alonopsis elongata*, *Daphnia pulex* agg. and *Daphnia longispina* agg. are present at lower abundances. *Chydorus sphaericus* s.l. increases towards a maximum at 40 cm and *Bosmina (Eubosmina) coregoni* and *Daphnia* species attain minimum values in the zone at the same time. *Chydorus sphaericus* s.l. attains maximal occurrence (approx. 70%) close to the top of the zone

and begins to decline afterwards. The proportions of *Alonopsis elongate* often associated with sand sediments are maximal in this zone.

Analysis of species composition of Cladocera show that mostly pioneer species, tolerant to low level of biogenic substance existed in this zone. But an increase of the cladoceran *Chydorus sphaericus* s.l., a species associated with high nutrient status, suggests that the lake had elevated productivity. Well presented taxa typical for littoral zone as well as pelagical species.

In zone II (35–15 cm) *Bosmina (Eubosmina) coregoni* (13–50%), *Chydorus sphaericus* s.l. (10–46%), *Bosmina longirostris* (10–33%) and *Bosmina spp.* (6–26%) are the dominant species. Zone is characterized by a distinct decrease in *Chydorus sphaericus* s.l to 10% in the middle of the zone and increases back to approx. 45%. In comparison with previous zone the proportions of *Chydorus sphaericus* s.l are lower. *Bosmina (Eubosmina) coregoni* increases markedly.

In zone III (15–0 cm) *Chydorus sphaericus* s.l. and the *Bosmina longirostris* decrease distinctly. The most common taxa in the zone are *Bosmina (Eubosmina) coregoni* (42–80%) and the *Bosmina spp.* (10–24%). *Bosmina (Eubosmina) coregoni* increases markedly towards the top. *Pleuroxus sp.* requiring warmer water was found. The level of water in the lake probably increased which is mirrored by an increase of pelagic Cladocera species. Decrease in average values of Shannone-Wiener Index to 1.96 in this zone probably followed an increase in anthropogenous pollution of the lakes ecosystems of the study region in recent time.

Cladoceran assemblage changes occurred coincident with the timing of known regional warming. During the reference state the cladoceran community was dominated by the planktonic *Bosmina (Eubosmina) coregoni*, which thives under mesotrophic conditions. An increase in the filter-feeding taxon *Bosmina (Eubosmina) coregoni* and *Bosmina spp.* coincided with a decrease in the littoral taxa *Chydorus sphaericus* s.l. This response is analogous to what has been inferred for cladoceran communities across high-latitude regions in western Canada as evidence of consistent cladoceran changes to recent climate warming [11].

CONCLUSION

Species composition of subfossil Cladocera in sediments from Lake in Pyasedayakha river catchment area, and characteristic of its changes allowed to analyze the history of the development of the lake and made it possible to distinguish 3 phases of its evolution. The lake, during its development had well developed pelagic zone, what is confirmed by domination of planktonic forms belonging to the family of Bosminidae. The variety of species of Cladocera belonging to Chydoridae confirms a well developed and diversificated littoral zone. Cladoceran assemblage changes occurred coincident with the timing of known regional warming and were strongly linked to estimated changes in primary production. Last warming has resulted in an increase of planktonic taxon *Bosmina* spp. in the core and coincided with a decrease in the littoral taxa *Chydorus sphaericus* s.l.

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