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Meiobenthic assemblages of moraine and tundra reservoirs of Coraholmen Island (Central Spitsbergen) and their differences

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Running title: Meiobenthos assemblages of Coraholmen's reservoirs

Abstract: The aim of the study was to estimate the diversity of contemporary meiobenthic communities of selected water reservoirs of the small island of Coraholmen (Central Spitsbergen), and to identify abiotic and biotic factors influencing their diversity. The landform of Coraholmen is unique: the eastern part is flat and covered with tundra, while the south-western part is dominated by postglacial moraine hills, between which small water bodies are located. Different nature of the bottom surface allows determining the abiotic factors influencing the composition and diversity of meiobenthos. Sediment and water samples were taken from 10 reservoirs, equally from tundra and moraine areas. The moraine reservoir's substrate was deposited by glacier and is characterized by accumulation of marine fossils, mainly calcareous benthic foraminifera, till with gravels and pebbles. Tundra reservoirs (often periodic/ astatic) are characterized by accumulation of sandy-muddy sediments with rich content of organic matter. The waters in these reservoirs were characterized by low salinity and alkaline pH. The concentration of TN ranged from 328 μg/l to 1004 μg/l, the concentration of TP from 3.2 μg/l to 43.1 μg/l, and the ratio of TN/TP_{mol} ranged from 52 to 300. The molar ratio of TN/TP obtained in tundra ponds was on average twice as high as in moraine ponds. The meiobenthic assemblages found were typical of the freshwater reservoirs of Spitsbergen. The examined epibenthic assemblages from all reservoirs were of low diversity. Meiobenthic assemblages were represented by 9 major taxa: Rotifera, Nematoda, Gastrotricha, Oligochaeta, Cladocera, Copepoda, Ostracoda, Diptera larvae and Arachnidae. Ostracoda and Diptera larvae were relatively numerous. The most numerous crustaceans were Ostracoda: *Candona rectangulata* Alm, 1914 *Tonnacypris glacialis*, G.O. Sars and *Limnocytherina sanctipatricci*. The topography, geology, and soil characteristics of the catchment area do not influence the aquatic ecosystem.

Keywords: Arctic, Svalbard, Coraholmen, meiobenthos, moraine and tundra reservoirs

Introduction

Meiobenthic marine and freshwater organisms, also called Meiofauna, according to some authors, are small invertebrates belonging to Metazoan (Reise 1979; Schizas & Shirley, 1996; Sommerfield & Warwick, 1996), while according to other authors, they also include Foraminifera, which are classified as Protozoa (Giere 2009; Gal'tsova et al. 2004; Brandt et al. 2007), Definitions of meiofauna sizes vary, but a range of 0.042 - 1 mm is generally accepted (Wojtasik 2016). Meiofauna is a functional group (Warwick 1990) and is a sensitive indicator of changes in the aquatic environment both in contemporary environments (Särkkä, 1992; Soltwedel, 1997; Da Fonseˆca-Genevois et al. 2006; Chainho et al. 2007), and for geological past (Machaniec & Zapałowicz-Bilan 2005a; Machaniec et al., 2011; Worobiec et al., 2015; Machaniec et al., 2020). Meiofauna species are an increasingly common used group of bioindicators (Soares et al. 2007, Wojtasik 2012; 2015; Markowski, Wojtasik 2024). Some of them are very sensitive, however, some belong to pioneering taxa, resistant to changes in extreme physical and chemical conditions (Wojtasik & Cieszyńska, 2008, Wojtasik 2020a,b). Many of them appear in different aquatic marine and freshwater, such as eutrophic or polluted water bodies (Wojtasik, 2018), on carbonate platform and in deep water environment (Machaniec & Zapałowicz-Bilan, 2005b; Machaniec et al., 2005; Tshakreen et al., 2017). In addition, meiobenthic taxa react to local changes in environmental conditions by creating specific, characteristic assemblages for specific areas e.g.: depending on the type of coastline, the type of coastal development, local pollutant inflows, hydrotechnical devices (Wojtasik et al. 2009; 2013; 2020b). Meiobethic assemblages are a valuable and sensitive ecological indicator of Arctic ecosystems (Alves et al. 2013; Schneider et al. 2016; Leasi et al. 2021). Freshwater major meiobenthic taxa include: Turbellaria, Rotifera, Gastrotricha, Nematoda, Oligochaeta, Crustacea (Cladocera, Copepoda, Ostracoda), Insecta larvae and adults, Tardigrada, Arachnida, Gastropoda and Bivalvia.

Many of these organisms constitute the lower floor of the food chain on which the development of larger organisms depends: macrobenthos, young fish. Many meiobenthic organisms feed on detritus, which is important for the circulation of matter in the environment (Giere, 2009).

The aim of the research was to assess the diversity of contemporary meiobenthic communities in selected stations located on the border of moraine hills and the Coraholmen tundra area and to try to identify and determine the relationship between abiotic and biotic factors influencing their diversity.

Study area

Coraholmen is a small island located in the northern part of the Ekmanfjorden, which is a part of Isfjorden on James I Land, the central part of Spitsbergen, the largest island of the Svalbard archipelago, which borders with the Arctic Ocean, the Norwegian Sea, and the Greenland Sea (Fig.1). The island has a unique character due to its diverse landform: the eastern part of Coraholmen is flat and covered with tundra, while the south-western part of the island is dominated by moraine postglacial hills, red clay deposited by the Sefströmbreen glacier during a surge in 1896 (Hagen et al. 1993; Boulton et al. 1996).

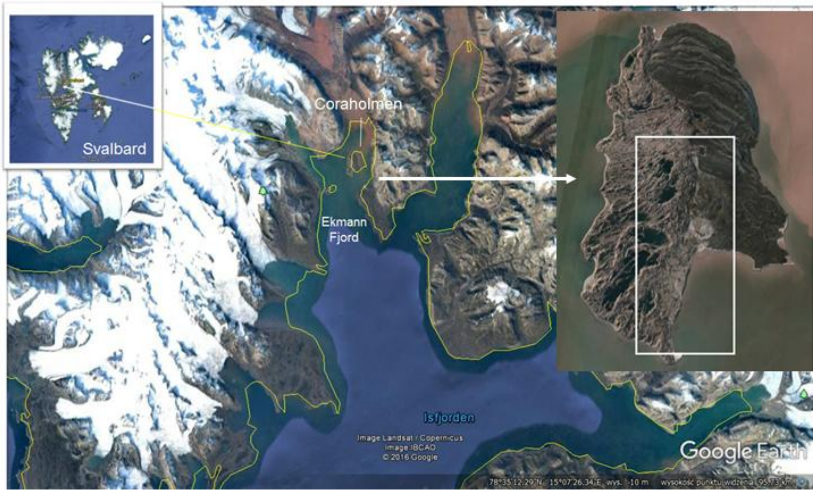

Fig. 1. The study area: Svalbard and the Ekman Fjord incl. the Coraholmen Island (Google Maps)

The Coraholmen island is built of limestones bedrock (rising up to about 10–20 m above the sea level), and is about 3.3 km long and 1.8 km wide. Between the glacial till hills of the south-western part, small water reservoirs are located (Fig.2). These basins are endorheic and are contributed to only by precipitation. The hills are composed of weathered marine sediments (Fig. 3A, B), as indicated by numerous fragments of bryozoans, serpulids, corals, molluscs and foraminiferal shells (Bates & Schwarzacher, 1958).

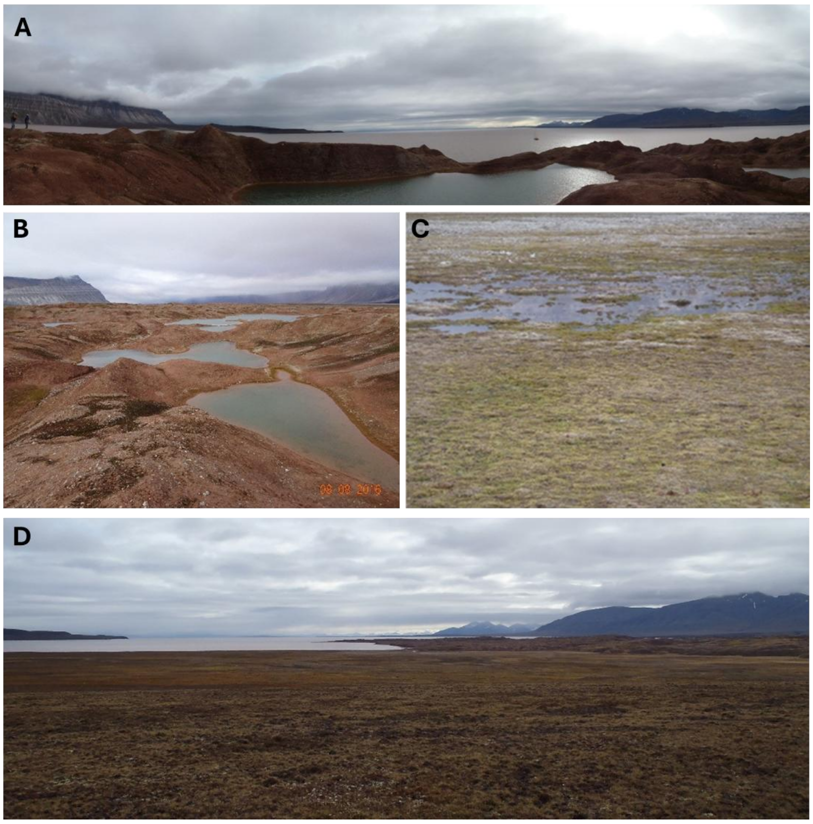

Fig. 2. Coraholmen island, SW part with moraine reservoirs (A and B), E part with tundra reservoirs (C and D)

The bay on the north-western side of the island (Mudderbukta) has a steep bottom and depth of about 30–40 m, while up to about 1 nautical mile offshore it is quite shallow (from a few to about 20 m) and the sea bottom topography is irregular. According to data presented by Aashein Stein (2008) the distribution of marine sediments and the moraines is a result of a surge of Sefström glacier, located in north-west branch of the fjord. This surge took place between 1882 and 1886. The glacier front moved about 6.5 km forward. Consequently, about 10–20 m of sediments was deposited, and the island's area was enlarged to double (as was a nearby island Flintholmen). The slow recession of several glaciers, commenced in 1898, and in 1908 the recessing glacier separated from the ice remaining on Coraholmen. In 1927 there was no more visible ice cover on Coraholmen, although ice covered with sediments was probably still present at the time (Boulton, 1996; Boulton et al. 1996).

Fig. 3. Moraines muddy sediments with fossils (A and B), the shell of Bivalvia Productus (**C**), cora, Coraholmen (Central Spitsbergen); 8 August 2016

Methods

Sampling positions were located from the south-eastern coast to the inland part of the island of Coraholmen, on the border of the moraine part and the tundra part. Surface samples of bottom sediments and near-bottom water were collected on August the 8th 2016 from 10 water reservoirs (Table 1, Fig.4): five of tundra (East part of island, locations (No.1–5) and five of till ponds (south-west part of the Coraholmen island, stations No.6–10).

Tundra reservoirs are often periodic/astatic, which are characterized by the accumulation of organodetritic/sandy-muddy sediments with pebbles and gravels (lithoclasts). Moraine reservoirs are characterized by the accumulation of rock debris and tills on the substrate, deposited by the glacier. The fraction of material, which ranges in size from small boulders to sand and clay, is unstratified when dropped by the glacier and shows no sorting or bedding. The rock debris of these reservoirs contains large amounts of bioclasts, among which the dominant group are the smallest organisms Foraminifera, among which was distinguished over twenty-five taxa of calcareous benthic foraminifera, and only two with agglutinated tests. In the sediments occured also: Ostracoda, Bryozoa, Gastropoda, and other macrobenthos and meiobenthos remains of sub-fossils organisms. These sub-fossils of Foraminifera and Ostracoda are the subjects of other studies (see Machaniec et al. 2021).

Table 1. Geographical position, hydrological parameters (temperature T [^{o}C] conductivity C [mS/cm], salinity S [psu], pH [-]), and sediment parameters (type and structures of bottom sediment, content of organic matter) of sampling stations: 1-5 tundra, 6-10 moraine, Coraholmen, Svalbard; 8 August 2016

Station	Geographical position	Hydrological parameters				Structures of sediment/ Content of organic matter	Type of substrate sediment
	Latitude φ Longitude λ	T	C	S	pH		
1	78°40.884’N 014°43.026’E	4.1	1.94	1.0	8.17	disturbed, birds guano, rich in organic matter	detritic/ sandy-muddy with pebbles
2	78°40.836’N 014°43.044’E	4.0	2.58	1.3	8.18	disturbed, birds guano, rich in organic matter	detritic/ muddy with pebbles
3	78°40.644’N 014°43.194’E	4.1	2.31	1.2	8.16	disturbed, birds guano, rich in organic matter	detritic/ san-muddy with pebbles
4	78°40.578’N 014°43.314’E	4.8	2.02	1.0	8.18	disturbed, birds guano, traces of bird paws and feathers, rich in organic matter	detritic/ muddy-sandy with small amont gravels
5	78°40.500’N 014°43.386’E	5.9	3.81	2.0	8.09	disturbed, birds guano, traces of bird paws and feathers, rich in organic matter	muddy-sandy
6	78°40.380’N 014°43.038’E	5.5	2.66	1.4	8.10	notdisturbed, poor in organic matter	muddy-sandy with gravels, pebbles, calcareous fossils
7	78°40.212’N 014°42.378’E	6.1	3.34	1.7	8.52	disturbed, birds guano, bird paws and feathers, poor in organic matter	muddy-sandy with gravels, pebbles, calcareous fossils, microplastic
8	78°40.116’N 014°42.360’E	6.3	4.16	2.2	8.20	disturbed, birds guano, traces of bird paws and feathers, poor in organic matter	muddy-sandy with gravels, pebbles, calcareous fossils
9	78°40.081’N 014°42.119’E	6.8	3.87	2.0	8.45	disturbed, birds guano, traces of bird paws and feathers,	muddy-sandy with gravels, pebbles, calcareous fossils
10	78°40.044’N 014°42.066’E	6.7	9.58	5.4	8.26	disturbed, birds guano, traces of bird paws and feathers,	muddy-sandy with gravels, pebbles, calcareous fossils

Fig. 4. Sampling stations, Coraholmen (Central Spitsbergen); 8 August 2016

An exact place of the sampling stations (the location is in Table 1) and sediment surfaces is shown on Fig.5 and Fig.6. The samples were taken from water reservoirs with short sediment cores (~10 cm long and 2.5 cm in diameter) from the surface layer down to 5 cm. For each station, five replicates were taken. The samples designated for meiobenthic assemblages analysis were preserved with 70% ethanol and marked with Rose Bengal sodium salt (Sigma R3877-5G).

Fig. 5**.** Tundra type reservoirs, place of sampling stations and microscopic photo of sediments; Coraholmen Island

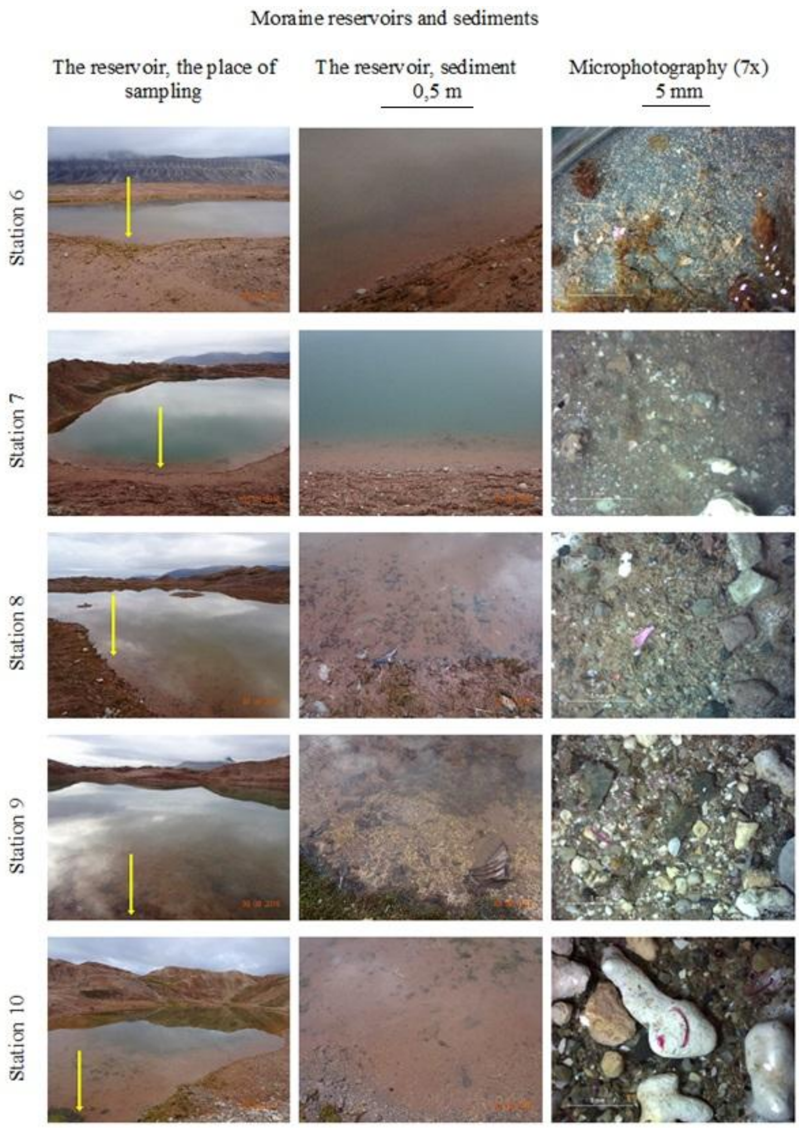

Fig. 6. Moraine type reservoirs, place of sampling stations and microscopic photo of sediments; Coraholmen Island

Analysis of water

Physical water parameters including temperature, salinity, conductivity, pH were measured below the surface (0.5 m) using a WTW Multi 3430 SETG meter. Total nitrogen (TN) and phosphorus (TP) were determined by measuring NO_3^- and PO_4^{-3} of unfiltered water samples (after digestion with persulfate) by standard colorimetric methods (Koroleff 1983; UNEP/IOC/IAEA, 1988). For each sample, the analysis was performed twice, and mean values were calculated.

Meiobenthic analysis

Meiobenthic organisms coloured by Bengal Rose were identified by microscope (zoom 1x – 40x). Meiobenthic was conducted on the basis of calculated: Frequency F, number of stations with examined taxa / number of all stations ($0 \leq F \leq 1$, $F_{max} = 1$ when a taxa inhabiting all studied stations); relative abundance (percentage of examined taxa in all material and material of every station); cluster analyses and MDS (program Primer-E, v.6, Clarke & Gorley 2006); taxa dominance analysis for selected stations and all material (mega dominant (MD): MD > 75%, dominant (D): 75% ≥ D > 50%, subdominant (sD): 50% ≥ sD > 25%, influent (I): 25% ≥ I > 12.5%, subinfluent (sI): 12.5% ≥ sI > 6.25%, ultrainfluent (uI): 6.25% ≥ uI > 3.125%, recedent (R): 3.125% ≥ R > 1.5625%, subrecedent (sR): 1.5625% ≥ sR > 0.78125%, ultrarecedent (uR): 0.78125% ≥ uR > 0%) and MeioEco analysis. Analyses MeioEco were performed based on the methodology developed for assessing the ecological status by meiobenthos assemblages (Wojtasik, 2013; 2020a; 2020b, Wojtasik et al. 2019, Markowski, Wojtasik 2024) with *MeioEco* program (Wojtasik et al. 2016). Analyses are conducted for the relative scale taking into account the minimum and maximum parameters in the obtained results: N10 – the number of individuals per 10 cm², Ntaxa – the number of identified major meiobenthic taxa. Arithmetic means were calculated, for maximum and minimum values of both parameters, and the boundaries of the interval. Also included is a new algorithm developed Bw to calculate the balance of taxa present in the assemblage (Wojtasik, 2013; 2020a, Wojtasik et al. 2019, Markowski, Wojtasik 2024).

Results and Discussion

Substrate of reservoirs

Microscopic and macroscopic images of bottom sediment from the tundra ponds (No.1–5) and moraine ponds (No.6–10) are distinctly different. Sediments from the tundra ponds were rich in flora and leftovers of dwelling birds (e.g. feathers and guano), and other kinds of organic matter. Meanwhile, the sediment of the moraine ponds was muddy, rich in marine calcareous fossils in forms of calcareous tests of Foraminifera, Ostracoda, Bivalvia, skeletons of Bryozoans, pebbles, gravels of different fraction and small amount of flora (Fig.5 and Fig.6).

Chemical analysis

The temperature in the water varied from 4.0 to 6.8 °C (Table 1). Water in tundra ponds (No.1-5) was more than 1.5 °C lower than in the moraine ponds (No.6-10). Salinity and conductivity ranged between 1.0–5.4 psu and 1.94–9.58

mS/cm respectively (Table 1, Fig.7). Strong correlation (0.999) between salinity (S) and electrolytic conductivity (C) indicates a seawater. For freshwater, the correlation between S and C is not that strong, because the increase of salinity is not necessarily caused by the increase of concentration in chlorides. The pH-value of water samples of the studied reservoirs on Coraholmen were 8.09–8.52 (Table 1, Fig.7). The variation in pH values was much greater (mean value: pH 8.31±0.16) in moraine ponds water (No.6–10) than in tundra ponds (mean value: pH 8.16±0.04; stations No.1–5).

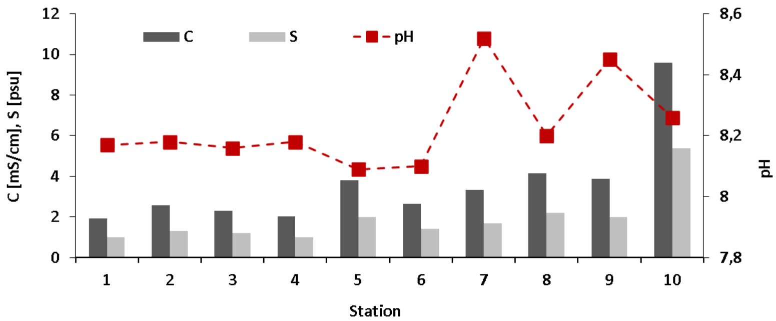

Fig. 7. Water analyses in 2016, conductivity (C) salinity (S) and pH of water samples of studied reservoirs of Coraholmen (Central Spitsbergen); 8 August 2016

The TN concentration was 328–1004 µg/l and TP 3.2–43.1 µg/l, with an average value of 522 µg/l and 11 µg/l, respectively (Fig.8). In the case of both TN and TP, lower concentrations were recorded in tundra waters (mean value: 412 µgTN/l and 4.51 µgTP/l; stations No.1–5) than in moraine waters (mean value: 631 µgTN/l and 16.7 µgTP/l; stations No.6–10). The variability of concentrations TN and TP in tundra ponds did not exceed 20%. In the waters of moraine ponds, the variability of TN and TP concentrations was higher, respectively about 2 and 4 times. The TN/TP_{mol} ratio in the studied ponds ranged from 52 to 300 and on average was 209 and 115 in tundra ponds (No.1–5) and moraine ponds (No.6–10), respectively. The relationship between N and P assumed the exponential character (Fig.9) with the lowest observed values of both parameters in tundra ponds waters (minimum values in station No.1) and the highest in moraine ponds water (maximum values in station No.10; without stations No.7 and No.9).

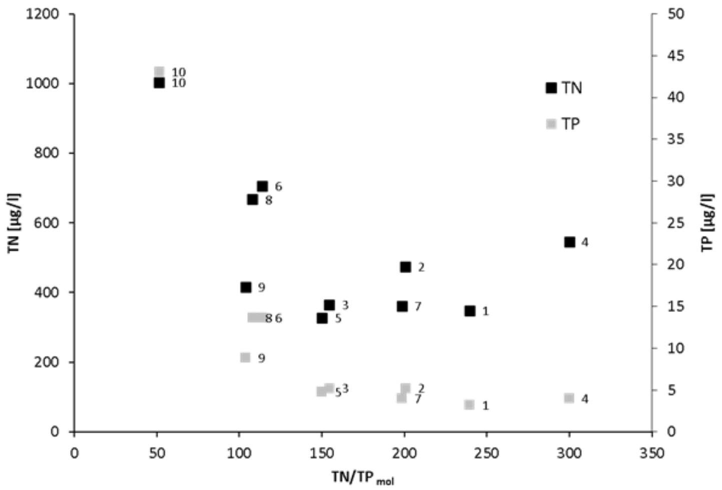

Fig. 8. The nitrogen concentration TN, the phosphorus concentration TP and the value of the molar ratio of these elements (TN/TP_{mol}) in tundra (No.1–5) and moraine (No.6–10) pond waters; Coraholmen (Central Spitsbergen); 8 August 2016

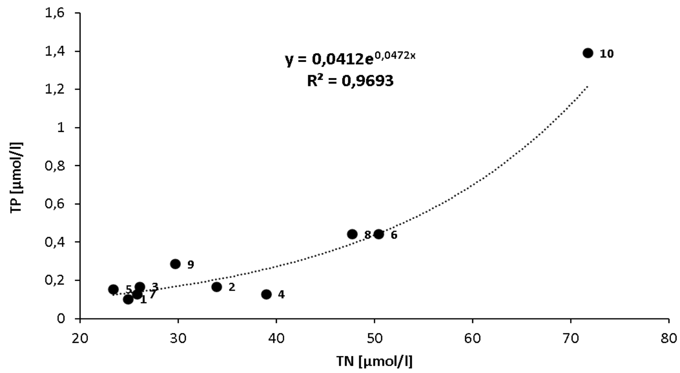

Fig. 9. The nitrogen concentrations – TN and phosphorous concentrations TP in tundra (No.1–5) and moraine (No.6–10) pond waters; Coraholmen (Central Spitsbergen); 8 August 2016

TN and TP concentrations in the waters of the study area are in the range of values given by other authors for Arctic lakes (Ogbebo et al. 2009; Hogan et al. 2014; Burpee et al. 2016; Whiteford et al. 2016; Liang&Aherne 2020). Liang and Aherne (2020) presented physical and chemical parameters for 1300 lakes and ponds across the Canadian Arctic. The ranges of TN, TP, pH measured in the waters of the ponds of the island of Coraholmen were within a wide range of values presented there. Burpee et al. (2016) observed in June and July in Arctic lakes and permafrost landscape of south-west Greenland a slightly wider range of 178–1132 µgTN/l and 2–12 µgTP/l. At the same time, lower values of TN concentrations and higher TP were measured in June than in July. Significantly lower (<2.2 µg/l for TP and <721 µg/l for TN) than in moraine and tundra pond waters on Coraholmen (Central Spitsbergen) was obtained in the study of lakes from three areas of Ice sheet, margin, Inland Coast (southwest Greenland) in June–September by Hogan et al. (2014). Significantly higher phosphorus concentrations, reaching 40 µg/l, were measured in lakes located in the Northwest Territories, Canada, along a transect from the Mackenzie River Delta south to Travaillant Lake (Ogbebo et al. 2009). During the growing season, the lowest concentrations of TN and TP were most often observed in the period June–July, and their marked increase in August–September (Ogbebo et al. 2009; Whiteford et al. 2016).

Many Arctic lakes are oligotrophic systems where phototrophic growth is controlled by nutrient supply. Total phosphorus concentrations generally were typical of oligotrophic lakes (<10 mg/l). In our research, except for three moraine ponds (No.7, No. 8 and No.10), the remaining waters can be considered oligotrophic. In the current study, the majority of lakes recorded high atomic TN/TP_{mol} values, exceeding the Redfield (1958) ratio of 16:1. All the obtained values of this ratio were within the range of values given by other authors for Arctic lakes. Burpee et al. (2016) in June and July found TN/TP_{mol} 206 and 245, respectively. A molar ratio of TN/TP_{mol} in the range 47–496 was observed by Ogbebo et al. (2009). Values of this ratio in an even wider range (28–600) were recorded by Whiteford et al. (2016) conducting research depending on the seasons and taking into account the different locations of the lakes: coast, inland, ice sheet margin.

The authors of the publications mentioned (e.g. Ogbebo et al. 2009; Whiteford et al. 2016) note the significant concentrations of TN and TP show a wide range of variability in a small area of research. The TN/TP_{mol} ratios also show the different degrees of trophy of the examined lakes. This indication should be considered a characteristic feature of the Arctic lakes, and the results obtained locally should be carefully extrapolated to the regional or broader level.

Meiobenthos

In the studied samples, nine major meiobenthic taxa were collected and distinguished: Rotifera, Nematoda, Gastrotricha, Oligochaeta, Cladocera, Copepoda, Ostracoda, Diptera larvae, and Arachnida (Table 2). These assemblages are typical of Spitsbergen freshwater reservoirs. The most numerous groups were Diptera larvae and Ostracoda (Table 2). The pioneer taxa of freshwater meiobenthic assemblages (Wiśniewska-Wojtasik & Walczak, 2005; Wojtasik, 2009b), these taxa have had the highest frequency (F = 1.0). The lowest frequency (F = 0.1) were Gastrotricha and Arachnidae represented by one individual each. The percentage number of taxa is presented by Figure 10.

Table 2. Meiobenthic assemblages of (fresh) water reservoirs, Coraholmen, 8 August 2016

Taxa	Station / number of individuals										N	F
	1	2	3	4	5	6	7	8	9	10		
Rotifera	5		1			3				2	11	0.4
Nematoda	99	8	8		71	25	55	42	3	84	395	0.9
Gastrotricha				1							1	0.1
Oligochaeta	4	1			40	2	1		8	55	111	0.7
Cladocera		1	171	3		153	2	15	3	37	385	0.7
Copepoda	12	1	21	2	1			22	5	118	182	0.8
Ostracoda	29	36	119	6	58	73	96	128	50	48	641	1.0
Diptera larvae	76	34	41	147	80	65	38	27	44	132	684	1.0
Arachnidae		3				1			2	2	8	0.4
N	225	84	361	159	250	322	192	234	115	478	2418	

N – number of individuals of major meiobenthic taxa in all sampling stations,
F – frequency (number station with observed taxa / number all stations)

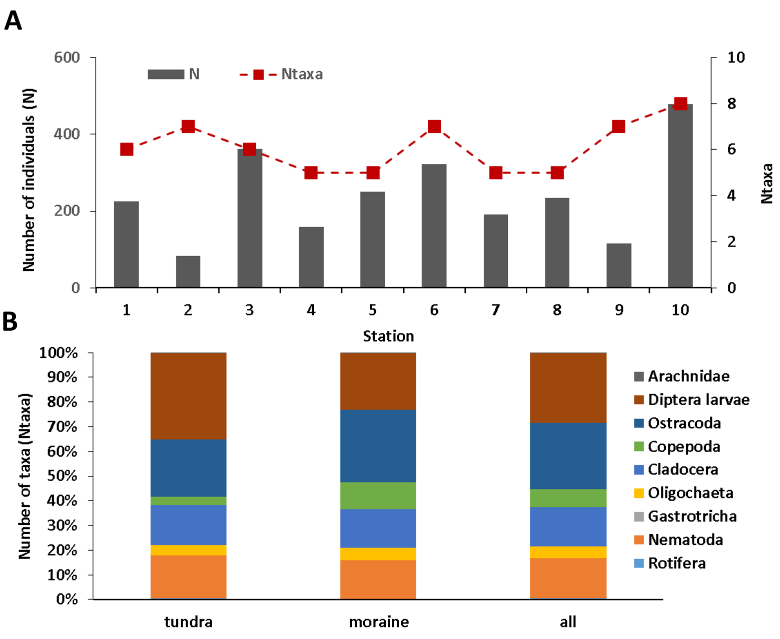

Fig. 10. A – Number of individuals (N) and number of major meiobenthic taxa (Ntaxa) of sampling stations, B – The structure of relative abundance of meiobenthos assemblages of tundra, moraine and all material from sampling stations, Coraholmen, 8 August 2016

In the Crustacean group (Table 3), the most numerous were Ostracoda, represented by three species *Candona rectangulata* Alm, 1914, *Tonnacypris glacialis* (G.O. Sars, 1890), and *Limnocytherina sanctipatricci* (Brady & Robertson, 1869). *T. glacialis* is a common Arctic species (Bronstein, 1947; Griffiths et al. 1998), which has a short life cycle, and only one generation during the Arctic summer season (Wojtasik, 2008) was extremely rare. In the studied samples, an adult female was found only in one studied tundra reservoir (No.3). The freshwater Arctic species *C. rectangulata* was a common find (Olofsson, 1918; Bunbury & Gajewski, 2009; Semenova & Sharapova, 2012; Wojtasik, 2012). It is an opportunistic species, tolerant to changes in environmental factors including temperature, salinity, heavy metals, POPs, pH>5,5 and type of sediment. This species in Spitsbergenian environment needs from four to eight years to grow up (Wojtasik, 2012; Wojtasik & Kuczyńska-Wiśnik 2012). In station No. 9, one individual of the Ostracoda species *L. sanctipatricci* was found. It was an exciting result, because this species was found only in a few areas before. These areas were Brattegdalen, near Polish Polar Station in Hornsund (South Spitsbergen) and Petuniabukta (Billefjorden, Central Spitsbergen). This species inhabits shallow, freshwater reservoirs and has a two year life cycle in the Arctic (Wojtasik, 2012).

Table 3. CRUSTACEANS ASSEMBLAGES OF FRESHWATER RESERVOIRS, CORAHOLMEN, 8 AUGUST 2016

Taxa	**Station / number of individuals**										**N**	**F**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
Ostracoda												
C. rectangulata	24	34	115	4	55	73	95	127	42	44	613	1.0
T. glacialis	5	2	4	2	3		1	1	3	4	25	0.9
L. sanctipatricci									3		3	0.1
N (Ostracoda)	**29**	**36**	**119**	**6**	**58**	**73**	**96**	**128**	**48**	**48**	**641**	1.0
Cladocera												
Daphnia sp.			12						2	37	51	0.3
Bosmina sp.		1	159	3		253	2	15	1		434	0.7
N (Cladocera)		**1**	**171**	**3**		**253**	**2**	**15**	**3**	**37**	**485**	0.8
Copepoda												
Cyclopoida			1					17	5	39	62	0.4
Harpacticoida	12	1	20	2	1					59	95	0.6
Calanoida								5		1	6	0.2
N (Copepoda)	**12**	**1**	**21**	**2**	**1**			**22**	**5**	**99**	**163**	0.8
N(Crustacea)	41	38	311	11	59	326	98	165	56	184	1289	1.0

N – number of individuals of major meiobenthic taxa in all sampling stations, F – frequency (number station with observed taxa / number all stations)

Analysis of Frequency F of *C. rectangulata* showed that in all reservoirs studied, occurrence was very high (F = 1.0), the frequency of *T. glacialis* was high too (F = 0.9). The frequency of *L. sanctipatricci* was rare (F = 0.1) (Table 3). For comparison, in the tested reservoirs in the central Spitsbergen the frequency of *C. rectangulata* was 0.33 (F = 0.33): e.g., on the north-western coast of Spitsbergen (Kaffiøyra, Forlandsundet) three reservoirs (one tundra and two moraines) were studied, the frequency was 0 (F = 0); for Longyearbyen (S coast of Isfjorden), three tundra reservoirs were studied, and the frequency was 0.67 (F = 0.67), and in the northern part of the Billefjord, in the Petunia Bay area, four tundra reservoirs were studied, and the frequency was relatively high 0.75 (F = 0.75); in Pyramiden (Mimerbukta, Billefjorden) and the surrounding area five tundra reservoir s were studied, and the frequency was 0 (F = 0). The frequency of *T. glacialis* (which was observed on Coraholmen reservoirs) was low (F = 0.1), by comparison to reservoirs (in the same time and reservoirs as *C. rectangulata*) of Central Spitsbergen F = 0.4. For the Kaffiøyra area the frequency was 0 (F = 0); for Longyearbyen it was 0.67, for the Petunia area – it was 1 (F = 1), while for Pyramiden and the surrounding area it was F = 0 (Wojtasik 2012). The occurrence of *L. sanctipatricci* was first identified in 2000 in three moraine reservoirs of the Werenskiold Glacier (SW Spitsbergen). In 2001 this species was reported in 6 reservoirs of the Werenskiold glacier, one reservoir near the Polish Polar Station (Isbjørnhamna, Hornsund) and one reservoir near Skottehyta (Petuniabukta, Billefjorden) (Wojtasik 2012). The obtained result indicates the rapid pace of colonization of reservoirs in remote areas such as Coraholmen. Cladocera was represented by two taxa Daphnidae, *Daphnia* sp. (F = 0.3) and Bosminidae, *Bosmina* sp. (F = 0.7). Copepoda was represented by three Orders: Cyclopoida (F = 0.4), Harpacticoida (F = 0.5) and Calanoida (F = 0.2). Harpacticoida was the most numerous taxa of Copepoda and rather common in our studied reservoirs (F = 0.6).

In the studied material there was no observed tadpole shrimp, common Arctic Notostraca (Crustacea) *Lepidurus arcticus* (Pallas, 1793). Young instars of *L. arcticus* belong to meiobenthos. This species is widespread and characteristic for freshwater reservoirs in the Arctic including Svalbard (Olofsson, 1918; Janiec, 1996; Wiśniewska-Wojtasik & Walczak, 2005; Wojtasik & Bryłka-Wołk, 2010). They were observed in recent Spitsbergen's freshwater reservoirs of tundra and glacier moraines (Olofsson, 1918; Wojtasik & Bryłka-Wołk, 2010). The lack of the *L. arcticus*, unfortunately, does not confirm the theory about the possibility of migrating invertebrates between reservoirs with the help of birds (Sywula et al.1994), whose traces of life activity are visible in almost every studied reservoirs on the Coraholmen Island.

The Bray-Curtis diversity of meiobenthic assemblages recently inhabiting moraine and tundra water reservoirs of Coraholmen shows a significant diversity between stations examined. Nevertheless, it cannot be ascertained that the assemblages are different for moraine and tundra stations (Fig.11). This conclusion seems to be important information, because the ground, type of the bottom sediment, which is the environment of life of meiobenthos, is largely distinct for the tundra and moraine stations.

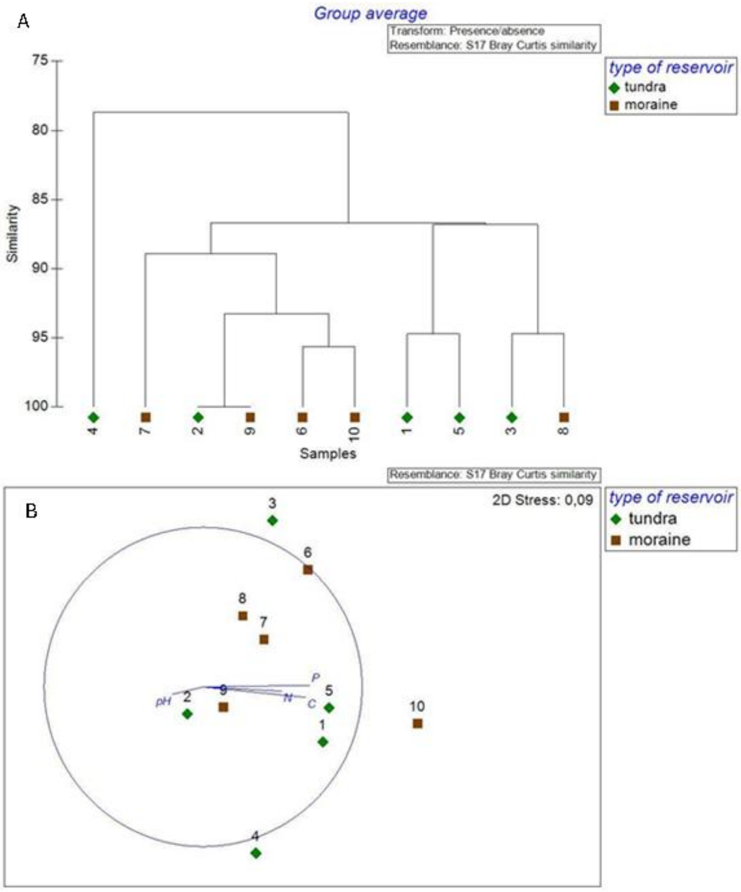

Fig. 11. Meiobenthic assemblages of samples station of Coraholmen, faunistic similarity (Bray-Curtis analysis); A – cluster analysis B – MDS analysis

The structure of domination at individual sites indicates the diversified nature of meiobenthos communities. Apart from the position of No.4 where there is a mega dominant (MD) of Diptera larvae, and site No.8 where (D) Ostracoda is dominant, the remaining groupings have co-dominant taxa, albeit different (Table 4).

Table 4. The structure of domination in meiobenthos assemblages of Coraholmen sampling stations; 8 August 2016

Station	Domination of meiobenthic taxa								
	Dominants			Influents			Recedents		
	MD	D	sD	I	sI	uI	R	sR	uR
1			Ne ID	Os		Co	Ro Ol		
2			Os ID		Ne	Ar	Ol Cl Co		
3			Cl Os		ID	Co	Ne		Ro
4	ID					Os	Cl	Co	Gr
5			Ne ID	Ol Os					Co
6			Cl	Os ID	Ne			Ro	Ol Ar
7			Os Ne	ID				Cl	Ol
8		Os		Ne	ID Co Cl				
9			Os ID		Ol	Co	Ne Cl Ar		
10			ID	Co Ne	Ol Os Cl				Ro Ar

MD (100 % ≥ MD > 75 %) D (75 % ≥ D > 50 %) sD (50 % ≥ sD > 25 %)
I (25 % ≥ I > 12,5 %) sI (12,5 % ≥ sI > 6,25 %) uI (6,25 % ≥ uI > 3,125 %)
R (3,125 % ≥ R > 1,5625 %) sR (1,5625 % ≥ sR > 0,78125 %) uR (0,78125 % ≥ uR > 0%)

MD – mega dominant, D – dominant, sD – subdominant, I – influent, sI – subinfluent, uI – ultra influent, R – recedent, sR – subrecedent, uR - ultrarecedent
Ro – Rotifera, Ne – Nematoda, Gr – Gastrotricha, Ol – Oligochaeta, Cl – Cladocera, Co – Copepoda, Os – Ostracoda, ID – Insecta larvae Diptera, Ar – Arachnida

MeioEco analysis

The ecological status of examined stations, defined on meiobenthic assemblages analysis, suggest assemblage of low diversity 3D analysis of parameters N10, Ntaxa and Bw (Fig.12). A map of ecological status shown on Fig.13. Half of studied reservoirs are in initial phase of development (violet points). Meanwhile, station No.4 remains in the initial phase of development, but the distorted taxonomic balance of meiobenthic assemblages can be observed, which may indicate less favourable environmental conditions than in other stations at the initial development stage (a red point). Two of reservoirs show a more advanced trophic state (blue points), whereas the station No.3 (the light green point) has distorted taxonomic balance of the assemblage, but a quite high state of trophic development. Stations No.6 and No.10 (the dark green points) have the highest degree of development. The values of parameters N10, Ntaxa and Bw are shown in table 5.

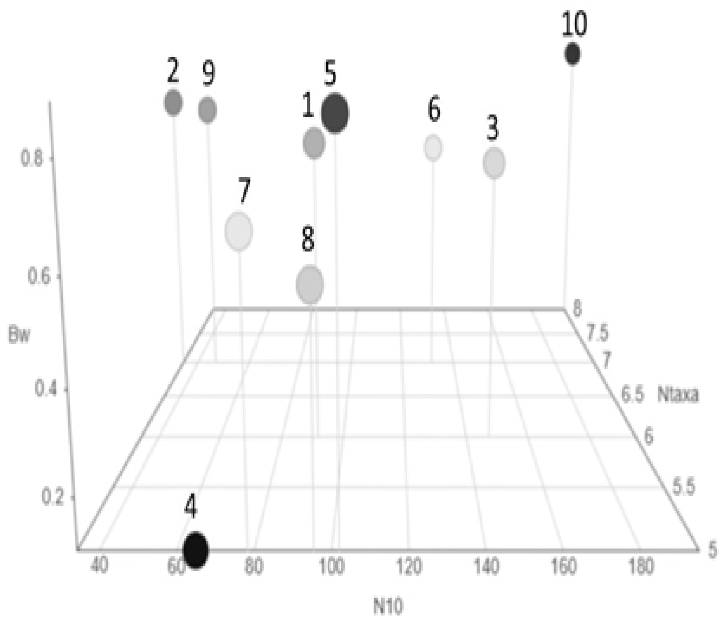

Fig. 12. 3D analysis of parameters: N_{10}, N_{taxa} and B_w of sampling stations (meioeco.pl application)

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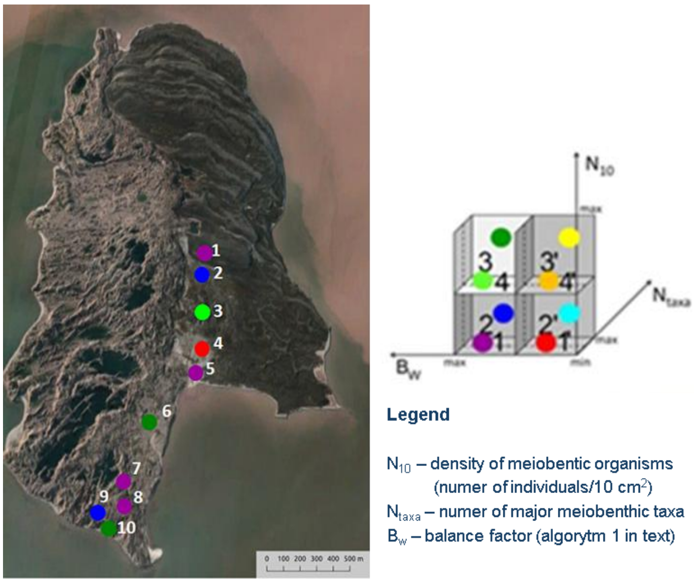

code	N10	Ntaxa	Bw	Ecological status
	low	low	balance	low trophy or start of colonistation
	low	high	balance	increase in biodiversity
	low	high	unbalance	disturbed growth of biodiversity
	high	high	balance	high trophy (maximum)
	high	low	balance	decrease in biodiversity with high trophy
	high	high	unbalance	disturbed high trophy
	high	low	unbalance	progressive degradation
	low	low	unbalance	final phase of degradation

Fig. 13. Ecological status of selected reservoirs, Coraholmen, 8 August 2016 (meioeco application)

Table 4. PARAMETERS N_{10}, N_{TAXA} AND B_W CALCULATED OF MEIOBENTHIC ASSEMBLAGES (MEIOECO.COM APPLICATION), S = 24.5 (AREA OF SAMPLES OF ONE STATION)

Parameter / Station	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
N	225	84	361	159	250	322	192	234	115	478
N_{10}	91.84	34.29	147.35	64.9	102.04	131.43	78.37	95.51	46.94	195.1
N_{taxa}	6	7	6	5	5	7	5	5	7	8
B_w	0.759	0.796	0.717	0.1	0.875	0.68	0.678	0.586	0.777	0.894

Ecological status of studied reservoirs

The differentiation was expected to be consistent with the ground on which the cluster was formed, i.e. division into two classes of meiobenthos assemblages corresponding to moraine and tundra reservoirs. However, the conducted analysis shows a different relationship, a strong relationship between the meiobenthic community and the development of the reservoir, which may be indicated by the degree of covering the reservoirs with aquatic plants vegetation. The greatest cover of the bottom in the shore zone of the reservoir was found in reservoir No.10. Even though the substrate was moraine and had the highest salinity among the examined (5.4 psu), the richest freshwater meiobenthic community was found there (the highest number, taxonomic diversity and balance of the grouping, which may indicate its stable character). The reservoir with high biodiversity, taxonomic balance, but the lowest number of meiobenthic organism is reservoir No.2. Reservoir No.3 is an extensive tundra reservoir, which allows water to be preserved throughout the hydrological season (research was carried out in August, when the hydrological season is coming to an end, usually in September freshwater reservoirs begin to freeze). On the other hand, reservoir No.9 has quite rich coastal vegetation. Reservoir No.4 is in a taxonomic imbalance, low number of individuals and biodiversity. The reservoir No.10 with high biodiversity and abundance. This reservoir is located closest to the moraine belt and is intensively fed by water flowing down from the moraine. It has rich vegetation and detritus, which means that it may constitute favorable conditions for the formation of a meiobenthos assemblages. The remaining reservoirs are in the initial stage of trophy development. Additionally, a correlation was found between the N10 parameter (density of meiobenthos) and the content of phosphates, which is 0.719. The correlation between N10 and nitrates is not that strong and amounts to 0.593. The obtained results indicate a strong relationship between the trophic development of the reservoir, expressed in the concentration of biogenic substances, and the degree of its colonization by meiobenthos .

Due to the temporary nature of shallow tundra reservoirs, meiobenthos communities may form de novo depending on the conditions in a given hydrological season (length of the hydrological season, amount of precipitation). This situation does not apply to moraine reservoirs, which are the melting basins. A special situation was found for the tundra reservoir No.5. It is located in the coastal zone and the silty bottom contains large amounts of fossil organisms. It is taxonomically poor and the grouping includes pioneering taxa: Nematoda (dominant taxon), Oligochaeta and Insecta larvae Diptera, as well as Ostracoda.

Conclusions

Meiobenthic assemblages inhabiting freshwater reservoirs of low salinity on Coraholmen show a quite significant diversity between stations examined and do not create specific and different groups for moraine and tundra reservoirs (the Bray-Curtis diversity and MeioEco analysis).

Ostracoda: three species *C. rectangulata*, *T. glacialis* and *L. sanctipatricci* were observed in studied reservoirs. However *C. rectangulata* was very common, more common than in other areas of the Central Spitsbergen (Kaffiøyra, Longyearbyen, Petuniabukta, Pyramiden). Results suggest that the type of reservoir does not determine the biodiversity of meiobenthic assemblages of studied reservoirs, and does not significantly affect their composition in Coraholmen reservoirs.

The tested waters were characterized by low salinity and alkaline pH. In the case of tundra ponds, the concentrations of TN and TP were lower, and the TN/TP_{mol} ratio was higher than in the waters of moraine ponds. Phosphorus concentrations indicate that the reservoirs were mostly oligotrophic. The chemical composition of the waters was clearly influenced by the character of the catchment, the type of sediment, the vegetation cover or the slope of the surface.

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Appendix. Appendixes, if needed, appear before References.

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