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WATER QUALITY IN CUTAWAY PEATLAND LAKES IN SEDA MIRE, LATVIA

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Transformation into shallow lakes can be a major post-harvesting land-use option for cutaway peatlands. The aim of our study was to analyse factors influencing water quality and communities on lakes created in a cutaway bog in the Seda Mire, Latvia. The residual peat amount and the lake feeding conditions (the balance between ground water and inflow from adjacent river during the spring season) were found to be major factors influencing aquatic chemistry and studied habitats. The studied cutaway lakes cannot be considered as typical bog lakes regarding hydrochemical composition (especially regarding concentrations of major dissolved ions, pH and water colour) and hydrobiological features (metabolic activity, biomass and number of species of phytoplankton and zoobenthos). Considering aquatic chemistry and community structure of the cutaway lakes, a recommendation was made in respect to peat excavation to transform peat mining sites to lakes.

Key words: *biological diversity, cutaway lakes, cutaway peatland, Latvia, water quality.*

INTRODUCTION

Remediation of industrially-milled peatland is an important task in the sustainable management of natural resources. Several approaches for wetland restoration, depending on local climatic and hydrological conditions, topography, physico-chemical properties of peat, as well as peat mining techniques, have been developed worldwide. However, most of the restoration activities include regulation of hydrological regime and surface topography in order to reintroduce typical bog vegetation, especially, *Sphagnum* cover, and to restore the peatland's ecosystem close to its original conditions (Lamers *et al*., 2002; Farrell and Doyle, 2003; Gorham and Rochefort, 2003). In many countries, a significant part of peat mines are and will be left as semi-natural wilderness areas, and spontaneous re-vegetation is taking place (Lavoie *et al*., 2003; Girard *et al*., 2002). In recent years, creation of shallow lakes (1–2 m depth) in territories of cutaway peatlands is also considered as a valuable management activity. After the cessation of peat harvesting, different areas within a single peat field can vary considerably in terms of depth and type of the residual peat, the underlying soil type and drainage characteristics (McNally, 1998). Previous studies (Higgins and Colleran, 2004; Lally *et al*., 2008; Lundin *et al*., 2008) have indicated that, prior to the creation of cutaway lakes, considerable on-site management work should be carried out. Much of the residual peat substrate usually is removed from the cutaway to create a basin, exposing some of the underlying mineral sub-soil (Higgins and Colleran, 2004), but significant amounts of peat mass from highly decomposed peat layers may be left after major peat mining. Depending on the lake depth, size, aquatic chemistry, vegetation and other properties, the created lakes can be used for recreation purposes or can be important sites for wildlife, especially waterfowl conservation (Lamers *et al*., 2002).

Peat deposits cover about 10.4% of the area of Latvia, of which the mined peat area occupies 0.4% of the country. Currently, about 25% of the peat deposits prepared for mining are being utilised, and major development of new fields is not expected (Anonymous, 1999). However, management activities for reclamation of cutaway peatlands in Latvia have not been carried out. These territories are abandoned to naturally re-vegetate, or flood if the site lies below the water table. Peat harvesting in the Seda mire started after the Second World War and has been very intensive, exhausting much of the peat reserves. Peat harvesting is gradually ceasing, leaving large areas of abandoned cutaway peatland requiring reclamation. A significant part of the area has flooded.

This study was focused on determining various physico-chemical and biological parameters in lakes created on cutaway territories in the Seda mire, in order to elucidate the primary factors impacting water quality in the cutaway lakes and to aid future design for optimal water quality.

MATERIALS AND METHODS

Study area. The Seda mire developed as a result of paludification of land and partially overgrown lakes after the Ice Age. The area of Seda mire is estimated to be 7582 ha, of which 6300 ha are fen, 941 ha is raised bog and 341 ha is transitional bog (Krauklis, 1998). As a result of peat mining, some parts of the mire were transformed to meadows or overgrown by shrubs and later transforming to forest land (Larmanis, 2003).

The climate in area of the Seda mire can be described as wet and comparatively cold, with yearly mean sum of precipitation 650 mm per year. Mean annual temperature (1950–2003) is ~5.2 °C; mean temperature in January is ~ –6 °C, and in July is ~17 °C. During the last decades, the temperature in the region of the Seda bog has increased by 0.8 °C, in comparison with the temperature mean for 1961–1990.

Currently, the biggest area of the mire consists of peat extraction fields, including some where peat excavation is ongoing (approximately 3 km^2). Other parts of the prior fields are overgrown with shrubs or flooded. Average thickness of the peat layer is approximately 3 m, with maximum thickness up to 5 m. Peat resources are estimated at approximately 97.6 millions tons. Industrial peat mining started in 1954 and recently significant parts of the former abandoned peat mining sites have flooded. Channels and dams take up a significant part of the landscape (Larmanis, 2003).

The studied cutaway lakes (sampling stations Nos. 1 and 2) and a lake of natural origin (Lake Seda, sampling station No. 4) are located in the Seda mire in North Vidzeme (Fig. 1). Water depth at sampling station No. 1 was 0.7–1 m. Sediments were composed of peat rich in detrital material. Water depth at sampling station No. 2 in the pelagic zone was 1–1.5 m, and in the littoral zone around 0.5 m. A substantial part of profundal sediments was composed of mineral material, while organic-rich mud dominated in the littoral zone. Both of the cutaway lakes were overgrown by macrophytes (*Potamogeton* sp., *Phragmites* sp., *Typha* sp., *Juncus* sp., *Lemna* sp., *Nymphaea candida C. Presl.*, *Nuphar lutea*). Sampling station No. 3 was located in the River Stakļupīte, which drains the peat extraction fields. Lake Seda (sampling station No. 4) is a dystrophic brown-water lake of natural origin. The water depth in the pelagic zone was approximately 2 m, and in the littoral 1.5 m. The lake littoral sediments were composed of peat and the profundal sediments were covered by the bryophyte *Fontinalis* sp. The other natural lakes — L. Tolkovas (sampling station No. 5) and L. Islienas (sampling station No. 6; sampling of water chemistry only) are situated in the Teiči mire (Teiči Nature Reserve). Lake Tolkovas is a typical dystrophic bog lake with low mineralisation, and L. Islienas is a dyseutrophic lake with low mineralization and brown water colour. Water depth in the pelagic zone of L. Tolkovas was 6.5 m and profundal sediments were composed of loamy mud. Littoral sediments were composed of compact peat, partly covered with *Sphagnum sp*.

Sampling and laboratory analysis. Samples for hydrochemical analysis were taken in March, June, August and September of 2005 and in March, June and August of 2006. Surface water samples were collected at a depth of 0.5 m using a Ruttner bathometer. Water temperature and dissolved oxygen were measured on site using an oxymeter (HACH LDO HQ10). Concentrations of nutrients and major

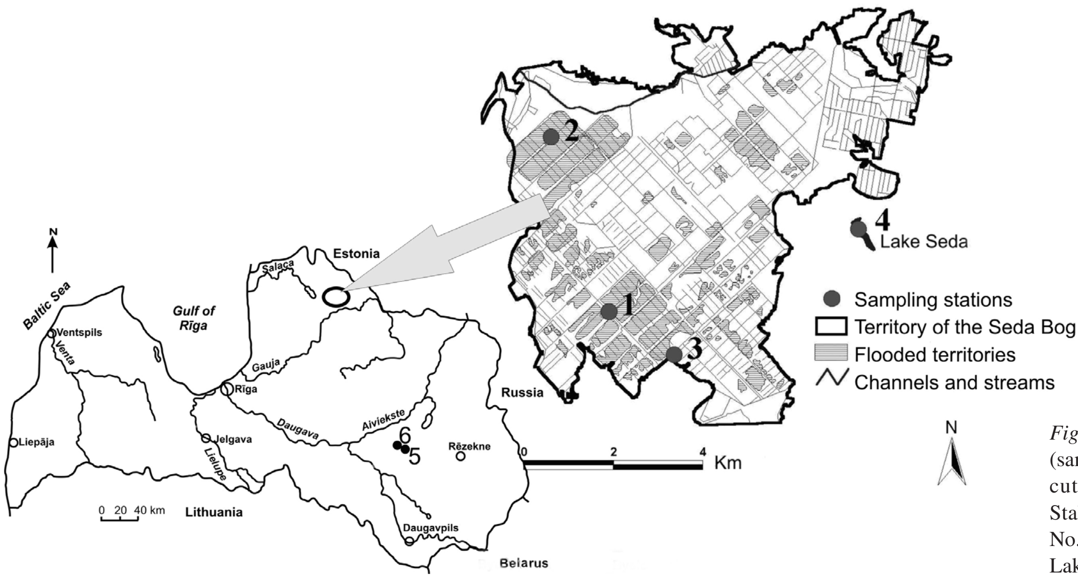

Fig. 1. Location of the study sites (sampling stations Nos. 1 and 2 – cutaway lakes, No. 3 – River Staklupite, No. 4 – Lake Seda, No. 5 – Lake Tolkovas, No. 6 – Lake Islienas).

inorganic ions were analysed in the Laboratory of Environmental Quality and Monitoring, University of Latvia. Water samples were delivered to the laboratory and analysed within 24 hours. pH was measured using a "HACH one pH meter", conductivity and total dissolved solids were determined using a HACH conductometer. Colour (true) was measured spectrophotometrically at 455 nm (Anonymous, 1992). Phosphate ion concentration was determined using the ascorbic acid reduction method with persulphate digestion (Anonymous, 1992) and ammonia by the indophenol method. Phosphate ion, total nitrogen, silica, total iron, nitrate and nitrite concentrations were determined spectrophotometrically using a HACH DR2000 (Anonymous, 1992). Sulphate ion concentration was measured by turbidimetric method. Concentrations of chloride, calcium, bicarbonate ions and total hardness were determined titrimetrically. Chemical oxygen demand was determined using oxidation with $K_2Cr_2O_7$ (Anonymous, 1992).

Sediment samples for analysis of heavy metals were taken in September of 2005 and in June 2006 using an Ekman sediment grabber. Concentrations of heavy metals (Cd, Cu, Mn, Pb, Zn, Ni, Co, Fe) in sediments were determined using atomic absorption spectrometry (AAS Perkin-Elmer 403). Analyses were conducted at the Institute of Biology.

Water and sediment samples for bacterial analysis were taken in September 2005. The following groups of bacterioplankton and bacteriobenthos were determined according to methods previously described (Romanenko and Kuznetsov, 1974; Clesceri *et al*., 1998): aerobic psychrophilic, facultatively anaerobic, oligocarbophylic and cellulose-destroying bacteria. Results were expressed as colony forming units (CFU) per 1 cm^3 of water or 1 gram of sediments.

Phytoplankton samples were collected in August and September of 2005 at depth 0.5 m and preserved with Lugol solution. Phytoplankton cells were identified, measured and counted with a Leica DML inverted microscope. Biovolumes were calculated by comparing cells to simple shapes and applying standard geometric formulae (Utermohl, 1958).

Samples for zooplankton analysis were collected in August and September of 2005. 100 dm^3 of water were filtered through an Apstein net (64 µm) and zooplankton samples were preserved with 40% formalin solution. Quantitative and qualitative analyses were conducted on 1 cm^3 subsamples under a Carl Zeiss Jena microscope. Biomasses were calculated by comparing organisms to simple shapes and applying standard geometric formulae (Bottrell *et al.*, 1976).

Samples of benthic macroinvertebrates were collected in September of 2005 from the profundal zone using an Ekman sediment grabber (opening of 20 × 20 cm). The number of organisms per square meter was calculated and their biomass was estimated. Macroinvertebrates were categorised according to Family or Order.

Data from sampling stations Nos. 1, 2 and 4 were compared with mean values (1997–2003 and 2007) from sampling stations Nos. 5 and 6. Water quality data were analysed using the programmes SPSS 14.0 and AquaChem 3.70. Comparison of sampling sites was performed using one way analysis of variance (ANOVA) followed by a Tukey HSD test as *post hoc* procedure at $P \leq 0.05$.

RESULTS

Major differences in the aquatic chemistry of the studied lakes were found (Table 1, Figs. 2 and 3). Both cutaway and natural lakes of Seda mire had similar pH levels (6.92–7.43), moderately high conductivity (145.9–286.8 µS cm^{-1}) and concentrations of dissolved inorganic ions as well as moderately high colour. The dystrophic L. Tolkovas (sampling station No. 5) was acidic (pH 4.44), with low concentrations of dissolved inorganic ions and very low water colour (97 °Pt/Co), which is unusual for dystrophic lakes (Table 1). The dyseutrophic L. Islienas has very high water colour (>500 °Pt/Co), but comparatively higher pH (5.82). Dissolved oxygen levels were similar in all four waterbodies of the Seda mire and followed typical seasonal trends, with higher concentrations in summer and low concentrations (up to 0.18 mg dm^{-3} at sampling station 1) during winter and early spring (Fig. 2).

Concentration of total dissolved solids in cutaway lakes of the Seda mire was higher than in the studied natural dystrophic lakes. Both cutaway and natural lakes of Seda mire belong to the Ca-Mg-HCO_3 group, while L. Tolkovas (sampling station No. 5) has relatively higher concentrations of chloride, bicarbonate and sulphate ions, and therefore, belongs to the Cl-HCO_3-SO_4 group. Piper diagrams (Piper 1944), which can be used to characterise different water types, show that both typical surface waters of Latvia (Lakes Burtnieks, Dridzis, Cieceres and Engures) and waterbodies of the Seda mire have elevated temporary hardness due to increased Ca^{2+}, Mg^{2+} and HCO_3^- concentrations (Fig. 4). Bog lakes with low mineralisation have a relatively increased the proportion of sulphate and chloride ions.

Concentrations of heavy metals in the cutaway lake sediments are lower than in dystrophic lakes, as they have not been influenced by pollution (Fig. 5).

The bacterioplankton and bacteriobenthos of the cutaway lakes were dominated by oligocarbophylic and cellulose-degrading bacteria, while saprophytes typically dominated in the natural lakes. However, this dominance was comparatively more expressed at sampling station No. 2, shown by the CFU both in bacterioplankton and bacteriobenthos (Table 2).

Phytoplankton samples at sampling station No. 1 contained a low number of taxa and low phytoplankton biomass (0.12–0.18 mg dm^{-3}). Phytoplankton was represented by Cyanophyceae, Euglenophyceae, Dinophyceae, Cryptomo-

Table 1

CHEMICAL COMPOSITION OF THE STUDIED LAKES*

Parameter	Sampling station No. 1	Sampling station No. 2	Sampling station No. 3	Sampling station No. 4	Sampling station No. 5	Sampling station No. 6
PO_4^{3-}, mg dm^{-3}	0.033 (±0.03)ab	0.022 (±0.015)a	0.029 (±0.012)a	0.064 (±0.014)b	0.015 (±0.015)a	0.031 (±0.014)a
n	7	7	6	6	7	7
N-NH_4^+, mg dm^{-3}	0.65 (±0.49)ab	0.32 (±0.07)a	0.48 (±0.10)a	0.71 (±0.19)ab	0.32 (±0.10)a	1.03 (±0.31)b
n	7	7	7	7	7	7
N-NO_2^- mg dm^{-3}	0.014 (±0.006)a	0.009 (±0.003)a	0.013 (±0.004)a	0.024 (±0.007)b	0.010 (±0.003)a	0.032 (±0.007)b
n	7	7	7	7	7	7
Si_{tot}, mg dm^{-3}	4.93 (±2.82)b	2.41 (±0.79)ab	5.00 (±2.92)b	5.64 (±2.99)b	1.27 (±0.64)a	2.50 (±1.96)ab
n	7	7	7	7	7	7
Fe_{tot}, mg dm^{-3}	1.58 (±0.91)a	0.48 (±0.24)a	1.87 (±1.47)a	5.01 (±2.23)b	0.32 (±0.09)a	1.22 (±0.49)a
n	7	7	7	7	7	7
pH	7.33 (±0.45)c	7.43 (±0.43)c	7.15 (±0.32)c	6.92 (±0.60)c	4.44 (±0.15)a	5.82 (±0.98)b
n	7	7	7	7	7	7
Colour, ^{0}Pt/Co	187 (±60)a	108 (±35)a	236 (±72)a	562 (±201)b	97 (±38)a	537 (±132)b
n	7	7	7	7	7	7
COD, mg dm^{-3}	39.57 (±15.67)ab	45.57 (±11.93)abc	54.71 (±17.55)bc	76.43 (±35.01)cd	15.86 (±6.20)a	92.43 (±18.54)d
n	7	7	7	7	7	7
Cond, μS cm^{-1}	286.8 (±87.5)d	226.8 (±31.2)cd	216.0 (±53.5)cd	145.9 (±56.4)bc	25.0 (±3.6)a	72.8 (±38.0)ab
n	6	6	6	6	7	7
HCO_3^-, mg dm^{-3}	191.7 (±62.0)d	149.0 (±23.6)cd	161.2 (±57.4)d	95.9 (±34.8)bc	18.3 (±6.1)a	47.1 (±18.9)a
n	7	7	7	7	7	7
SO_4^{2-}, mg dm^{-3}	8.28 (±0.95)a	8.00 (±0.82)a	10.86 (±3.44)a	18.00 (±5.60)b	8.14 (±2.27)a	18.71 (±4.03)b
n	7	7	7	7	7	7
Cl^-, mg dm^{-3}	9.47 (±2.39)	9.75 (±1.75)	8.81 (±1.81)	9.13 (±1.91)	15.67 (±10.60)	16.63 (±13.81)
n	7	7	7	7	7	7
Ca^{2+}, mg dm^{-3}	43.91 (±13.93)d	34.57 (±4.49)cd	39.42 (±12.48)d	23.28 (±3.66)bc	3.09 (±3.44)a	10.26 (±5.40)ab
n	7	7	7	7	7	7
Mg^{2+}, mg dm^{-3}	12.10 (±3.13)b	11.99 (±3.39)b	11.53 (±6.93)b	7.96 (±5.01)ab	1.87 (±2.44)a	6.65 (±7.39)ab
n	7	7	7	7	7	7
Na^+, mg dm^{-3}	2.07 (±0.67)ab	2.90 (±0.96)b	2.40 (±0.53)ab	2.37 (±1.05)ab	0.82 (±0.25)a	1.50 (±0.75)ab
n	3	3	3	3	5	5
K^+, mg dm^{-3}	0.93 (±0.45)	1.77 (±0.65)	1.00 (±0.26)	0.90 (±0.63)	0.70 (±0.21)	1.06 (±0.77)
n	3	3	3	3	5	5

* mean ± S.D., *n* – number of samples. Different letters within a row indicate significantly different groups in Tukey HSD test at $P \leq 0.05$

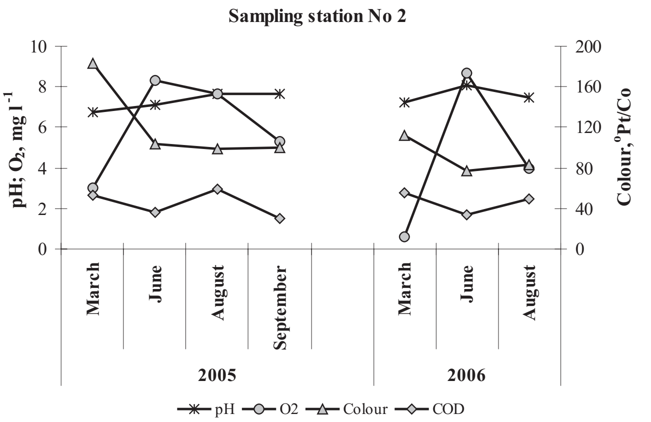

Fig. 2. Seasonal changes of pH, dissolved oxygen, water colour and chemical oxygen demand at sampling station No. 2.

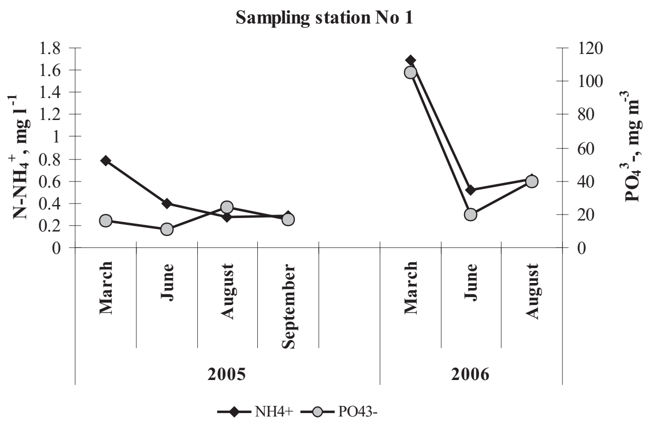

Fig. 3. Seasonal changes in ammonium and phosphate ion concentration at sampling station No. 1.

nadineae, Chrysophyceae, and Bacillariophyceae. Phytoplankton samples had a high number of taxa, but low biomass (0.12–0.22 mg dm^{-3}), in sampling station No. 2, where phytoplankton was represented by eight algae divisions: Cyanophyceae, Cryptophyceae, Chrysophyceae, Euglenophyceae, Dinophyceae, Raphidophyceae, Bacillariophyceae, and Chlorophyceae (Table 3). Phytoplankton at sampling station No. 4 was practically dominated by

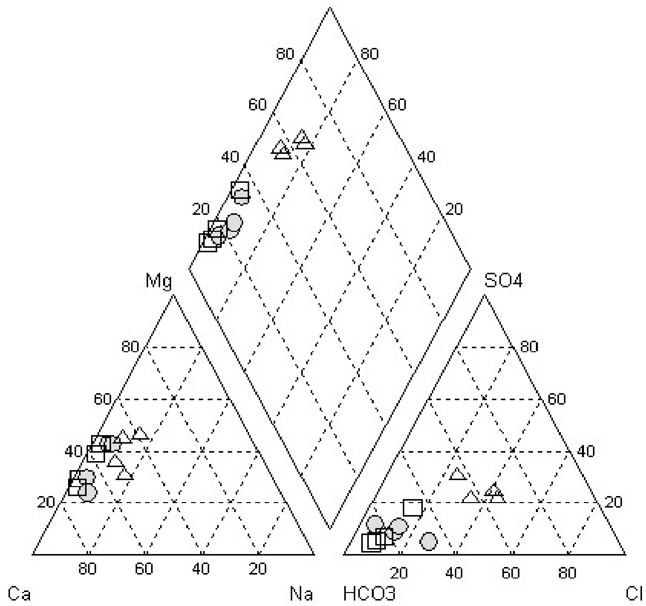

Fig. 4. Piper diagram (O - Lakes Burtnieks, Dridzis, Cieceres and Engures; △ - bog lakes: Siksalas, Tolkovas, Lielezers, Islienas; □ - lakes of Seda Bog).

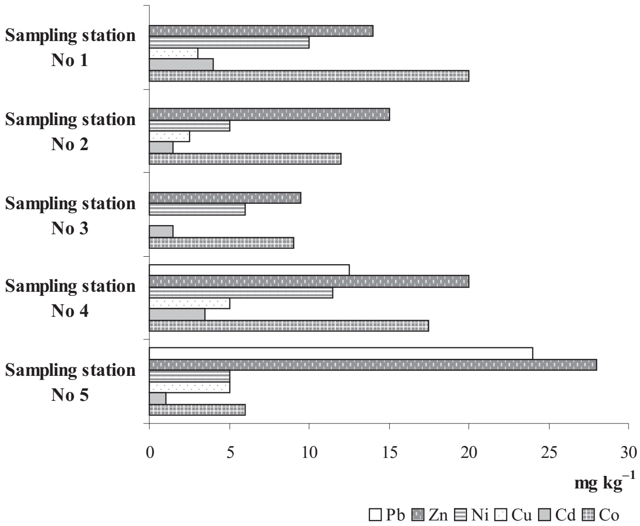

Fig. 5. Concentrations of heavy metals in sediments.

Table 2

NUMBER OF AEROBIC SAPROPHYTES (SB_{aer}), ANAEROBIC SAPROPHYTES (SB_{anaer}), OLIGOCARBOPHYLIC (OB) AND CELLULOSE-DESTROYING (CB) BACTERIA IN THE STUDIED WATERBODIES

Sampling station	Bacterioplankton (CFU cm^{-3})				Bacteriobenthos (CFU g^{-1})			
	SB_{aer}	SB_{anaer}	OB	CB	SB_{aer}	SB_{anaer}	OB	CB
No. 1	690	90	870	700	4000	1750	7250	9250
No. 2	720	390	3650	4000	15750	485000	50000	26250
No. 4	240	200	960	1300	4000	3000	11250	9250
No. 5	460	-	-	-	4470	-	-	-
Dyseutrophic lakes	2320	-	-	-	131651	-	-	-

Raphidophyceae, particularly by *Gonyostomum semen*, which is typical for dystrophic lakes, with low numbers of Chrysophyceae, Cryptomonadineae, Euglenophyceae and Bacillariophyceae. Total biomass at this sampling station was comparatively high (2.4–4.9 mg dm^{-3}) in August and September. In September, there was a decrease in the biomass of blue-green algae at sampling station No. 3.

Zooplankton abundance was higher in September than in August. At sampling station No. 1, a comparatively low number of individuals (28.0–32.2 indiv. dm^{-3}) and high biomass (179.56 mg dm^{-3}) of zooplankton were observed due to large-bodied Cladocera (for example, *Acroperus harpae* and *Graptoloberis testudinaria*). Among the Rotifera, *Keratella cochlearis* and *Polyarthra* sp. dominated. At sampling station No. 2, Rotifera was the largest group, dominated by *Synchaeta* sp., followed by *Asplanchna priodonta/henrietta*, *Lecane* sp., *Keratella cochlearis*, *Keratella quadrata*, and *Polyarthra* sp. The zooplankton community at sampling station No. 4 (natural L. Seda) was dominated by *Asplanchna priodonta/Henrietta*, followed by *Polyarthra* sp., *Keratella cochlearis*, *Conochiloides* sp. and the cladocerans *Bosmina longirostris*, *Ceriodaphnia quadrangula*, and *Chydorus sphaericus,* similar to the zooplankton of dyseutrophic lakes in Teiči Nature Reserve.

Considering high habitat heterogeneity in the littoral zone, for the analyses of benthic macroinvertebrates, only samples from the profundal zone were chosen.

Table 3

PHYTOPLANKTON BIOMASS (mg dm^{-3}) IN AUGUST AND SEPTEMBER OF 2005

	Cyanophyceae	Chrysophyceae	Cryptophyceae	Euglenophyceae	Dinophyceae	Bacillariophyceae	Chlorophyceae	Chloromonadophyceae	Total
Station No. 1, August	0.001	0.097	0.002	0.003	0.072	0.003	0.001		0.179
Station No. 1, September		0.084	0.001	0.002	0.036	0.001			0.124
Station No. 2, August	0.057	0.074	0.002	0.044	0.028	0.008	0.007	0.003	0.223
Station No. 2, September	0.022	0.014	0.004	0.037	0.017	0.006	0.008	0.015	0.123
Station No. 3, August	0.002	0.001	0.034		0.001	0.001			0.039
Station No. 3, September	0.004	0.001	0.049	0.001	0.001				0.056
Station No. 4, August		0.003	0.001	0.002		0.002	0.006	4.874	4.888
Station No. 4, September		0.001		0.001				2.372	2.374

The highest number of taxa was found at sampling station No. 2 (18 taxa), lower at stations No. 1 and No. 4 (9 taxa) and the lowest at No. 5 (6 taxa).

The highest density of benthic macroinvertebrates was found at sampling station No. 4 (41 700 indiv. m^{-2}), mainly due to Oligochaete abundance. Lower density was characteristic for sampling station No. 2 (7200 indiv. m^{-2}), and the lowest at station No. 5 (2100 indiv. m^{-2}).

The highest biomass was observed at sampling station No. 2 (15 g m^{-2}), mainly composed of herbivorous snails, larvae of insects (mayflies Ephemeroptera) and filterers — mussels Sphaeridae. Slightly lower biomass was found at the reference sampling station No. 4 (12 g m^{-2}), mainly composed of sediment feeders Oligochaetes, snails and detritivorous larvae of non-biting midges Chironomidae (Fig. 6). Low biomass (6 g m^{-2}) was characteristic for L. Tolkovas (station No. 5). The lowest biomass was found at sampling station No. 1 (2 g m^{-2}).

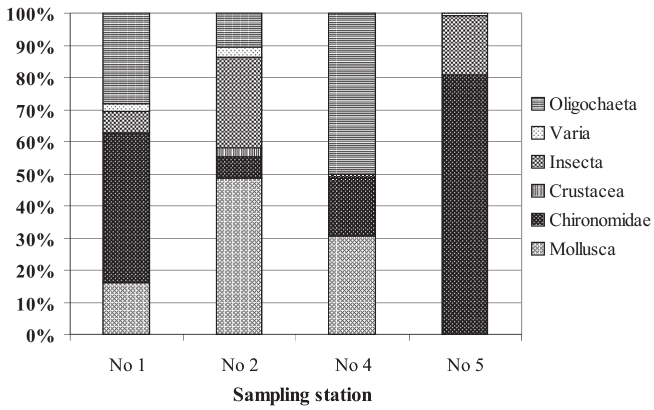

Fig. 6. Percentage of dominating taxa (%) of total macroinvertebrate biomass (g m^{-2}) in the profundal zone.

DISCUSSION

The studied cutaway lakes differ in physico-chemical characteristics and nutrient concentrations (Table 1). The studied cutaway lakes and the River Stakļupīte have significantly ($P \leq 0.05$) higher pH, conductivity and concentrations of HCO_3^-, Ca^{2+}, Mg^{2+}. These differences might be related to the diverse underlying sediments and major differences in hydrological regimes, as studies on artificial cutaway lakes in other countries suggest (Higgins and Colleran, 2004; Lundin *et al*., 2008). In some areas in the Seda mire, the peat layer left after peat extraction was insufficient to prevent the influence from mineral soil and ground water. This might be a possible explanation for lower water colour observed in the cutaway lakes compared to brown-water lakes (sampling stations No. 4 and No. 6). During the 1980s, some areas of the Seda mire were ploughed, thus increasing the rate of mineralisation, or even were fertilised with the aim to establish more productive grassland. Due to the economical crisis, these activities ceased in the early 1990s. Mineral rich waters from the River Seda flooded areas in the northern part of the mire during spring. As a result, the chemical composition characteristic for a mesotrophic lake has developed. This trophic state is characteristic for the cutaway lakes (stations No. 1 and No. 2), where water is alkaline, with high concentrations of calcium, magnesium and other inorganic ions. In these lakes the water buffering capacity is high, but colour values are low as well as phosphorus concentrations. In previously studied dystrophic bog lakes (Urtane and Klavins, 1995; Klavins *et al*., 2003), much higher values of water colour (200–800 °Pt/Co) have been found. The large standard deviations in chemical parameters of the studied lakes (Table 1) can be explained by seasonal variations in water composition, with higher pH values and dissolved oxygen levels and lower nutrient concentrations during the summer growing season (Figs. 2 and 3). Aquatic chemistry in these lakes influences primary production, causing relatively low phytoplankton biomass. Presently, the vegetation of the area is characterised by dense macrophyte stands covering up to 40% of the total water surface area, dominated by reed and bobtail (*Phragmites* and *Typha sp*) stands in the emergent waterplant zone and pondweeds *Potamogeton natans* and *Potamogeton zosterifolius* dominating in floating-leaved and submerged aquatic plant zones.

The aquatic chemistry and community structure in the two newly developed lakes much differ in comparison with the natural L. Seda (station No. 4). In L. Seda, the littoral sediments were composed of peat, as is common for natural humic lakes, and profundal sediments were covered by the bryophyte *Fontinalis* sp. This lake had low levels of dissolved ions, inorganic carbon, silica, and nitrogen concentrations. However, phosphate concentrations were higher in comparison with typical phosphate concentrations in lakes of Latvia (Klavins *et al*., 2002). It could be supposed that elevated concentrations of phosphates are the reason for high phytoplankton biomass in sampling station No. 4. However, the very high biomass in station No. 4 was comprised only by *Gonyostomum semen*, which occurs in large quantities in brown-water lakes in Northern Europe (Hongve *et al*., 1987; Cronberg *et al*., 1988; Lepistö *et al*., 1994). During the last decades, *G. semen* has been found in dystrophic and dyseutrophic lakes in Teiči Nature Reserve, in lakes around Riga, and in the Eastern part of Latvia (Druvietis, 2007). The invasion of *G. semen* might be explained by expansion of its distribution, occupying new lake types, intensive biomass development in several lakes, anthropogenic impact, or more intensive investigation of small lakes (Hörnström, 2002; Findlay *et al*., 2005).

The trophic status of lakes is associated with nutrient content, which has significant impact on species diversity, richness and seasonal population dynamics (Lindstrom, 2000, Kent *et al*., 2004; Tadonleke *et al*., 2005). The main trophic link between chemical components and biota in waterbodies is via the bacterial component. The nutrient content in lakes, at least indirectly, can influence the structure of the bacterioplankton community (Lindstrom, 2000). In humic lakes bacterial development is largely determined by humic substances. An increased level of humic substances increases bacterial abundance in humic lakes (Vrede *et al*., 2003). Autochthonous bacteria utilise and transform aquatic humic substances (HS), decreasing particle size and aromaticity, aliphatic carbon in HS, and increasing the nitrogen content of HS, probably due to some constituents of microbial biomass, such as proteins and amino sugars (Hertkorn *et al*., 2002). Reduced humic substances (HS) can be reoxidised by anaerobic bacteria, and in general microbial oxidation of HS is a ubiquitous metabolism in the environment (Coates *et al*., 2002). Simultaneously, decrease in bacterioplankton is caused by consumption by grazers, mainly flagellates (Kent *et al*., 2004).

In L. Seda, counts of typical saprophytic bacteria were low, which may reflect the low concentration of easily available organic matter. Communities of cellulose destroyers were comparatively more developed. The deeper cutaway lake (station No. 2) had higher bacterial numbers both of saprophytic, and especially oligocarbophylic and cellulose destroying bacteria than those in station No. 1 and L. Seda (station No. 4). In sampling station No. 2, the bacterial processes are likely more active, and consequently also the pelagic food web. Generally, a large proportion of particle-associated bacteria are metabolically active, while only a small fraction of free-living pelagic bacteria are metabolically active (Haglund *et al*., 2002). We can assume that bacteria in the sediments are more dependent than pelagic forms on HS. Bacteriobenthos counts were low at sampling stations No. 4 and No. 1, but were comparatively high at sampling station No. 2, especially for oligocarbophylic and facultatively anaerobic saprophytic bacteria. Composition of bacterioplankton and bacteriobenthos communities suggest that cycling of organic matter, both in the water column and sediments, was more intense at sampling station No. 2, compared to that in other lakes.

A comparison of the studied waterbodies in the Seda mire (sampling stations Nos. 1–3) with the natural dystrophic lakes in Teiči Nature Reserve confirmed that, in general, bacterial counts in the Seda territory are low, and accordingly metabolic activity is also low.

The high number of taxa and biomass of macrozoobenthos at sampling station No. 2 might be explained by diverse microhabitat composition and favourable feeding conditions for the macroinvertebrates, provided by the mineral friable sand sediments with a thin mud layer and patchy macrophyte stands. These conditions contrasted with the cutaway lake sampling station No. 1, which contained a deep layer of peat.

Macroinvertebrate communities in both natural lakes (sampling stations Nos. 4 and 5) differed. Lake Tolkovas (station No. 5) is a typical dystrophic lake. Species richness characteristically is low in small humic lakes with simple bottom structure and low abundance of aquatic plants (Heino, 2000). The low biomass in L. Tolkovas (6 g m^{-2}) may be associated with the low pH. A limited number of species of Hemiptera, Coleoptera, Trichoptera, Odonata and Diptera are typically present in lakes with low pH (Ward, 1992). The bottom structure of L. Sedas is heterogenous, and peat sediments are covered with *Fontinalis* sp. stands, rich in Oligochaeta populations. Nutrient content and abundance of food is an important factor for growth of oligochaetes. Growth rates of aquatic oligochaetes feeding on algae are expected to increase with increased N and P availability in the surface water, whereas detritivorous oligochaetes, which feed on dead organic matter, fungi and bacteria, are expected to increase with a higher nutrient content and decomposition rate of dead organic matter (Van Duinen *et al*., 2006).

Gradual accumulation of nutrients in the form of plant detritus and the spread of macrophytes are ongoing processes in shallow parts of the water bodies. In the future, the development of marshes may take place. Newly formed habitats in flooded peat harvest fields could be transformed into important bird nesting and resting locations. Lakes created on cutaway peatlands also could be used for recreation purposes (fishing, bird-watching).

In conclusion, the studied cutaway lakes can not be considered as typical dystrophic or humic lakes, regarding hydrochemical and hydrobiological features, due to diversity of underlying sediments as well as major differences in hydrological regimes. Waters of cutaway lakes are alkaline, with significantly ($P \leq 0.05$) higher concentrations of calcium, magnesium and bicarbonate ions as well as higher pH level, but lower water colour, than those in typical brown-water lakes. A comparison of the cutaway lakes in the Seda mire with natural dystrophic lakes confirmed that, in general, bacterial counts in the Seda territory are low, and accordingly, metabolic activity is also low. Number of taxa and biomasses of macrozoobenthos in cutaway lakes differ, mainly due to microhabitat composition (sediment properties and vegetation). In the nearest future, the rehabilitation or reclamation aim — natural regeneration or managed activities — for cutaway peatlands should be defined, planned and managed.

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ŪDEŅU KVALITĀTE KŪDRAS KARJERU EZEROS SEDAS PURVĀ

Pēdējos gados kā viena no iespējām izstrādāto kūdras karjeru rekultivācijai tiek piedāvāta seklu ezeru veidošana. Šī darba ietvaros tika pētīti applūdušie kūdras karjeri Sedas purvā ar mērķi novērtēt ūdens kvalitāti un noteikt galvenos faktorus, kas ietekmē ūdens kvalitāti applūdušajās teritorijās. Pētījumā konstatēts, ka Sedas purva teritorijās esošo applūdušo kūdras karjeru ķīmiskais sastāvs (īpaši pēc galveno neorganisko jonu satura, pH un ūdens krāsainības), kā arī makrozoobentosa, fitoplanktona un mikroorganismu cenozes atšķiras no tipisku purva ezeru ūdeņu kvalitātes rādītājiem. Tas varētu liecināt par to, ka ūdeņu sastāvu apsekotajās ūdenstilpēs ietekmē teritorijas ģeoloģiskā uzbūve un gruntsūdeņu ķīmiskais sastāvs, jo pēc kūdras izsmelšanas karjeros nav atstāts pietiekams kūdras slānis. Turklāt Sedas purva applūdušajos karjeros pavasara palu laikā vērojama arī virszemes ūdeņu pieplūde no Sedas upes. Jau tuvākajā nākotnē būtu nepieciešams noteikt izstrādātā mitrāja atjaunošanas mērķi konkrētās teritorijās — dabiska reģenerācija ar minimālu cilvēka iejaukšanos vai arī mērķtiecīgi virzīta darbība, lai veidotu bioloģiski daudzveidīgas un saimnieciski izmantojamas platības.