Proc. Estonian Acad. Sci. Biol. Ecol., 2000, **49**, 1, 19–33
https://doi.org/10.3176/biol.ecol.2000.1.02

ROLE OF INFLOWS IN THE PHYTOPLANKTON COMPOSITION OF LAKE PEIPSI

Reet LAUGASTE[a] and Vyacheslav YASTREMSKIJ[b]

[a] Võrtsjärv Limnological Station, Institute of Zoology and Botany, Estonian Agricultural University, 61101 Rannu, Tartumaa, Estonia; reet@zbi.ee
[b] Pskov Department of the Institute of Lake and River Fishery (GosNIORH), Gor'kij 13, 180007 Pskov, Russia

Received 8 June 1999

Abstract. The phytoplankton of the major streams flowing into L. Peipsi–Pihkva (altogether 14 streams out of 237) were studied by Estonian researchers in 1985–87 and by Russian (Pskovian) researchers in 1991–94. Two groups of inflows can be distinguished on the ground of phytoplankton composition: (1) large rivers with true phytoplankton, with an average of 40 (17–87 depending on the season) species in a counted sample of the vegetation period (Emajõgi and Velikaya rivers) and (2) small rivers whose plankton consist mainly of nonplanktonic diatoms and littoral forms and a few true planktonic flagellates or chlorophytes, as a rule less than 30 (8–43) species per sample. Generally, the abundance of algae and the number of species are positively correlated with the length and catchment area of the river. In small rivers diatoms and chlorophytes dominate with respect to the number of species, while diatoms and cryptomonads dominate with respect to biomass; in large rivers cyanobacteria (blue-green algae) prevail. In some cases where samples were collected near river mouths plankton were strongly affected by lake water depending on the direction of the wind. The inflows exert a strong influence on the lake; however, it is expressed mainly as an increase in the amount of several chemical compounds and only to a minor extent as direct introduction of certain algal species. The state of major inflows was quite adequately characterized by the composition and biomass of phytoplankton, which correlate with parameters of bacterioplankton as well as with hydrochemical parameters. Benthic and epiphytic diatoms and the saprobic index were found to reflect the state of small rivers better than phytoplankton.

Key words: inflows, phytoplankton biomass, saprobic index, species number.

INTRODUCTION

Lake Peipsi–Pihkva or L. Peipsi belongs to the basin of the Gulf of Finland of the Baltic Sea. It is a typical eutrophic plain lake with a large surface area (3555 km^2) and a small depth (maximum 15.3, mean 7.1 m). The catchment area, lying on Quaternary moraine sediments, is 44 245 km^2. The main inflows are the Velikaya River (catchment area 25 200 km^2) and the Emajõgi River (9960 km^2). The towns of Pskov (Pihkva in Estonian) with more than 200 000 and Tartu with

100 000 inhabitants are situated on the banks of these rivers, respectively. The oil shale industry of North-East Estonia affects the lake both through the inflow of mine water and through air pollution.

Lake Peipsi–Pihkva consists of three parts (Fig. 1). The northern part, meso-eutrophic L. Peipsi *s.s.* (*sensu stricto*) covers 75% of the whole area (2611 km^2, maximum depth 12.9, mean depth 8.3 m); the southern part, L. Pihkva (Pskovskoe ozero in Russian, 708 km^2, maximum depth 5.3, mean depth 3.8 m) is strongly eutrophic and even hypertrophic. These two parts are connected with narrow L. Lämmijärv (Teploe ozero or Warm Lake; 236 km^2, maximum depth 15.3, mean depth 2.5 m), whose water quality is close to that of L. Pihkva. The transparency of water is 2.8 m (average of the year) in the middle part of L. Peipsi *s.s.* and 1.6 m in L. Pihkva; minimum values occur in autumn (average 1.1–2 and 1 m, with an absolute minimum of 0.6 and 0.4 m, respectively). The average pH of surface water in summer is 8.0 in the northern part and 8.2 in the southern part; the values for the bottom layer are not considerably different (Sokolov, 1983).

A total of 237 streams fall into L. Peipsi. Only 28 of them are over 10 km in length and 5 are longer than 100 km. The catchment area of the four longest rivers covers more than 80% of the whole drainage basin of the Peipsi–Pihkva lake system (Fig. 2). Although the inflows exert a strong influence on the lake, it

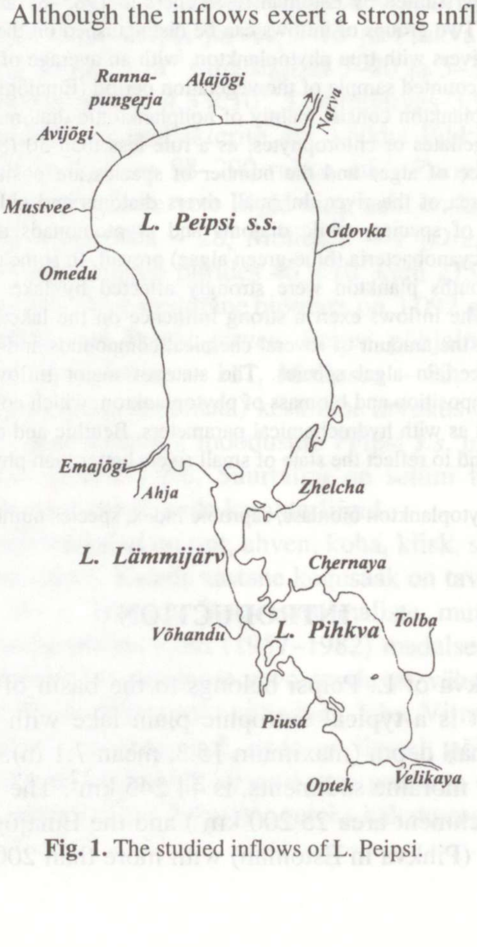

Fig. 1. The studied inflows of L. Peipsi.

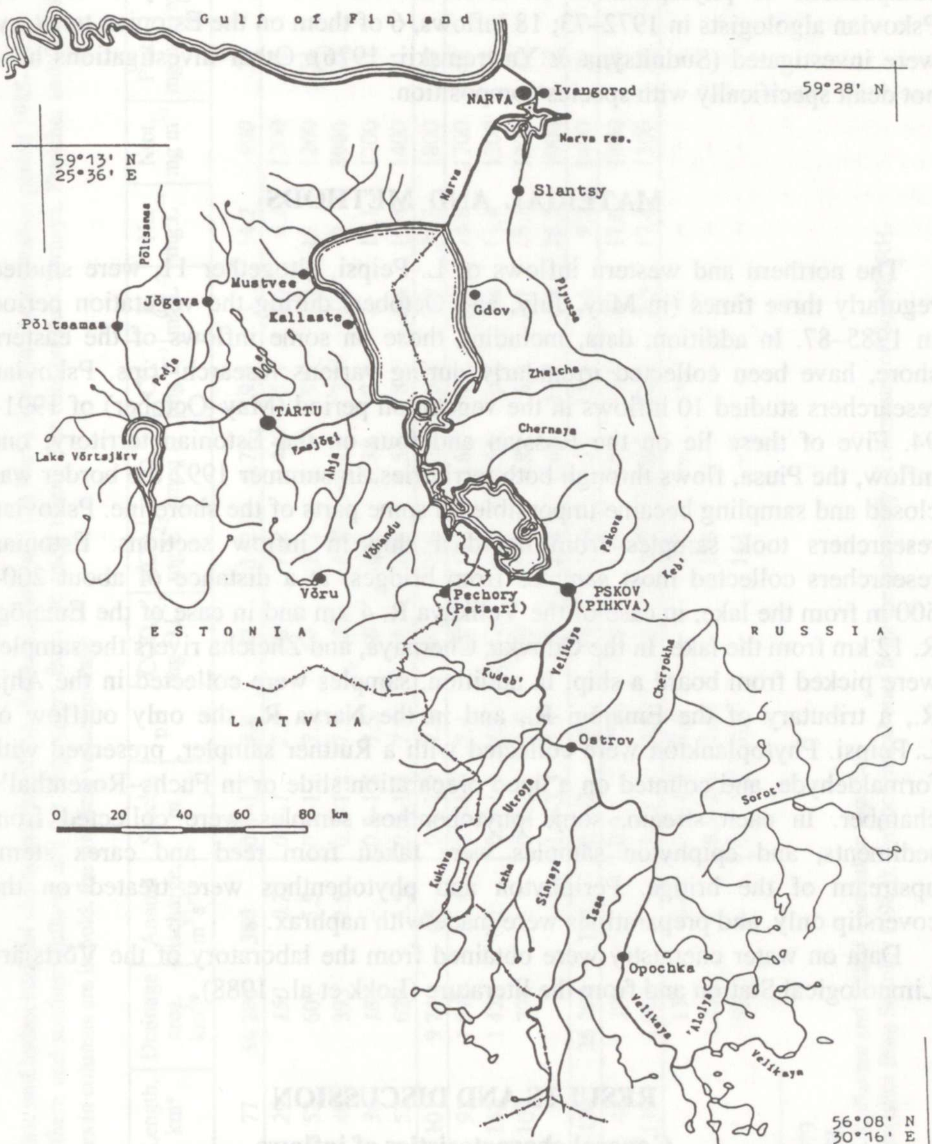

Fig. 2. Catchment area of L. Peipsi (Jaani & Raukas, 1999, p. 10).

is expressed mainly as an increase in the amount of several chemical compounds and, to a minor extent, as direct introduction of certain algal species. The species composition of phytoplankton in river mouths was thoroughly studied by Pskovian algologists in 1972–73; 18 inflows, 6 of them on the Estonian territory, were investigated (Sudnitsyna & Yastremskij, 1976). Other investigations have not dealt specifically with species composition.

MATERIAL AND METHODS

The northern and western inflows of L. Peipsi, altogether 11, were studied regularly three times (in May, July, and October) during the vegetation period in 1985–87. In addition, data, including those on some inflows of the eastern shore, have been collected irregularly during various research trips. Pskovian researchers studied 10 inflows in the vegetation period (May–October) of 1991–94. Five of these lie on the Russian and four on the Estonian territory; one inflow, the Piusa, flows through both territories. In summer 1992 the border was closed and sampling became impossible on some parts of the shoreline. Pskovian researchers took samples from board a ship in inflow sections. Estonian researchers collected most samples from bridges, at a distance of about 200–500 m from the lake, in case of the Velikaya R. 4 km and in case of the Emajõgi R. 12 km from the lake. In the Gdovka, Chernaya, and Zhelcha rivers the samples were picked from board a ship. In addition, samples were collected in the Ahja R., a tributary of the Emajõgi R., and in the Narva R., the only outflow of L. Peipsi. Phytoplankton were collected with a Ruttner sampler, preserved with formaldehyde, and counted on a lined preparation slide or in Fuchs–Rosenthal's chamber. In each stream, some phytobenthos samples were collected from sediments, and epiphyton samples were taken from reed and carex stems upstream of the bridge. Periphyton and phytobenthos were treated on the coverslip only, and preparations were made with naphrax.

Data on water chemistry were obtained from the laboratory of the Võrtsjärv Limnological Station and from the literature (Lokk et al., 1988).

RESULTS AND DISCUSSION

General characteristics of inflows

The inflows can be divided into large rivers with a catchment area of about 10 000 km^2 or more (Emajõgi, Velikaya) and small streams (Fig. 1, Table 1). Of the latter four have a catchment area of more than 500 km^2 (the Võhandu, Piusa, and Chernaya flowing into L. Pihkva and the Zhelcha in the south-eastern part of L. Peipsi *s.s.*). The small inflows of L. Peipsi *s.s.* are on average smaller than those of L. Pihkva, have a forested or swampy catchment area, and their water is

Table 1. Some morphometric and hydrochemical characteristics of the studied inflows and the Narva River in the vegetation period 1985–87. The lines separate the northern and southern inflows and the large rivers from the small rivers. The data on the Chernaya, Zhelcha, and Gdovka are for 1991–94. The largest values in columns are in bold, the smallest values in italic

River	Length, km*	Drainage area, km^2*	Annual discharge, m^3 s^{-1}*	Secchi, m	pH	COD$_{Cr}$, mg O L^{-1}	HCO_3^{I}, mg L^{-1}	SO_4^{II}, meq L^{-1}	Cl^{I}, mg L^{-1}	K, mg L^{-1}	Na, mg L^{-1}	Ntot, mg m^{-3}	Ptot, mg m^{-3}	Nmin, mg m^{-3}**
Narva	77	**56 200**	**380**	0.8–1.5	**7.8**	47	142	0.78	9.9	3	14.2	*900*	27	140
Alajõgi	*29*	*150*	*0.75*	*0.5–1*	*7.0*	59	*132*	0.44	*5.5*	*1.5*	*6.3*	1200	23	820
Rannapungerja	52	601	5.5	0.5–1.1	7.3	59	152	**2**	9.7	3.5	13	1200	34	*40*
Avijõgi	49	393	2.5	0.5–1.2	7.5	**62**	*138*	0.42	7.6	*1.6*	9	**3000**	22	**1630**
Mustvee	*36*	*180*	–	0.8–1.8	7.5	**60**	151	*0.38*	7.2	2	10.1	1700	31	1030
Omedu***	53	627	5.5	0.9–1.8	7.5	48	167	0.52	8.2	2.4	19.4	1400	31	960
Emajõgi	101	**9 740**	**65**	0.7–1.2	**7.8**	49	206	0.62	10.8	2.9	29.3	1800	**49**	1220
Ahja	95	1 070	7.5	0.7–1.6	7.4	47	182	0.64	9.6	2.9	14.8	1700	**48**	970
Võhandu	**162**	1 420	12	0.7–1.6	7.5	42	159	0.54	10.8	3.2	14.4	1200	45	790
Piusa	109	796	6	0.8–1.5	7.5	*20*	187	0.82	8.9	3.1	15.1	1200	42	960
Optek	–	–	–	**1.5–2.3**	7.5	*14*	**228**	0.65	**21.7**	**4.8**	**25.1**	1000	*12*	760
Velikaya	**430**	**25 200**	**124**	0.7–2	**7.7**	54	190	0.57	11.5	3.6	9.2	1400	39	750
5 northern small rivers	44	390		0.9	7.36	58	148	0.75	7.6	2.1	11.6	1800	28	920
4 southern small rivers	119	1 021		1.25	7.5	33	189	0.66	12.8	3.5	17.4	1300	35	840
Gdovka****		150	0.42	0.5–1.3	7.4	–	**282**	–	–	–	–	–	–	**2400**
Zhelcha****		1 220	8	0.5–2.1	7.35	–	138	–	–	–	–	–	–	*60*
Chernaya****		530	–	0.5–1.2	7.6	–	161	–	–	–	–	–	–	*60*

* From Loopmann, 1979.

** From Lokk et al., 1988.

*** Here two tributaries – Kullavere and Kääpa – are taken together.

**** Morphometric characteristics from Sokolov (1983); hydrochemical ones from the laboratory of chemistry of GosNIORH.

– No data available.

poorer in carbonates and nutrients and richer in organic substances. There are two exceptions: the Rannapungerja with inflowing mining water, very rich in sulphates, and the Avijõgi, which takes its beginning in the karst region on the Pandivere Upland, an intensive agricultural area, and is therefore rich in nitrogen. The inflows of lakes Pihkva and Lämmijärv have a more cultivated catchment area and higher total alkalinity, and are richer in sulphates, chlorides, Na, and K. As an exception among all the studied rivers, the Optek (Obdeh) has the lowest level of nutrients and organic substances, the highest transparency and content of chlorides, Na, and K, and also the highest total alkalinity (Table 1). Settlements on small rivers (Avijõgi, Mustvee, Võhandu, Gdovka) are located immediately at their mouths. The Piusa R. is the only inflow without any settlement worth mentioning on it.

Although some small rivers (Gdovka, Võhandu, Avijõgi) have a very high concentration of biogenic substances or minerals, their impact on the lake is not great as the amount of the water discharge of all small rivers does not exceed 22% of the inflowing water; while the Velikaya R. accounts for about 50% and the Emajõgi R. for 30% (Loigu et al., 1999).

The large rivers Emajõgi and Velikaya are strongly eutrophied compared with small ones. Their water is rich in nutrients and organic and mineral substances, including chlorides and sodium, which are evidence of strong human impact. These two rivers account for 65% of the inflowing waste water, 93% of BOD, 92% of nitrogen, and 90% of phosphorus (Järvet & Laanemets, 1990).

Data on the outflowing Narva R. are also presented in Table 1 to allow comparison of the parameters of inflows with those of the lake (samples were taken at the very beginning of the river). In the northern part of the lake, the concentration of biogenic substances, particularly nitrogen, in inflowing rivers is higher than in the lake. The southern part of L. Peipsi *s.s.* is more eutrophic. Lakes Pihkva and Lämmijärv are strongly eutrophic and the concentrations of nutrients in them are close to those of the inflowing large rivers.

The microbiological characteristics of inflows correlate with the nutrient concentration: streams rich in nutrients have a high concentration of saprobic bacteria, coliform bacteria, and enterococci (Lokk et al., 1988).

Phytoplankton of inflows

On the basis of phytoplankton composition the inflows fall into two groups: (1) large rivers with true phytoplankton, 40 (17–87 depending on the season) species in a counted sample as the average of the vegetation period (Emajõgi, Velikaya, and Zhelcha rivers); and (2) small rivers whose plankton consists mainly of nonplanktonic diatoms and littoral forms and a few true planktonic flagellates or chlorophytes, usually less than 30 (8–43) species per sample (Table 2). In small rivers, diatoms and chlorophytes dominate with respect to the number of species, while diatoms and cryptomonads dominate with respect to biomass; in large rivers, cyanobacteria (blue-green algae) prevail. Samples from the Narva R. were taken at its very beginning and they reflect the situation in the northern part of L. Peipsi *s.s.* In some cases where samples were collected near river mouths (Võhandu, Mustvee, Omedu, Piusa, and Gdovka) plankton were strongly affected by lake water depending on the direction of the wind.

Table 2. Average phytoplankton characteristics in the vegetation period 1985–87 ($n = 9$). Abbreviations: bac = diatoms, cy = blue-greens, cryp = cryptomonads, chl = green algae, chr = chrysophytes. The lines separate the northern and southern inflows and the large rivers from the small rivers

Inflow, Narva R. (outflow)	Biomass		Species number		Dominant group	Saprobic index	
	Mean g m^{-3}	SD	Mean	SD	V, VII, X	Plankton	Benthos + epiphyton
Narva	4.29	5.24	41	16.9	bac, bac, bac	1.90	1.73
Alajõgi	0.15	0.08	19	7.4	chr, bac, cy	2.28	2.07
Rannapungerja	0.61	1.35	14	4.9	cy, cryp, cy	2.06	1.92
Avijõgi	0.28	0.38	17	5.7	cryp, bac, cryp	2.12	1.89
Mustvee	1.45	1.84	22	12.8	bac, cryp, bac	2.18	2.22
Omedu	0.88	0.76	29	13.1	bac, cryp, cryp	2.03	2.30
Emajõgi	3.12	2.05	51	12.1	bac, cy, cy	2.08	2.00
Ahja	0.78	0.46	28	9.3	bac, cryp, chl	2.20	2.06
Võhandu	1.97	3.05	28	8.1	bac, cryp, cryp	2.15	1.80
Piusa	0.61	0.73	26	6.4	bac, chl, bac	2.18	2.09
Optek	1.54	1.70	26	4.5	bac, cy, cryp	2.06	1.95
Velikaya	2.88	1.58	43	19.0	bac, chl, bac	2.07	1.95
5 northern small rivers	0.81		19			2.13	2.13
4 southern small rivers	1.23		26			2.15	1.96

The large rivers Velikaya and Emajõgi surpass the others with respect to phytoplankton biomass (Figs. 3, 4) and species number in a counted sample. The Emajõgi R. is conspicuous for its stable phytoplankton composition. This is due to its connection with large eutrophic L. Võrtsjärv with which it shares the same dominant species though with a considerably smaller biomass. The samples taken from the Emajõgi at distances of about 12 km and 300–500 m from the lake (Table 3, Emajõgi 1 and Emajõgi, respectively) have quite a similar algal composition; it is also evident that the similarity index of phytoplankton (river vs. the nearby lake part) by Sørensen & Czekanovski (Masing, 1992) does not depend on the distance from the lake in the case of this river. The dominant species in the river are among the dominants or subdominants of the nearby lake part and in some cases also of the whole southern region of L. Peipsi *s.s.* (like in the summers of 1988 and 1989). This reflects the remarkable influence of the Emajõgi R. on the blue-green algae flora of L. Peipsi.

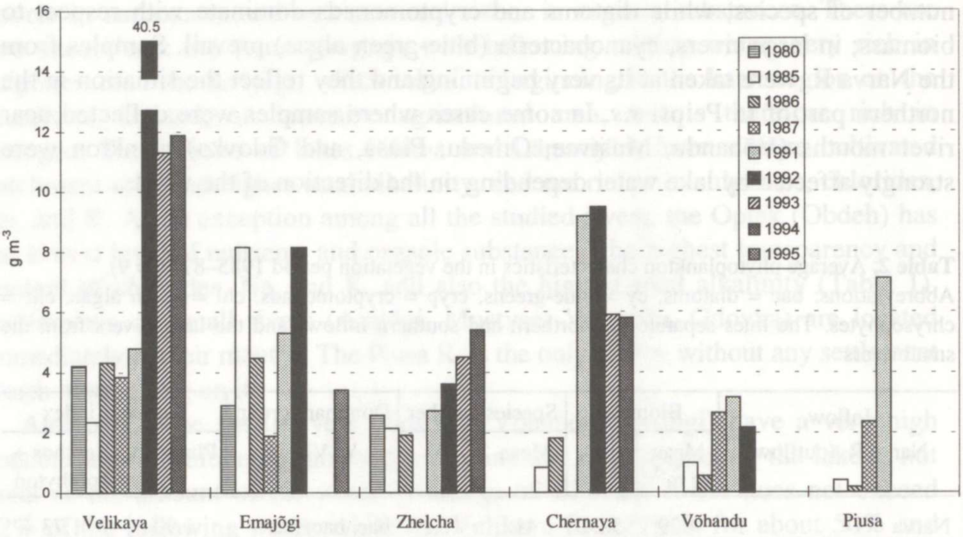

Fig. 3. Average phytoplankton biomass in two large and four medium-sized rivers.

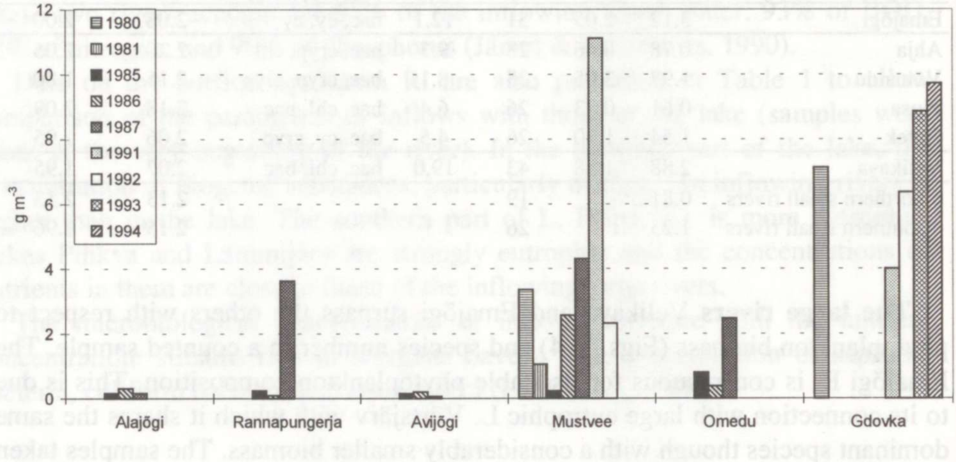

Fig. 4. Average phytoplankton biomass in small inflows.

The Velikaya R. was somewhat poorer in phytoplankton both with regard to their biomass and species number than the Emajõgi R., but significantly richer in chlorophyte species (constantly more than 25 species in a counted summer sample) in the 1970s and 1980s. In 1992, a strong algal bloom, caused by varieties of *Microcystis pulverea*, occurred in this river. Phytoplankton biomass was 97.5 g m^{-3} in the vicinity of the town of Pskov and 152 g m^{-3} in the river mouth in September 1992, which was close to the respective values for L. Pskov. The saprobity index by Pantle & Buck (1955) was 2.6, exceeding considerably the index measured in the 1980s (Table 2). The values of similarity indices (river vs. the nearby lake part) are quite high (Table 3) and indicate a strong effect of the river on the composition of chlorophyte species in the lake.

Small inflows are usually poor in phytoplankton. Some high biomass values in the mouths of the Mustvee, Gdovka, Chernaya, and Piusa rivers are caused by invasion of lake water due to wind action. The values of similarity indices (river vs. the nearby lake part) for small inflows were considerably lower than for the two largest rivers (Table 3). The poorest in phytoplankton were small streams on the northern coast; the more southward a river is located, the richer is its phytoplankton (Table 2). This phenomenon is related to different bedrock (limestone in the northern part and sandstone in the southern part of Estonia), as well as to the situation in catchment areas in the northern part which cover extensive forests and mires not influenced by human activity. The lower reaches of some rivers, however, run through settlements (Avijõgi, Mustvee, Omedu, Gdovka, Võhandu), which affects the amount of nutrients and may cause occasionally very high values of phytoplankton biomass (e.g. biomass about 9 g m^{-3} and saprobic index 2.9 in the Gdovka R. in the 1990s). Still, the influence of small inflows is restricted within a very small lake area. The values of similarity indices were remarkably lower in case of small inflows (35.6 ± 5, $n = 29$) compared with those of the two largest rivers (53.5 ± 4.9, $n = 15$).

Comparison of saprobic indices derived on the basis of different investigation material is presented in Fig. 5. In most cases the saprobic index of the inflows is higher than that of the lake; however, the index of some rivers of the eastern shore (Chernaya, Tolba) is lower than that of L. Pihkva. As regards the saprobic index, neither the rivers of the northern and southern lake parts nor small and large inflows reveal any difference. However, some discrepancy is evident in the figures presented by different researchers (in most cases the index calculated by R. Laugaste is higher). It should be taken into account that the site and time of collecting samples and number of samples studied, as well as the personal experience of the researchers, were different.

The species number in a counted phytoplankton sample for the large rivers Emajõgi and Velikaya (Fig. 6) exceeds that for the lake (R. Narva), is close to that for the lake in case of some inflows of the eastern shore (Gdovka, Chernaya, Zhelcha), and is very low for northern inflows (Alajõgi, Rannapungerja, Avijõgi). As a rule, the abundance of algae and the number of species are positively correlated with the length and catchment area of the river. In 1991–94 an increase in the phytoplankton abundance was observed in some small river mouths: the average biomass for the vegetation period fluctuated from 3 g m^{-3} in the Piusa R. to 8.9–9.4 g m^{-3} in the Gdovka and Chernaya rivers, and increased up to 23–34 g m^{-3} in some windward areas. Saprobic indices were the highest in the rivers of Gdovka (2.9) and Velikaya (2.6). In general, the aquatory of L. Peipsi–Pihkva can be characterized as ß-mesosaprobic.

Table 3. Phytoplankton characteristics in inflows and in nearby lake areas. Abbreviations: cryp = cryptomonads

Inflow, nearby lake area	Date	Biomass, g m^{-3}	Number of species	Dominant	Similarity index*
Emajõgi	26.07.80	2.88	63	*Limnothrix redekei, Microcystis wesenbergii*, cryp	51
Lake	26.07.80	14.56	63	*Stephanodiscus binderanus, Aphanothece* sp.	
Emajõgi 1**	09.07.85	4.37	57	*L. redekei, Planctolyngbya limnetica*	45
Emajõgi	24.07.85	8.15	74	*L. redekei, P. limnetica*	62
Lake	24.07.85	14.53	62	*Aulacoseira ambigua, P. limnetica, L. redekei*	
Emajõgi 1**	23.07.86	3.66	69	*L. redekei, Cyclotella* spp.	52
Emajõgi	15.07.86	4.44	47	*L. redekei*	56
Lake	15.07.86	2.21	29	Cryp, *Aulacoseira ambigua*	
Emajõgi 1**	23.07.87	1.89	63	*L. redekei*, cryp	56
Emajõgi	13.07.87	1.16	54	Cryp	51
Lake	13.07.87	2.36	50	Cryp	
Emajõgi	01.08.95	3.4	65	*P. limnetica, L. redekei*	
Lake	01.08.95	11.4	72	*Gloeotrichia echinulata, P. limnetica*	55
Velikaya	19.07.80	4.21	57	*Oedogonium* sp.	50
Lake	19.07.80	6.67	66	*Cyclotella* spp., *Anabaena lemmermannii, Dictyosphaerium* sp.	
Velikaya 1**	09.07.85	1.49	54	*Cyclotella* spp., cryp	54
Velikaya	23.07.85	2.35	50	Cryp, *Chlamydomonas* spp., *Pandorina* sp.	59
Lake	23.07.85	6.23	83	*Aulacoseira ambigua, Cyclotella* spp., cryp	
Velikaya 1**	23.07.86	4.3	87	*Cyclotella* spp., *Chlamydomonas* spp.	48
Velikaya	16.07.86	2.1	45	Cryp, *Chlamydomonas* spp.	60
Lake	16.07.86	5.85	56	*Microcystis viridis*, cryp, *A. ambigua*	
Velikaya 1**	23.07.87	3.84	40	Cryp, *Cyclotella* spp., *Chlamydomonas* spp., *Carteria*	56
Velikaya	13.07.87	1.6	39	*Cyclotella* spp., cryp	47
Lake	13.07.87	13.45	49	*S. binderanus, Aphanizomenon flos-aquae*, cryp	
Small inflows					
Alajõgi	12.07.85	0.17	29	*Anabaena* sp.	38
Lake	25.07.85	1.37	34	Cryp, *Aulacoseira islandica*	
Alajõgi	21.07.86	0.31	20	*Melosira varians, Fragilaria* sp.	27
Lake	15.07.86	3.95	31	*A. ambigua*, cryp	
Alajõgi	21.07.87	0.17	27	Cryp	33
Lake	14.07.87	1.38	26	Cryp	

Table 3 continued

Inflow, nearby lake area	Date	Biomass, g m^{-3}	Number of species	Dominant	Similarity index*
Rannapungerja	12.07.85	0.25	18	Cryp, *Hyaloraphidium* sp.	41
Lake	25.07.85	0.44	20	Cryp	
Rannapungerja	21.07.86	0.1	12	Cryp	40
Lake	15.07.86	1.41	32	Cryp	
Rannapungerja	21.07.87	3.63	23	Cryp	40
Lake	14.07.87	0.7	16	*Microcystis pulverea*	
Avijõgi	12.07.85	0.16	24	Benthic diatoms	35
Lake	25.07.85	0.65	18	Cryp	
Avijõgi	21.07.86	0.21	18	Cryp	40
Lake	15.07.86	1.36	27	Benthic diatoms	
Avijõgi	21.07.87	0.07	13	Benthic diatoms	44
Lake	14.07.87	0.39	12	Cryp	
Mustvee	04.08.80	3.35	51	*Aphanothece* sp.	31
Lake	04.08.80	8.62	56	*Gloeotrichia echinulata, A. islandica*	
Mustvee	04.06.81	1.06	32	*Fragilaria* sp., *Microcystis pulverea*	35
Lake	04.06.81	2.63	40	*Uroglena americana, Aulacoseira granulata*	
Mustvee	12.07.85	0.24	30	Benthic diatoms	27
Lake	25.07.85	0.75	14	Cryp	
Mustvee	21.07.86	2.57	39	*Carteria* sp., *Pandorina morum*	30
Lake	15.07.86	1.81	27	Cryp	
Mustvee	21.07.87	4.3	28	Cryp	42
Lake	14.07.87	2.19	22	Cryp	
Omedu	12.07.85	0.81	13	Benthic diatoms	30
Lake	25.07.85	1.24	22	Cryp	
Omedu	21.07.86	0.39	44	Benthic diatoms	29
Lake	15.07.86	1.48	35	Cryp	
Omedu	21.07.87	2.47	40	Cryp, *Cyclotella* spp.	37
Lake	14.07.87	2.37	42	Cryp, *A. ambigua*	
Võhandu	09.07.85	0.99	28	*Melosira varians*	38
Lake	23.07.85	6.84	60	*Microcystis pulverea, A. ambigua*	
Võhandu	23.07.86	0.55	34	*Oscillatoria* sp., cryp	42
Lake	16.07.86	10.23	55	*S. binderanus, A. ambigua*	

Table 3 continued

Inflow, nearby lake area	Date	Biomass, g m^{-3}	Number of species	Dominant	Similarity index*
Võhandu	23.07.87	2.66	24	Cryp, *Carteria* sp., *Pandorina morum*	35
Lake	13.07.87	7.17	25	*S. binderanus, A. ambigua*	
Piusa	09.07.85	0.39	25	Benthic diatoms	28
Lake	23.07.85	7.1	73	*Gloeotrichia echinulata, A. ambigua*	
Piusa	23.07.86	0.19	26	Chlorophytes, unidentified	33
Lake	16.07.86	6.85	32	*S. binderanus*	
Piusa	23.07.87	2.36	30	*Melosira varians*	33
Lake	13.07.87	13.96	25	*S. binderanus, A. ambigua*	
Gdovka	31.07.80	7.13	63	*A. islandica, Cyclotella* spp.	30
Lake	31.07.80	2.78	39	*Dinobryon divergens, D. sociale, D. bavaricum*	
Zhelcha	28.07.80	2.57	48	*A. ambigua*, cryp	40
Lake	28.07.80	6.83	73	*G. echinulata, A. ambigua*	
Zhelcha	23.07.85	2.14	38	*Melosira varians, M. pulverea*	38
Lake	23.07.85	5.65	75	*G. echinulata*, cryp	
Zhelcha	16.07.86	1.93	39	*Limnothrix redekei*, cryp	40
Lake	16.07.86	5.5	47	*A. granulata, S. binderanus*	
Chernaya	23.07.85	0.85	36	*Microcystis pulverea*	36
Lake	23.07.85	2.63	70	*A. ambigua*	
Chernaya	16.07.86	1.8	35	*Fragilaria* sp., cryp	39
Lake	16.07.86	10.17	30	*S. binderanus, G. echinulata*	

* According to Sørensen & Czekanovski (Masing, 1992).

** Samples were taken at a different time and at a longer distance from the lake.

The state of large inflows is quite adequately reflected by phytoplankton composition and biomass, which correlate with the bacterioplankton and hydrochemical parameters (Lokk et al., 1988). The state of small rivers is characterized better by benthic and epiphytic diatoms and the saprobic index than by the phytoplankton parameters. It is remarkable that saprobic indices based on phytoplankton are in most cases higher than those based on benthos and epiphyton, counted together (Table 2). This may be caused by incomplete identification of diatoms resulting from inadequacy of methods (treatment on the coverslip).

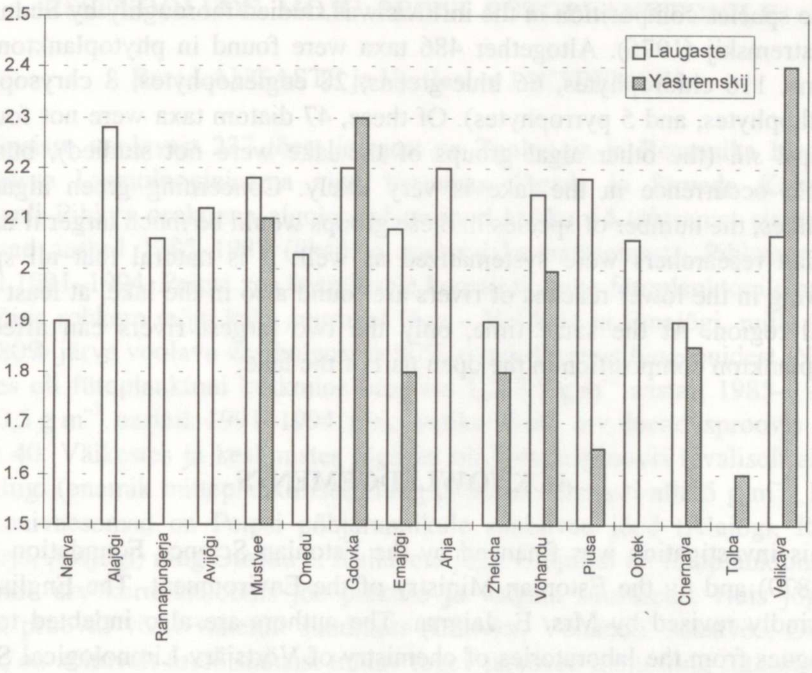

Fig. 5. Average saprobic index of inflows.

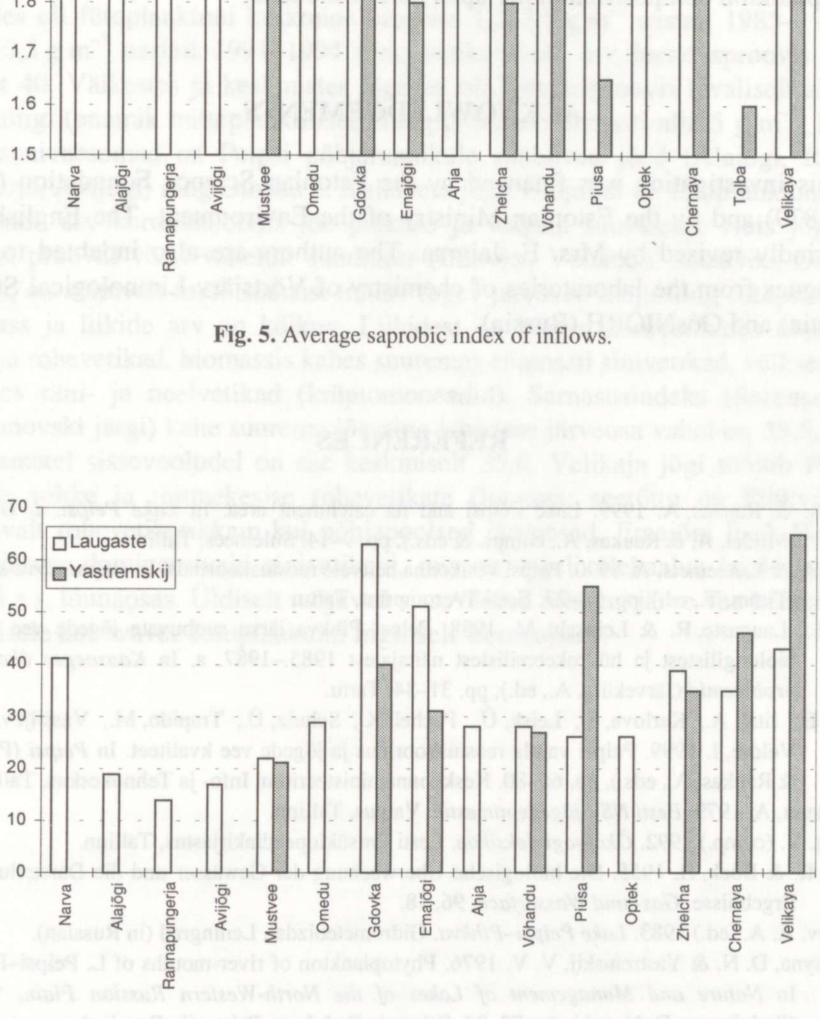

Fig. 6. Average number of phytoplankton species per counted sample.

The species composition in the inflows was studied thoroughly by Sudnitsyna & Yastremskij (1976). Altogether 486 taxa were found in phytoplankton (257 diatoms, 116 chlorophytes, 66 blue-greens, 28 euglenophytes, 8 chrysophytes, 6 xanthophytes, and 5 pyrrophytes). Of these, 47 diatom taxa were not found in L. Peipsi *s.l.* (the other algal groups of the lake were not studied), but their possible occurrence in the lake is very likely. Concerning green algae and flagellates, the number of species in these groups would be much larger if data by Estonian researchers were systematized as well. It is natural that all species occurring in the lower reaches of rivers are found also in the lake, at least in the littoral region. At the same time, only the two largest rivers can affect the phytoplankton composition in the open part of the lake.

ACKNOWLEDGEMENTS

This investigation was financed by the Estonian Science Foundation (grant No. 2879) and by the Estonian Ministry of the Environment. The English text was kindly revised by Mrs. E. Jaigma. The authors are also indebted to their colleagues from the laboratories of chemistry of Võrtsjärv Limnological Station (Estonia) and GosNIORH (Russia).

REFERENCES

Jaani, A. & Raukas, A. 1999. Lake Peipsi and its catchment area. In *Lake Peipsi. I. Geology* (Miidel, A. & Raukas, A., comps. & eds.), pp. 9–14. Sulemees, Tallinn.

Järvet, A. & Laanemets, A. 1990. Peipsi vesikonna heitvete reostuskoormus. In *Peipsi järve seisund* (Timm, T., ed.), pp. 24–27. Eesti TA rotaprint, Tartu.

Lokk, S., Laugaste, R. & Leinsalu, M. 1988. Peipsi–Pihkva järve suubuvate jõgede vee hüdrobioloogilistest ja hüdrokeemilistest näitajatest 1985.–1987. a. In *Kaasaegse ökoloogia probleemid* (Järvekülg, A., ed.), pp. 31–34. Tartu.

Loigu, E., Iital, A., Karlova, S., Leisk, Ü., Pachel, K., Schulz, Ü., Trapido, M., Vassiljev, A. & Veldre, I. 1999. Peipsi valgla reostuskoormus ja jõgede vee kvaliteet. In *Peipsi* (Pihu, E. & Raukas, A., eds.), pp. 66–80. Keskkonnaministeeriumi Info- ja Tehnokeskus, Tallinn.

Loopmann, A. 1979. *Eesti NSV jõgede nimestik.* Valgus, Tallinn.

Masing, V. (comp.) 1992. *Ökoloogialeksikon.* Eesti Entsüklopeediakirjastus, Tallinn.

Pantle, R. & Buck, H. 1955. Die biologische Überwachung der Gewässer und die Darstellung der Ergebnisse. *Gas- und Wasserfach*, **96**, 18.

Sokolov, A. A. (ed.) 1983. *Lake Peipsi–Pihkva.* Gidrometeoizdat, Leningrad (in Russian).

Sudnitsyna, D. N. & Yastremskij, V. V. 1976. Phytoplankton of river-mouths of L. Peipsi–Pihkva. In *Nature and Management of Lakes of the North-Western Russian Plain,* Vol. 1 (Sudnitsyna, D. N., ed.), pp. 73–94. Pskovsk. Ped. Inst., Pskov (in Russian).

SISSEVOOLUDE MÕJU PEIPSI FÜTOPLANKTONILE

Reet LAUGASTE ja Vjatšeslav JASTREMSKI

Peipsisse voolavast 237 jõest ja ojast on Zooloogia ja Botaanika Instituudi Võrtsjärve Limnoloogiajaama ning Venemaa Jõgede ja Järvede Kalanduse Instituudi Pihkva osakonna algoloogid uurinud kokku 14 tähtsamat sissevoolu; eestlased aastail 1985–1987 (üksikud andmed ka varasemast), Pihkva uurijad aastail 1991–1994. Peipsi vee keemilisele koostisele ning fütoplanktonile avaldavad kõige rohkem mõju kaks suurimat jõge – Velikaja ja Emajõgi, mille kaudu tuleb 80% järve voolava vee hulgast ja 90% sissetulevatest biogeenidest. Nendes jõgedes oli fütoplanktoni keskmine biomass 1,2–8,2 g m^{-3} aastail 1985–1987 ja 4,8–40,5 g m^{-3} aastail 1991–1994 ning vetikaliikide arv loendusproovis keskmiselt 40. Väikestes ja keskmistes jõgedes oli loendusproovis tavaliselt alla 30 vetikaliigi (enamik mitteplanktilised) ning biomass enamasti alla 5 g m^{-3}. Kõige planktonivaesemad on Peipsi põhjarannikule suubuvad jõed (Alajõgi, Rannapungerja, Avijõgi) ning Omedu e. Kullavere jõgi. Üldjuhul on fütoplanktoni hulk ja liikide arv korrelatsioonis jõe pikkuse ja valgala suurusega. Neis jõgedes, millest proovid võeti vahetult suudmest (Gdovka, Võhandu, Mustvee, Omedu, Piusa), on sõltuvalt tuule suunast tuntav tugev järvevee mõju ning fütoplanktoni biomass ja liikide arv on kõikuv. Liikidest on kõigis sissevooludes ülekaalus räni- ja rohevetikad, biomassis kahes suuremas enamasti sinivetikad, väiksemates jõgedes räni- ja neelvetikad (krüptomonaadid). Sarnasusindeks (Sørenseni ja Czekanovski järgi) kahe suurema jõe ning lähedase järveosa vahel on 53,5, kuna väiksematel sissevooludel on see keskmiselt 35,6. Velikaja jõgi mõjub Pihkva järvele rohke ja mitmekesise rohevetikate flooraga; seetõttu on Pihkva järv tunduvalt rohevetikarikkam kui põhjapoolsed järveosad. Emajõgi lisab Peipsile Võrtsjärves domineerivaid sinivetikaid, mis on sageli ülekaalus laialdasel alal Peipsi *s.s.* lõunaosas. Üldiselt mõjuvad sissevoolud rohkem järve vee keemilisele koostisele kui avavee fütoplanktoni liigilisele koosseisule.