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CHANGES IN THE HUMAN IMPACT ON LAKE RUUSMÄE IN RECENT DECADES AND THEIR REFLECTION IN THE SEDIMENTARY ORGANIC MATTER

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Abstract. For the calibration of palaeoecological data, the history of man-induced processes on the catchment of Lake Ruusmäe in southern Estonia was studied and temporal comparison with carbon, nitrogen, and fossil pigment records in sediments was performed. The data of historical monitoring were systematized using the cartographic program MapInfo Professional. The maps characterizing the intensity of human load were compiled for three periods (up to 1948, 1949–78, 1979–98). The same time intervals were distinguished on the sediment records (C and N content, fossil pigment variations). The comparison of the history of potential human load with these records in the sediment showed that drastic external events led to major changes in the matter cycling in the lake, including changes in the trophic level. Within a certain level of trophicity internal mechanisms of the matter circulation can compensate to some extent for the variations in the external load.

Key words: historical monitoring, palaeoecology, carbon, nitrogen, fossil pigments, human impact, lake ecosystem.

INTRODUCTION

The state and evolution of ecosystems are affected by various biotic and abiotic factors, natural and man-induced processes of variable level and duration. The problem of human influence is particularly difficult to solve due to the multitude of variables that determine the changes in the biogeochemical cycling in lakes, as well as in the chemical and biological composition of the sediments. As the total impact of different processes on ecosystems will have complex consequences, the study of the acting mechanism and relations between the impact on ecosystems and its results is extremely complicated. Besides it is very rarely possible to reconstruct the correct past state of the studied ecosystems on the basis of the monitoring data. One of the best ways, and often the only way, to obtain long-term data on lake-water chemistry is the study of sediment cores. The information (biological, geochemical, lithological) stored in cumulative deposits (peat, lake deposits) allows us to follow the changes in the processes affecting the sediment deposition over certain periods (Chambers, 1993; Charles & Smol, 1994; Smol et al., 1997).

One of the most topical problems in the application of the palaeoecological approach is the interpretation of data obtained by sediment study and their temporal calibration, for which historical monitoring offers some possibilities. If the anthropogenic changes in biosphere cycles are strong enough to cause transformations in landscapes and ecosystems, it will be possible to correlate the palaeoecological information with certain events and impacts. The data obtained can be used to reconstruct cause–effect relationships and thus to model the dynamics of landscapes and ecosystems under the impact of various factors.

For the calibration of palaeodata a comprehensive application of the data of historical monitoring and palaeomonitoring is needed. This approach helps establish the relationship between certain events with a fixed load on the studied ecosystem (influx of nutrients and other chemical compounds, changes in the water balance, capacities of ecosystems, etc.) and the temporal changes in the qualitative and quantitative composition of sediments. This approach necessitates comprehensive study of different ecosystems under different impact (load) histories.

The purpose of the current research was to investigate the influence of man-induced processes on the catchment of Lake Ruusmäe and to study the changes in the structure and content of sediments deposited in certain time spans. The temporal changes in the human load were compared with the changes in the composition of organic compounds in successive sediment layers. As indicators of organic sedimentation, the contents of carbon, nitrogen, and fossil pigments in the sediments were analysed.

STUDY AREA

The catchment of Lake Ruusmäe lies in the Haanja Heights in southern Estonia (Fig. 1). The landscape is rather differentiated there with a large number of lakes. Lake Ruusmäe, directed SE–NW, is located between hills. The altitude of its catchment ranges from 228 to 270 m a.s.l. The lake is closed and feeds from precipitation and springs. Geomorphologically, the catchment represents a moraine plain where soddy-podzolic soils predominate. Also eroded and deluvial soils are present.

The area of Lake Ruusmäe varies, according to different maps, from 3.9 to 4.7 ha depending on the water level regulation and intensity of littoral vegetation.

At present the area of the lake is 4.7 ha and the total volume of water is about 160 000 m^3. The maximum length of the lake is 370 m and width 150 m. The greatest depth (up to 11 m) is in the NW part (Fig. 1).

Lake Ruusmäe is a hypertrophic lake (Milius & Starast, 1997). The water in this dimictic lake is strongly stratified in summer, and the seasonal and vertical differences in the oxygen content are very sharp. In the summer season the oxygen content in the surface layers is up to 130% from the saturation, but already at a depth of 3 m it is nearly zero. During the winter season anoxia occurs in the full profile. The bioproduction is very intensive in the lake and therefore the transparency by the Secchi disk is less than 1 m during the vegetation period. Since 1971, the researchers of the Institute of Zoology and Botany have performed irregular hydrological and hydrochemical monitoring in Lake Ruusmäe (Pihu, 1990). According to the monitoring data, the content of HCO_3 in the water is 122–223 mg L^{-1}. The content of nutrients is very high. So, the content of total P was up to 0.85 mg L^{-1} in the bottom layers and total N amounted to 5.45 mg L^{-1}

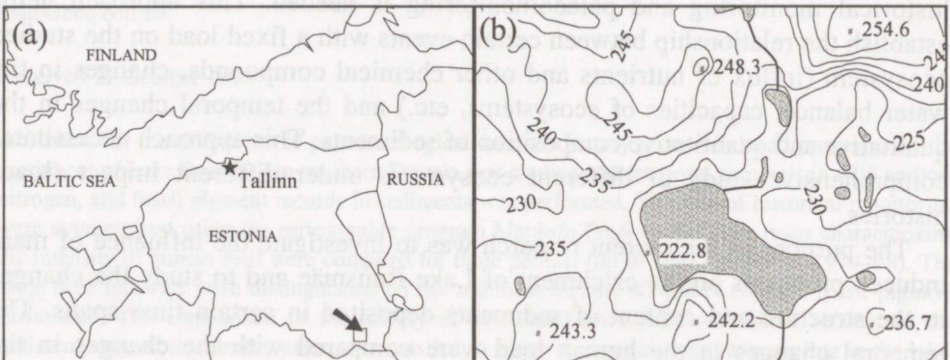

Fig. 1. Location of Lake Ruusmäe (a, b) and its bathymetry with the sampling point (c).

in the upper layers in summer 1990. The pH values varied from 8.2 to 10.4 in surface layers and from 6.4 to 9.2 in nearbottom layers.

The vegetation on the catchment is represented by the mixed and pine forest, meadow, and paludified pasture communities. For centuries the area around the lake has been intensively farmed. Since the 1970s cattle breeding has been especially extensive.

MATERIALS AND METHODS

To estimate the dynamics of the temporal intensity of human impact on Lake Ruusmäe, we used materials (maps, projects, documents) from several archives, as well as information from interviews with local inhabitants. The obtained data cover different periods:

1. Maps and Revision books for Rogosi estate from the Estonian Historical Archive (3724 5:2861/1, 3724 6:7319) provided the history of the area from the 17th century up to 1917;
2. Documents (maps and written sources) from the Estonian State Archive in Tallinn (58 4:2699, 58 3:118, 58 3:31) were used for the period of 1917–1944;
3. Materials dealing with the agricultural and building activity from Võrumaa Archive and the National Land Board of Estonia provided information from 1944 onwards. These materials include land-use maps, aerophotos, and various documents on land amelioration and building.

During the preliminary processing of the materials obtained from archives and interviews mainly the reliability and consistency of information were checked. The maps contained different information, depending on their purpose and special interests of the compilers. For example, on forest appraisal maps the contours of water bodies are typically less detailed; the land-use maps, however, pay less attention to the untilled land, etc. Moreover, for the compilation of specific maps, earlier base maps have often been used.

In case of interviews, the main discrepancy lies in the dates (years); the events connected with personal experience are amplified, whereas spatially more distant happenings are less important. Still, most of the contradictions could be removed quite easily by comparing different pieces of information.

Human impact on Lake Ruusmäe was rather modest before World War II, and therefore we started our analyses since the early 1940s. On the basis of the information collected, we divided the whole postwar history of human activities on the catchment of Lake Ruusmäe into three periods. The distinction of the periods was based primarily on the existing reliable maps, which were used to compile topographic and land-use maps for the years 1948, 1978, and 1996. The data on loads (Fig. 2), presented on the maps, are actually maximum loads characterizing the period considered. The human load during the three periods could be briefly characterized as follows:

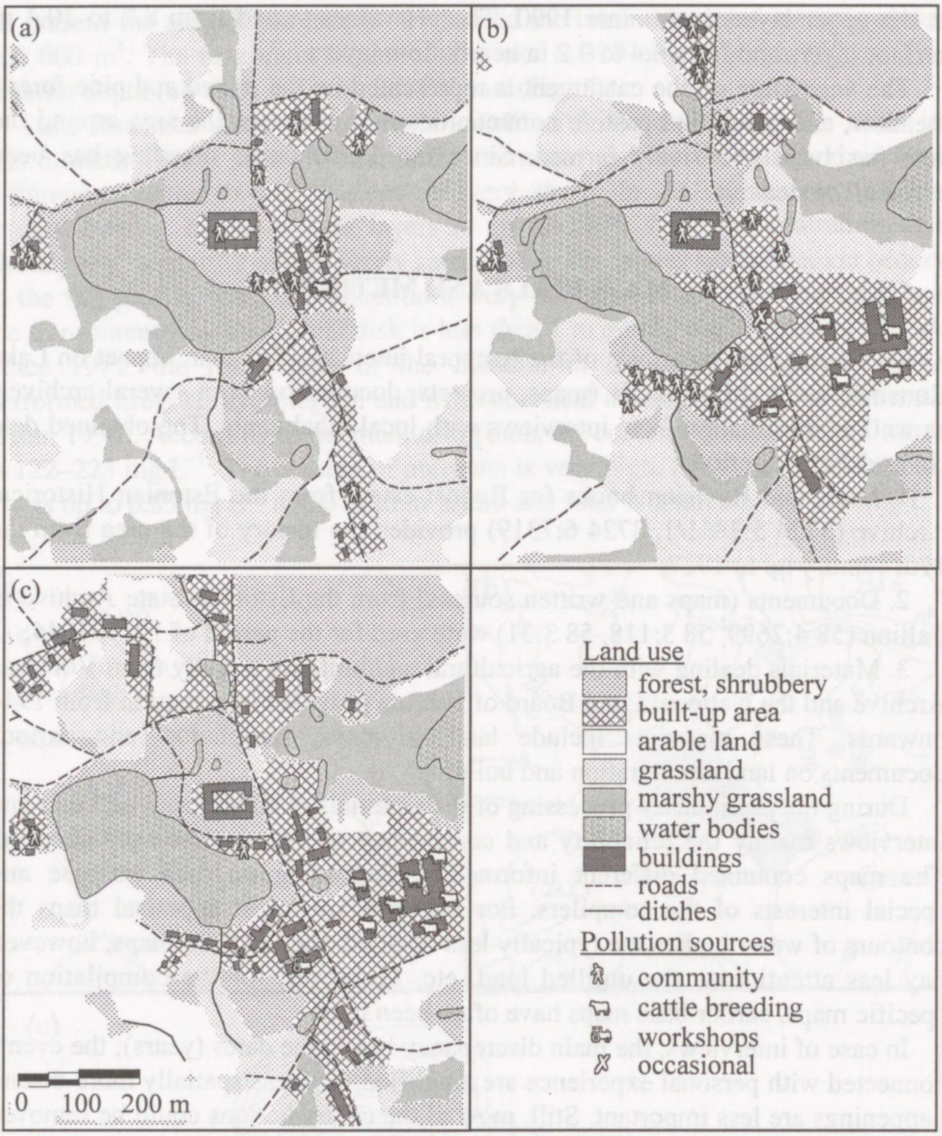

Fig. 2. Land use around Lake Ruusmäe and the history of potential load on the lake for the periods up to 1948 (a), 1949–78 (b), and 1979–98 (c). The maps were compiled on the basis of topographic maps from 1948, 1979, and 1996. The human load presented on the maps reflects the maximum values during each period. Note the changes in the shape and flat of lake seepage.

1. The period before 1948. Some farms with a rather sustainable way of life occurred around the lake. In 1948 the concentration of cattle breeding started and Ruusmäe became the centre of a collective farm.

2. The period from 1949 to 1978 was the time of intensive development of the administrative and economic centre of the collective farm near the lake. During

this period many new apartment houses were built, also a sauna on the shore of the lake, a workshop and garages, oil storage, and two cattle sheds for 104 head were constructed. The building of a big cattle shed (for 500 head) started at the end of the period.

3. The period from 1979 up to the early 1990s is characterized by intensification of cattle breeding and related activity. The end of the 1980s was the economic heyday of state farms (reorganized from collective farms). In the early 1990s, production decreased very rapidly, but the state of the lake did not improve very quickly, mainly due to the continuous inflow of nutrients from heavily contaminated soils around the lake.

For every selected period, the information obtained was integrated using the cartographic program MapInfo Professional 4.0. As the main aim of our cartographic analysis was to compare land-use and human impact during different periods, it was necessary to use only the maps containing information of the same level. Such maps were those from the years 1948 and 1978 (scale 1 : 10 000), available at the Estonian National Land Board, and square 44.98 of the base map of Estonia printed in 1996 (scale 1 : 20 000), which covers the territory of Ruusmäe. This square was supplemented with an aerophoto taken in 1993 (scale 1 : 10 000), also obtained from the Estonian National Land Board.

To enable a comparison of different maps, these were transferred into the system compatible with the program MapInfo. The base map of Estonia from 1996 has a system of coordinates marked on it (Lambert conformal conical projection basing on GRS-80 ellipsoid). As the map was provided also with the system of coordinates used earlier (kilometre-based grid of the rectangular coordinate system in Gauss–Krüger projection, introduced in the Soviet Union in 1942), all the maps used were transferred into this system.

For map analysis, the raster maps that had been scanned into the computer had to be first transferred into the vector format, so that the program would be able to treat different map layers as information bearers. Each land-use map presented here has ten layers: built-up area; forest, shrubbery; arable land; grassland; marshy grassland; water bodies; buildings; roads; ditches; pollution sources.

A sediment core was taken from the upper soft layers of the deepest part of the lake (Fig. 1c) with a modified Livingstone–Vallentyne piston corer. The lithology of the core was recorded in the field and continuous sampling with an interval of 1–2 cm performed. Samples were tried to a constant weight at 110 °C. The content of fossil pigments was measured by K. Tõugu by the method described by Bengtsson & Enell (1986). The measurements were carried out on a spectrophotometer "Cadas100", and the content of pigments was expressed as pigment units per gram of organic matter, one unit being equivalent to an absorbency of 0.1 in a 1 cm quartz cuvette.

The C and N contents were measured by L. Lahe in the Institute of Chemistry at Tallinn Technical University with a Perkin Elmer-Analyser, type PE 2400/2.

RESULTS

History of land-use and human impact on Lake Ruusmäe

The cartographic presentation of the land-use around the lake and human load on the lake for the three periods distinguished is given in Fig. 2. The map for the years before 1948 (Fig. 2a) demonstrates that the most intensive activity on the catchment was connected with agriculture. The share of arable land nearby the lake was 39%, built-up area made up 10%. In the nearest vicinity of the lake marshy grassland with a good filtering capacity for infiltrating nutrients predominated. The population around the lake numbered ca 20 persons in 1948 and if also the number of cows in the farms in the nearest vicinity (oral information of H. Parts) is taken into account the total potential load on the lake was about 90 person-equivalent (p.e.), or ca 23 p.e. per 1 hectare of seepage. According to Maastik (1984) 1 p.e. is equal to 56 g COD_5.

The second period is characterized by a sharp increase in the human load on the lake. In 1948 the village of Ruusmäe became the centre of a collective farm (in 1958 reorganized into a state farm). It was the benchmark for extensive development of the village and in 1978 already some 70 people lived in the closest vicinity of the lake. The sauna was expanded, an oil storage and some garages were built.

Near the lake (Fig. 2b, c) a cattle shed for 500 head was built from where part of the dung water might have reached Lake Ruusmäe. Though the central waste water system was constructed in 1964, the total potential load for 1978 was estimated at up to 580 p.e. per 1 ha of the lake area (Pihu, 1990). That permanent load was supplemented with some occasional disasters, as the accidents in 1960 when a lorry with white paint ran into the lake, and in 1969, when 3 tonnes of a fertilizer (ammonium nitrate) was washed into the lake from the shore by precipitation (Fig. 2b). Therefore the ecological state of the lake was very bad at the end of the period. Fish disappeared almost completely from the lake and the water smelled badly, by the reminiscences of local people.

As the state farm specialized in animal husbandry, the share of arable land decreased and that of grassland increased. Owing to land amelioration at the end of the period the share of marshy grassland decreased by about 45% near the lake. Consequently, the settled area (built-up area, roads, etc.) in the nearest vicinity of the lake increased from 10% to 22%.

In the early 1980s (third period), the intensity of land-use around the lake reached its maximum level and it was more or less stable during the next decade. Some new 12-flat houses were built, but the population around the lake stabilized at around 70 persons. The settled area increased by about 10% at the beginning of the 1990s (Fig. 2c), and the total potential load was up to 217 p.e. per 1 ha of the lake (Pihu, 1990). The surroundings of the lake were completely ameliorated and wet areas disappeared.

Because of the decreasing intensity of cattle breeding (in 1996 ca 100 head), the share of grassland became smaller and that of arable land bigger than during the previous period. In connection with land privatization and reorganization of the state farm the people started to leave the centre and now the population around the lake is smaller than in the 1980s. Today the potential load on the lake is about 140 p.e. per 1 ha of seepage.

Distribution of carbon, nitrogen, and fossil pigments in the sediment

The data on the vertical distribution of total carbon (C), total nitrogen (N), chlorophyll derivatives (CD), and total carotenoids (TC) in the L. Ruusmäe sediment core (Fig. 3) show certain regularities. A remarkable variation in the C and N content in the core can be observed. The contents of both elements increase slightly up to a depth of 40–35 cm. Then follows a distinct drop, with minimal values at a depth of 31 cm. After that a permanent increase begins, leading to ca thrice higher concentrations of both C and N on the surface compared with minimum values at a depth of 31 cm. These regularities speak about major changes in the internal biogeochemical matter cycling in the lake. The variations in the C/N ratio, reflecting to some extent the composition of organic matter in the process of sediment forming (Hassan et al., 1997), are smaller, except at depths from 28 to 21 cm where the ratio increases sharply up to 6.

The CD and TC concentrations are relatively constant from the bottom of the analysed cores up to a depth of about 30 cm. In the upper layers both fractions of pigments vary greatly and have distinctly higher values at depth intervals of about 28–24 and 15–11 cm. In the interval from 33 to 26 cm the CD/TC ratio is transitional from the highest values to stable low values.

For temporal analysis we used the obtained records and the data on the human load on the lake. As a result, we correlate preliminarily the changes in the lithology of sediments, a sharp decrease in the C and N contents, and the first remarkable increase in fossil pigments, as well as an increase in the abundance of diatoms (data of M. Sakson), indicators of eutrophic conditions in the samples from a depth of 32–31 cm, with the inflow of 3 t of a fertilizer (ammonium nitrate) into the lake in 1969. This accident may have added some 6.5 mg L^{-1} N into the lake, which might have doubled the nitrogen content in the water (by data of Pihu (1990), the N concentration in the lake was 5.0 mg L^{-1} in 1990).

Another reference level for dating the sediment core might be connected with a sharp increase in the C/N ratio at depths of 28–21 cm. According to the reminiscences of local people and aerophotos, in the late 1970s muskrats cut mat peat in the littoral NW part of the lake and peat pieces were floating on the lake, partly sinking and partly blown by winds to the SE part of the lake. The addition of non-planktonic organic matter increased markedly the C/N ratio in accumulated deposits. As is known, the protein content in macrophytes is higher than in the *in situ* formed plankton, which is reflected as a decrease in the N content and an increase in the C/N ratio (Ho & Meyers, 1994).

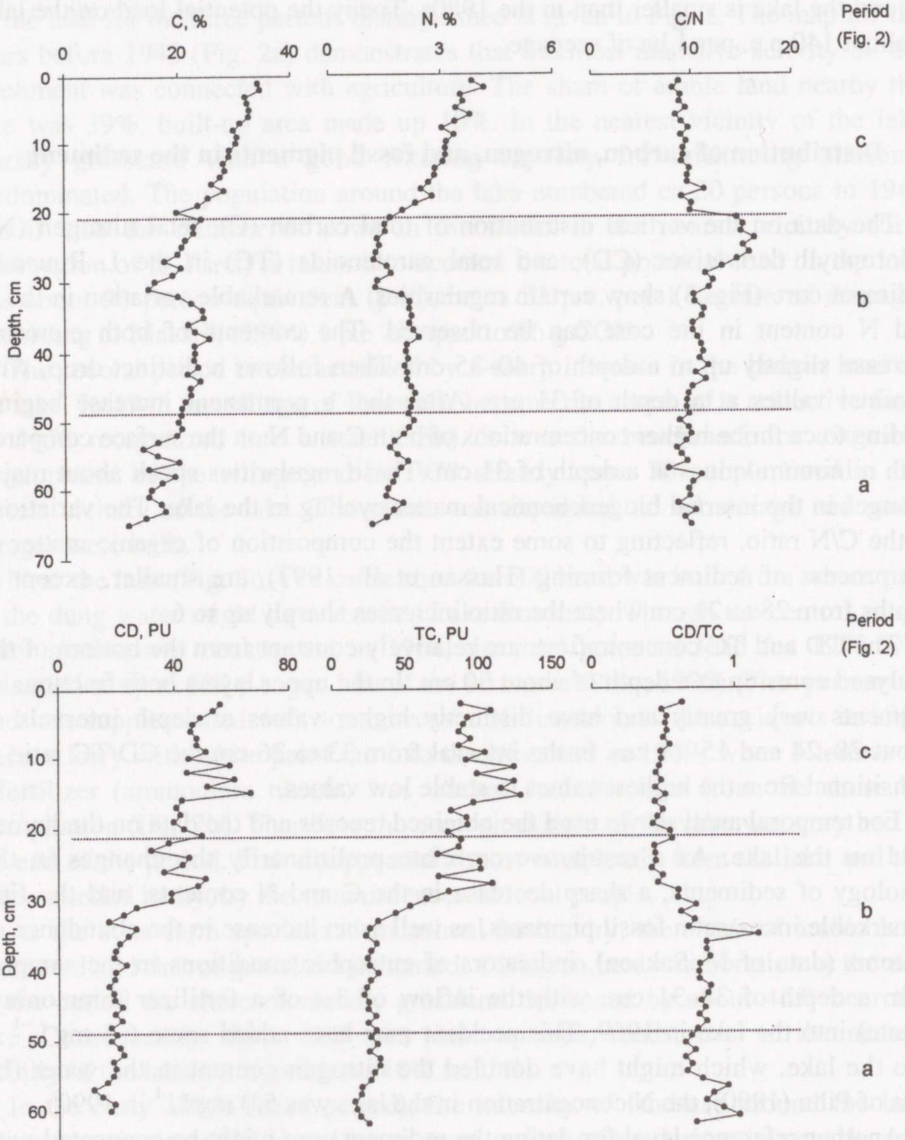

Fig. 3. Vertical (e.g. temporal) changes in C, N, and fossil pigment concentrations in the sediment core from Lake Ruusmäe and the relevant approximate time periods (see Fig. 2) in the potential anthropogenic load. CD, chlorophyll derivatives; TC, total carotenoids; PU, pigment unit.

DISCUSSION

Based on the above markers and on the obtained records, it is possible to roughly distinguish time intervals according to our periodization of the human load history (Fig. 3). Human impact on Lake Ruusmäe was rather weak till the late 1960s. The changes in the content and composition of deposited organic matter were insignificant and demonstrate rather a stable process of bioproduction and sedimentation. The CD/TC ratio (about 0.6–0.8) is typical of mesotrophic lakes. It is known that the content of fossil pigments in sediments is determined by their content in the water and by the decay factors, including chemical oxidation, photooxidation, and microbial activity. According to many scientists examining the nature of sedimentary chlorophylls and carotenoids from lakes and sediments (Gorham et al., 1974; Sanger, 1988; Leavitt, 1993), the fossil pigment records reflect the sedimentation history and simultaneously give information on the dynamics of the abundance of algae in lakes.

The sharp drop in the carbon content at a depth of 31 cm and a remarkable increase in the content of fossil pigments in the sediment core indicate significant changes in the lake ecosystem. The increase in the content of inorganic matter at this level compared to the underlying layer speaks about a sharp increase in the mineralization of organic matter. The impact caused by a short transition of that kind must have been a shock to the existing equilibrium in the biogeochemical matter cycling in the lake. Using the obtained data about the history of human load during the recent decades, we can correlate the sediments from that depth with the accumulation time of 1969, when the nitrogen fertilizer was washed into the lake. The sharp increase in the N concentration in the lake caused essential changes in the matter cycling in the lake, and the ecosystem lost its equilibrium. According to local inhabitants this event was followed by mass death of fish. Most probably the intensification of the algal production and the growth in the sedimentation rate were reasons for the rapid increase in the content of buried fossil pigments. From a depth of 30 cm upwards the CD/TC ratio began to decrease, but stabilized at a depth of 25 cm at the value of ca 0.5. This means that important changes took place in the state of the ecosystem and the lake passed into a new trophic state (hypertrophic), which is typical of it also today.

We correlate the sediment records from the depth interval of ca 48–21 cm with the second period of human impact (1949–78, Fig. 2b). The essential growth of the load during these years, caused by the intensification of cattle breeding and an increase in communal wastes, led to high values of pigments at depths from 30 to 20 cm. Great fluctuations in the pigment content might be connected with some attempts to improve the condition of the lake by means of regulating its water level. For this purpose a new dam was built on the outlet in 1980 and the water level rose about 0.6 m. Our assumption is also supported by the presence of higher peaks of Fe-bound phosphorus content in the sublayers at this depth interval (data of K. Kruusement).

The sublayers (18–20 cm) that deposited in the early 1980s show short-term stabilization of the pigment content and some increase in the CD/TC ratio. According to local people, at that time the lake smelled badly and the water level had risen about 60 cm, which increased the lake volume by about 18%. This may have been the reason for some improvement of the lake ecosystem. In any case, from that depth the concentrations of N and C in the sediments start to increase continuously.

A new, and the highest, increase in the fossil pigment content was observed in layers from the depth interval of 15–11 cm, which accumulated approximately in the middle and late 1980s. Most probably this rise is connected with the heyday of the extensive economic activity of the state farm. In the late 1980s, and especially in the early 1990s, when the state farm was completely reorganized, a quick decrease in agricultural activity took place. On the fossil pigment records this is expressed by a slow but permanent increase in the CD/TC ratios in the sediment core beginning from a depth of about 10 cm (Fig. 3).

As the above-said proves finding a one-to-one correlation between the events having an impact on the ecosystem and the content and composition of fossil pigments in the layers which accumulated at that time is rather complicated. There are several reasons for such uncertainties. In the first place, the historical monitoring data, and especially the integrated cartographic outputs of these data given in Fig. 2, express the potential load, e.g. practically the amount and character of the impurities that have been produced in the nearest vicinity of the lake and emitted to the environment. Naturally, there are different ways for the transformation and even neutralization of every kind of these impurities, depending on the soil peculiarities and on the inflow direction (Mander et al., 1997). Also, the retention time in the lake and the impact on the ecosystem depend on the type of the external load. It is known (Wetzel, 1983) that recycling of nutrients from internal sources in the sediments can sustain high rates of production for many years after the influent loading has been reduced. This makes finding exact temporal correlation between the impact of single events and changes in the composition and structure of sediments deposited at that time especially complicated.

As we see in Fig. 3, the deposits fall into two distinct parts as to the content of fossil pigments: lower than 30 cm (prior to 1970) and the upper 30 cm thick part. In the upper part we can distinguish the periods corresponding to 28–24 cm, 20–16 cm, 15–11 cm, and 10–0 cm. Each of these periods is characterized by certain trends in the carbon, nitrogen, and fossil pigment content in sediments, which in turn most probably reflect the changes in the carbon cycling in the lake.

The most important events for Lake Ruusmäe are those having an immediate and rapid impact on its ecosystem, like the fertilizer spill in 1969. This event caused directly essential changes in the whole biogeochemical matter cycling, as a result of which the lake became hypertrophic. Because of an excess of nutrients, planktonic productivity increases markedly, so that it causes the depression of the light-demanding trophogenic zone, and thus the growth rate of the planktonic population reaches some constant value limited by the penetrated solar irradiance. So, the Secchi transparency in L. Ruusmäe was only 30 cm in the 1980s (Pihu, 1990). This means that the content of fossil pigments in the sediments might have reached a certain level. This event is rather difficult to interpret in the context of the dynamics of the external loading.

CONCLUSIONS

Cartographic expression of the dynamics of human load on lakes gives good possibilities of integrating the data on potential external impact on the catchment. Also, this approach allows us to estimate the reliability of different information sources.

The objective information on the potential impact, systematized in this way, and its temporal comparison with carbon, nitrogen, and fossil pigment records from sediment cores shows that drastic external events that have led to major changes in the matter cycling in the lake are well recorded. It is more complicated to calibrate changes in the potential external load within a certain trophicity level. Here the temporal differences between the events on the catchment and direct impact of the external load on the lake, as well as the transformation of the chemical compounds on their way to the lake have to be taken into account. Also, the internal regulation mechanisms of the matter circulation can compensate to some extent for the variations in the external load within a certain level of the trophicity.

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REFERENCES

Bengtsson, L. & Enell, M. 1986. Chemical analysis. In *Handbook of Holocene Palaeoecology and Palaeohydrology* (Berglund, B. E., ed.), pp. 423–451. John Wiley & Sons, Chichester.

Chambers, F. M. (ed.). 1993. *Climate Change and Human Impact on the Landscape*. Chapman & Hall, New York.

Charles, D. F. & Smol, J. P. 1994. Long-term chemical changes in lakes: Quantitative inferences using biotic remains in the sediment record. In *Environmental Chemistry of Lakes and Reservoirs. Advances in Chemistry* (Baker, L., ed.). Series 237, Washington D.C., 1–31.

Gorham, E., Lund, J. W., Sanger, J. E. & Dean, W. E. Jr. 1974. Some relationships between algal standing crop, water chemistry, and sediment chemistry in the English lakes. *Limnol. Oceanogr.*, **19**, 601–617.

Hassan, K. M., Swinehart, J. B. & Spalding, R. F. 1997. Evidence for Holocene environmental change from C/N ratio, and $\delta^{13}C$ and $\delta^{15}N$ values in Swan Lake sediments, western Sand Hills, Nebraska. *J. Paleolimnol.*, **18,** 121–130.

Ho, E. S. & Meyers, P. A. 1994. Variability of early diagenesis in lake sediments: Evidence from the sedimentary geolipid record in an isolated tarn. *Chem. Geol.*, **112**, 309–324.

Leavitt, P. R. 1993. A review of factors that regulate carotenoid and chlorophyll deposition and fossil pigment abundance. *J. Paleolimnol.*, **9**, 109–127.

Maastik, A. 1984. *Veekaitse põllumajanduses*. Valgus, Tallinn.

Mander, Ü., Kuusemets, V., Lõhmus, K. & Mauring, T. 1997. Efficiency and dimensioning of riparian buffer zones in agricultural catchments. *Ecol. Eng.*, **8**, 299–324.

Milius, A. & Starast, H. 1997. A three-parameter trophic state index for small lakes. *Proc. Estonian Acad. Sci. Biol. Ecol.*, **46**, 27–39.

Pihu, E. (ed.). 1990. *40 järve seisundi hinnang, meetmed ja soovitused nende kasutamiseks II. Põlvamaa ja Võrumaa järved*. Eesti TA ZBI, Tartu.

Sanger, J. E. 1988. Fossil pigments in paleoecology and paleolimnology. *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, **62**, 343–359.

Smol, J. P., Cumming, B. F., Douglas, M. & Pienitz, R. 1997. Inferring past climatic changes using paleolimnological techniques. *Geosci. Can.*, **21**, 3, 113–118.

Wetzel, R. G. 1983. *Limnology*. Saunders College Publishing, Fort Worth.

INIMMÕJU RUUSMÄE JÄRVELE VIIMASTEL AASTAKÜMNETEL JA SELLE PEEGELDUS PÕHJASETETE ORGAANILISES AINES

Jaan-Mati PUNNING, Jaanus TERASMAA ja Kaire TÕUGU

Artikkel on suunatud Ruusmäe järve valgalal ekstensiivse põllumajandustegevuse tagajärjel viimastel aastakümnetel ilmnenud ja järve ökosüsteemi potentsiaalselt mõjutavate toimefaktorite analüüsile. Kasutades programmi MapInfo tehti üksikute toimefaktorite ajaline analüüs ja koostati kaardid, mis kajastavad summaarseid koormusi kolmes ajarühmas: enne 1948. aastat, aastail 1949–1978 ja 1979–1998.

Järve sügavaimast kohast võetud põhjasetete puursüdamikust tehti kihtkihiline fossiilsete pigmentide sisalduse analüüs, mille andmete ajaline korrelatsioon valgalal asetleidnud sündmustega näitas, et oluliseks järve arengule oli 1960. aastate lõpp, kui toiteainete hulga järsk suurenemine viis järve hüpereutroofsesse seisundisse. Järgnevad koormuse suurenemised (suure loomafarmi ehitus, kommunaalheidiste rohkenemine) ei kajastu adekvaatselt fossiilsete pigmentide profiilis. See näitab kompensatsioonimehhanismi olulist osa järvesisese aineringe regulatsioonis.