EKOLOGIJA. 2004. Nr. 2. P. 58–63

The impact of climate change on thermal regime of Lithuanian lakes

Birutė Pernaravičiūtė

Institute of Ecology
of Vilnius University
Akademijos 2,
LT-08412 Vilnius, Lithuania

The article analyses the long-term impact of climate change on the bottom and surface temperatures of water layers in some thermally well-studied Lithuanian lakes under natural and thermogradient conditions during 1976–2000.

Key words: water temperature, climate change

INTRODUCTION

Studying the development of inland waters, including lakes, the impact of climate change on water reservoirs has recently been in the focus of interest.

The levels of carbon dioxide (CO_2) are increasing in the atmosphere, and the air temperature of the Earth (t_a) rises. Possible global thermal changes in the Earth's atmosphere due to the increasing concentrations of CO_2 are estimated to make on average $2 \leq \Delta t_a \leq 3$ °C (Δt_a is the variable of t_a) (Антропогенное..., 1984).

As a result of meteorological observations in Central England for over 300 years, it was established that t_a had been increasing for three hundred years, and the rates of the increase became higher early in the 20th century.

European scientists have arrived at a unanimous conclusion that in Northern Europe these are mostly winters that are becoming warmer. In spring, summer, and autumn, on the other hand, t_a demonstrates a positive trend in the western part of Northern Europe, whereas in its eastern part it is of a zero or even negative value. Such trends of t_a change testify to the fact that in general the continental character of the climate in Northern Europe declines (Kilkus, Valiuškevičius, 2001).

The temperature of lake water mass is one of the major factors modifying the biological, hydrochemical, sedimentational and hydrophysical processes occurring in a lake. Heat turnover and the atmosphere for the most part determine the thermal regime of water bodies. It is heat that mostly predetermines the species composition and physiological processes as well as the productivity of phytoplankton and the higher water flora. The vertical distribution of water temperature determines water mass stability, gas regime, hydrochemical gradients, etc. (Allonson, 1990). Thus, the thermal regime of water bodies is one of the major ecological factors that exert a considerable influence on the functioning of their ecosystems.

Observations of the thermal regime and t_a of Estonian lakes during 1946–2000 showed that in the past decades the limnological spring became 2 weeks longer. Springs, too, became earlier. In Estonian lakes, the summer thermal stagnation period became a week earlier, and autumn begins slightly later. Limnological winter has become shorter by 17 days and the period with ice cover is a month shorter (Järvet, 2001).

According to hydrological forecast for some large lakes of high latitudes of Russia, where t_a has increased by 2 °C, in Lake Baikal water temperature will increase by 15 °C in summer and 5 °C in winter, in Lakes Onega and Ladoga by 0.5 and 6.2 °C, and in Lake Taimyr by 8.5 and 12 °C, respectively. The number of warm days with a positive t_a will increase from 20 days in the Lake Baikal region to 60 days in the region of Lake Taimyr, thus increasing evaporation from water surface, shortening the winter period with ice cover, reducing ice thickness, and other parameters (Lemeshko, Borzenkova, 2001).

Investigation of climatic fluctuations is very complicated. The reasons for global climate change intermingle with regional ones: they often smother or, *vice versa*, enhance each other.

During the recent two hundred years the climatic system became even more complicated due to the increased anthropogenic impact.

Climatic fluctuations in Lithuania are an inseparable part of global climate change.

It was established that the annual t_a in Lithuania during 1970–1990 increased by 0.5–0.9 °C and an increased t_a was recorded in all seasons of the year (the highest in winter and the lowest in summer). Since the end of the 19th century short-term waves of climate warming approximately 20 years long have been singled out (Korkutis, 1995).

By comparing the mean duration of the seasons of the two twenty-year periods, I. Markevičienė ascertained that during 1971–1990 summer and especially winter became shorter at all the investigated meteorological stations (6–11 and 12–29 days, respectively), whereas the duration of autumn and especially of spring increased (up to 11 and 12–28 days, respectively). This means that the contrast of the seasons of the year is declining, the duration of intermediate seasons is becoming longer, *i.e.* the marine character of the climate is becoming more pronounced (Klimato…, 1998).

Based on the results of the calculation of five climate change models designed in different countries of the world, t_a in Lithuania has to rise in the 21st century. The climate there is believed to change most probably in the second part of the century. An especially pronounced rise is expected for t_a of the cold period (December–March) and for the warm period somewhat less (Kilkus, Valiuškevičius, 2001).

In Lithuania, the impact of climatic fluctuations on the hydrological and hydrophysical parameters of natural regime lakes was studied in more detail by K. Kilkus and G. Valiuškevičius (Kilkus, Valiuškevičius, 2001). They established that water surface temperature of the last ten days of July responds to long-term climatic fluctuations most evidently.

The warming climate will change not only the physical parameters of natural aquatic ecosystems, but also species composition and community structure therein. The biodiversity of the ecosystems, including endemic species, will decline.

This work aims at evaluation of the impact of climate change during 1976–2000 on the fluctuations in bottom and surface water temperatures in some thermally well-studied lakes of Lithuania under natural and thermogradient conditions.

MATERIALS AND METHODS

For the research, the longest data sequences of uninterrupted observations conducted by hydrological stations, operating or recently closed (Hidrologijos…, 2001), and data from expeditions were selected.

On selecting lakes of a natural or thermogradient regime, it was taken into account how well they had been studied thermally.

In the work, data on the vertical temperature in the lakes (surface – 0.5 m and near-bottom – 30 m) taken with an accuracy of 0.1° by electric and deep water thermometers are presented. During expeditions water temperature was taken at a different time of the day, whereas at hydrological stations it was taken at 8.00 AM and 8.00 PM. The mean monthly water temperature estimation was based on the mean temperature values of three ten-day periods.

The selected lakes represent different physical-geographical and climatic regions. The small area and comparatively low relative landscape altitudes of the country determine the uniformity of climatic conditions. Thus, it could be suggested almost unmistakably that the dynamics of heat accumulation is similar in all the lakes (Хомскис, 1969) (Table 1).

Table 1. **Physical dimensions and thermal data on the lakes: f – surface area (km^2), $d_{\max}$ – maximum, d_{av} – average, d_r – relative depth (m), t_{s1} – mean temperature (°C) in the surface water layer in May–October 1964–1971, t_{s2} – in 1981–1990, t_{s3} – in 1991–2000**

Lake	f	$d_{\max}$	d_{av}	d_r	t_{s1}	t_{s2}	t_{s3}
Drūkšiai	49	33.3	7.5	2.0	14.9	17.7	–
Dusia	23.3	32.4	14.7	5.1	15.1	15.1	15.5
Lūkstas	10.2	7.0	3.6	1.0	15.0	15.0	15.5
Plateliai	12.0	46.0	10.4	4.5	14.6	14.7	15.2
Tauragnas	5.1	60.5	18.7	10.9	14.9	15.1	15.5
Totoriškių	0.8	20.0	10.1	11.1	15.6	16.0	16.7
Žeimenys	4.5	23.5	6.9	4.2	16.3	16.3	16.6
Žuvintas	10.3	3.4	1.2	0.6	15.9	16.0	16.1

On preparing the work, an analysis of climatic fluctuations and climate change made by Lithuanian scientists-meteorologists was used (Bukantis et al., 2001).

Fluctuations in air temperature in different parts of Lithuania were established to be quite synchronous. Based on the spatial correlation of mean monthly t_a values, the correlation coefficients (r) exceeded 0.9. The fluctuation r of the June t_a changes within a range of 0.92–0.99. In summer, this change is more dependent on the uneven distribution of solar radiation and landscape. A close correlation was also found among annual t_a fluctuations at Lithuanian meteorological stations: r changes within a range of 0.95–0.99. The value of the coefficient mostly depends on the distance between the stations. Therefore, a comparison of t_a change at different meteorological stations in different months (in 1925–1995) did not reveal any significant regional differences (Kilkus, Valiuškevičius, 2001).

For the evaluation of the thermal regime of Lake Drūkšiai prior to the exploitation of the Ignalina

Nuclear Power Plant (INPP) (1976–1983) archive data were used, and the thermal regime during its exploitation (1984–1997) was assessed using data on the temperature taken by the author in different parts of the lake and at a different time of the year. For calculating the mean long-term water temperature values in Lake Drūkšiai, material from different institutions of Lithuania was used, too.

RESULTS AND DISCUSSION

It is known that heat resources in water mass are determined by climatic factors: solar radiation intensiveness, cloudiness, air temperature, wind velocity, etc. The amount of heat resources is dependent on the hydrodynamic state of a lake as well, and the latter is for the most part conditioned by the area and depth of a lake, or by its relative depth, which relates the former two (Kilkus, 1989).

In Lithuanian lakes, the largest amount of heat resources is formed in June–August. If the meteorological conditions are identical, the relative amount of heat resources is modified by lake morphometry, especially area and depth. The former determines heat resources and the latter their realisation, *i.e.* distribution of heat accumulated in the surface water layer and its transfer to the deeper water layers.

The relative depth of a lake plays an important role in the changeability of heat resources. In shallow lakes relative depth is less, and heat exchange is determined by the thermal state of the epilimnion (surface water level), which directly depends on air temperature fluctuations. In relatively deep lakes, however, heat resources are determined by the thermal state of the hypolimnion (bottom water layer), which depends on a synoptic situation at the beginning of temperature rise. In 1972–1989, trends of maximal heat resources change in lakes increased in relatively deep lakes and declined in shallow ones.

Lake surface water temperature (t_s) is known to be a limnological index reflecting changes in air temperature (t_a) best of all. The monthly t_s of Lithuanian lakes markedly changes during a long-term period, therefore it is difficult to single out t_s fluctuation cycles. This depends not only on natural conditions, but also on an insufficient sequence of t_s observation data.

It is known that in natural regime lakes t_s values first of all depend on a season of the year, *i.e.* on t_a and other meteorological factors. It was established that the relationship between t_s and t_a of a year differs, but a long-term one is statistically reliable (Kilkus et al., 1997).

One can see from Table 1 how the mean t_s values of the lakes changed during the warm season of the year in a long-term period. In this respect, the most outstanding is the 1991–2000 decade, during which the t_s values fluctuated from 0.1 (Lake Žuvintas) to 0.7 °C (Lake Totoriškės).

The mean t_s values of 1981–1990 where similar to those of 1964–1971.

This kind of the thermal state of lakes shows that during the recent decade t_a has been rising not only during the cold but also during the warm period of the year.

Since 1987, positive mean annual t_a values have been observed in Lithuania. Investigation of the long-term t_s dynamics of seven natural thermal regime lakes, thermally studied best of all, of different character and located at different places of Lithuania, during the ice-free period in 1981–2000 revealed that in all of them t_s started to increase rapidly just in 1987–1988, though K. Kilkus, G. Valiuškevičius (Kilkus, Valiuškevičius, 2001) suggest that the rise of t_s in all Lithuanian lakes began approximately in 1981–1985 and has been ongoing ever since.

The division of the long-term (1981–2000) research on the change in the temperatures of natural thermal regime lakes of Lithuania into two decades, 1981–1990 and 1991–2000, helped to reveal that during ice-free periods the most marked mean t_s differences were recorded in April: in all the lakes the

Table 2. **Mean temperature (°C) values of surface water of natural thermal regime lakes of Lithuania during 1981–1990 (A) and 1991–2000 (B)**

Lake		Month							
		IV	V	VI	VII	VIII	IX	X	XI
Dusia	A	5.1	11.8	16.7	18.8	19.1	14.5	9.8	4.0
	B	**5.4**	**11.4**	**17.2**	**20.1**	**19.9**	**15.0**	**9.6**	**4.4**
Lūkstas	A	5.3	14.6	18.2	20.0	18.8	13.7	10.5	2.7
	B	**5.7**	**13.7**	**18.4**	**20.3**	**19.5**	**13.6**	**7.3**	**2.7**
Plateliai	A	4.1	11.1	16.2	18.6	18.2	14.4	9.9	4.8
	B	**4.9**	**11.0**	**16.6**	**19.2**	**19.0**	**15.1**	**10.0**	**5.0**
Tauragnas	A	2.9	11.3	16.9	19.6	18.8	14.2	9.6	5.5
	B	**4.4**	**11.0**	**17.5**	**19.8**	**19.7**	**15.3**	**9.8**	**5.6**
Totoriškių	A	5.2	13.6	18.3	20.0	19.6	14.7	9.7	4.6
	B	**6.7**	**13.7**	**19.2**	**21.1**	**20.7**	**15.6**	**10.1**	**5.2**
Žeimenys	A	5.7	14.1	18.8	20.6	19.8	14.8	9.7	4.3
	B	**6.6**	**13.7**	**19.2**	**21.0**	**20.4**	**15.5**	**9.7**	**4.2**
Žuvintas	A	7.3	15.5	18.4	20.1	19.2	13.7	9.3	3.2
	B	**7.7**	**14.2**	**18.1**	**20.5**	**20.1**	**15.0**	**8.9**	**5.1**

t_s gradient of 1991–2000 was on average by 0.8 °C higher compared to that of 1981–1990 (Table 2).

During the last decade, the spring t_a was rising and spring was coming earlier. In 1961–1990, springs were on average by 0.5 °C warmer (March even by 1.4 °C) compared to 1931–1960 (Klimato…, 1998).

The analysis of long-term change in t_s of the lakes in July demonstrated that during 1991–2000 the t_s gradient was by 0.6 °C higher than during 1981–1990.

K. Kilkus, G. Valiuškevičius (Kilkus, Valiuškevičius, 2001) suggest that in 1981–1985 during the third ten-day period of July in some Lithuanian lakes the surface water variable t_s was 0.5 °C (Lake Tauragnas) and 3 °C (Lake Totoriškės). The temperature change gradients were also high considering that the annual mean values analysed were as high as 0.3 °C.

In 1991–2000, higher t_s gradients of the lakes were observed in August and September, too. They were respectively by 0.8 and 0.7 °C higher compared to 1981–1990 (Table 2). It is a reflection of the warming climate in the second part of summer, recorded throughout Lithuania during the recent decade.

This climatic situation influenced the temperature values (t_b) of bottom water layers in Lithuanian lakes.

In this respect, it is interesting to analyse vertical changes in the mean long-term water temperature of the Lithuania's deepest Lake Tauragnas in summer (Table 3).

One can see from Table 3 that with depth the water temperature gradients diminish, to make $\Delta t = 0$ in the deepest part (60 m) of Lake Tauragnas.

In 1991–2000, the mean values of annual water temperatures in the vertical gradient of Lake Tauragnas were higher than in 1981–1990 only in surface water layers, whereas in its deep parts the climatic impact was minimal.

It was established that the correlation of temperatures of the vertical water levels declines with depth not only in the natural, but also in the thermogradient water bodies of Lithuania and are quite significant: $rt_{max} = 0.997$ (t_s), $rt_{min} = 0.881$ (t_b) (rt – the correlation coefficient of water temperature, t_s – mean temperature in the surface water layer, t_b – mean temperature in the bottom water layer) (Pernaravičiūtė, 1997).

Table 3. **Vertical distribution of mean annual water temperatures (t, °C) of Lake Tauragnas in 1981–2000**

Depth, m	1981–1990	1991–2000	Δt
$t_{0.5}$	12.0	13.0	1.0
t_{10}	7.8	8.7	0.9
t_{20}	6.0	6.5	0.5
t_{30}	5.7	5.9	0.2
t_{60}	5.2	5.2	0.0

It is known that under natural conditions heat resources in a lake water mass are determined by various natural heat flows. In lakes of an altered thermal regime (coolers of power plants), however, thermogradient conditions are formed as a result of an additional emission of heat produced while cooling reactors of power plants. They influence the hydrothermal regime and result in hydrochemical changes and alterations in the trophic regime.

The peculiarities of thermal regime of Lithuanian lakes under natural conditions have been raher thoroughly investigated. Under thermogradient conditions they, however, acquire specific features characteristic just of that type water bodies.

Since 1984 when the first power block of the INPP was launched, Lake Drūkšiai has become a cooler. The thermal loading of Lake Drūkšiai with one 1500 MW reactor in operation is 0.06 kW/m^2 and with both of them 0.11 kW/m^2. In 1986, the second reactor of the INPP was launched. The two reactors operating at 2500 MW, 17.4.10^{15} J of heat is discharged to the lake per month, increasing the water temperature by 3–4 °C and evaporation by 64.8 mill. m^3 per year. After the launch of the INPP, the mean temperature of the whole water mass rose by 2–3 °C (Janukėnienė, 1994).

It was established that in 1984–1997 in Lake Drūkšiai the spring homothermy was formed two decades earlier and the autumn one a decade later. The period of summer thermal stagnation became on average two weeks longer. It was also established that in 1985–1989 the t_s of Lake Drūkšiai compared to that of natural lakes rose on average by 2–3 °C and t_b (at a depth of 30 m) by 2.2 °C. This was due to the warm water discharged by the plant and to an increased air temperature (Pernaravičiūtė, 1999).

Since one of the major ecological problems of the last century is related to anthropogenic impact on aquatic systems on the background of climatic fluctuations, on investigating the impact of thermal pollution by power coolers on the environment a question arose what part of additional heat is received by coolers from plants and what from the atmosphere, the temperature of which has been gradually rising over the past decades.

Accordingly, when changes in the thermal regime of Lake Drūkšiai due to the operation of the INPP had been studied in detail, a question arose what impact on lake water temperature is made by climatic fluctuations. In summer, when t_a is high, the highest t_s values occur not only in Lake Drūkšiai, but in natural lakes, too. However, it is difficult to make a comparative thermal analysis of long-term natural lakes and Lake Drūkšiai (the cooler of the INPP) because of the changing regime of the INPP operation.

The analysis of the dynamics of long-term t_b in July in 1981–1982 in Lakes Drūkšiai, Dusia, Plateliai, and Tauragnas revealed that t_b increased in all of them.

One can see from Figure that t_b in all the lakes studied is almost synchronous. The t_b values of Lake Dusia markedly stand out from those of the other lakes due to particularly good conditions of water mass mixing, the formation of which is promoted by the lake shape favourable to wind activities and by its large area. Prior to the launch of the INPP, the highest t_b values in Lake Drūkšiai were observed in the summer of 1982 (from 8.8 °C in June to 10.1 °C in August).

In Lakes Dusia, Plateliai and Tauragnas the following situation was observed: during the warm period of the year t_b of Lake Dusia fluctuated from 9.7 to 11.5 °C, in Lake Plateliai t_b was stable – 7.3 °C, in the deepest Lake Tauragnas t_b varied from 5.6 °C in June to 7.6 °C in August. That apparently was due to the particularly windy summer of 1982.

Interesting in this respect is an increasing t_b in bottom water layers (at a depth of 30 m) in Lake Drūkšiai. A long-term analysis showed that the t_b of Lake Drūkšiai gradually rises. However, there is still no unanimous opinion weather the rise of t_b is related just to the INPP operation or is being influenced by the climatic factor, too.

From 1987 in the dry season of the year and when the mean annual t_a values were positive, t_b was rising in all the lakes studied. This was especially obvious in 1991 and not only in Lake Drūkšiai, but also in Plateliai and even Tauragnas, where in August at a depth of 30 m t_b was as high as 10 °C. Meteorological data (Hidrologijos…, 1990–2000) show that the spring of 1991 started early, and already in the middle of March the mean t_a was positive. Although at the end of April as well as throughout May and June the weather was windy and rainy, in July and August it was quite warm (the mean 24-h t_a ~20.7–22.6 °C), westerly and south-westerly winds prevailed, resulting in lake water mass mixing and thus in high temperatures of the near-bottom water layer.

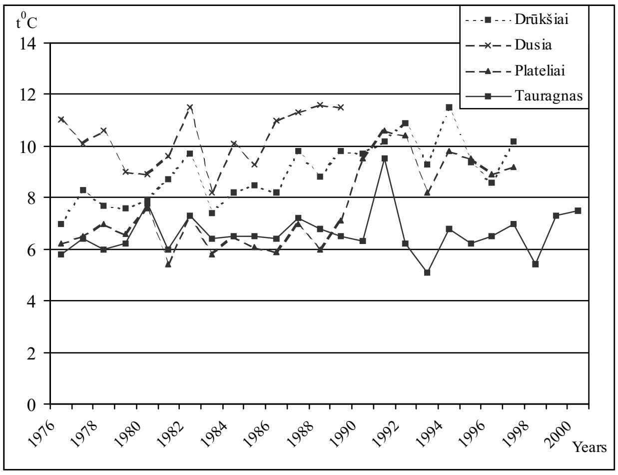

Figure. Distribution of the mean temperature of the near-bottom water layer at a depth of 30 m in Lithuanian lakes in July 1976–2000

It should be noted that when in July 1993 the t_b values of the natural thermal regime lakes dropped, t_b in bottom layers of Lake Drūkšiai decreased as well.

A comparison of the long-term mean t_b values of Lake Drūkšiai in the summer months (June–August) prior to the launch of the INPP (1976–1983) and with the INPP in operation (1984–1997) revealed that t_b increased by 1.2 °C. However, that was also true of natural thermal regime lakes: in 1984–1997, compared to 1976–1983, in Lake Plateliai the mean t_b values in summer months increased by 1.6 °C and in Lake Tauragnas by 0.7 °C.

CONCLUSIONS

A research on the climatic impact on the long-term (1976–2000) thermal regime of some lakes of Lithuania revealed that the mean annual temperature values of both surface (t_s) and bottom (t_b) water layers in the lakes of natural thermal regime during the ice-free period were higher in 1991–2000. In all the investigated lakes of Lithuania t_s began to increase rapidly in 1987–1988.

A comparison of the periods 1981–1989 and 1991–2000 showed that the highest t_s gradients (0.8 °C) of the study lakes were recorded in April and August 1991–2000.

When a long-term change in t_b observed in July in deep lakes (at a depth of 30 m) of Lithuania had been studied, it was established that in all the lakes studied the t_b fluctuations were of a cyclic and synchronous character due to a variety of meteorological conditions. A comparison of the mean t_b of the summer months in 1976–1983 and 1984–1997 showed that in the summer time of 1984–1997 the t_b value increased not only in the thermogradient Lake Drūkšiai, but also in the natural thermal regime lakes. Accordingly, the t_b of Lake Drūkšiai (the cooler of INPP) increases not only due to the amount of warm water released by the INPP, but also as a result of climatic impact. Therefore, while estimating changes in the thermal regime of water bodies, the evolution of their ecosystems on the background of climate change should be accounted for.

Received
14 February 2003

References

1. Allanson A. K. Physical processes and their biological impact. *Verh. Internat. Verein. Limnol.* 1990. No. 24. P. 112–116.
2. Bukantis A., Rimkus E., Stankūnavičius G. Lietuvos klimato svyravimai ir kaita. *Klimato svyravimų poveikis fiziniams geografiniams procesams Lietuvoje*. Vilnius, 2001. P. 27–99.
3. *Hidrologijos metraštis. Ežerai ir tvenkiniai*. Vilnius, 1990–2000.
4. Janukėnienė R. Drūkšių ežero-aušintuvo kai kurie hidroterminiai aspektai. *Energetika*. 1994. Nr. 1. P. 95–98.
5. Järvet A. Climatological calendar of lakes in Estonia and its long-term changes. *Proc. 9th Inter. Confer. on the Conservation and Management of Lakes*. Japan, 2001. Vol. V. P. 51–54.
6. Kilkus K., Bukantis A., Rimkus E., Valiuškevičius G. Ežerų terminio bei ledo režimo prognozė pagal oro temperatūrą. *Geografijos metraštis*. 1997. Nr. 30. P. 117–126.
7. Kilkus K. *Lietuvos ežerų hidrologija*. Vilnius, 1989. P. 55–80.
8. Kilkus K., Valiuškevičius G. Klimato svyravimų atspindžiai ežerų ir upių hidrologiniuose bei hidrofiziniuose rodikliuose. *Klimato svyravimų poveikis fiziniams geografiniams procesams Lietuvoje*. Vilnius, 2001. P. 194–230.
9. *Klimato elementų kintamumas Lietuvos teritorijoje*. Vilnius, 1998. P. 5–18.
10. *Klimato svyravimų poveikis fiziniams geografiniams procesams Lietuvoje*. Vilnius, 2001.
11. Korkutis P. Oro temperatūros svyravimai. *Klimatologija. Geografijos instituto darbai*. Vilnius, 1995. Nr. 7. P. 14–30.
12. Lemeshko N., Borzenkova I. Hydrological regime of the Large Russian Freshwater Lakes by 2 °C global warming. *Proc. 9th Inter. Confer. on the Conservation and Management of Lakes*. Japan, 2001. Vol. V. P. 13–16.
13. Pernaravičiūtė B. Drūkšių ežero – Ignalinos AE aušintuvo ir kai kurių vandens telkinių terminio režimo palyginamoji charakteristika. *Ekologija*. 1997. Nr. 3. P. 28–37.
14. Pernaravičiūtė B. *Drūkšių ežero vandens temperatūros ir optinių rodiklių pokyčių įtaka stenoterminių šaltamėgių žuvų populiacijų funkcionavimui* (daktaro disertacijos santrauka). Vilnius, 1999. 47 p.
15. Антропогенное изменение климата. *Метеорология и гидрология*. 1984. № 6. С. 117–122.
16. *Государственный водный кадастр. Реки, озера и водохранилища*. Минск, 1981–1989.
17. Хомскис В. *Динамика и термика малых озер*. Вильнюс, 1969. С. 13.

Birutė Pernaravičiūtė

KLIMATO KAITOS ĮTAKA LIETUVOS EŽERŲ TERMINIAM REŽIMUI

Santrauka

Ištyrus klimato kaitos įtaką Lietuvos kai kurių ežerų daugiamečiam (1976–2000 m.) terminiam režimui, nustatyta, kad 1991–2000 m. tirti be ledo, natūralaus terminio režimo ežerai pasižymėjo didesne vidutine metine ne tik paviršinio (t_s), bet ir giluminio (t_b) vandens sluoksnio temperatūra. Visuose tirtuose Lietuvos ežeruose t_s ženkliai pradėjo kilti 1987–1988 m.

Palyginus 1981–1989 m. su 1991–2000 m., didžiausi tirtų ežerų t_s gradientai (0,8°C) buvo stebėti 1991–2000 m. balandžio ir rugpjūčio mėn.

Ištyrus gilesnių Lietuvos ežerų daugiametės t_b (30 m gylyje) kaitą liepos mėnesį, nustatyta, kad visuose tirtuose ežeruose dėl meteorologinių sąlygų įvairovės t_b kaita buvo cikliška ir sinchroniška. Palyginus tirtų ežerų vidutinę t_b kaitą 1976–1983 ir 1984–1997 m. vasarą, nustatyta, kad 1984–1997 m. vasarą t_b kilo ne tik termogradientiniame Drūkšių ežere, bet ir natūralaus terminio režimo ežeruose. Vadinasi, Drūkšių ežero – Ignalinos AE aušintuvo t_b kyla ne tik dėl AE išleidžiamo šilto vandens kiekio, bet ir dėl klimato kaitos poveikio, todėl vertinant terminio režimo pokyčius termogradientiniuose vandens telkiniuose reikėtų atsižvelgti ir į jų ekosistemų evoliuciją klimato kaitos fone.

Raktažodžiai: vandens temperatūra, klimato kaita