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TRANSFORMATIONS OF RECREATIONAL BIOCLIMATE IN THE CARPATHIAN FORELAND AT THE END OF THE 20TH CENTURY FOR GAIK-BRZEZOWA AS AN EXAMPLE

Abstract: The paper presents the structures of biotopoclimates in the Raba river valley due to integrated impact of natural factors controlling climate, and the anthropopression. Changes of chosen temperature characteristics of the recreational bioclimate are discussed, for the period 1971-1996, for two sites: the horn-oakbeam forest *Tilio-Carpinetum* and a slope in the Raba river valley (covered with grass). The authors propose the suggestions concerning the environment's management following the needs of tourism and recreation, together with forest management, in the discussed part of the Carpathian Foreland.

Key words: recreational bioclimate, anthropopression, water reservoir, oak-hornbeam forest *Tilio-Carpinetum*, Carpathian Foothills, transformation of the topoclimate structure

Introduction

At the end of 1970s, P. Toyne (after Krzymowska-Kostrowicka 1997) proposed the concept of the so-called recreational sphere, consisting of the soil layer up to 20 cm depth, and the air layer up to 200 cm height above the ground. In that sphere the recreational bioclimate is formed, as the result of interaction among physical, chemical, biological and antropogenic factors. Sets of those factors form stimuli for living organisms and influence them directly and indirectly in various weather situations. They can also control different models of human behaviour, including touristic and recreational ones (Krzymowska-Kostrowicka 1997).

Transformation of recreational bioclimate's features results from the temporal and spatial differentiation of its components, together with the relations among them. According to the concept of Toyne, it is expressed by amplifying or reduction of the so-called modifiers' role, which are of geomorphologic, hydrological and biological nature. All together they control the recreational bioclimate's character in a given place and moment, and may be identified with the set of basic environmental factors. It seems

that the recreational bioclimate should be considered the common outcome of those factors' influence and human activity.

Combinations of environmental factors (i.e. modifiers of recreational bioclimate) may be analysed in different spatial and temporal scales, depending on the character of the phenomena. It refers to altitude and bioclimatic influence of relief, together with the location of a meso-scale bioclimatic unit in a mountain ridge (different slope aspects and occurrence of concave and convex land forms). Great spatial variability of bioclimate is controlled mainly by plant communities.

Differentiation of recreational bioclimate is then the consequence of relations occurring at various levels among the components of natural environment, and the type of heat balance and water cycle. In a local scale, there are usually many significant interactions within spatial units, between various forest communities and other forms of land use. Forest influences heat balance, anemological conditions, air and soil temperature and humidity, and aerosanitary conditions. Therefore, it effects largely the realisation of recreational function.

Studying the features of recreational bioclimate at different levels of environmental modifiers' influence aims to evaluation of the meteorological conditions' effect on physical and psychical state of human body, on thermoregulation, and on applying different therapy programmes planned to maintain favourable reactions of the body, its good condition and activity.

Krzymowska-Kostrowicka (1997) states that human body is influenced by the whole landscape and by particular geoecosystems. It is important for the development of a certain type of natural environment, and for taking advantage of different forms of therapy usually associated with that type of environment. Large diversity of effects on the psychological human conditions is created by mountain climate, which results from impacts of various combinations of stimuli.

1. Objectives, area of research and methods of analysis

During the last 50 years, the functioning of natural environment and its components became the subject of increasing interest, similarly to the tendencies of changes and variability of climate, due to natural and anthropogenic factors. Until recently, those issues were elaborated only by the researchers working on reconstruction of climatic conditions for the periods of tens and hundreds years or the last millennium, in global and regional scale. Comparison of those results allowed to state that particular temperature fluctuations appear with a certain shift in different continents. Analysing climate change tendencies becomes much more complicated when the secular course of seasonal air temperature is concerned (Obrębska-Starklowa 1997).

Parallel to the mentioned tasks, the field research in detail scale is realised, using experimental methods. The field measurements are carried in small areas, with dense network of sensors, depending on land use and weather conditions. Climatic measurements are taken in the air layer near the ground and over different surfaces, therefore the measurement network is linked to spatial structure of topoclimates. Recently, the representativeness of obtained results, depending on the length

of measurement series, is considered also for such a type of research. If the measurements are taken for a few years, or a few tens of years, it allows to define tendencies of climate change in local scale in connection with the tendencies in regional scale, which makes the background of environmental changes.

The present paper shows some possibilities how to use the results of field climatological research, presenting a certain detailed fragment of the environment, for the purposes of the geoecology of recreation. The authors describe changes of the environment in a relatively little differentiated area with the relief of the Carpathian foothills (at the research station in Gaik-Brzezowa). Considering the context of detailed climatological research, this study presents modifications of the topoclimates' spatial structure, together with their rate and intensity. Another discussed aspect is the importance of the mentioned modifications for the environmental management, as the society should use the knowledge about the environmental changes for its welfare. The question arises: to what extent those changes effect the society's life level and whether they imply revising people's attitudes and habits concerning living in certain conditions. Do they e.g. demand activating special mechanisms of the adaptation to a certain combination of environmental stimuli? Therefore, at the end of the present study, there should appear the answer how to interpret the changed quality of our environment and how it can e.g. influence the touristic and recreational behaviour, and the psychical and physical regeneration.

The work presented below shows changes of topoclimates' structure in the Raba river valley due to integrated impact of natural and human climate factors: incoming solar radiation, atmospheric circulation and anthropopression. Observations were carried with thermohygrographs placed in Stevenson's shelters, at the height 2 m above the ground, in the period 1971-1997.

The chosen area of research (Fig. 1) represents a fragment of the Raba river basin, in the Wieliczka Foothills near Dobczyce, which is now the vicinity of the water reservoir (delivering potable water for Cracow), and belongs to the temperate warm vertical climatic zone, with moderate intensity of climatic stimuli. The present paper shows some symptoms of changes in the spatial pattern of topoclimates, which influences the properties of recreational bioclimate. The changes of local climate in the ecosystem of the oak-hornbeam forest *Tilio-Carpinetum* were analysed as especially interesting, and were then compared with the results for river valley slope, covered only with grass. The first mentioned topoclimate is characterised with the stability of physical properties' pattern of the air, i.e. temperature and humidity, which is typical for climax stage of the forest development.

The climatic and phytosociological measurement network in the Raba river valley was organised in the 1960s, that is before the construction of the Dobczyce water reservoir (Fig. 1). When the reservoir began to function, a wider programme of research concerning soils, waters, vegetation and topoclimate was undertaken. Maps of soil and vegetation distribution were prepared, and the local climate was analysed in seasons for two periods: 1971-1984 (i.e. before the construction of the reservoir) and 1988-1996 (for the Zuchowa Góra Mt., which forms a sort of peninsula reaching into the reservoir). From all the measurement points shown in Fig. 1, only Zbocze (Slope, 283 m a.s.l.) and Las (Forest,

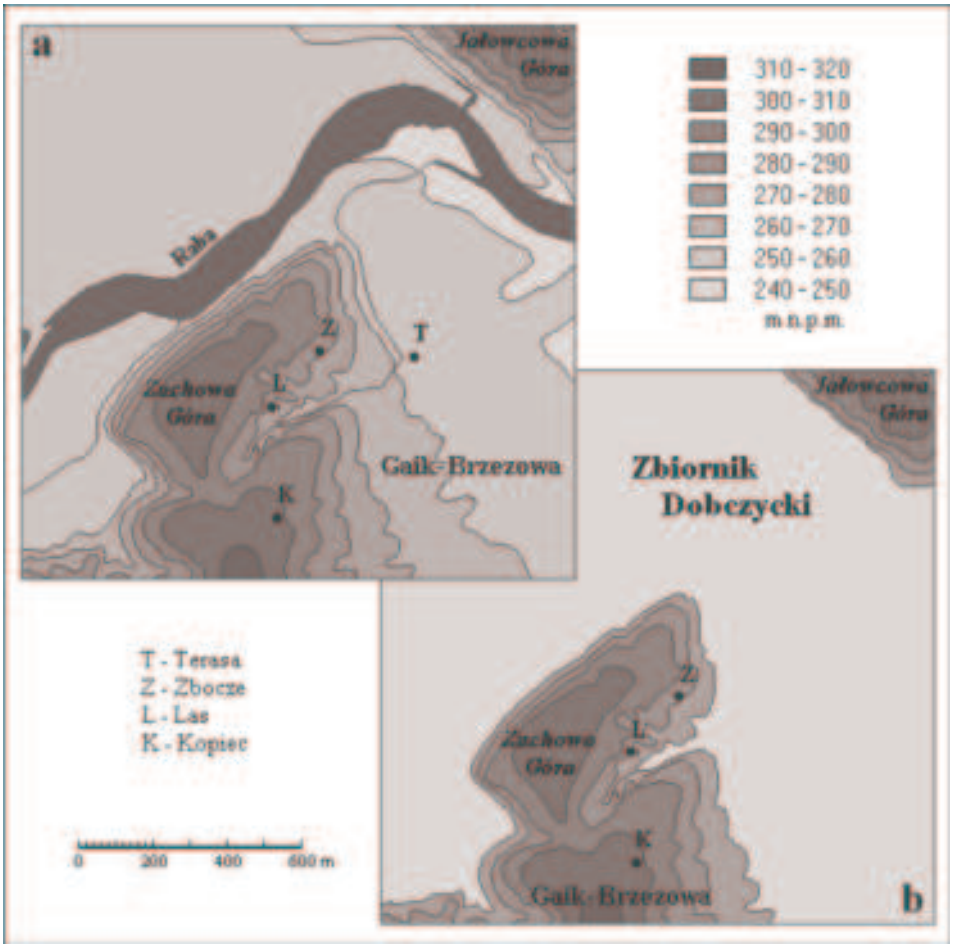

Fig. 1. Localisation of measurement points in Gaik-Brzezowa: a – in the Raba river vally until 1984; b – since 1988, after the construction of the Dobczyce water reservoir (Zbiornik Dobczycki) (by P. Jezioro, 2000)

285 m a.s.l.) have remained unchanged until today. The only factor which caused breaking the homogeneity of measurement series for those points was the construction of the medium-size Dobczyce water reservoir. The changes may be seen at the local level beginning in 1988, by analysing daily, annual and multi-annual courses of air temperature and humidity values, and especially of the saturation deficit. Before the construction of the water reservoir, the temperature stratification in the Raba river valley indicated the existence of local air circulation within the valley. It consisted of: so-called reservoir of cold air represented by the measurement point Terasa (Terrace, 259 m a.s.l., the main measurement station in the years 1971-1984), the warm zone

on the slope (Zbocze (Slope), 283 m a.s.l.), and a ridge flattening (measurement station Kopiec (Hill top), the main measurement station since 1988).

The Dobczyce water reservoir is characterised by the following parameters: mean pool level 269.9 m a.s.l., mean pool area 970 ha, mean storage capacity 99.5 million m^3, reservoir's depth 29 m at maximum pool level 272.4 m a.s.l.

2. Results

The construction of the water reservoir in the Wieliczka Foothills changed the mesoclimatic conditions, including the topoclimates' structure in its vicinity. According to H. Trzcińska-Tacik and A. Stachurska-Swakoń (2001), it was also marked by the changes in vegetation at three levels: 1. Local landscape, 2. Number and composition of plant communities, and 3. Qualitative changes of those communities. The plant communities which are indices of local climate change, especially the forest ones, were placed in sites which were not flooded by the waters of the reservoir. Therefore, their area and composition have not changed (Obrębska-Starkel et al. 2001a).

The relative height of the measurement points Zbocze (Slope) and Las (Forest) decreased by ca. 20 m comparing to the situation before the construction of the reservoir. In 1995, the changes of temperature and humidity conditions in the Raba river valley in Gaik-Brzezowa were summarised, on the ground of the observation series from the period 1971-1992. Those changes were consequences of local environment's modification and were related with alternations in the character of atmospheric circulation in regional scale (Obrębska-Starkel 2001). The latter were marked by the prevalence of anticyclonic situations frequency (51.9%) over the cyclonic ones (46%) in the whole period 1971-1997, while since 1988 the frequency of anticyclonic patterns (62.5%) has been almost doubled comparing to cyclonic ones (36.5%). That proves that atmospheric circulation and the changes of local land use contributed to the origin of the warming effect and probably decreasing tendency of relative air humidity in the second half of the 20th century. The most important and the largest tendencies of changes in mean annual air temperature and mean annual minimum temperature at Zbocze (Slope) measurement point in the Raba river valley varied between 0.3 and 0.4 ^oC/10 years, and were differentiated depending on the location of the point in the topoclimatic structure.

In 1988, the following changes in the Raba river valley were revealed:

1. modification of topoclimates' structure, resulting from the reduction of long-wave outgoing radiation and significant weakening of air temperature inversions, so characteristic before the construction of the water reservoir in the Raba river valley, due to their high intensity and frequency;
2. change of tendency in annual and daily course of hourly values of air temperature and humidity, which causes the origin of the so-called allochtonic topoclimate, dependent on advective factors' impact on the flattened ridge of the Zuchowa Góra Mt., and homogenous autochtonic topoclimate on the slope of the Raba river valley. Those two types of topoclimate are separated by the border between the slope and the ridge flattening;

3. the topoclimate of valley slope during the day-time depends on insolation. Therefore, it is characterised by the highest mean seasonal tempeartures comparing to other measurement points. In spring and summer, mean maximum temperature was higher for Zbocze (Slope) than for other points by 0.5°C, regardless cloudiness. Mean annual and seasonal values of relative humidity were lower by 4% comparing to the ridge flattening;
4. seasonality of topoclimate changes at the banks of the water reservoir, at the zone of contact between the surfaces of water and ground. The topoclimate of the reservoir bank showed the highest mean daily and mean maximum temperatures in summer and autumn. Moreover, the vicinity of the water body smoothed mean minimum air temperatures in spring and summer, but in particular in autumn (0.1-0.4°C).

The focus on seasonal changes of basic air temperature characteristics in the period 1971-1996 resulted from the fact that there were no unequivocal tendencies in the multi-annual course of the radiation balance elements (Olecki 2002). The total incoming solar radiation was higher in spring by 35% than in autumn. However, annual sum of sunshine duration was the lowest in 1980, with reference to the Cracow series of observation for the period 1881-1997; it meant a decrease below 24% of potential sunshine duration. On the other hand, the analysis of sunshine duration data presented as mean 10-year annual sums for the period 1971-2000 proves progressive increasing tendency (Tab. 1). All those factors may cause the observed increase of mean air temperature and a new character of temperature differences between transitional seasons (Tab. 2).

In the presented interpretation of topoclimatic changes in the vicinity of the Dobczyce water reservoir, the evaluation of their influence on the climate of surrounding areas was not accomplished. The main obstacle was the lack of measurement points located in profiles of a few kilometers length, reaching from the reservoir banks to the inland areas. The changes of the climatic elements' values resulted from overlapping effects of atmospheric circulation and anthropopression. The circulation impacts are of regional scale and relatively long-time duration, while anthropopression modifies the ground surface quickly and radically, which means that it controls the heat balance, water cycle and local air circulation in the environment.

Additionally, in the analysed period, air temperature was the subject of two fluctuations: cold one (1971-1987) and warm one (1988-1996). That enabled setting off the influence of the water reservoir on the surrounding area. As states Trepińska (2002), the changes in multi-annual course of air temperature in the reservoir's vicinity took place faster and were of higher magnitude than in the areas of intensive urbanisation, e.g. in Cracow agglomeration. The turning point separating both fluctuations is well marked in the multi-annual course of mean annual temperature, and especially in the case of mean annual minimum temperature at the measurement sites located in the studied area (Obrębska-Starkel et al. 2001a, b).

Tab. 1. Mean 10-year sunshine duration in Gaik-Brzezowa in the years 1971-2000

Years	Months												Year
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1971-1980	53.7	72.7	111.2	125.7	174.6	190.1	184.7	193.3	128.2	102.5	58.7	52.2	1451.2
1981-1990	57.4	74.1	103.5	128.4	187.2	166.4	210.0	195.1	121.4	119.4	63.6	42.2	1468.8
1991-2000	59.5	77.0	101.8	143.7	201.2	206.3	215.6	211.8	132.6	98.8	55.9	40.1	1544.0

Tab. 2. Duration of thermal seasons in Gaik-Brzezowa in the periods:
a – 1971-1984, and b – 1988-1996, i.e. before and after the construction of the water reservoir, respectively

Station	Period	Early spring	Spring	Summer	Autumn	Early winter	Winter
Forest	a	79	23	82	77	66	38
	b	63	41	74	87	66	34
difference	a-b	**16**	**-18**	**8**	**-10**	**0**	**4**
Slope	a	57	23	68	98	64	55
	b	61	42	67	98	64	33
dfference	a-b	**-4**	**-19**	**1**	**0**	**0**	**22**
Terrace/	a	80	24	78	81	64	38
Hill top	b	63	45	69	89	64	35
difference	a-b	**17**	**-21**	**9**	**-8**	**0**	**3**

3. Modifications of ecoclimate in the oak-hornbeam forest *Tilio-Carpinetum* in the vicinity of the Dobczyce water reservoir

The plant community *Tilio-Carpinetum* belongs to the most stable types of natural environment in the Wieliczka Foothills. It is characterised by flexibility and resistance to the anthropopression. According to Drużkowski (2001), it is also well adopted to average and even high fluctuations in the matter and energy circulation conditions.

The stability of the foothills landscape, evolving during last 300 years, is favoured by the high spatial differentiation, forming a habitat mosaic and a mixture of natural and anthropogenically modified vegetation, as a result of long-lasting land-use changes. In the climate change scenarios for the temperate warm vertical climatic zone in the Carpathians, concerning the greenhouse effect, an increase of tree species' number is predicted. The possibility of growing meso- and topoclimatic preferences for deciduous species since the end of the 20th century is of special interest (Mindoš, Škvarenina 1994). However, the phytosociological research in Gaik-Brzezowa proved that the increase in mean annual air temperature documented for the forest community in the period 1971-1996 did not exceed the tolerance limits of particular tree species. It could only contribute to the larger tree crown density (which achieved 80% in the vicinity of the measurement point Las), and to smoothing air temperature changes from day to day in the recreational season (or vegetation season which is also defined as a period with mean daily temperature above 5°C). Generally, it caused the shortening of the thermal summer in the forest patch by 10 days in comparison with the basic station Kopiec (Hill top) and the measurement point Zbocze (Slope) (Obrębska-Starkel et al. 2001a).Moreover, in the years 1995 and 1996, which represent the warm fluctuation, the frostless period was enlarged in the forest by 31 and 27 days, respectively, comparing to the open space of the slope. It resulted from the lower rate of cooling in the forest environment combined with longer lasting foliage of the tree crowns and mildening effect of the water reservoir on temperature conditions in autumn.

Duration of the thermal seasons in the years 1971-1984 and 1988-1996 was also symptomatic (Janusz 2001). After the construction of the water reservoir, the summer (defined as a period with mean daily temperature above 15°C) was shorter by 15 days in the forest, while the spring was longer by 4-9 days comparing to the Zbocze (Slope). During the cold fluctuation, the early winter season lasted longer by 2.5 weeks on the slope than in the forest, while during the warm fluctuation its length was similar at both sites.

Differences in thermal seasons' length were largest for the slope and forest, i.e. for the points located almost at the same altitude and similar height above the water level of the reservoir. Additionally, those points were effected by a complicated combination of overlapping local factors like ventilation, incoming solar radiation, presence or lack of foliage, and the favourable conditions or air stagnation within the tree stand. Spatial distribution of topoclimates was also influenced by the vertical structure of the forest and its species composition.

The largest differences in duration were observed for winter. Before the construction of the water reservoir (1971-1984, cold fluctuation), winter (mean daily

temperature below 0°C) lasted for 79 days, while in the years 1988-1996 (warm fluctuation) only for 63 days. It was then longer by 16 days on the slope before the construction of the reservoir than after it began to function. Basically, changes in winter duration were controlled by natural factors linked to modification of the atmospheric circulation's character, and by anthropopression. It is worth mentioning that the changes of winter duration in the forest and in the open space of the slope were accompanied in particular years by the change of duration of either early winter or early spring, depending on atmospheric circulation character.

4. Potential usability of the topoclimatic changes' effects for the recreation in the vicinity of the Dobczyce water reservoir

Modification of the temperature conditions in the air layer near the ground leads to new quality of climate in ecosystems, including the oak-hornbeam forest already described in more details. The intensity of observed changes activates many adaptation mechanisms in human organism. Their efficacity depends for example on intensity of external physical stimuli (radiation, thermal, humidity and mechanical ones). The new features of local climate presented in this paper should be implemented in the programmes of environmental management, concerning the possibilities of their application for tourism and recreation. That could ensure the development of recreation forms best linked to natural environment conditions and their seasonal changes.

The present study shows some tendencies of the changes, mainly for the temperature conditions in the air layer near the ground. Detailed analysis of the particular bioclimatic factors' changes in different types of topoclimate, i.e. in forest communities and on the slope, exceeds by far the scope of the present paper. Therefore, only the features of potential recreational bioclimate's differentiation are briefly described, depending on the intensity of the anthropopression, and maintaining the level of climatic conditions' stability, achieved by a certain ecosystem.

In the studied environment, the most important feature turned out to be the change of air temperature and humidity stratification, caused by the construction of the water reservoir in the Raba river valley. It resulted in elimination of the inversive air temperature distribution in the vertical valley profile (the lowest values in the valley bottom and the increase of many thermal characteristics toward the higher parts of slopes and lower flattened ridges). The changed stratification caused mildening of the thermal contrasts in the vicinity of the reservoir thanks to lower roughness indices allowing increased wind speed. Consequently, the daily variations of air temperature were lowered due to the impact of the water reservoir; earlier those variations formed human thermal feelings: hyperthermal conditions prevailed during the day-time, while hypothermal during the night-time. The construction of the water reservoir in the Raba river valley caused a significant decrease also in the annual values of air temperature range, defined as the difference between the lowest and the highest mean monthly temperatures. Temperature range was also an important factor controlling human heat feelings before the construction of the water reservoir. Additionally, often occurrence of air stagnation in the Raba river valley in the winter half-year in the period 1971-1984 favoured formation

of the cold days series, with strong stimulating influence on the human thermoregulation system. Moreover, the foehn phenomena formed in the Carpathians contributed to the origin of the periods with high air temperature and significant decreases of air humidity parameters. Thermal contrasts were then a typical feature, especially before the construction of the water reservoir, in the series of colder years (1971-1984). In the whole studied period 1971-1996, there was an increasing tendency of mean annual air temperature, mean annual maximum air temperature and mean extreme temperatures in summer and autumn. Moreover, changes in land use, introduced in different land forms could intensify or weaken the recreational biotopoclimate's features, which in turn controlled physical and mechanical stimuli and therefore influenced human thermoregulation processes in different seasons.

Average increase of air temperature in the whole studied period was differentiated depending on local conditions. The preliminary analysis of air temperature data for the measurement point Zbocze (Slope) allowed to estimate average increase of mean annual air temperature at 0.4°C/10 years, and for mean annual minimum air temperature at 0.34°C/10 years. Magnitude and character of those tendencies changed in seasons depending on the localisation of particular measurement points. The modifications at the measurement point Brzeg (Reservoir bank), where the water and ground surfaces contact, were particularly characteristic. The highest mean seasonal temperatures and the highest mean annual maximum temperatures occurred there. Before the construction of the reservoir, average increase of mean annual air temperature was 0.21°C/10 years, while after the flooding of the Raba river valley it increased almost eight times (1.5°C/10 years). The increase rate of mean minimum temperature estimated for those two periods was 0.41°C/10 years and 1.69°C/10 years, respectively.

The described change rates of air temperature characteristics were estimated for relatively short periods, but they prove that this issue should be further investigated.

5. Concluding remarks

While estimating general directions of changes in mean annual temperature, it should be emphasized that they include seasonal increases of temperature, of different magnitude and direction. Usually, they were the highest in winter and the lowest in summer. Additionally, in summer, in some cases, even a slight decreasing tendency was observed for mean daily and mean maximum air temperature.

The facts presented above prove that during last 30 years of the 20th century, a significant change of temperature conditions in local scale occurred in the Raba river valley. The intensity of thermal stimuli within particular biotopoclimates was modified, and so were the relations of temperature conditions among the types of biotopoclimate in the structure of local climate. However, the basic features of medium stimulative biotopoclimate in winter and moderately sparing one in summer were preserved in the reservoir's vicinity. In such conditions, the factors decisive for maintaining the psychical health are climatic conditions, waters, reach complex of natural and landscape values, including attractive foothills landscape with differentiated colour palette and richness of seasonal aspects. In case of strong bioclimatic stimuli, forests

may have a protective function. The landscape mosaic of meadows and forests has positive impact on psychical and physical human sensations. However, due to relatively small area of the investigated terrain and the necessity of its protection, the control of the size of recreational attendance in the zone surrounding the reservoir is of high importance. The forest community *Tilio-Carpinetum* dominates in the foothills area, and the increase of the tree crowns density by 5% observed since the end of 1960s resulted in their exceptionally high present density equal to 80%. That factor causes lowering of daily and annual air temperature variations, weakening of wind speed, and changes in solar radiation spectrum in the crown level, and in light conditions at the bottom of the forest. The most favourable situation concerning solar radiation income to the forest bottom occur in early spring, late autumn and in winter, i.e. the periods without foliage. Large stability of air temperature in the forest's interior is also the result of rather stable water flow intensity during the year in the Raba river. All the mentioned factors indicate that the values of climate and local biotopoclimate may be used more efficiently in the development of recreation.

The present topoclimatic differentiation of the area surrounding the Dobczyce water reservoir should be used for planning and management of recreational function, in the form of active recreation for the Cracow's agglomeration habitants, in different seasons. The principles of dosing thermal stimuli in such environment should be considered for that purpose. While planning the touristic function, the existing temperature contrasts between open space of the flattened ridges and small areas of the river valley and forest interior should be properly used. The presence of forests allows to modify the intensity of bioclimatic stimuli. Planning of forest management should also be directed towards recreational needs, concerning for example modelling and shaping the intensity of ventilation, income of solar radiation and heat. The preferred forms of active recreation do not demand a high form and training from thier participants. Moreover, in the vicinity of the reservoir, the recreation must be organised for small groups of people, using the network of paths and roads, for walking, hiking and passive relaxation.

References

Drużkowski M., 2001, *Współczesne i prognozowane aspekty funkcjonowania krajobrazu Pogórza karpackiego,* [w:] K. German, J. Balon (red.), *Problemy ekologii krajobrazu,* Inst. Geogr. i Gosp. Przestrzennej UJ, Kraków, 599-606.

Janusz A., 2001, *Okresy termiczne w grądzie Tilio-Carpinetum w Gaiku- Brzezowej w latach 1971-1996,* [w:] K. German, J. Balon (red.), *Problemy ekologii krajobrazu,* Inst. Geogr. i Gosp. Przestrzennej UJ, Kraków, 633-640.

Krzymowska-Kostrowicka A., 1997, *Geoekologia turystyki i wypoczynku,* PWN, Warszawa, 1-239.

Mindoš J, Škvarenina J., 1994, *Possible impacts of climate change on forest ecosystems,* [w:] *Národný klimatický program Slovenskej Republiky,* I, 1994, 1, 50-82.

Obrębska-Starkel B., 2001, *Wpływ zmian użytkowania ziemi w dolinie Raby na warunki termiczne zbiorowiska leśnego Tilio-Carpinetum,* [w:] M. Kuchcik (red.), *Współczesne badania topoklimatyczne,* Dok. Geogr. PAN, IG i PZ, 23, 59-73.

Obrębska-Starkel B., Grzyborowska A., Janusz A., 2001a, *Struktura topoklimatu w dolinie Raby w Gaiku-Brzezowej – przykłady przekształceń*, [w:] K. German, J. Balon (red.), *Problemy ekologii krajobrazu*, Inst. Geogr. i Gosp. Przestrzennej UJ, Kraków, 615-622.

Obrębska-Starkel B., Olecki Z., Trepińska J., Skiba S., Soja R., Trzcińska-Tacik H., Stachurska-Swakoń A., 2001b, *O lokalnych zmianach środowiska geograficznego w otoczeniu Dobczyckiego zbiornika wodnego*, [w:] K. German, J. Balon (red.) *Problemy ekologii krajobrazu*, Inst. Geogr. i Gosp. Przestrzennej UJ, Kraków, 607-613.

Obrębska-Starklowa B., 1997, *Współczesne poglądy na zmiany klimatyczne w Europie u schyłku małego glacjału*, [w:] *Wahania klimatu w Krakowie (1972-1995)*, J. Trepińska (red.), Inst. Geogr. UJ, Kraków, 163-190.

Olecki Z., 2002, *Differentiation of solar conditions in the Carpathian Foothils during 1971-1997*(maszynopis).

Trepińska J., 2002, *Multi-annual course of air temperature and precipitation in Cracow, Gaik-Brzezowa and Szymbark (1971-1997)*, (maszynopis).

Trzcińska-Tacik H., Stachurska-Swakoń A., 2001, *Przemiany roślinności pod wpływem zmian w gospodarowaniu przestrzenią (na przykładzie okolic Gaika-Brzezowej)*, [w:] K. German, J. Balon (red.), *Problemy ekologii krajobrazu*, Inst. Geogr. i Gosp. Przestrzennej UJ, Kraków, 624-631.

Przekształcanie bioklimatu rekreacyjnego na Pogórzu Karpackim u schyłku XX. stulecia na przykładzie Gaika-Brzezowej

Streszczenie

Artykuł jest poświęcony zmianom struktury przestrzennej topoklimatów, ich tempa i natężenia w Gaiku-Brzezowej na Pogórzu Karpackim w ostatnim trzydziestoleciu XX w. w związku z budową dobczyckiego zbiornika wodnego. Autorzy przeanalizowali zróżnicowanie termicznych warunków powietrza w tzw. warstwie rekreacyjnej (zgodnie z koncepcją Toyne do wysokości 2 m nad poziomem gruntu), w której na organizm człowieka oddziałują czynniki fizyczne, chemiczne, biologiczne i antropogeniczne. Rozpatrzyli oni zróżnicowanie warunków klimatu lokalnego w dwóch podokresach: 1971-1984 – przed budową zbiornika wodnego na Rabie oraz w latach 1988-1996 po jego wybudowaniu. Jednocześnie pierwszy z tych podokresów reprezentował skutki chłodnej fluktuacji klimatu, drugi zaś – łączył skutki naturalnej fluktuacji ciepła, wywołanej przez czynniki radiacyjne i cyrkulacyjne z następstwami przekształcania modelu użytkowania ziemi (antropopresja).

Jako przewodnie wskaźniki zmian rozpatrzone zostały tendencje w przebiegu wieloletnim średniej rocznej i średnich sezonowych temperatury powietrza, jak też odpowiednich charakterystyk średnich maksymalnych i minimalnych wartości. Specjalna uwaga została skoncentrowana na skutkach przekształcania biotopoklimatu grądu pogórskiego *Tilio-Carpinetum*, który należy do najbardziej stabilnych naturalnych zbiorowisk leśnych na Pogórzu.

Jednym z najistotniejszych następstw obserwowanych zmian w przebiegu wieloletnim wskaźników temperatury powietrza była zmiana czasu trwania poszczególnych pór roku lub okresów termicznych. Tak na przykład, w okresie fluktuacji ciepłej okres bezprzymrozkowy w grądzie (stacja Las) wzrósł około 30 dni w stosunku do stanowisk na wolnej przestrzeni (stacje: Zbocze i Kopiec), a trwanie zimy ze średnią dobową temperaturą poniżej 0° C obniżyło się z 79 do 63 dni. Są to więc charakterystyczne symptomy przekształceń natężenia bodźców termicznych w obrębie poszczególnych biotopoklimatów, których efekty są widoczne w krótkim czasie.

Istotnym stwierdzeniem jest zachowanie w otoczeniu zbiornika dobczyckiego w całym badanym okresie właściwości bioklimatu średniobodźcowego w okresie zimowym i umiarkowanie oszczędzającego latem. Specjalną rolę w kształtowaniu cech fizycznych w warstwie bioklimatu rekreacyjnego winny na tym terenie spełniać lasy, korzystnie wpływające na odczucia psychofizyczne. Jednakże ich niewielki udział w krajobrazie wymaga opracowania zaleceń dotyczących frekwencji rekreacyjnej, zaś dla całego badanego obszaru zaplanowania funkcji turystycznej z uwzględnieniem form rekreacji ruchowej, umożliwiającej stosowne dawkowanie bodźców bioklimatycznych.

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