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MAN-MADE LANDSCAPES AS THE FACTORS OF REGIONAL MICROCLIMATIC CHANGES

In the 21st century, the level of economic development of the Earth's landscape sphere has reached significant scales. The transformation of natural conditions and natural resources occurs both horizontally and vertically. Specialists record the trends of increasing the temperature regime of the planet, changes in humidification regimes, an increase in the number of adverse meteorological phenomena, and the development of cataclysms. Climate change is an actual scientific problem.

The purpose of the article is to investigate the influence of man-made landscapes on regional microclimatic changes and to argue assumptions about the possibilities of global climate changes as a result of the modern transformation of the Earth's landscape sphere. Research was carried out according to the generally accepted method of performing microclimatic observations.

The man-made landscapes as the factors of regional microclimatic changes were investigated in the article. The work gives examples of their influence on the climatic features of the territories as a underlying surface. The indirect influence on the distribution of solar radiation and atmospheric circulation was analyzed. On the example of garden and park landscapes, changes in meteorological indicators were analyzed, namely: air temperature, humidity, wind speed. The article presents research on the surface layer of the atmosphere on the territory of the garden and park landscape of the National Dendrological Park «Sofiivka» of NAS of Ukraine.

Key words: man-made landscapes, climate changes, microclimatic observations, underlying surface, garden and park landscape, National Dendrological Park «Sofiivka» of NAS of Ukraine.

Кравцова І.В., Стефанков Л.Л. АНТРОПОГЕННІ ЛАНДШАФТИ ЯК ЧИННИКИ РЕГІОНАЛЬНИХ МІКРОКЛІМАТИЧНИХ ЗМІН

У XXI столітті рівень господарського освоєння ландшафтної оболонки Землі досягнув значних масштабів. Перетворення природних умов і природних ресурсів відбувається як у горизонтальному, так і у вертикальному напрямках. Фахівці фіксують тренди підвищення температурного режиму планети, зміни у режимах зволоження, збільшення кількості несприятливих метеорологічних явищ, розвиток катаклізмів. Зміни клімату є актуальною науковою проблемою.

Мета статті – дослідити вплив антропогенних ландшафтів на регіональні мікрокліматичні зміни та аргументувати припущення щодо можливостей глобальних змін клімату в результаті сучасної трансформації ландшафтної оболонки Землі.

Дослідження проводилися за загальноприйнятою методикою виконання мікрокліматичних спостережень. Роботи виконувалися у весняний період (20 березня, 03 квітня, 19 травня, 22 травня). Спостереження проводилися за температурою повітря за допомогою аспіраційного психрометра, за швидкістю вітру за допомогою анемометра чашкового і за відносною вологістю повітря – гігрометра. Прилади були повірені із приладами, що використовуються на реперній метеостанції «Умань».

У статті розкриваються антропогенні ландшафти як чинники регіональних мікрокліматичних змін. У роботі наводяться приклади їхнього впливу на кліматичні особливості територій як підстильної поверхні.

Аналізується опосередкований вплив на розподіл сонячної радіації та циркуляції атмосфери. На прикладі садово-паркових ландшафтів аналізуються зміни метеорологічних показників, а саме: температури повітря, вологості, швидкості вітру. У статті наводяться дослідження за приземним шаром атмосфери на території садово-паркового ландшафту Національного дендрологічного парку «Софіївка» НАН України. А саме: виконані мікрокліматичні спостереження за температурою повітря за допомогою аспіраційного психрометра, за швидкістю вітру за допомогою анемометра чашкового і за відносною вологістю повітря – гігрометра. Прилади повірені із приладами, що використовуються на реперній метеостанції «Умань». Дослідження виконані у весняний період.

Ключові слова: антропогенні ландшафти, зміни клімату, мікрокліматичні спостереження, підстильна поверхня, садово-парковий ландшафт, Національний дендрологічний парк «Софіївка» НАН України.

Relevance of the research topic. There has been a scientific debate between geologists and landscape scientists for a long time about whether human influence can have a global character, or whether human economic activity can be compared with the forces of the Earth? The fact that anthropogenic processes are extremely dynamic and purposeful in terms of intensity, direction and speed is proven and indisputable. Man accelerates many times all the components of the modern functioning of landscape systems at both local and regional levels of organization. Ukrainian geographers emphasize that the consequences of interaction between society and nature are negative and they cover all levels of organization of landscape systems, manifested in «... violation of the integrity of the biosphere, changes in land use, biochemical cycles and planetary climate changes...» [12, p. 8]. Among the groups of potential threats by origin, threats of a natural and natural-anthropogenic nature are distinguished, among which a separate group is «Threats caused by climate change and adverse hydrometeorological phenomena and processes». «The consequences of global climate changes, including not only temperature rise, but also the increase in the intensity of abnormal weather phenomena are already visible in Ukraine, causing significant changes in climatic conditions, characteristics and manifestation of climate-forming factors: changes in basic climatic parameters; dynamics of adverse meteorological phenomena; dynamics of adverse hydrometeorological phenomena. Key indicators are: air temperature, amount of precipitation, number of adverse meteorological and hydrometeorological phenomena, etc.» [12, p. 11].

Can man-made landscapes be factors of «climate change»? Has human activity reached such a level and intensity that it (the economic activity of modern humanity) could be compared with geological processes, for example, with external magmatism, in terms of strength, volume and consequences for the landscape sphere of the Earth? Are human activities on such a scale and volume that these activities will have a direct impact on the climate on a planetary scale, rather than on individual microclimatic characteristics of the territory? These questions are raised by modern scientists of various fields of knowledge. Therefore, the study of the man-made landscapes as factors of regional and possibly global climate changes is an actual scientific problem of modern Anthropogenic Landscape Science.

The state of study of the issue, the main works. The issue of climate change is a particularly actual scientific problem. Only the scientometric database Web of Science Core Collection provides 118,282 [17] search results on the topic «Global changes of climate». These are scientific articles, review articles, book chapters, editorial materials, etc. It should be noted that the publications cover various sciences and fields of

knowledge. Also, the analysis of statistical data proves that the issue of global climate change has become an actual scientific problem in the last 20 years, and since 2012, the number of scientific works is counted in thousands. For example, in 1989, 17 scientific works were devoted to this problem, in 2003 – 1,151; in 2012 – 4,563; and in 2019 – 10,460; 2020 – 12126; 2021 – 13747.

In scientific research, the authors investigate changes in climate indicators and conditions within different regions (N.B. Taranova, L.B. Zastavetska, T.B. Zastavetskyi, 2020; V.I. Osadchyi, E. Ahuilar, O.A. Skrynyk, D.O. Boichuk, V.P. Sidenko, O.Ia. Skrynyk, 2018; O.I. Sytnyk, T.H. Trokhymenko, 2016; O.I. Sytnyk, L.A. Ruda, 2020; L.P. Tsaryk, P.L. Tsaryk, I.R. Kuzyk, 2021), formation and development of adverse meteorological phenomena (A.B. Semerhei-Chumachenko, R.R. Ozymko, 2019), the impact of modern climate changes on the state of surface waters and other components of landscape complexes (V.H. Marharian, 2021; S.I. Snizhko, O.H. Obodovskyi, O.H. Shevchenko, V.V. Hrebin, Yu.S. Didovets, I.V. Kuprikov, O.O. Pochaievets, 2020; V.V. Fedoniuk, M.A. Fedoniuk, M.V. Khrystetska, S.P. Bondarchuk, 2021; V.M. Chekhnii, 2021; Daniel A. Friess, Maria Fernanda Adame, Janine B. Adams, Catherine E. Lovelock 2022; Midgley GF, Thuiller W, 2005), xerophytization of the conditions of natural zones of Ukraine and desertification of its territories (G.I. Denysyk, 2022; O.A. Apostolov, L.O. Yelistratova, I.F. Romanchuk, V.M. Chekhnii, 2020), study of the temperature regime as the main meteorological factor of climate change (V.F. Martazynova, 2019), problems of global warming, climate change, emerging risks, and public perception of climate change (Kijpokin Kasemsap, 2018; Windsor Duane, 2009; Xianyao CHEN, 2017; Lempert L.J., 2021), global warming and climate change as psychological barriers to the awareness of their existence and the desire to act (Milfont Taciano L., 2010), social perception of climate change (Neumann Claudio, Stanley Samantha K., Leviston Zoe, Walker Iain, 2022).

From the point of view of Anthropogenic Landscape Science, this issue is poorly researched. G.I. Denysyk, M.O. Shmahelska, L.I. Stefankov in the monograph «Micro-centered processes in man-made landscapes» («Мікроосередкові процеси в антропогенних ландшафтах») [5] note that the study of dynamic processes in the development of geocomponents and landscape complexes, their changes and the study of regularities of functioning in modern conditions is one of the main tasks of modern Constructive Geography and Landscape Science. The modern concept of a landscape and ecologically destabilized environment is based on provisions that indicate abnormally fast rates of changes in the structural organization of geocomponents and landscape complexes and the relationships between them. It should be noted that the surface layer of the atmosphere is not only an environment for the development of dynamic processes, it is actually formed from quite dynamic and mobile matter. The authors emphasize that micro-local processes reveal the causes and mechanisms of ongoing transformation trends at the local level and the possible perspective of their regionalization [5]. Carrying out the classification of anthropogenic micro-centered processes, in the class «Micro-centered processes» G.I. Denysyk, M.O. Shmahelska, L.I. Stefankov distinguish the subclass «Natural micro-centered processes», in the structure of which there is a type «Climatogenic micro-centered processes». The issues of global climate changes, the intensification of weather anomalies in the conditions of the interzonal geoecotone «Forest-Steppe – Steppe» of Right Bank Ukraine are revealed in the works of O.I. Sytnyk [14-16].

The purpose of the study – to investigate

the influence of man-made landscapes on regional microclimatic changes and to argue assumptions about the possibilities of global climate changes as a result of the modern transformation of the Earth's landscape sphere.

Research methods. The study of the man-made landscapes as the factors of regional microclimate changes is based on the principle of natural and anthropogenic combination, which is thoroughly revealed in the works of G.I. Denysyk, F.M. Milkov. Research was carried out according to the generally accepted method of performing microclimatic observations. The works were performed in the spring period (March 20, April 3, May 19, May 22). Observations were made of air temperature using an aspiration psychrometer, wind speed using a cup anemometer, and relative humidity using a hygrometer. The devices were verified with the devices used at the reference weather station «Uman».

Presentation of the main material with substantiation of the obtained scientific results. The modern landscape sphere of the planet is a complex system of interaction between man and nature. As noted by O.O. Grigoriev, the latter is a complex sphere within which living and non-living shells penetrate and interact; it is the sphere of intensive economic activity of a person, which determined the formation and functioning of the sociosphere. That is, the sociosphere is the next stage of development of the Earth's landscape sphere, and the anthroposphere is actually the Earth's landscape sphere of the 21st century. Components of this anthroposphere are man-made landscapes. This group of landscapes forms the modern landscape structure of any territory on the surface of our planet. The higher the level of economic development of the territory, the larger the share in the landscape structure is occupied by man-made landscapes. Today, we have a direct relationship between the intensity of management and the speed of anthropogenic transformation of landscape systems. As noted by O.M. Marynych, P.G. Shishchenko, that in our time, there are practically no landscapes left in Ukraine that have not been changed by human economic activity. Little-changed landscapes make up 15-20% of the territory, these are mainly territories with secondary plantations, wetlands, protected complexes [9, p. 220]. G.I. Denysyk in his work «Anthropogenic landscape Science» [3] emphasizes that the modern image of the landscape sphere of the Earth was formed under the significant influence of the anthropogenic factor, the role and importance of which will constantly increase over time. The author also points out that natural landscapes within individual natural strips (zones) and even continents are relics. Thus, one can only guess about the nature of the natural landscapes of the steppes, forest-steppe and mixed forests of the East European plain.

Man-made landscapes form the modern physical surface of the Earth. They determine the nature of the underlying surface and directly or indirectly affect other climate-forming factors. V.M. Lipinskyi, V.A. Diachuk, V.M. Babichenko note that the climate of the city is formed as a result of the interaction of atmospheric processes and local features of the city itself. The differences in the weather conditions of the city and the suburban area are due to the properties of the underlying surface and the physical state of the atmosphere (thermophysical and hydrodynamic contrasts). On the territory of the urban subclass of the residential class of man-made landscapes, changes in the number of hours of sunshine are observed, which is associated with significant dustiness and gassing of urbanized territories, as well as with shading, especially in those microdistricts occupied by high-rise and industrial-residential types of landscapes. In some industrial cities, the duration of sunshine decreases by 10-20% [6, p. 246]. Also within urban landscapes, inhomogeneities in the duration of sunlight can

be observed, for example, in industrial areas, the reduction of this characteristic is caused by the presence of dust and smoke in the atmospheric air. In areas with high-rise buildings, the duration of sunshine decreases due to a significantly closed horizon [6, p. 247].

The formation and functioning of man-made landscapes changes the natural indicators of the albedo value, because when they are organized, the character of the covering of the physical surface changes: communication routes are laid, the surface is covered with brick and concrete buildings, paints of different colors are used to cover artificial surfaces, greening of various infrastructure objects, construction reservoirs, ponds, etc. The high heat capacity of building materials and the dark asphalt of the streets change the heat accumulation of the physical surface. The city heats up more and gives off heat more slowly. The amount of heat of anthropogenic origin radiating from the city is close to the values of the radiation balance, and in northern latitudes even exceeds them [6, p. 246]. Urban landscapes form so-called «heat islands».

The influence of man-made landscapes on the climate as the underlying surface is especially noticeable. After all, during their organization, the ratios of various active surfaces change. For example, the construction of water man-made landscapes leads to a change in meteorological indicators. Breeze circulation will develop in the summer, and large reservoirs also increase the duration of the frost-free period by 2-3 weeks; a reservoir with an area of 20 km^2 contributes to a decrease in air temperature on hot days in the zone of 200-400 m by 2-4^0 C at a height of 150 cm and an increase in air humidity by 15-20% [6].

Regarding the influence of man-made landscapes on atmospheric circulation as a climate-forming factor, it can be assumed that the development of arable and semi-cultivated landscapes will cause a change in wind speed in the respective territories and, as a result, there will be changes in the speed of movement of cyclones and anticyclones over the territories.

Man-made landscapes as the underlying surface affect the distribution of meteorological indicators. For example, within residential landscapes, garden and park landscapes create their geophysical fields in the wind and solar regime of the territory. In summer, the air temperature is 10-12% lower among the green areas of the parks than among buildings, the relative humidity increases by 5-10%, and the wind speed decreases by 7 times, and in the middle of the areas by 11 times. The difference in air temperature on greened and ungreened streets can reach 4-5^{0}C. Large green massifs help increase air humidity. The average annual difference in relative air humidity in the forest and parks compared to the field is 10%, and the maximum is 40%. At a distance of 500 m from a green massif, air humidity can increase by 30% compared to open terrain. The great importance of trees and grasses in humidifying the air is connected with the ability of vegetation to evaporate: 1 hectare of oak forest evaporates 26 tons of water per day, 1 hectare of lawn during the growing season evaporates an average of 5–7 thousand m^3 of water. Urban green spaces reduce the force of the wind three times compared to its speed in an open urban area [2, 7, 8].

During study garden and park landscapes of the Dniester-Dnieper forest-steppe region as paradynamic and paragenetic systems, the microclimatic features of landscape complexes at the local level of garden and park landscape organization of the National Dendrological Park «Sofiivka» of the National Academy of Sciences of Ukraine (Uman, Cherkasy Oblast, Ukraine) and adjacent territories were taken into account. The interaction of the atmosphere with the substratum is mainly manifested in the lower layer of the atmosphere. The regime of meteorological elements in this layer always has some features that

change rapidly from place to place. Microclimatic contrasts of meteorological values depend on the geographical location and weather conditions in certain seasons of the year. They are traced not only horizontally, but also vertically, which is caused by turbulent heat exchange. Contrasts reach their highest values in clear, windless weather, when during the day there is a significant difference between the components of the radiation and heat balance of non-homogeneous underlying surfaces. Within the garden and park landscape of the National Dendrological Park «Sofiivka» of the NAS of Ukraine, the interaction of various horizontal and vertical active surfaces is observed, which determine the formation of a peculiar active layer: fields, forest massif, water surfaces, surfaces covered with asphalt, traditional buildings 3-5 floors high, a modern building with a height of 9 floors, etc. Six points in the eastern part of the garden and park landscape on the southern exposure slope were chosen for the research. Reference meteorological station «Uman» of Cherkasy Oblast is the reference. Point 1 – «Hrybok» meadow, forest edge; point 2 – «Hrybok» meadow, 50 m from the edge of the forest; point 3 – forest massif (10 m from the fence); point 4 – forest massif (40 m from the fence); point 5 – field (10 m from the fence); point 6 – field (60 m from the fence).

Analyzing the obtained data of microclimatic observations, it should be noted that the graphs of the temperature course are represented by similar curves. The daily course of air temperature has the following features. On March 20, 2015, there was a gradual increase in temperatures at natural points 1–6 with maxima at 12:00 and 15:00 and a gradual decrease until 18:00. The amplitude of daily temperature fluctuations is at point 1 - 2.8^{0}C, point 2 - 1.8^{0}C, point 3 - 2.6^{0}C, point 4 - 2.3^{0}C, point 5 - 3.6^{0}C, point 6 - 3.9^{0}C. At the «Uman» weather station, the amplitude of temperature fluctuation is 3.3^{0}C, a gradual increase is observed during the day with a maximum at 18.00. On April 3, the air temperature has a more drastic course of change. The amplitude of oscillations is at point 1 – 14.7^{0}C, point 2 – 10.1^{0}C, point 3 – 10.3^{0}C, point 4 – 10.8^{0}C, point 5 – 13.8^{0}C, point 6 – 7.9^{0}C, at the «Uman» weather station – 15.2^{0}C. The minimum air temperature indicators were registered at 9:00 a.m. at all sampling points, and the maximum at 3:00 p.m. On May 19, 2015, the daily course of air temperature changes has a smoother character. The movement graphs illustrate the insignificant amplitudes of oscillations, which are at point 1 - 7.6^{0}C, point 2 - 7.1^{0}C, point 3 - 5.6^{0}C, point 4 - 6.1^{0}C, point 5 - 7.0^{0}C, point 6 - 7, 2^{0}C, weather station «Uman» - 6.0^{0}C. Minimum air temperatures were recorded at 9:00 a.m. at all observation points, and maximum at 3:00 p.m. at points 1-6, at 6:00 p.m. at the «Uman» weather station. On May 22, 2015, the graphs of the air temperature change have a smooth character. The lowest temperatures were recorded at 9:00 a.m. at all observation points, and the highest from 3:00 p.m. to 6:00 p.m. The amplitude of temperature fluctuations is on average 5.0 - 7.0^{0}C. (Fig. 1-4).

The analysis of wind speed indicators makes it possible to conclude that the lowest speeds were registered at field points 3 - 4, which were located within the forest park massif, and the highest – at field points 5, 6 and the weather station «Uman» (Figs. 5-8).

The underlying surface affects the relative humidity of the air. Relative humidity in the surface layer always has a diurnal and annual trend opposite to that of air temperature. That is, as the temperature decreases, the relative humidity increases, and as the temperature increases, it decreases. On March 20, 2015, the daily amplitude of the relative humidity was 15-20%. The highest values (about 95-85%) were registered at 9:00 a.m., and the lowest (70-66%) from 3:00 p.m. to 6:00 p.m. The highest values were recorded at sampling points 5 and 6, and the

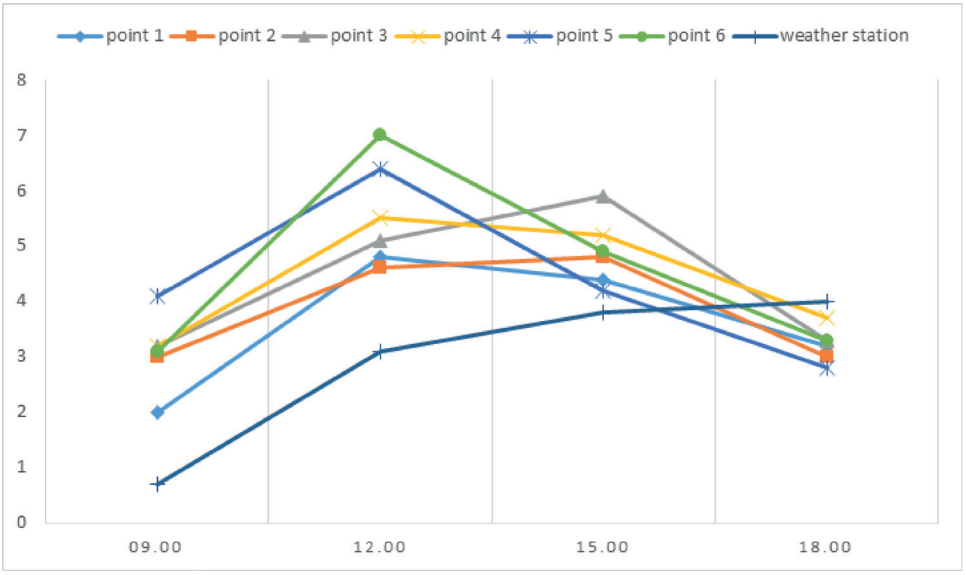

Fig. 1. Schedule of air temperature on March 20, 2015

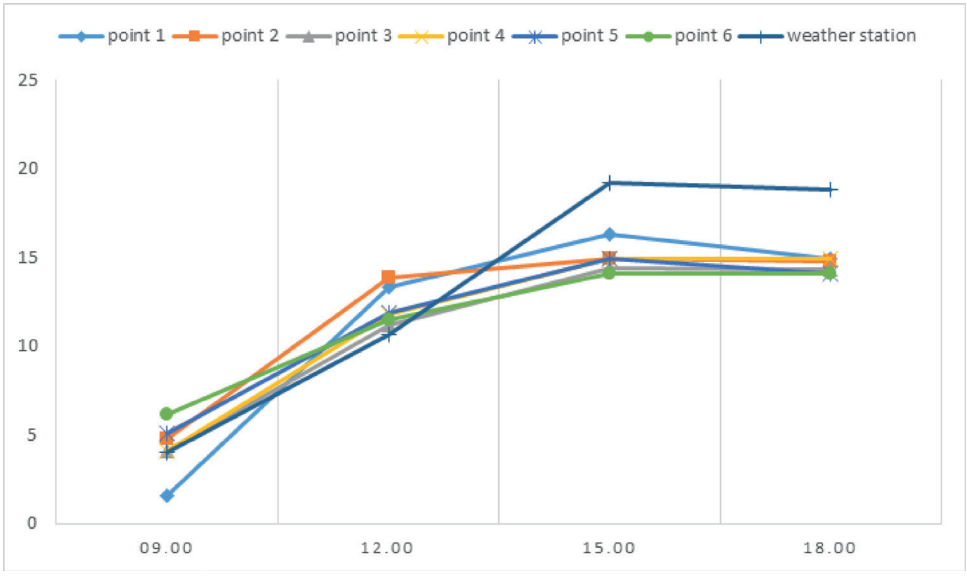

Fig. 2. Schedule of air temperature on April 3, 2015

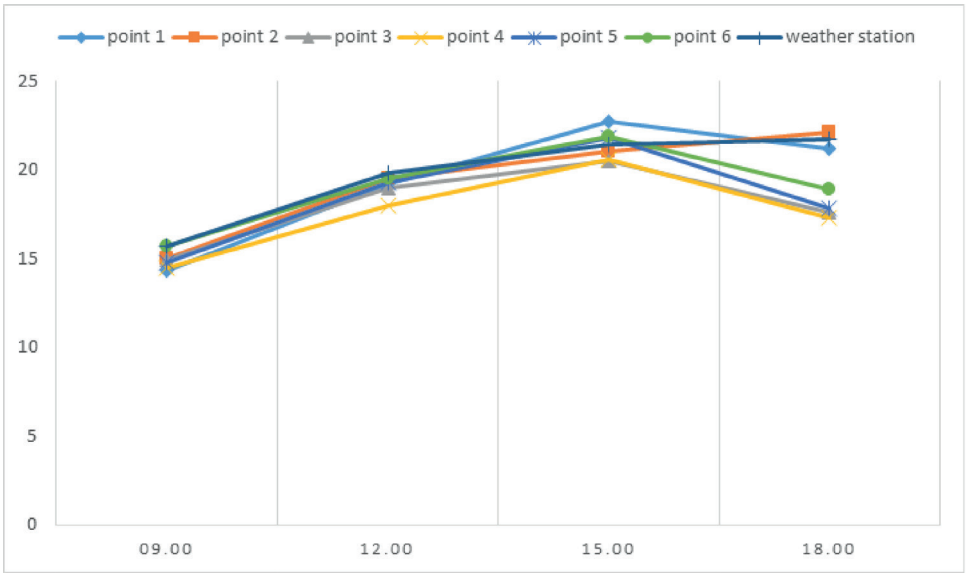

Fig. 3. Schedule of air temperature on May, 19, 2015

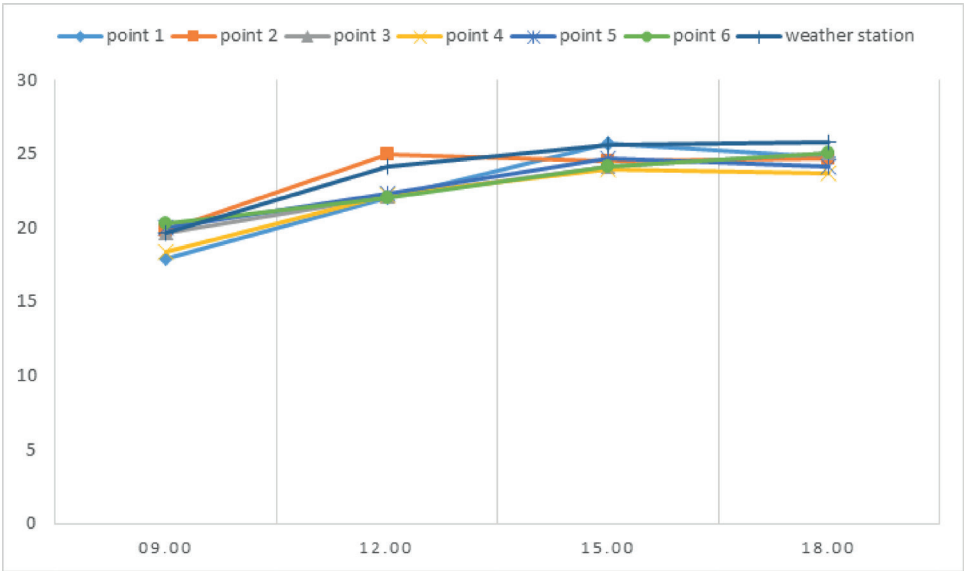

Fig. 4. Schedule of air temperature on May 22, 2015

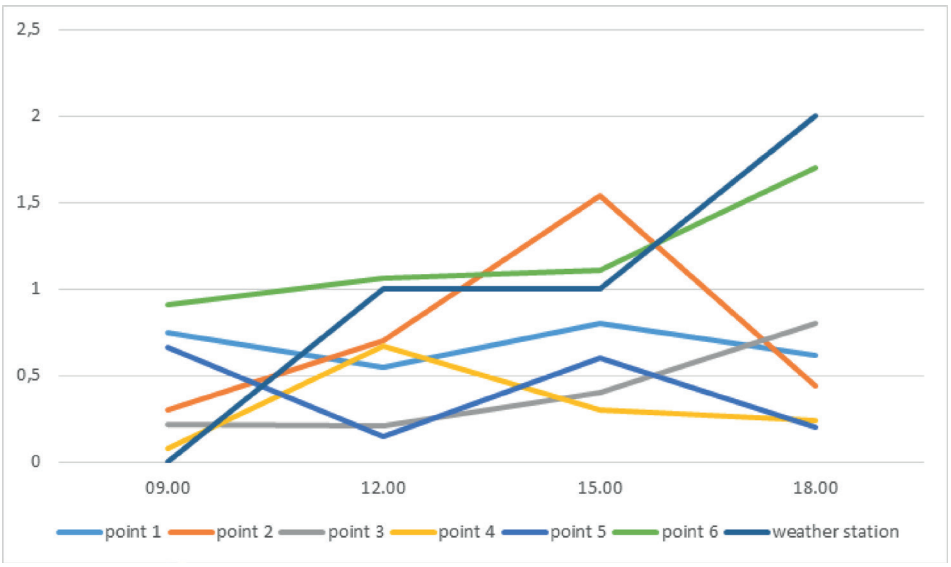

Fig. 5. Wind speed change schedule on March 20, 2015

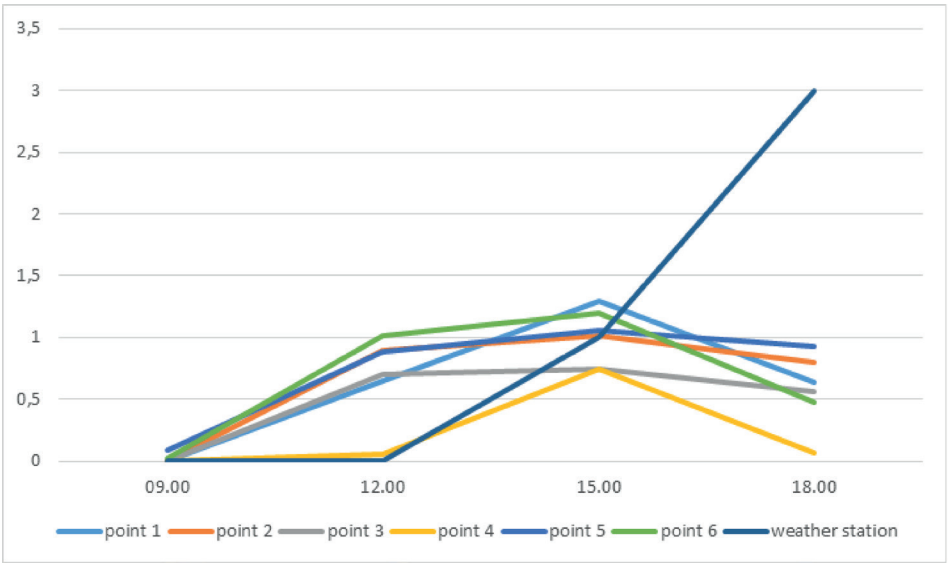

Fig. 6. Wind speed change schedule on April 3, 2015

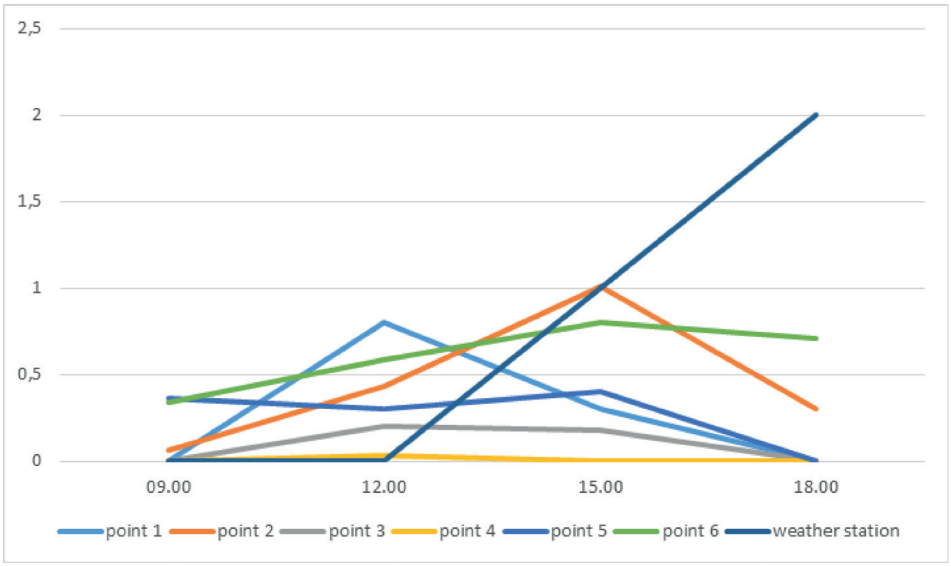

Fig. 7. Wind speed change schedule on May 19, 2015

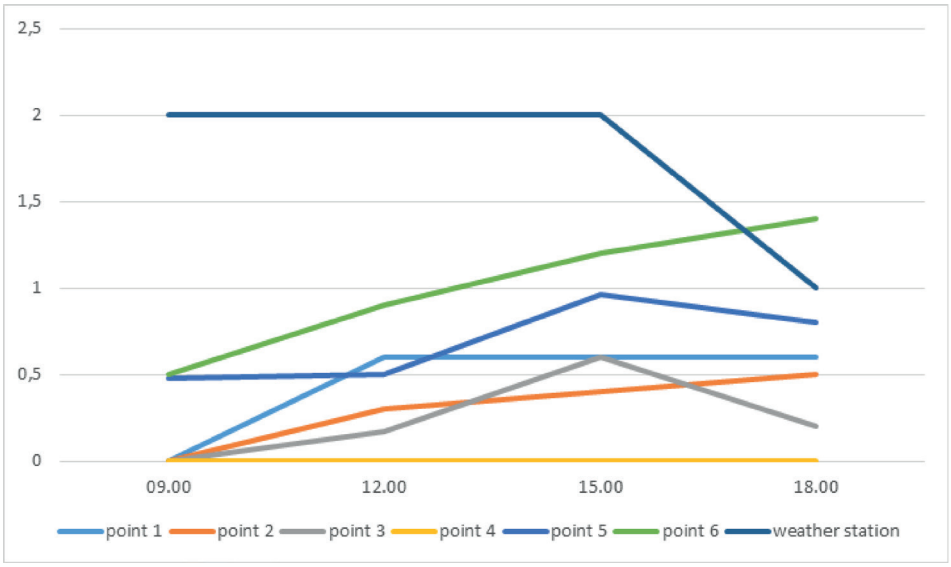

Fig. 8. Wind speed change schedule on May 20, 2015

lowest at sampling points 1 and 2, at the «Uman» weather station. The state of the sky is gloomy. On April 3, 2015, the amplitude of the daily movement was 30-40%. The highest relative humidity values were recorded (83-79%) at 9:00 a.m., and the lowest at 3:00 p.m. The state of the sky is slightly cloudy. On May 19, the amplitude of the daily movement averaged 20%. The maximum values were registered at 9:00 a.m., and the minimum at 3:00 p.m. at all observation points. The sky is clear. On May 22, the amplitude of the daily movement was about 15-20%. The maxima were registered at 9:00 a.m. and 6:00 p.m., and the minimum values of relative humidity were recorded from 12:00 p.m. to 3:00 p.m. (Figs. 9–12).

Conclusions. Thus, man-made landscapes are the factors of regional climate changes. This is a new active surface that determines the nature of the underlying surface as a climate-forming factor. It has an indirect effect on solar radiation and atmospheric circulation. But it most noticeably affects the distribution of climatic indicators at the nano- and micro-levels. Man-made landscapes change the temperature regime of the physical surface, affect relative humidity, wind speed, etc. On the example of landscape com-

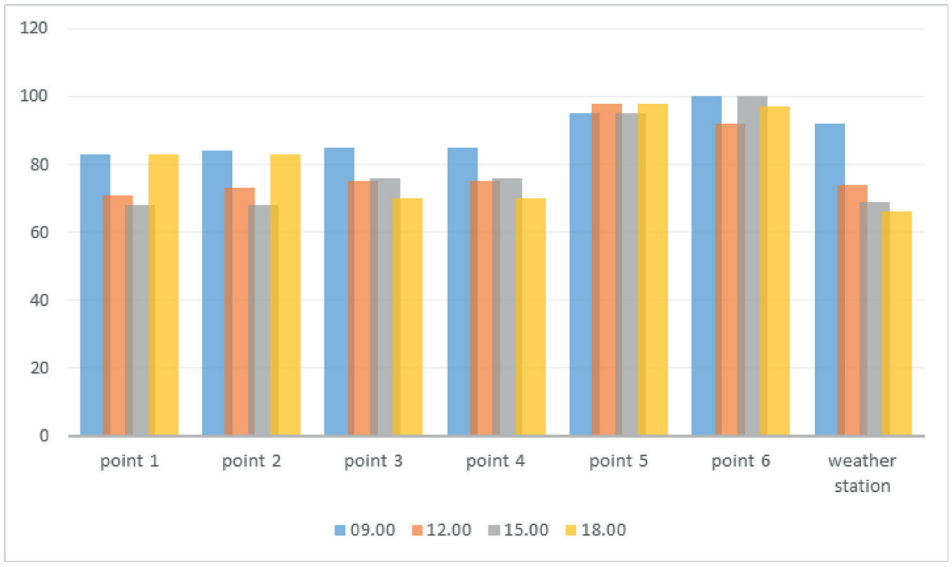

Fig. 9. Diagram of changes in relative air humidity on March 20, 2015

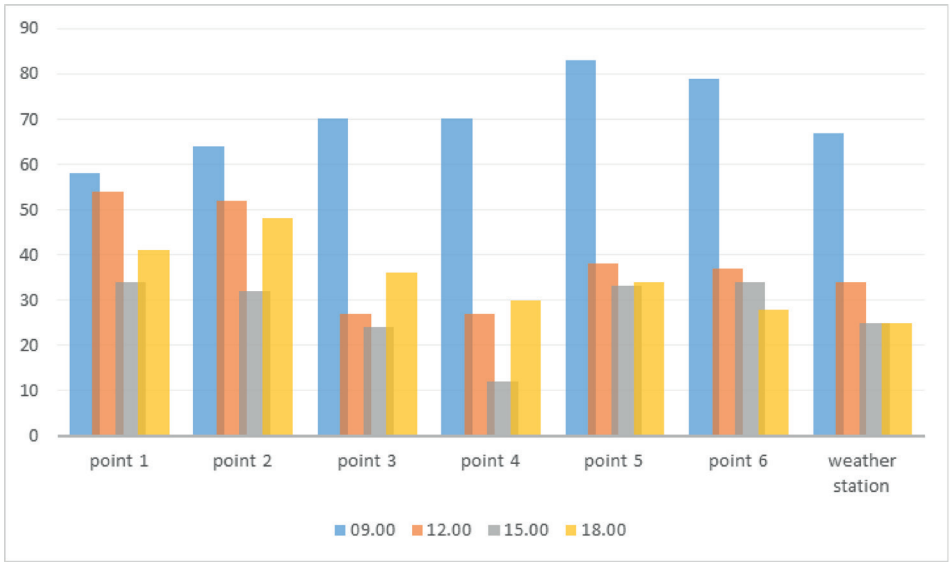

Fig. 10. Diagram of changes in relative air humidity on April 3, 2015

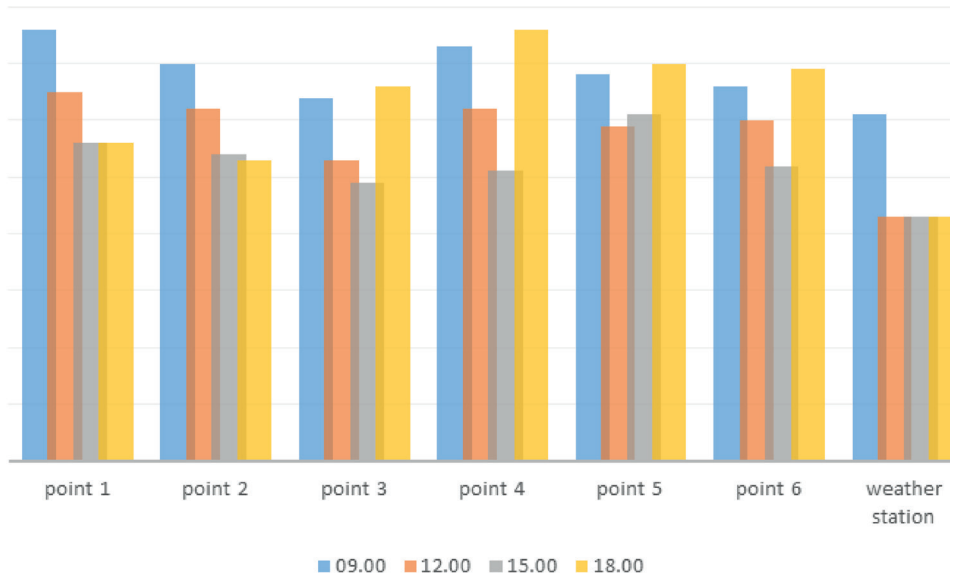

Fig. 11. Diagram of changes in relative air humidity on May 19, 2015

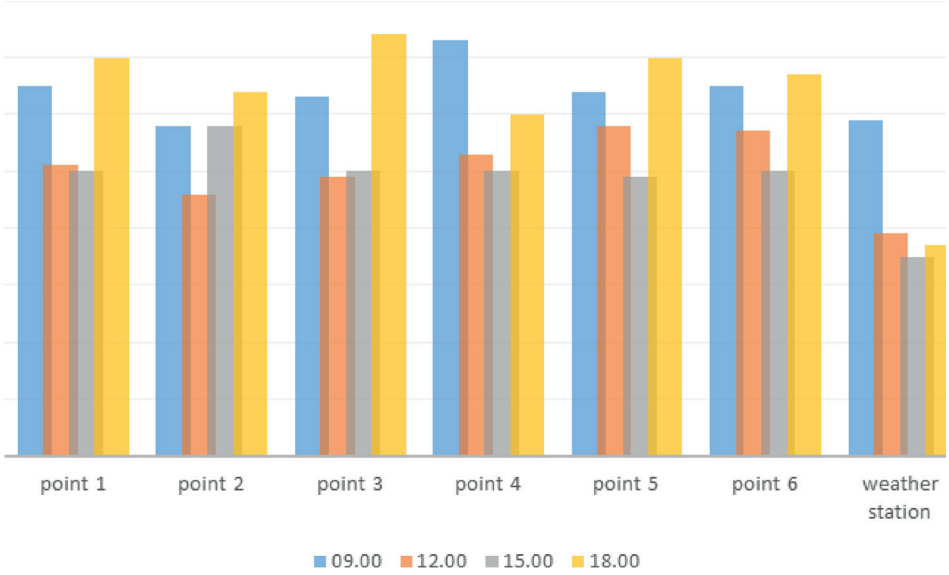

Fig. 12. Diagram of changes in relative air humidity on May 22, 2015

plexes at the local level of garden and park landscape organization of the National Dendrological Park « Sofiivka» of the NAS of Ukraine (Uman, Cherkasy Oblast, Ukraine), meteorological observations were made and data on changes in air temperature, relative humidity and wind speed at six natural points and benchmark meteorological station «Uman» in the spring period (March 20, April 3, May 19, May 22).

Man-made landscapes are components of the modern anthroposphere, the anthropogenic subsurface that has a direct impact on the microclimatic features of territories at the local and regional levels of organization. These are factors of intense regional microclimatic changes. Considering the degree of transformation of the modern physical surface of the Earth, it is worth speaking that today global climate changes are caused by the functioning of various classes and groups of man-made landscapes. Climate changes are the consequences of modern human activity, and the cause is a profound transformation of the planet's natural conditions and resources; intensive formation, functioning and development of man-made landscapes in the vast majority of cultivated ones. Perhaps today the level of human development has reached such a scale that the consequences of its influence, unfortunately, have a planetary character. However, the last thesis requires careful scientific research not only by landscape scientists, but also by the comprehensive work of geographers in various directions.

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