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ARTICLE

To the Question of the Assessment of Ecological Comfort of the Climate

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ABSTRACT

The article is devoted to the discussion of the advantages of assessing the environmental comfort of the climate, based on the natural features of the climate and the bioclimatic conditions of the territory. The study assessed the ecological comfort of the climate in the city of Taganrog on the basis of the developed original sequence of performing three stages of assessing the totality of bioclimatic indicators with the final calculation of the values of the integral indicator of the bioclimatic comfort of the climate. The results of the assessment showed, according to the average long-term climatic data, the presence of sub-comfortable climates with a tendency to transition to comfortable climate conditions in the warm period of the year. The cold season was distinguished by uncomfortable conditions according to long-term average climatic data. Modeling calculations of the possible risk to the health of city residents in the presence of concentrations of suspended solids in the surface air layer, together with carbon monoxide, exceeding the maximum one-time values by more than 7 times, showed that the development of possible resorptive or carcinogenic effects in these circumstances will occur in 1/3 the population of the city. The prospects for the assessment of the ecological comfort of the climate, which allow in the future to adequately calculate the magnitude of environmental risks to public health caused by pollution of the surface air layer, are shown.

1. Introduction

According to the authors of the study, at present, an assessment of the ecological state of a territory or a specific point object necessarily includes an analysis of all the components of the sources of pollutant release, as well as the pollutants themselves in terms of their environmental (toxicological, carcinogenic, mutagenic) hazard. However, the natural characteristics of the territory, mainly its climatic features, which make not only no less, but often even the greatest contribution to the ecological state of the area that is formed in the complex, taking into account anthropogenic activity, remain without attention. In this

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connection, as the analysis of a number of scientific studies shows, the environmental assessment carried out is not always objective and adequate to the conditions under consideration. In this regard, in order to eliminate the contradictions described above, in 2010 an approach was proposed based on the concept of ecological climate comfort, which allows taking into account the natural component of climatic and bioclimatic conditions and features of the study area [1].

As is known, in order to assess the biological impact of climatic conditions on human health and the state of ecological systems, already in the middle of the 20th century, a number of bioclimatic indicators were first developed and applied, which, among others, include indicators that allow assessing the total impact of groups of meteorological parameters, such as air temperature, air humidity, surface wind speed, atmospheric pressure, as well as the number of days with fogs, wind speeds of more than 6 m/s, with precipitation or lack of surface wind (calm), etc.

The concept and methodology for assessing the environmental comfort of the climate makes it possible to comprehensively take into account the environmental impact of not only bioclimate parameters, but also the level of pollution of the surface air layer of the study area [1]. In particular, based on the analysis and ranking of bioclimatic indicators in, it was found that the most informative bioclimatic indices (with an anthropocentric approach, if we focus on the impact on public health) include the following: BAP - biologically active temperature; ET - equivalent effective temperature; REET - radiation equivalent effective temperature; QS is the human heat balance; I - index of pathogenicity of the meteorological situation; KM - climatic potential of self-purification of the atmosphere [2].

Within the framework of the developed methodology for assessing the environmental comfort of the climate, it was proposed not only to carry out a phased assessment of all groups of the above bioclimatic indicators, but as a result, to calculate and analyze the value of the integral indicator of environmental comfort of the climate developed, IPBC, which allows comprehensively taking into account both natural climatic (bioclimatic) features of the study area, as well as parameters characterizing the level of pollution of its surface air layer in the first approximation [1].

2. Materials and Methods

To conduct this study, the authors proceeded from the concept of assessing the environmental comfort of the climate, which involves the implementation of a three-stage assessment of the parameters of the bioclimate, as well as the calculation of the integral indicator of the environmental comfort of the climate [1].

At the same time, at the first stage of the assessment, the thermal effect was considered and such parameters as ET - equivalent effective temperature were calculated; REET - radiation equivalent effective temperature; QS is the human heat balance [1]. In particular, “hard thermal impact of high or low temperatures “discomfort” could be observed at the value of the bioclimatic comfort score equal to “1”; with the value of the bioclimatic comfort score equal to “3”, “moderate thermal effects of high or low temperatures “subcomfort” were diagnosed; finally, with the value of the bioclimatic comfort score equal to “5”, comfortable thermal effects of high or low temperatures “comfort” were diagnosed.

At the second stage, the degree of pathogenicity of weather conditions (I) was assessed in the work, that is, the negative impact of a complex of meteorological conditions (including the value of surface atmospheric pressure, heliogeophysical factors, cloudiness, sudden changes in air temperature and atmospheric pressure per day). The following interpretation of the obtained results was accepted: “a high degree of pathogenicity of meteorological conditions “discomfort” could be observed with the value of the bioclimatic comfort score equal to “1”; with the value of the bioclimatic comfort score equal to “3”, the “medium degree of pathogenicity of meteorological conditions “subcomfort” was diagnosed; finally, with the value of the bioclimatic comfort score equal to “5”, a “low degree of pathogenicity of meteorological conditions “comfort” was diagnosed.

The third stage involved the evaluation of the potential for self-purification of the atmosphere (km). With the value of the bioclimatic comfort score equal to “1”, a low potential for self-purification of the atmosphere, “discomfort” was observed; with the value of the bioclimatic comfort score equal to “3”, the “average potential for self-purification of the atmosphere” subcomfort was diagnosed; finally, with the value of the bioclimatic comfort score equal to “5”, high potential for self-purification of the atmosphere “comfort” was diagnosed.

The integral indicator of bioclimatic comfort is determined as the sum of bioclimatic assessment scores obtained at three stages, according to the following formula:

$$IBK = \frac{\sum \mathrm{Ki} * \mathrm{B\ BK}}{\sum Ki} \quad (1)$$

in formula

I BK	–	integral indicator of bioclimatic comfort
Ki	–	informative coefficient
B BK	–	bioclimatic assessment score
i	–	bioclimatic index

It is important to note that the developed integral indicator [1], with the help of which an integral assessment is carried out, including intermediate 3 stages, is universal for any study area and makes it possible to identify such characteristics of climatic comfort as: comfort; discomfort and sub-comfort. This takes into account the important influence of natural, natural meteorological factors on health and life, as well as the possibility of reducing the pollution of the troposphere due to its potential for self-purification. Interpretation of the given integral index of IPBC practically repeats those described above, that is: with the value of the integral score of bioclimatic comfort equal to "1", "discomfort" is observed; with the value of the integral score of bioclimatic comfort equal to "3", "subcomfort" is diagnosed; finally, with the value of the bioclimatic comfort score equal to "5", the "comfort" of the environmental conditions of the climate is noted.

Reference data on the climate of the south of the European part of Russia, as well as a number of synoptic maps that are in the public domain, were used for the calculations.

3. Results

The assessment of the integral indicator of bioclimatic comfort on the example of the city of Taganrog, Rostov Region, showed, on the whole, quite comfortable environmental conditions of the climate (higher than "subcomfort"). So, for the warm season, the calculated value of the integral indicator of bioclimatic comfort within the city of Taganrog was 4.4 points, that is, according to the average long-term climatic data, a transition from "subcomfort" to "comfort" was established, which is higher than the values of the considered integral indicator of bioclimatic comfort for the neighboring the city of Rostov-on-Don (IPBK values were 3.2 points, "subcomfort"). The cold season for both the city of Taganrog and Rostov-on-Don was characterized by uncomfortable conditions, not exceeding the IPBC value of 1.2 - 1.0 points, respectively (Table 1).

From the data in the Table 1, it can be seen that for the city of Taganrog, the climatic conditions, especially in the warm season of the year, are distinguished by environmental comfort. In order to understand this situation, consider the geographical characteristics of the city's environs. So, as you know, the city is located in the northeastern part of the Miussky Peninsula, which juts out into the Sea of Azov. In the east, the territory of the city is limited by the Sambek River, and in the southeast and south it is washed by the waters of the Taganrog Bay of the Sea of Azov. The western border of the city runs along the Mius River, which ends with the Mius Estuary, connecting with the Sea of Azov 36 km from it. In fact, the city is located within the triangular cape of the Miussky Peninsula, surrounded by water from almost all sides of the shallow and well-heated Sea of Azov or its Taganrog Bay, as well as the Miussky Estuary.

It seems that these circumstances not only have a warming, but also a moisturizing effect on the climate of the adjacent territory. In addition, the proximity to the system of the Azov-Black Sea basin determines the intensive dispersion of impurities, including anthropogenic impurities in the lower air layer of the urban environment of Taganrog, since different environments (land-sea) with different physical characteristics cause heterogeneous atmospheric pressure fields and, as a result, significant changes in the values of the horizontal baric gradient. Anthropogenically caused impurities in the surface layer and the breeze circulation that is formed in this area have a very favorable effect on the dispersion. In addition to the coefficient of self-purification of the atmosphere, KM, within the framework of this study, the meteorological indicator of atmospheric pollution, MPA, developed in was also calculated and evaluated, the values of which recently also steadily show the predominance of dispersion conditions over the accumulation of impurities in the surface layer of the atmosphere [3-7].

Table 1. Comparative analysis of the indicators of the integral assessment of the environmental comfort of the climate for the cities of Taganrog and Rostov-on-Don

No.	Station	I stage of bioclimatic assessment				II stage	III stage	Meaning *I BK*, points
		BAT	*REET*	*ET*	*Qs*	*I*	*Km*	
		warm climate season of the year						
1.	Rostov-on-Don	20.6	19.8	9.4	–0.6	12.4	0.9	3.2
2.	Taganrog	21.2	20.6	10.3	–0.6	9.2	0.4	4.4
		cold climatic season of the year						
3.	Rostov-on-Don	5.0	–0.4	–14.9	–1.6	25.9	1.3	1.0
4.	Taganrog	6.1	0.9	–13.3	–1.5	24.7	1.4	1.2

4. Discussion

It seems to the authors that the very favorable conditions for the environmental comfort of the climate of the city of Taganrog in the warm season of the year are explained, on the one hand, by a significant warming of the air in the warm season, which, however, is compensated by the moistening and reducing the heat load by the influence of the Sea of Azov. It is the breeze circulation in the warm season that reduces the likelihood of dry days with calm, when an intensive accumulation of impurities in the lower layer is possible. More precipitation falls in July, during the warm season of the year, which also contributes to an increase in the self-purification coefficient of the atmosphere.

The discomfort of winter conditions within the city is explained, apparently, not only by possible breakthroughs of the Arctic air masses both in the rear of the Atlantic cyclones and in the form of spurs of the Arctic High. But, also with an increased probability of calm weather (1/3 of all studied cases of calm weather was observed in winter - in early spring, in the first quarter of the year), which were more often set at night, contributing to the accumulation of impurities in the lower atmosphere. In addition, the minimum amount of precipitation in autumn and winter reduces the self-cleaning ability of the atmosphere within the city.

According to the authors, the results obtained are not only of theoretical significance, expanding the limits of knowledge about the biological aspects of the impact of climate on the human body and its environment, but also of undoubted practical value, making it possible to apply the findings to planning the modes of work and rest of the population. In this regard, it seems very promising to further consider at the next stage of research the role of anthropogenic factors that affect the level of pollution of the surface air layer, since the increase in the optical turbidity of the air layer at a level of 2 m from the surface, as well as the appearance of a number of toxic and carcinogenic substances in the air of the urban environment can cause very significant environmental risks to public health. So, for example, within the framework of this study, an assessment of a possible health risk in the presence of concentrations of suspended solids in the surface air layer together with carbon monoxide exceeding, say, the values of the maximum single maximum permissible concentration by more than 7 times showed that the development of possible resorptive or carcinogenic effects in these circumstances will occur in 1/3 of the population of the city of Taganrog.

5. Conclusions

Thus, as a result, of the assessment of the environmental comfort of the climate, as well as the calculated values of the possible environmental health risk, including carcinogenic health risk, the following results were obtained, which made it possible to formulate the main conclusions of the study:

1) Natural characteristics, among which climatic and bioclimatic features play a leading role, the cities of Taganrog are extremely favorable. The territory of the city is washed by the waters of the warm and shallow Sea of Azov, which has a warming and moisturizing effect, and also determines the specifics of the local circulation of air masses.

2) The assessment of the ecological comfort of the climate in the territory of Taganrog showed, according to the average long-term climatic data, the presence of sub-comfortable climates with a tendency to transition to comfortable climate conditions in the warm period of the year. The cold season was distinguished by uncomfortable conditions according to long-term average climatic data.

3) Modeling calculations of a possible health risk in the event of the presence in the surface air layer of concentrations of suspended solids together with carbon monoxide exceeding, say, the values of the maximum one-time maximum permissible concentration by more than 7 times showed that the development of possible resorptive or carcinogenic effects in the indicated circumstances will occur in 1/3 of the population of the city of Taganrog.

Author Contributions

All authors of this article took an equal part in writing it: they formulated the idea, carried out calculations, wrote the text, and took care of the design of the article.

Conflict of Interest

There is no conflict of interest.

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