

## Study of the influence of large forest areas on the quality of the city's air environment (on the example of Barnaul, Russia)

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### ABSTRACT

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The purpose of the article was to study the degree of influence of large forest areas on the quality of the city's air environment. The geomorphological signs of the formation of qualitative parameters of the city's air environment in connection with the orographic features of the area were studied. The influence of natural factors and the location of the city on the quality of the air environment were determined, which made it necessary to conduct further scientific research. The geographical features of the formation of the qualitative composition of the air environment of cities located in certain conditions, taking into account natural factors and urbanization processes were determined. The locations of industrial and residential areas of Barnaul and the ribbon-like forest near the city, the Ob River, were determined using interactive maps of GPS subsatellite surveillance. The main direction of the wind rose and the processes of atmospheric air saturation with oxygen and humidification were determined. The regularities of the deterioration of the qualitative indicators of the city's air environment in individual districts were determined. Original solutions were proposed to improve the quality of the air environment in certain urban areas (on the example of Barnaul). The author's studies of the influence of natural factors and urbanization processes on the quality of the city's air environment (using the example of Barnaul) have shown that dangerous zones of accumulation of pollutants are being created against the background of unjustified economic activity, in particular construction.

**Keywords:** Natural factors, Urbanization processes, Pollution, Ways of improvement, Quality indicators

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### 1. Introduction

Recently, an important role in determining the impact of urbanization processes on geosystems, in particular on the quality of the air environment, has been played by the study of environmental conditions using maps, especially the use of satellite maps, GIS and other information systems [1-3]. Urban air pollution is a major environmental problem of our time [4-6]. The reasons that create the possibility of accumulation of harmful substances in the atmospheric air are different. These are geographical reasons, the location of settlements in mountain systems, intermountain basins and the reasons associated with the processes of urbanization, these are emissions of the heat and energy complex and motor transport, as well as unjustified, from an ecological point of view, economic activity, in particular construction [7-14].

One of the most powerful natural sources of confrontation with urban air pollution are adjacent large forests located in the main directions of the wind rose or park areas and squares located directly in urban ecosystems [15, 16]. The trees and shrubs located there repeatedly reduce the amount of carbon dioxide in the atmospheric air, processing it into oxygen, reduce the amount of heavy metals and a large amount of dust by the leaf

surface [17-19]. The possibilities of improving the issues of environmental safety of the air of urbanized geosystems, for various conditions, have been repeatedly considered in the works of the author [20-26].

The object of the study is the air environment of individual urban areas on the issues of pollution and quality deterioration. The purpose of the study is to study natural factors (the presence of large forest areas and the geographical location of certain areas of the city (on the example of Barnaul) and the processes of urbanization, in particular, construction that is unjustified from the ecological field, affecting the quality of the air environment.

## 2. Materials and methods

Natural factors were studied using geographical, cartographic, historical methods, as well as remote observations (satellite technologies, geoinformational Internet resources: interactive map of Russia with heights, etc.). Statistical data from the following official sources were used for the research: The Federal State Statistics Service of Russia, CJSC "Regional Information Center" of Russia, official websites of subjects of federal districts and their municipalities, Annual state reports "On the state and protection of the environment in Russian Federation", annual collections "Social status and standard of living of the population of Russia" [27].

The presence of large forest areas adjacent to urbanized geosystems (cities), if they are located in the main directions of the wind rose, is a powerful source of oxygen supply to urban neighborhoods. It is known that the percentage of oxygen in the atmospheric air over one hectare of forest is up to 80 %, and over ordinary urban areas with weak landscaping up to 20 %. It turns out that there is almost a four-fold excess between these volumes of oxygen masses in the atmospheric air. Barnaul was chosen as a model city for research. In time, the head of the ribbon-like forest near Barnaul was destroyed for the construction of residential quarters (Figure 1); the wind rose (Figure 2). According to long-term statistical data, this territory is considered unfavorable in terms of the environmental situation in terms of air quality. Figure 3 shows a cartogram of the real environmental situation in relation to the air quality of Barnaul.



Figure 1. The ribbon-like forest near the south-western outskirts of Barnaul

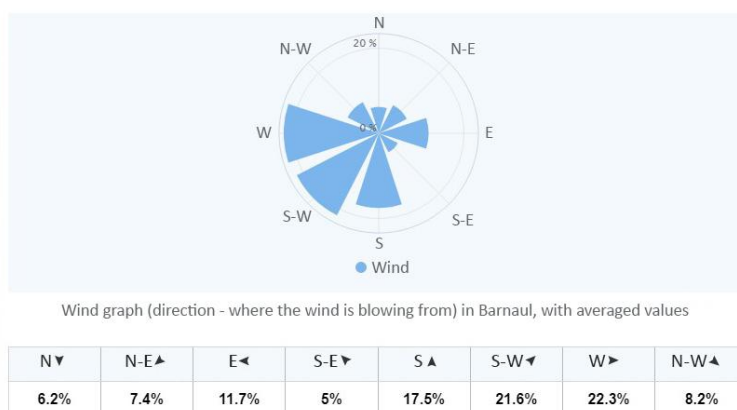


Figure 2. Wind Rose, Barnaul



Figure 3. A cartogram of the real environmental situation

*Notes: a) a section of a ribbon-like forest that has gone under the development of the central districts of Barnaul; b) the main directions of the wind rose; c) an oxygen plume; d) a humidity plume; e) city districts with a favorable environmental situation in terms of air quality (industrial areas); f) city districts with an unfavorable environmental situation in terms of air quality (residential areas)*

From the resulting area cartogram, the following is obvious:

- a) The head (area) of the ribbon-like forest to the border of the Ob River was destroyed for the construction of the central districts of the city.
- b) The main annual directions of the wind rose are western, southern and south-western.
- c) The main direction and area of the oxygen plume from the ribbon-like forest is formed in the south-western industrial areas of Barnaul.
- d) A moisture plume is formed from a water body – the Ob River, covering part of the ribbon-like forest in all areas in the south-western direction.
- e) Main areas (square) Barnaul prosperous as to the quality of the air environment are located in the technical (industrial) zone, due to the coincidence with an area of oxygen and moisture plume (areas c, d, e) [28].
- f) The most unfavorable environmental conditions on the quality of the air environment are in the Central area of the city because of the coincidence with the ribbon-like forest, destroyed during construction (square a, f). The volume of oxygen that should have been supplied to these areas of the city has been reduced by 4 times.

### 3. Results and discussion

Thus, the results of the study of natural factors and the location of the city and individual urban areas (on the example of Barnaul), the processes of air mass movement allowed us to identify patterns of formation of an environmentally high-quality air environment and an unfavorable situation in this regard, created by unjustified human economic activity, in particular – construction [29, 30].

Geotechnical, organizational and technical proposals for the restoration of the ecological situation with regard to the quality of the air environment in the central districts of Barnaul:

1. Creation of geotechnical structures, park zones and squares, which will maximally compensate the loss of a part of the ribbon-like forest and, accordingly, the volume of necessary oxygen.
2. Creating the maximum number of pedestrian zones instead of motor vehicles.
3. Transfer stationary boilers running on coal fuel to gas fuel [31].

Based on the proposed method for assessing the quality of the air environment of a model urbanized geosystem (Barnaul), an integral criterion of environmental safety (a mathematical model) has been developed. Since the analysis of data characterizing the state of the atmospheric air of the studied territories takes into account the influence of several indicators, therefore, when assessing the level of self-saturation of

atmospheric air with oxygen and humidification, they should be based on an integral (general) criteria of environmental safety. The summation of the following values is proposed:

$\sum_{k=1}^n Ci(O_2)$  – the concentration of oxygen and impurities released into the atmospheric air of the city from sources generated by the  $i$ -types of the object (park zones and squares) that form the current flow of emissions;

$\sum_{k=1}^n Ci(\varphi_H)$  – increase in humidity and impurities entering the atmospheric air of the city from the water area (river), forming humidifying streams.

The following restrictions are introduced for the mathematical model:

- 1) for the conditions of geosystems with a large forest area in the main direction of the wind rose.
- 2) for the conditions of urbanized geosystems with a large forest area destroyed in the main direction of the wind rose.
- 3) for the conditions of urbanized geosystems with a restored large forest area in the main direction of the wind rose.

The integral criterion of environmental safety for assessing the air quality of urbanized geosystems with a restored large forest area in the main direction of the wind rose (mathematical model) is proposed to be determined by the formula:

$$\sum_{k=1}^n Ci = \sum_{k=1}^n Ci(O_2) + \sum_{k=1}^n Ci(\varphi_H) \rightarrow \max, \quad (1)$$

Figure 4 shows a cartogram of the environmental situation in relation to the air quality of Barnaul after the implementation of geotechnical proposals



Figure 4. A cartogram of the environmental situation after the implementation of geotechnical proposals

Notes: a) a section of ribbon-like forest restored during the construction of geotechnical structures (parks and squares); b) the main directions of the wind rose; c) oxygen plume; d) humidity plume; e) city districts with a favorable environmental situation in terms of air quality.

#### 4. Conclusions

As a result of the conducted research, it was found that the quality of the air environment of the central districts of Barnaul was particularly affected by the destruction of a part of a large forest area for construction, namely a ribbon-like forest located in the main directions of the wind rose, which is a powerful supplier of oxygen masses. It is established that the water body, namely the Ob River, is located in relation to the city and the main directions of the wind rose, is a constant supplier of humidity to the central districts of the city. It is obvious that the very location of the ribbon-like forest and the water body (the Ob River) creates a giant natural air conditioner for all the studied areas of the city.

It is proposed to implement certain proposals to restore the environmental situation with regard to the quality of the air environment in the central districts of Barnaul: – creation of geotechnical structures, park areas and squares maximally compensating for the loss of a part of the belt boron and, accordingly, the volume of necessary oxygen; – creating the maximum number of pedestrian zones, instead of motor vehicles; – to transfer stationary boiler houses running on coal fuel to gas fuel. All these measures correspond to the priority direction of the Concept of long-term socio-economic development of the Russian Federation for the period up to 2030, the direction of creating favorable living conditions for the country.

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