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THE INFLUENCE OF TERRAIN, CLIMATIC CONDITIONS AND FACTORS ON THE ATMOSPHERIC AIR MONITORING SYSTEM, BASED ON THE IMPLEMENTATION OF EU LEGISLATION ON THE EXAMPLE OF LVIV REGION

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Abstract. The article is devoted to the influence of terrain, landscapes, and meteorological conditions on the establishment of air quality monitoring points in the relevant territory of the Lviv region. The main factors affecting the distribution of the concentration of pollutants in atmospheric air during the design of air monitoring stations have been determined. It was established that the level of the surface concentration of pollutants increases with an increase in the power of the emission source, the density, and size of impurity particles, and decreases with an increase in the height and radius of the orifice of the emission source, the temperature of the emission, and the rate of release of impurities from the source.

Keywords: terrain, landscape, meteorological conditions, atmospheric air, Lviv region, wind direction.

1. Introduction

To implement the requirements of Directive 2008/50/EU, in 2019, Ukraine must fully bring its national legislation on atmospheric air quality closer to EU requirements. The implementation of the Resolution provides for the implementation of requirements for the implementation of Ukrainian legislation to EU law in the field of environmental protection, respectively (Constitution of Ukraine, 1996; Law of Ukraine, 1991).

On September 5, 2019, Resolution №827 of the Cabinet of Ministers of Ukraine dated August 14 “Some issues of state monitoring in the field of atmospheric air protection” came into force, approving the new Procedure for state monitoring in the field of atmospheric air protection (hereinafter referred to as the Procedure).

The Procedure defines the mechanism of organizing and implementing state monitoring in the field of atmospheric air protection, the interaction of executive authorities in the process of such monitoring and providing the specified authorities with information for making decisions related to the state of atmospheric air and informing the population about such a state (Postanova Kabinetu ministriv Ukrainy, 2019).

For the purposes of atmospheric air monitoring and atmospheric air quality management, the territory is divided into zones and agglomerations. The

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Procedure defines 25 zones (the boundaries of the zones coincide with the boundaries of the respective administrative territorial units) and 24 agglomerations (the boundaries of the agglomerations coincide with the boundaries of the respective cities).

Regional state administrations and city councils, which perform the functions and powers of local self-government in the territory of the relevant agglomeration, within the framework of fulfilling the requirements of the resolution, first, it is necessary to define within its composition a structural unit or an executive body that will perform the functions of an atmospheric air quality management body, publish this data in mass media (Onyščenko, 2017; Law of Ukraine, 1992).

Currently, there is not a single scientific research institute, agency, besides, the territorial bodies of the Ministry of Environment have been liquidated.

Also, establishment by regional state administrations, executive bodies of city councils of observation points and monitoring of the levels of pollutants specified in the Procedure in list A, item 1 of appendix 2, within the territory of the relevant zone or agglomeration, considering that the structural subdivisions of the regional state administration do not have the availability of specialized sampling laboratories, specialists for sampling and conducting observations (Postanova Kabinetu ministriv Ukrainy, 2019).

The next stage is the creation of committee for state monitoring in the field of atmospheric air protection and atmospheric air quality management.

Within a year, it is necessary to develop state monitoring programs in the field of atmospheric air protection and submit them for approval to the Ministry of Environmental Protection and Natural Resources and approve them by regional and city councils.

In accordance with the above, there are tasks that must be solved.

1. Development of a draft strategy for improving atmospheric air quality.

2. Preparation and implementation of pilot projects for monitoring the level of emissions of pollutants into the atmospheric air at the sources of emissions and the implementation of modern systems for their purification at the enterprises of economic entities, the consequence of whose production activities are the emissions of pollutants into the atmospheric air.

3. Implementation of the European air quality assessment model, development of air quality improvement plans for zones and agglomerations in which pollution levels exceed any of the limit values or any target indicator or there is a risk of such an exceedance.

2. Theoretical part

2.1. The influence of terrain, landscapes, and meteorological conditions on the establishment of air quality monitoring points in the relevant territory of the Lviv region.

2.1.1. Influence of terrain

The Lviv region (zone) located in the extreme west of Ukraine within the boundaries of the Volyn and Podilsk highlands and crosses three natural zones: forest, forest-steppe, and the Carpathian high-altitude zone. The territory of the Lviv region has a diverse relief and is divided into several geographical regions, differing in geological structure, height above sea level and fragmentation.

There are eight natural regions on the territory of the zone – the mountainous Carpathians in the south, to which the Precarpathian Upland adjoins, the Podillia Upland (plateau) in the central part, Male Polissia and the Volhynian Upland – in the north. In the southern part of the Lviv zone are the Ukrainian Carpathians (Fig. 1). According to the nature of the relief, they belong to medium-high mountains, their slopes are gentle, the peaks are smoothed. Within the borders of Lviv Oblast, the mountain ranges extend in parallel strands from the northwest to the southeast up to 60 km in length and 65 km in width. The ridges are dissected by deep transverse and longitudinal valleys of the Dniester, Stryi rivers and their tributaries.

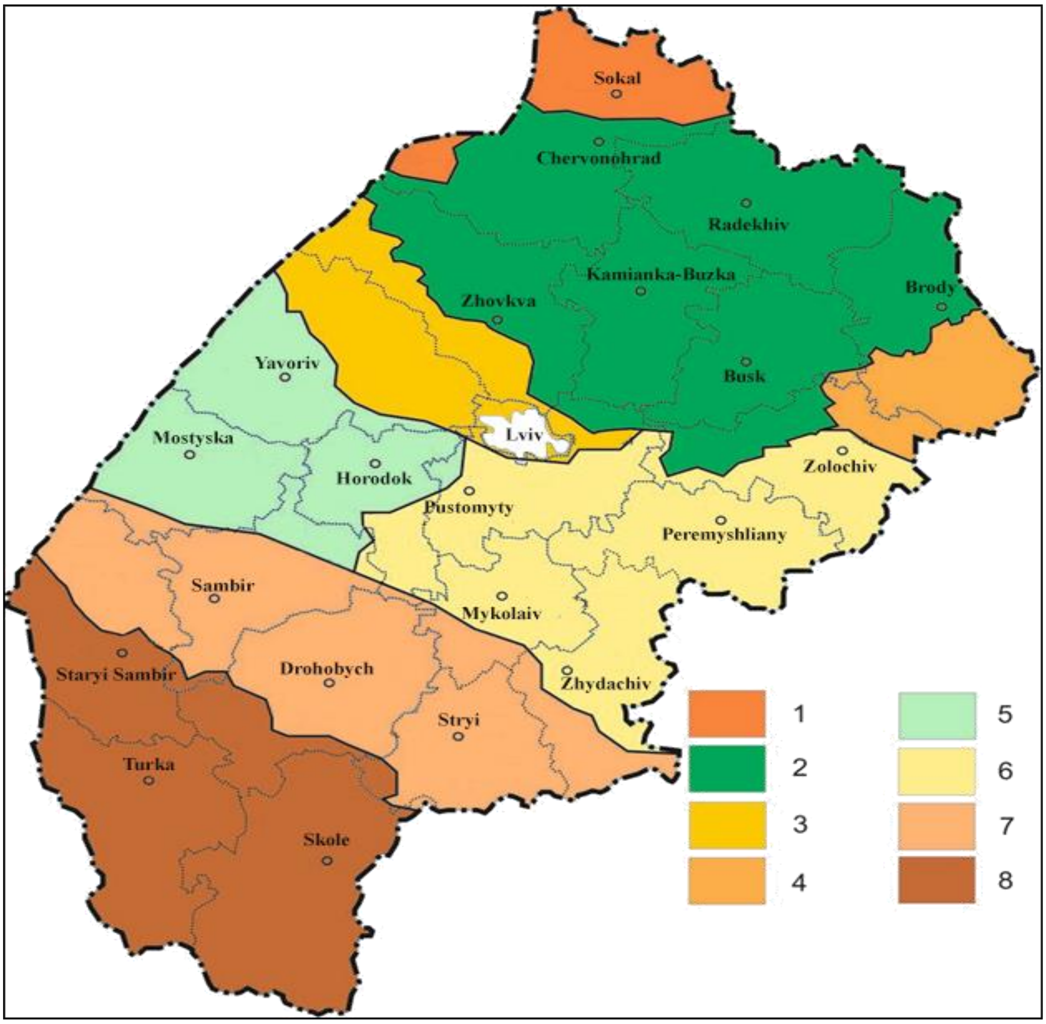

Fig. 1. Physical and geographic zoning of the Lviv region: 1 – Volyn upland; 2 – Male Polissia; 3 – Roztochchya; 4 – spurs of the Podilsk Highlands; 5 – Nadsyan plain; 6 – Opillia; 7 – Precarpathia; 8 – Carpathians

Within Lviv Oblast, the Ukrainian Carpathians are divided into the following natural areas: Upper Dniester Beskids, Skole Beskids, Striysko-Syanskaya Verkhovina and Verkhovynsky watershed ridge. The highest points of the territory are Mount Pikuy (1405 m) on the border with Zakarpattia Oblast and Mount Kamula (471 m) in the plain part. The most picturesque in the Carpathians are the Parashka (1271 m), Trostyan (1235 m), Zelemin (1167 m), Yavirnyk (1123 m) ridges.

2.1.2. Influence of climatic conditions and winds

The climate is temperate continental, humid: mild winter with thaws, wet spring, warm summer, warm dry autumn. The annual amount of precipitation varies from 600 mm on the plain to 1000 mm in the mountains.

The coldest month of winter in the region is January, the average monthly temperature of which is 2–3 °C lower than in December. The lowest average January air temperatures of -6.1…-6.6 °C are observed in the Carpathians. All winter months are characterized by high variability of air temperature.

The average annual air temperature in the region is 5.2-8.0 °C. The amplitude of annual fluctuations is from 20.7 to 23 °C. The value of the annual amplitude (the difference between the temperatures of the coldest and warmest months) increases to the east, which indicates the growth of the continental climate of the region in this direction.

The climatic conditions of the Carpathians are diverse and are characterized by significant instability in height, square and time, characteristic vertical zonation. In the part of the watershed, the conditions are more severe, in Precarpathia they are somewhat milder. The average air temperature in Precarpathia is +7...+8°C, in the mountainous regions of the Carpathians – +3...+6°C.

The amplitude of the monthly temperatures ranges from +20 to +24 °C and decreases with the ascent to the mountains.

Western and north-western winds prevail throughout the year. In the cold period of the year, eastern air masses prevail. North-western and western cyclones cause intense snowfall. Often, the change of air masses in the spring causes an unstable weather regime. In summer, western, and north-western cyclones cause showers and prolonged rains. In October and November, western cyclones cause precipitation, ice and strong wind, frequent periods of warming. The cold period is characterized by gloomy weather, fog, and thaws, during which the average daily temperature rises to +5 °C and above. In summer, the activity of cyclones subsides, the temperature regime becomes more stable. The warmest month is July, the average temperature is +17...+18°C, the coldest is January (-4...-6°C). The sharpest decrease (to -38...°C) occurs under the influence of stationary anticyclones from the north. The absolute maximum temperature is +36°C.

The precipitation regime is characterized by an excess of precipitation over the amount of evaporation. Alternation of dry years and years with excessive precipitation (Fig. 2).

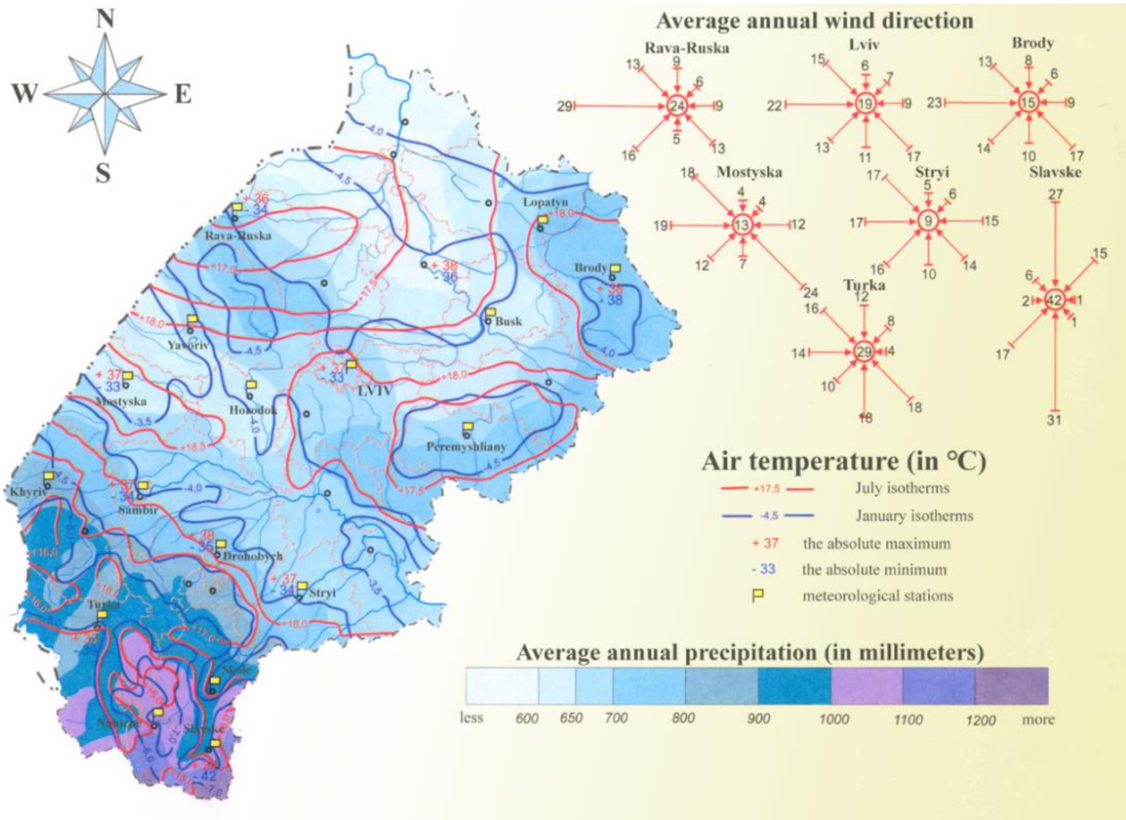

Fig. 2. Climate map of Lviv region

Table 1

Repeatability of wind direction and calm for the period 1991-2020 at weather stations of the Lviv region

1. Rava-Ruska								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
11.0	5.2	8.8	12.7	5.5	14.7	31.2	10.9	14.4
2. Kamianka-Buzka								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
3.7	7.0	13.3	13.5	12.6	14.5	25.1	10.3	11.4
3. Drohobych								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
6.0	6.0	17.8	7.0	12.9	14.3	26.2	9.8	31.8
4. Stryi								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
6.6	3.2	15.2	7.8	13.7	10.2	27.2	16.1	29.9

Table 2

Repeatability of wind and calm direction for 2020 at weather stations of the Lviv region

1. Rava-Ruska								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
13	5	4	12	7	12	39	8	10
2. Kamianka-Buzka								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
6	4	10	11	17	12	29	11	22
3. Drohobych								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
5	5	19	5	17	12	24	13	30
4. Stryi								
North	Northeast	East	Southeast	South	Southwest	West	Northwest	Calm
6	3	6	17	17	16	11	24	24

*Wind direction for populated areas, determined based on long-term observations of weather stations in the Lviv region.

According to the wind rose, the influence of prevailing winds should be considered – winds that blow mainly in one direction in a certain area (Pljacuk, 2011). Prevailing winds are mostly part of the global picture of air circulation in the region's atmosphere. According to the above-mentioned factors of influence of changes in relief, temperature, speed, and wind direction, it follows that prevailing winds prevail in Lviv region: westerly and southwestern, partly easterly in the territory of Drohobytsky district of Lviv region (Fig. 3).

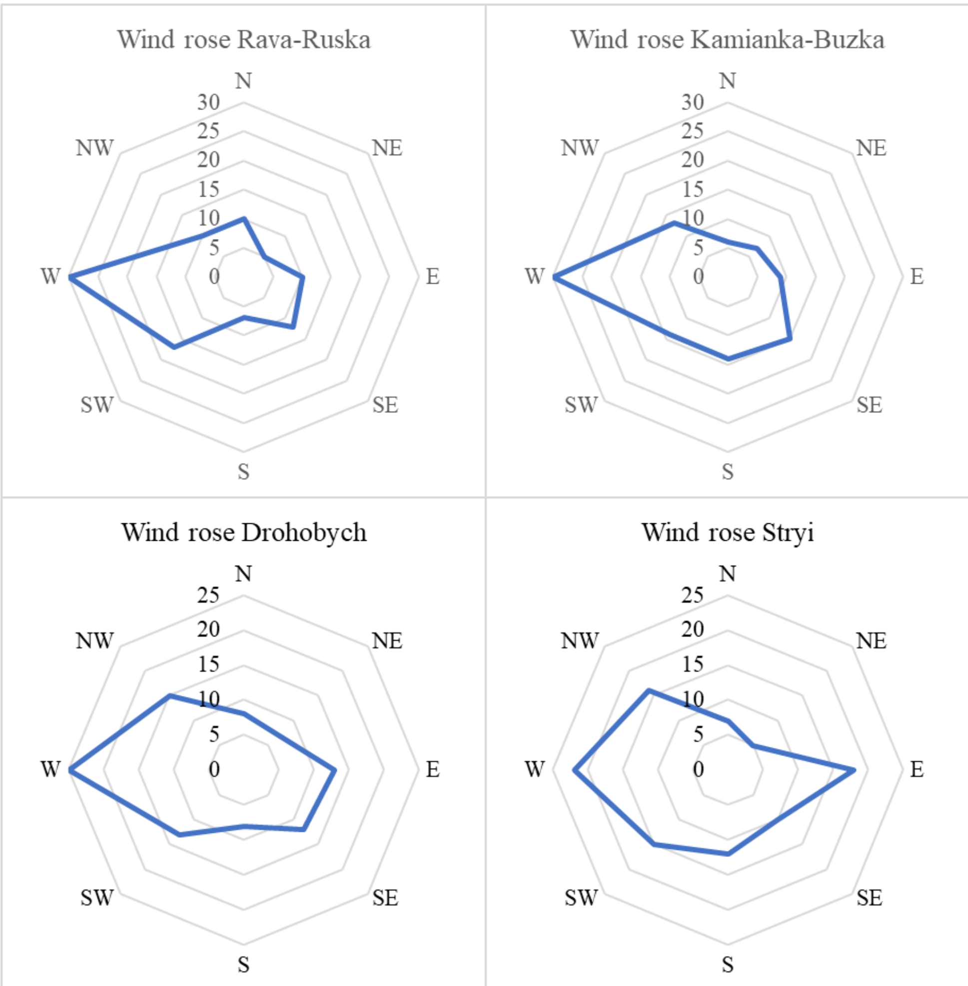

Fig. 3. Wind rose at weather stations of Lviv region and Lviv agglomeration*

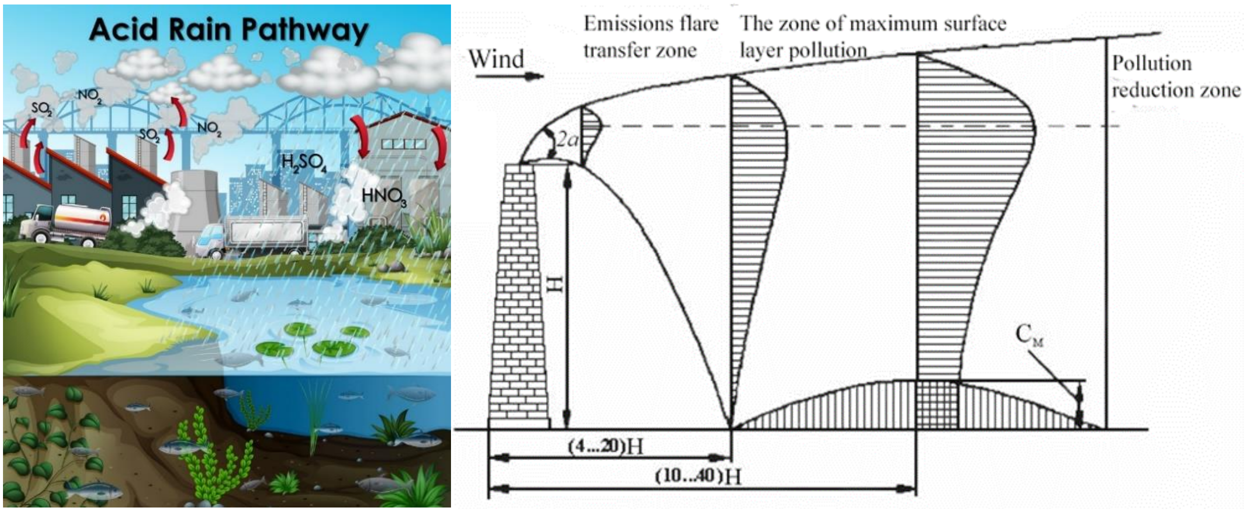

Fig. 4. Meteorological pollution that affects the quality of atmospheric air and the distribution scheme of the concentration of harmful substances in the atmosphere under the torch of an organized emission source

Also, the spread of impurities in the atmosphere and thereby the surface concentration level is affected by fog, precipitation, and solar radiation (Fig. 4).

Under the influence of fog, air pollution increases. Fog droplets absorb harmful substances both near the surface and from higher polluted air layers. As a result, the concentration of impurities increases strongly in the fog layer and decreases above it (Docenko & Demydenko, 2014; Kovalʹčuk et al., 2004).

Atmospheric precipitation plays an important role in the process of self-cleaning of the atmosphere. Raindrops or snowflakes capture dust particles and carry them to the surface of the earth. The more precipitation, the cleaner the atmosphere. However, precipitation becomes a source of contamination of soil and surface water bodies with harmful substances.

Solar radiation causes photochemical reactions in the atmosphere with the formation of various secondary products, which often have more toxic properties than substances emitted by pollution sources.

In addition, during diffusion, impurities may undergo changes in physical properties due to coagulation – the fusion of particles.

In the real atmosphere, the emissions of industrial enterprises are exposed to the action of the entire complex of meteorological factors, which determines one or another level of pollution. The combination of meteorological conditions that contribute to the accumulation of impurities in the atmosphere is usually called the meteorological potential of atmospheric pollution, and the combination of factors that cause dispersion is called the dispersive capacity of the atmosphere (Snižko & Ševčenko, 2011; Sonʹkyn, 1991). The influence of different components of the meteorological potential depends on the location of the sources, emission parameters, and the repeatability of its components. The greater the repeatability of adverse conditions, the more often impurities accumulate and the higher the average level of pollution.

The repeatability of conditions favorable for the dispersion of impurities varies significantly throughout the year and from year to year. Depending on the type of sources and the nature of their location on the territory of the city, the variability of the impurity concentration, which is due to changes in meteorological conditions, can be very significant. The role of meteorological conditions in shaping the average level of pollution can sometimes exceed the role of the quantity and composition of emissions (Bojko & Pljacuk, 2010; Korhanbajev, 2005).

3. Conclusions

Based on the results of the research, it was established that when designing atmospheric air quality monitoring stations, the most determining factors influencing the distribution of the concentration of pollutants in atmospheric air as a result of emissions from polluting objects are: mode and conditions of emission, type of source (point, linear, site), wind direction and speed, state of the atmosphere, chemical interaction with other substances in the atmospheric air, gravitational deposition, leaching by precipitation, absorption by the underlying surface, roughness of the underlying surface, terrain relief.

It was established that the level of the surface concentration of pollutants increases with an increase in the power of the emission source, the density and size of impurity particles, and air temperature, and decreases with an increase in the height and radius of the mouth of the emission source, the temperature of the emission, and the rate of exit of impurities from the source. The dependence of the concentration of pollutants on the wind speed is non-linear. Therefore, their installation on the leeward side of pollution objects (industrial and transport intersections) should be considered.

The obtained results are the first stage of the development of information and technical methods for establishing atmospheric air quality checkpoints caused by chemical pollution of the atmospheric air from pollution objects, and will be used in the future for the implementation of the second stage - the development of mathematical models of the distribution of polluting impurities in the atmospheric air from the emissions of enterprises – the biggest polluters, pollution along highways and roads.

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