Component composition of atmospheric dusts as a characteristic of environmental pollution

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Abstract. Air pollution from urban areas by solid dust particles potentially affects the level of chemicals in the soils of the surrounding area. Under the influence of gravity, solid particles settle, fall out in the form of rain and snow. The chemical composition of solid particles of atmospheric air contains a multicomponent mixture containing both organic and inorganic impurities, including extremely and highly dangerous ones. Based on the example of three central regions of Perm, comprehensive studies of the solid component of atmospheric air are carried out. The studies included determining the concentration levels of suspended solids and fine fractions PM10 and PM2.5, studying the component composition, forming a profile of solid particles and studying the morphological properties of the identified particles. During the study, an averaged profile of dust particles was formed, which is characterized by a wide range of chemicals, including: oxides of iron, calcium, silicon, aluminum, etc. The multicomponent nature of dust pollution of atmospheric air is confirmed by morphological features, solid particles are represented by a wide range of forms and various structures. Based on the results of the studies, proposals are made for the organization of environmental monitoring based on a detailed study of the component composition and inclusion of fine fractions PM10 and PM2.5 in the atmospheric air monitoring system of Roshydromet.

1. Introduction

Air pollution is one of the main factors of human impact on the environment. His condition remains unsatisfactory, which is primarily due to growing emissions of industrial facilities and an increase in the number of road transport. In 44 cities of the Russian Federation (21% of the number of cities with regular monitoring of air pollution) with a total population of 13.5 million people (12% of the urban population of the Russian Federation), the level of air pollution was characterized as high and very high (IZA> 7). More than half of them are located in the Siberian Federal District, where large enterprises of ferrous and non-ferrous metallurgy, as well as timber, woodworking, fuel, petrochemical, oil and gas, chemical industries are concentrated.

The tasks of improving the quality of atmospheric air in large industrial cities of the Russian Federation are set at the highest level. As part of the implementation of the Decree of the President of the Russian Federation, the Federal project “Clean Air” of the national project “Ecology” was developed and approved aimed at reducing the level of air pollution in 12 large industrial centers, including...
reducing by at least 20% the total amount of pollutant emissions into the atmosphere air in the most
polluted cities: Bratsk, Krasnoyarsk, Lipetsk, Magnitogorsk, Mednogorsk, Nizhny Tagil, Novokuznetsk,
Norilsk, Omsk, Chelyabinsk, Cherepovets, Chita [1].

According to the Federal State Budgetary Institution “Main Geophysical Observatory named after
A.I. Voeikova (“FSBI GGO”) Roshydromet priority list of chemicals that pollute the air, is char-
terized by a wide range, which includes: benz (a) pyrene, formaldehyde, nitrogen dioxide, etc. In addition,
suspended substances are annually included in the list of priority pollutants determining the level of air
pollution. Exceeding the hygienic standard for suspended solids, for 2018, was detected in 52 cities.
This trend has continued since 2010, the list of cities with excess MPCs of suspended particles ranges
from 69-43, the maximum number of cities was recorded in 2012. The established data indicate the
general problem of a high content of solid dust particles in the atmospheric air of large urban
agglomerations [2].

Monitoring and evaluation of dust pollution of atmospheric air in the urban area is carried out
exclusively on the level of suspended solids, the information obtained is an information and analytical
basis for the formation of conclusions and preparation, if necessary, of management decisions, while the
fine fractions PM10 and PM2.5 are included in the control program only in 4 of 25 territories: Trans-
Baikal, Irkutsk, Sakhalin, UGMS of the Republic of Tatarstan UGMS.

In practice, the regulation of emissions, suspended solids are accepted solid dust particles that are
not differentiable both in chemical and dispersed composition. At the same time, the separate accounting
of PM10 fine fractions is completely excluded from the system for calculating emissions of stationary
and mobile sources, therefore, they are not included in the inventory of enterprise emission sources and
projects of sanitary protection zones. The approved hygienic criteria for suspended particles of PM10
remain unclaimed, despite their inclusion in the list of pollutants for which state regulatory measures
are applied [3, 4].

For the tasks of correctly assessing the quality of atmospheric air and developing sufficient
management decisions, reliable data on the structure of the dust composition are required. The process
of pollution of the soil cover of the territory is largely dependent on the quality of atmospheric air, solid
particles settle in open areas or precipitate in the form of rain and snow. Dust pollution of atmospheric
air contains both organic and inorganic impurities, including extremely and highly dangerous ones. [5-
8]. In turn, soils have been discovered, dusting the dumps of production, making a significant
contribution to the quality of atmospheric air [9].

The second important hazard factor for suspended particles is their dispersed composition. Particles
of small size - less than 10 microns, due to their low mass have a high "volatile" ability. Under the
influence of meteorological factors, particles smaller than 10 microns spread over large distances from
the source of precipitation [10]. Taking into account that motor vehicles and industrial enterprises are
the main sources of dust emissions, the pollution zone is actively distributed throughout the city territory,
covering the entire airspace of the city, including standardized territories with special modes of use: city
parks, sports bases, sanatoriums, kindergartens, country houses and garden plots, agricultural land.

2. Purpose of the study
The purpose of the study included a comprehensive assessment of the dispersed and component
composition of atmospheric air for the tasks of correctly assessing the sources of pollution of the soil
cover of adjacent territories, including park areas, garden plots, agricultural lands.

3. Materials and methods
Using the example of the city of Perm, comprehensive studies of the qualitative composition of dusts
identified in the atmospheric air of the central part of Perm were carried out. Air sampling was carried
out in three central areas of the city, through the territory of which there are large highways with high
traffic flows: ul. Highway Cosmonauts - point number 1, st. Popova - point number 2, st. Startseva - st.
Chkalova - point number 3. Selected highways are characterized by high daily traffic from 33580
cars/day. on the Cosmonaut Highway, up to 42300 cars/day on the street Startseva - Chkalova St., daily traffic of vehicles on the street. Popov is 35890 cars/day.

Air sampling was carried out by deposition of dust particles on open filters previously dried in a desiccator and weighed on an analytical balance. The duration of sampling for open filters ranged from 1 to 2 hours at a speed of 100 dm$^3$/min.

For microscopy of dusts in order to determine the component composition and determine the shape of dust particles, a high resolution scanning electron microscope (magnification - from 5 to 300,000 times; accelerating voltage - from 0.3 to 30 kV) was used with an S3400N HITACHI X-ray fluorescence attachment "(The detection limit is of the order of 10$^{-5}$ wt.%, The minimum research area is 100 microns).

When conducting research, we used instruments and equipment that are listed in the State Register of Measuring Instruments and in the prescribed manner and within the established time passed metrological control (verification) by accredited organizations.

4. Research results

Analysis of the selected samples confirmed the presence of suspended solids and fine fractions of PM10 dust in the atmospheric air of the studied areas of the city. The recorded maximum levels of dust pollution are characterized as low in relation to hygienic criteria: for suspended solids - 0.566 MPCm.r., for PM10 - 0.373 MPC.r. (Hazard Index, HI): for suspended solids - 0.943 RFC, for PM10 - 0.747 RFC. The results of instrumental determinations of the content of suspended solids and fine particles PM10 established in the selected air samples are presented in table 1.

Table 1. The content of suspended solids and fine fractions PM10 and PM2.5 at control points of observations, fractions of MPCm.r, fractions of ARFC.

| Control point | Suspended matter | PM 10 | PM 2.5 |
|---------------|------------------|-------|--------|
|               | MPC m.r.         | ARFC  | MPC m.r. | ARFC  | MPC m.r. | ARFC  |
| District No. 1| 0.282            | 0.470 | 0.227    | 0.453 | 0.238    | 0.585 |
| District No. 2| 0.566            | 0.943 | 0.213    | 0.427 | 0.194    | 0.477 |
| District No. 3| 0.386            | 0.643 | 0.373    | 0.747 | 0.381    | 0.938 |

Based on the results of a comprehensive analysis, information was obtained on the chemical composition of the selected samples. It was established that the suspended particles identified in atmospheric air are characterized by a wide range of solid chemical components related to the spectra: silicon, calcium, iron, aluminum, etc. An example of the multicomponent composition of dust is presented in figure 1.

Figure 1. Examples of the composition of suspended air particles in an urban area.
Based on the obtained elemental composition data, an averaged “profile” of dust pollution of atmospheric air was formed. The dust composition of solid particles contains oxides: iron - more than 40%, calcium - 14%, silicon - more than 7%, aluminum - 3%, etc. Figure 2 shows the dust profile of the selected samples.

![Figure 2. Mass fraction of chemicals in the air of an urban area.](image)

As a result of microscopic analysis, the morphological properties of the samples were established. The studied particles were characterized by various forms: angular, irregular, composite, etc. Particulate matter contains porous components that can trap other hazardous chemicals on its surface. The presented fragments confirm the multicomponent nature of solid particles contained in atmospheric air (figure 3).

![Figure 3. Forms of dust particles identified in the atmospheric air of an urban area.](image)

5. Conclusions
Studies have confirmed the presence of high concentrations of suspended solids and fine fractions of dusts PM10 and PM2.5 in the atmospheric air of urban areas. The established reference levels do not exceed current standards, while they are significant and close to threshold values.

The data obtained indicate the need to include finely divided fractions PM10 and PM2.5 in the monitoring system of Roshydromet authorities in all territories where suspended solids are monitored (TSP). Legislative consolidation of the approaches to rationing fine particles will make it possible to assess at the calculated level the potential risks of the adjacent territories for various purposes, including: park areas, garden plots, agricultural land.
During the complex analysis of the selected samples, chemical components characterizing the dust composition were established. It was established that the atmospheric air of the urban area contains oxides of iron, calcium, silicon, aluminum, etc.

The presence of a porous structure of the surface of solid particles indicates the potential possibility to deposit other hazardous chemicals on its surface and, under certain meteorological conditions, to be transport units during the spread of impurities throughout the territory, creating a risk of contamination of the soil cover at a great distance from the source.

The obtained results of the component and dispersed composition are the information basis for the development of managerial decisions, the search for priority pollutants, and the preparation of an action plan to reduce particulate pollution.

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