Dust emissions of industrial enterprises as a factor of negative impact on the agricultural territories

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Abstract. The study is devoted to the determination of the dispersed and component composition of industrial dust emissions as factors of a potential negative impact on the quality of atmospheric air, precipitation and soil, including agricultural use. It is shown that the dust emissions of ferrous and nonferrous metallurgy, engineering and the mining industry facilities have a complex composition, including toxic heavy metals. The presence in emissions of fine-dispersed fractions (PM10, PM2.5) causes the transfer of contaminants over long distances. The location of agricultural areas in close proximity to industrial enterprises can lead to snow and soil contamination by heavy metals. Agricultural plants can be included in the chain of heavy metals migration and accumulate them. In order to develop measures for the protection of environmental objects, studies have been carried out on the in-depth analysis of the component and dispersion composition of emissions. An estimate of the distribution areas of emissions has been performed. Proposals for the organization of environmental monitoring are developed.

1. Introduction

The current sanitary legislation of the Russian Federation, when approving the boundaries of the sanitary protection zones of industrial enterprises, separately regulates agricultural areas. In order to ensure the safety of food products in the border of the sanitary protection zone, the placement of agricultural land plots is prohibited. An exception may be situations where it is proven that there is no violation of the quality and safety of products, raw materials, etc.

This provision is determined by air pollution by industrial emissions. Production activities of various industries are accompanied by emissions of chemicals, including solid dust. Solids emitted into the atmospheric air are spread over different distances, further settling or washing out by meteorological sediments on the adjacent territories. Particles of the fine PM10 and PM2.5 fractions due to their low mass are retained in the atmosphere and can accumulate and spread over long distances, which significantly expands the industrial facility impact zone. The sedimentation of such particles on the soil can be triggered by rain or snow precipitation [1-2]. Dust emissions are characteristic for different stages of technological operations, as well as for storage and transportation of dusty raw materials, finished products or production wastes. Numerous studies indicate that solid dust emissions from enterprises are a composite mixture with multi-disperse (including PM10 and...
PM2.5 fractions) particles and complex chemical composition. Such a mixture often contains extremely and highly hazardous organic and inorganic impurities [3-7]. Data on the component and dispersion composition of enterprises emissions are not always sufficient and relevant. This makes it impossible to take timely and adequate measures to minimize the risk of air pollution, soil and agricultural plants. The urgency of the problem determined the purpose of the study.

2. Purpose of the study
Identification and quantitative determination of the component and dispersion composition of dusts emissions from a number of industrial facilities as risk factors for pollution of adjacent territories, including agricultural.

3. Research methods
The authors have carried out studies of the component and dispersion composition of dust emissions of about 80 technological processes of ferrous and non-ferrous metallurgy enterprises, machine-building and mining industries. Samples of emissions were collected at the dust emission sources by active sampling. The concentration of dust in the samples was determined by a gravimetric method and a laser analyzer. The dispersed composition of dusts was determined using a Microtrac S3500 laser particle analyzer (covered particle size range from 20 nm to 2000 μm). Particle morphology and component composition were determined by electron microscopy with a high resolution scanning microscope (magnification from 5 to 300,000 times) with the X34-fluorescent attachment S3400N "HITACHI". The chemical composition was identified by X-ray phase analysis of the samples using an XRD-700 X-ray diffractometer Shimadzu.

4. Research results
Studies of the dispersed composition of industrial from various facilities (ferrous and non-ferrous metallurgy, engineering, mining and mining processing) indicate the presence of fine particles PM 10 and PM 2.5 in the release. So, solid emissions from ferrous and non-ferrous metallurgy enterprises contain 8-84% PM10, 4-78% PM2.5, emissions from engineering enterprises contain 4-40% PM10, 5-20% PM2.5, mining emissions contain 15-50% PM10, 2-25% PM2.5. At the same time, the inventory records of none of the studied enterprises did not take into account the presence of fine fractions.

The simulation of the zone of enterprises impact showed that the areas of distribution of the fine PM10 and PM2.5 fraction exceed the zones of influence of dust particles without fractional composition by 20-30%.

Studies of the composition of solid emissions showed that 72% of samples did not did not match the inventory data on fractional and chemical composition characteristics. In addition to the commonly indicated silica oxides in dust, toxic substances such as cadmium, nickel, vanadium, manganese, lead, etc. were identified. Examples of the compositional spectrograms of dust emission series are shown in figure 1.

Figure 1. Components of dust emissions from the ferrovanadium smelting (metallurgical plant): sample №1 (a), sample №2 (b).
As another example, the deployed component and chemical composition of solid emissions from a process operation - unloading cars (dumpcars) is presented. The chemical composition of emissions from the source is characterized by a wide range of elements with a high content of solid particles attributable to the spectra of potassium, chlorine, sodium and silicon, aluminum, iron, etc. The identified component composition is presented in table 1.

### Table 1. Components of dust emissions from unloading cars (dump cars).

| Chemical element | Mass content of the element in the sample, % |
|------------------|--------------------------------------------|
|                  | Sample №1 | Sample №2 | Sample №3 |
| K (potassium)    | 23.38      | 38.33     | 10.09     |
| Cl (chlorine)    | 38.33      | 45.43     | 39.71     |
| O (oxygen)       | 21.78      | 11.53     | 11.53     |
| Na (sodium)      | 0.99       | 0.78      | 0.78      |
| Ca (calcium)     | 1.66       | -         | -         |
| Mg (magnesium)   | 0.60       | 0.71      | 0.71      |
| Si (silicon)     | 1.89       | 1.03      | 1.43      |
| S (sulfur)       | 0.81       | -         | -         |
| Fe (iron)        | 0.45       | -         | -         |

The morphology of dust particles emissions confirms the chemical composition of the emissions. Most of the photographed particles have a crystalline form with a predominance of salts. The forms of dust particles from unloading wagons (dumpcars) are presented in figure 2.

![Figure 2. Forms of dust particles from unloading cars (dump cars).](image)

The obtained results of dispersed and component composition are extremely important for the organization of the ambient air and soil monitoring systems. Thus, it was recommended to expand the air monitoring program at the boundary of the sanitary protection zone of the ferrous metallurgy enterprise to include vanadium compounds (in terms of vanadium). The results of instrumental measurements fully confirmed the validity of the recommendations - vanadium in significant concentrations was determined systematically both in the atmospheric air and in the soils of the adjacent territories. For other enterprises, “profiles” of dust emissions were built, highlighting the priority components of these emissions and developing measures to monitor and / or reduce emissions.

### 5. Conclusion

Solid emissions of the studied production (ferrous and nonferrous metallurgy, engineering, mining and mining, construction) contain fine dust particles PM 10 to 84%, PM 2.5 to 78%.
The chemical composition of the studied samples is characterized by a wide range of chemicals. Depending on the technological processes, dust particles contain: cadmium, nickel, vanadium, manganese, lead and other hazardous substances. The completed studies confirmed the imperfections of computational methods for estimating solid emissions and the need for instrumental studies of the dusts component composition.

Soils of agricultural areas located in impact zones of enterprises dust emissions are subject to the risk of pollution due to sedimentation of solid chemicals - components of dust.

The availability of up-to-date information on the component and dispersed composition of emissions allows to form correct management programs: to establish priority chemicals, to realize correct control program, to implement environmental protection measures.

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