Analysis and Evaluation of the Database on Soil Contamination of the Moscow Region with Heavy Metals

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Abstract. There is a risk to human health when eating agricultural products grown on soils contaminated with heavy metals. Currently, the monitoring of soil contamination with toxicants of industrial origin. This study is devoted to the analysis of information support and published official statistical data on soil pollution in the Moscow region, where the share of agricultural land accounts for 1,750. 5 thousand hectares, which corresponds to 38.22% of the region's territory. The study revealed certain shortcomings in the presentation of information on soil pollution, insufficient statistical data for the full implementation of environmental monitoring tasks, an increase in soil pollution with some heavy metals, etc.

1. Introduction
Nutrition is one of the most important factors that mediate the relationship of a person with the environment and determine the state of his health. Basically, various chemicals, both essential (practically not produced by the body and must come from the external environment with food), and toxic enter the human body orally with drinking water and food. Among toxic substances, a special role is given to heavy metals, which have a significant negative impact on the environment and humans. There are known works where the risk to human health is determined when eating agricultural products (vegetables, meat, dairy products, etc.) grown on soils contaminated with heavy metals [1-7].

As a result of human activity, there is a significant technogenic impact on the soil, which also changes its chemical composition. Some of the most dangerous and common pollutants are heavy metals. Heavy metals are usually called a group of chemical elements whose density exceeds 5 g/cm³. This term is borrowed from the technical literature, which indicates the classification of metals into light and heavy, but there is another way to classify the atomic mass of metals - this is the atomic weight, the average mass of the atoms of an element. Thus, based on this classification, heavy metals should include metals with an atomic mass of more than 50. According to GOST 17.4.1.02-83 «Nature Protection. Soil. Classification of chemicals for pollution control» heavy metals entering the soil from emissions, discharges, and waste belong to different hazard classes (table 1).

| Hazard class | Chemical substance                  |
|--------------|-----------------------------------|
| 1            | Cadmium, Mercury, Selenium, Lead, Zinc |
| 2            | Cobalt, Nickel, Molybdenum, Copper, Chromium |
| 3            | Barium, Vanadium, Tungsten, Manganese, Strontium |
The Moscow region is considered one of the most developed regions of the Russian Federation and occupies a fairly large territory, about 47 thousand square kilometers. The share of agricultural land in the Moscow region is large (they occupy the second place in the total area) the presence of heavy metals in the soil undoubtedly affects the quality of agricultural products and human health and affects the factors of sustainable development of society [4-7]. This determines the significance and relevance of the study.

2. Materials and methods
As initial data for the analysis and assessment of the content of heavy metals in the soil, official statistical data on soil pollution of the Moscow region were used (Yearbook "soil Pollution of the Russian Federation with industrial toxicants", official website of the Ministry of ecology and nature management of the Moscow region, Environmental passports of districts) [8-9]. The data were analyzed to identify:

- The main sources of soil contamination with heavy metals;
- Completeness and sufficiency to meet the objectives of environmental monitoring;
- Dynamics of soil pollution in the Moscow region;
- The possibility of using modern software products to determine the dynamics of pollution, the selection of a mathematical model of the trend, analysis and forecasting of the development of the process under study.

3. Results
Analysis and evaluation of statistical data on soil contamination of the Moscow region with heavy metals showed that for a long time in the period from 2006-2019, soil contamination with industrial toxicants is monitored [8]. Analysis of the data provided by the Roshydromet observation network on heavy metals contamination of the Moscow region's soils allowed us to identify the main sources of pollution.

In the Moscow region, the most significant contribution to soil pollution by heavy metals is made by enterprises of processing of non-ferrous and ferrous metals, mining and processing of minerals, plastic, rubber, oil and gas, machine-building, chemical, Metalworking, metallurgical industry, production of paint and varnish products and motor transport. These enterprises are located in the most polluted areas of the region: Shatursky, Noginsk, Podolsky, Sergiev Posad, Ramensky, Dmitrovsky.

Also, the analysis of data on soil contamination with industrial toxicants showed the following:

- Studies of soil contamination with industrial toxicants were conducted in accordance with the current methodological recommendations;
- The database contains indicators of the content of nine metals in soils, namely Pb, Zn, Cd, Cu, Co, Ni, Cr, Mn, Fe;
- Sampling was carried out on virgin land or on arable land;
- For the entire period of observation of soil contamination with heavy metals, different districts of the Moscow region were selected each year;
- 2019 - Stupinsky district;
- 2018 - Dmitrov district;
- 2017 - Ramensky district;
- 2016 - Solnechnogorsk and Klin districts;
- 2015 - Noginsk, Pavlovo-Posadsky and Orekhovo-Zuevsky, etc;
- During sampling:
  - The corresponding city – district center or Moscow was taken as the starting point of the report;
The selection was carried out in different directions from the point of the report (North, North-East, North-West, etc.);

- Zones were selected at different intervals (0-5 km; 0-15 km, 0-30 km or 0-10 km; 10-20 km; 20-25 km, etc.) from the report point;
- The number of samples varied from 1 to 5 in each of the sampling zones (although according to GOST R 53123-2008, which is based on the international standard ISO 10381-5: 2005, the number of sampling points in each potentially contaminated zone should be proportional to the size of the zone (and usually requires at least six samples to assess spatial variability within the zone);
- The database contains the maximum mass fractions, mg / kg, satisfying the inequality M1 ≥ m2 ≥ m3 and the arithmetic mean of the mass fraction of metal in the sampling zone.

The annual selection of different areas of the region for research, the choice of different directions and different intervals for zones during sampling do not allow the authors to obtain the necessary information for the full implementation of environmental monitoring tasks, namely (article 63.1 of the Federal law of 10.01.2002 N 7 "On environmental protection"):

- Analysis of the information received in order to timely identify changes in the state of the environment under the influence of natural and (or) anthropogenic factors;
- Assessment and forecast of these changes.

The creation of a more clearly structured database will allow the use of modern software products for determining the dynamics of pollution, selecting mathematical models of the trend, analyzing time series and predicting the development of the process under study, based on the fact that the development trend established on the basis of statistical analysis can be extended (extrapolated) for future periods (i.e., a more effective way to perform monitoring tasks).

It also revealed shortcomings in the information support of the population of the Moscow region in the field of soil pollution of the region with heavy metals:

- Insufficient data on local heavy metal contamination of soils in the Moscow region, as heavy metal contamination of soils is most often local in nature and is associated with specific enterprises and transport infrastructure facilities;
- Absence or irrelevant information on soil contamination with heavy metals in environmental passports of districts, etc.

As a result of our research, analysis and comparison of data on soil pollution provided in various official sources (Yearbook "Soil Pollution of the Russian Federation with industrial toxicants", official website of the Ministry of ecology and nature management of the Moscow region, Environmental passports of districts), an increase in the presence of heavy metals in the soil was established. Data on changes in zinc content in some areas are presented in (table 2).

Comparing the data of the 90s with modern data on the content of zinc in the soils of the Moscow region, it can be noted that for many areas of the region, an increase in the content of zinc is characteristic. For example, Kolomensky, Naro-Fominsky, Podolsky, Orekhovo-Zuyevo, Ramensky, Dmitrovsky districts are indicated on maps of the 90s as areas with a low zinc content in the range of 15-30 mg / kg. Pollution in the areas is in the range of 30-70 mg / kg of zinc content, which is considered an average level of pollution. In the Ramenskoye district, there is a strong level of pollution (132.2 mg / kg).
Table 2. Comparative analysis of zinc content in soils of the Moscow region.

| The observation period | The zinc content in the soils of the districts of MO, mg/kg |
|------------------------|----------------------------------------------------------|
|                        | Voskresensky district | Kolomenskiy district | Naro-Fominsk district | Shatursky district | Noginsk district | Podils'kyi district | Sergiev Posad district | Orekhovo-Zuyevo district | Ramensky district | Dmitrov district | Taldom district |
| 1990s years.           | -                      | 15-30                | 15-30                | <15                 | 15-30            | -                    | 15-30                   | 15-30                   | 15-30                  | 15-30                  | <15                  |
| 2006-2018              | 31.1                   | 35.4                 | 41.3                 | 32.1                | 20.6             | 10                   | 21.2                    | 47.1                    | 132.2                  | 51                     | 39                   |

A comparative analysis of the lead content (table 3) also shows an increase in this indicator.

Table 3. Comparative analysis of lead content in soils of the Moscow region.

| The observation period | The zinc content in the soils of the districts of MO, mg/kg |
|------------------------|----------------------------------------------------------|
|                        | Voskresensky district | Kolomenskiy district | Naro-Fominsk district | Shatursky district | Noginsk district | Podils'kyi district | Sergiev Posad district | Orekhovo-Zuyevo district | Ramensky district | Dmitrov district | Taldom district |
| 1990s years.           | -                      | 10-35                | 10-35                | 5-10                | 5-10            | 10-35               | -                      | 5-10                   | 10-35                   | 5-10                   | 5-10                  |
| 2006-2018              | 14.2                   | 14.7                 | 10.6                 | 12.5                | 12.1            | 22.9                | 22.2                    | 16.5                    | 24.5                    | 7.9                     | 18                    |

According to modern data, the soils of the Voskresensky district are within the average level of pollution, and the lead content was 14.2 mg/kg. Pollution of the Sergiev Posad district also showed an average level. It is worth noting that there are areas in which significant changes in lead content are not observed. Kolomensky, Naro-Fominsky, Podolsky, Ramensky, Dmitrovsky districts are also within the average level of pollution according to modern data. However, in the Shatursky and Noginsky districts, according to modern data, the lead content was 12.1 mg/kg. It is worth noting that significant differences are observed when comparing data on the Orekhovo-Zuyevo district, as according 90 it is characterized as an area with low pollution level in the range 5 – 10 mg/kg, according to modern levels of lead in the district was 16.5 mg/kg. Also, a significant difference in the data is present in the Taldomsky district - the lead content was 5-10 mg/kg, and according to modern data, 18 mg/kg.

Using the capabilities of the Microsoft Excel software environment, we performed a visualization (figure 1) that reflects:

- Indicators of soil contamination (arithmetic mean value of the mass fraction, mg/kg, in the samples area) in 2016 in the Moscow region (Solnechnogorsk and Klin districts) of different heavy metals (Pb, Zn, Cu, Ni, Cr, Co);
- In different areas of sampling in the North-Western direction from Moscow along the Leningradskoe highway (zone a – 0-26 km; zone b – 26-45 km; area c – 45-65 km; area d – 65-90 km).
Analysis of the data shows that the greatest pollution in all indicators in the case under consideration is observed in zone b (24-45 km from Moscow). This approach makes it possible to identify areas of maximum risk to humans and the environment in each municipality of the region.

It should be noted that the capabilities of the Microsoft Excel software environment are particularly effective for solving the problem of analyzing a time series (dynamic series), which consists in predicting the development of the process under study, based on the fact that the development trend established on the basis of statistical analysis can be extended (extrapolated) for the future period. The authors used this software product in various studies [10], and believe that if the necessary statistical data are available, it is advisable to use this program to model and predict the dynamics of changes in soil pollution with heavy metals.

4. Discussion
Studies have shown that the main sources of soil pollution with heavy metals in the Moscow region are primarily emissions from industrial enterprises and transport infrastructure.

The analysis of statistical data from official sources on the contamination of soil revealed insufficient number of samples to estimate the spatial variability within the zone.

The use of data for determining soil contamination in different areas of the Moscow region, in different directions and with different values of sampling zone intervals makes it impossible to analyze the information obtained in order to timely identify changes in the state of the environment under the influence of anthropogenic factors, as well as to assess and forecast these changes. Maintaining a more clearly structured database will allow you to determine the dynamics of pollution, select mathematical models of the trend, analyze time series and predict the development of the process under study, based on the assumption that the development trend established on the basis of statistical analysis can be extended (extrapolated) for the future period using modern software products.

A comparison of statistical data from various official sources of information (the Yearbook "Soil contamination of the Russian Federation with industrial toxicants", the official website of the Ministry of ecology and nature management of the Moscow region, Environmental passports of districts) allowed us to determine that the content of heavy metals in the soils of the Moscow region has changed over the past decades with a noticeable tendency to increase.

Also, irrelevant information of open data on official websites was revealed, and this plays a significant and important role in ensuring the constitutional right of citizens to reliable information about the state of the environment.

5. Conclusion
Lands located near large Metropolitan areas experience significant negative impacts and are contaminated with heavy metals, which creates certain risks for human health. It is necessary to improve the existing system of collecting and processing data on soil contamination with toxicants for
timely detection of changes in the state of the environment and the ability to assess and predict these changes, in order to make effective management decisions to protect people and the environment.

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