

Benz(a)pyrene content in soil and medicinal plants of Perm Krai (Russian Federation)

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Abstract. The article investigates the content of benz(a)pyrene in the soil and leaves of the medicinal plant *Plantago major*L. growing in the Perm Territory at different distances from a major highway. The authors found an increase in the concentration of benz(a)pyrene in the soil and in the leaves of *Plantago major* L. during three years from 2019 to 2021. This is associated with the increase in traffic intensity along the Perm-Ilyinsky highway. The article shows a tendency to decrease the concentration of benz(a)pyrene in all soil samples and leaves of the plant has as distance from the highway. The authors give recommendations regarding the harvesting of leaves of the medicinal plant *Plantago major* L. in Ilyinsky district, which is advisable to grow at a distance of at least 500 m from the highway.

1 Introduction

Since 2009, the Russian pharmaceutical industry has taken a strategic direction towards import substitution in the production of medicines. The state adopted the Pharma 2020 program. The Russian government approved a plan for the development of the pharmaceutical industry until 2030. The primary goal of the Pharma-2030 state program is to double the production of domestic pharmaceuticals and medical devices in monetary terms within nine years.

Pharmaceutical companies in Russia today face the problem of providing imported substances to produce pharmaceuticals, as well as dependence on foreign suppliers for repair, maintenance, and replacement of foreign equipment. The state program "Pharma-2030" provides to expand the production range of the main active pharmaceutical substances, as well as raw ingredients required for their production to ensure the country's drug security.

The Council of the Eurasian Economic Commission (EEC) plans to establish a list of medicines to be produced by the countries of the Eurasian Economic Union (EAEU) as a substitute for imported medicines by the end of 2022. Scientists are studying the amount of capacity and the availability of production sites that provide an opportunity for import substitution.

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People widely use medicinal plants in medicine to treat many diseases and as dietary supplements. Many of the plants are wild, so one factor that hinders the organization of their harvesting is the lack of data on their contamination with xenobiotics.

Pollution of all elements of the biosphere by alien substances is a global environmental problem. Migration of xenobiotics along food chains leads to inevitable cumulation in medicinal plants.

The ecological situation in Perm Krai (Russia) is favorable for harvesting high-quality and safe medicinal plant raw materials [1].

There are 82 species of official medicinal plants growing in Perm Krai, and according to [2] vegetation sites of 53 species have been identified on the territory of Ilyinsky and Karagaysky districts.

This work studies the dynamics of benz(a)pyrene accumulation in soil and in leaves of the wild medicinal plant *Plantago major* L. at different distances from the highway for three years from 2019 to 2021.

Benz(a)pyrene belongs to the substances of the first class of hazard, has a pronounced carcinogenic effect and the ability to bioaccumulate [3].

Natural sources of this xenobiotic include forest fires, volcanic activity, and fallows.

Sources of anthropogenic pollution of the habitat with this compound are burning of solid and liquid organic substances, processing of oil and oil products [4,5], wood, grass and crop residues on fields, solid municipal waste, and gaseous emissions of motor vehicles.

Our work [6, 7] showed the negative effect of petroleum hydrocarbons and benz(a)pyrene on useful soil microflora.

2 Materials and method

The objects of the study were soil samples of Ilyinsky district at 1 m, 100 m and 500 m from the Perm-Ilyinsky highway. During sampling we used the "envelope" method with obtaining a mixed sample of 100-200 g (dry weight). We took samples from horizons 0-10 and 10-20 cm from the surface [8].

We determined the content of benz(a)pyrene in the leaves of the medicinal plant *Plantago major* L., which is widespread throughout the Perm Krai. The plant grows scattered, in small "spots" or long narrow strips along roads or along the margins of agricultural fields.

The area of *Plantago major* L. thickets in Perm Krai is 88.9 ha, and the annual harvest of this medicinal plant reaches 916.5 kg [9].

We used standard methods of harvesting and drying of medicinal plant raw materials (shuttle method).

The method of high-performance liquid chromatography using an Agilent 1100 instrument with a fluorometric detector helped in determining the concentration of benz(a)pyrene in the samples [10].

3 Results

Tables 1 and 2 show the results of benz(a)pyrene content in soil samples and in leaves of *Plantago major* L.

Table 1. Results of the study of benz(a)pyrene content in soil samples.

№	Benz(a)pyrene content, mg/kg								
	2019			2020			2021		
	1M	100M	500M	1M	100M	500M	1M	100M	500M
1	0,048	0,036	0,012	0,057	0,045	0,013	0,058	0,047	0,018
2	0,058	0,033	0,022	0,055	0,045	0,025	0,068	0,048	0,035

Continuation of Table 1.

№	Benz(a)pyrene content, mg/kg								
	2019			2020			2021		
	1M	100M	500M	1M	100M	500M	1M	100M	500M
3	0,046	0,028	0,014	0,056	0,033	0,016	0,056	0,053	0,023
4	0,056	0,031	0,011	0,066	0,041	0,023	0,076	0,041	0,028
5	0,056	0,026	0,016	0,068	0,036	0,018	0,068	0,036	0,022
6	0,055	0,033	0,009	0,063	0,046	0,020	0,065	0,036	0,028
7	0,068	0,032	0,012	0,072	0,042	0,024	0,082	0,052	0,024
8	0,077	0,037	0,017	0,068	0,047	0,019	0,078	0,047	0,020

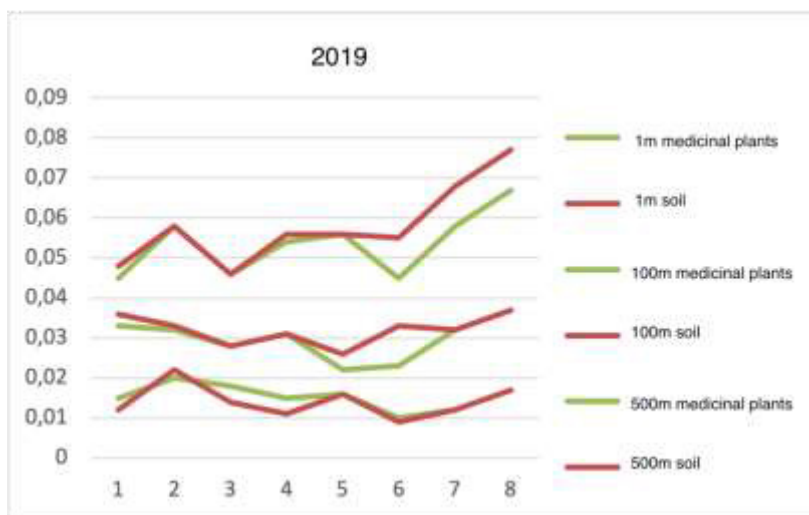
Table 2. Results of the study of benz(a)pyrene content in samples of *Plantago major* L.

№	Benz(a)pyrene content, mg/kg								
	2019			2020			2021		
	1M	100M	500M	1M	100M	500M	1M	100M	500M
1	0,045	0,033	0,015	0,057	0,045	0,017	0,048	0,047	0,018
2	0,058	0,032	0,020	0,059	0,035	0,025	0,060	0,038	0,035
3	0,046	0,028	0,018	0,057	0,030	0,019	0,056	0,033	0,023
4	0,054	0,031	0,015	0,056	0,031	0,018	0,056	0,041	0,018
5	0,056	0,022	0,016	0,058	0,026	0,017	0,062	0,036	0,019
6	0,045	0,023	0,010	0,053	0,036	0,018	0,055	0,038	0,023
7	0,058	0,032	0,012	0,062	0,042	0,014	0,072	0,042	0,019
8	0,067	0,037	0,017	0,068	0,037	0,019	0,068	0,037	0,020

4 Discussion

Statistical processing of the series of samples from 2019 to 2021, collected at different distances from the highway, allowed us to determine some regularities.

The content of benz(a)pyrene in *Plantago major* and soil samples decreases with distance from the highway, and at 500 m is within the permissible limits for benz(a)pyrene content in soil [11], both for 2019 and for 2020-2021 (Figure 1).



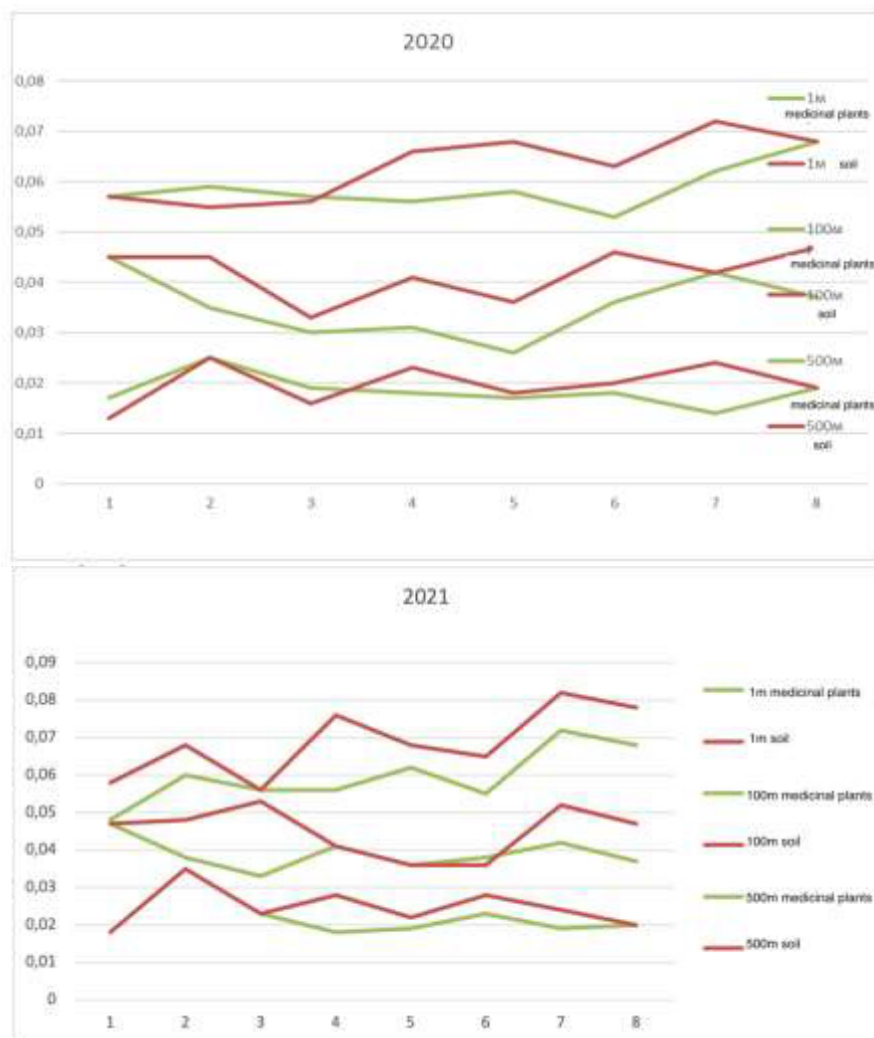


Fig. 1. Benz(a)pyrene concentrations in soil and medicinal plants relative to distance from the highway from 2019 to 2021.

The graphs show more intensive accumulation of benz(a)pyrene in the soil compared to the treatment vegetation.

Envelope sampling allows us to hypothesize the normal law of distribution of benz(a)pyrene content in samples, which makes it possible to determine the limits of random fluctuations of the got data. For this purpose, we calculated the arithmetic mean and standard deviation for all sample series by year, and within a year by distance from the sampling site to the highway (Tables 3 and 4).

The calculated confidence intervals according to rule 3 and other statistics show the homogeneity of the got data, thus the arithmetic mean will be the typical (central) value that characterizes the series of samples by distance from the highway according to the year. We can use the mean values for further analysis.

Table 3. Descriptive statistics on soil samples.

	2019			2020			2021		
	1 m	100 m	500 m	1 m	100 m	500 m	1 m	100 m	500 m
Average	0,058	0,032	0,014	0,063	0,042	0,020	0,069	0,045	0,025
Standard deviation	0,010	0,004	0,004	0,006	0,005	0,004	0,009	0,007	0,005
Interval	0,031	0,011	0,013	0,017	0,014	0,012	0,026	0,017	0,017
Minimum	0,046	0,026	0,009	0,055	0,033	0,013	0,056	0,036	0,018
Maximum	0,077	0,037	0,022	0,072	0,047	0,025	0,082	0,053	0,035
Left border confidence interval	0,028	0,021	0,002	0,044	0,027	0,007	0,041	0,025	0,008
Right border confidence interval	0,088	0,043	0,026	0,082	0,057	0,032	0,097	0,065	0,041
Variation	18%	12%	29%	10%	12%	21%	14%	15%	22%

Table 4. Descriptive statistics on medicinal plant specimens.

	2019			2020			2021		
	1 m	100 m	500 m	1m	100 m	500 m	1 m	100 m	500 m
Average	0,054	0,030	0,015	0,059	0,035	0,018	0,060	0,039	0,022
Standard deviation	0,008	0,005	0,003	0,005	0,006	0,003	0,008	0,004	0,006
Interval	0,022	0,015	0,01	0,015	0,019	0,011	0,024	0,014	0,017
Minimum	0,045	0,022	0,01	0,053	0,026	0,014	0,048	0,033	0,018
Maximum	0,067	0,037	0,02	0,068	0,045	0,025	0,072	0,047	0,035
Left border confidence interval	0,030	0,014	0,006	0,045	0,016	0,009	0,037	0,026	0,005
Right border confidence interval	0,077	0,045	0,025	0,072	0,054	0,028	0,083	0,052	0,039
Variation	15%	17%	21%	8%	18%	17%	13%	11%	26%

Figure 2 shows the increase in benz(a)pyrene concentrations in absolute terms in both soil and plants because of heavy use of the highway after 2019.

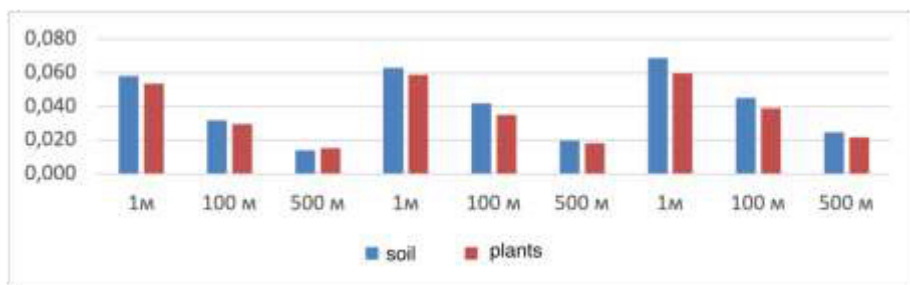


Fig. 2. Benz(a)pyrene concentrations averaged over the sample series in soil and medicinal plants.

5 Conclusion

Our study showed an increase in benz(a)pyrene concentration in soil and in plantain leaves during three years from 2019 to 2021, which is associated with the increase in traffic intensity along the Perm-Ilyinsky highway. Because of objective reasons, the rate of concentration growth decreased compared to 2019 and 2020.

The concentration of benz(a)pyrene in soil and in plantain decreases with increasing distance from the highway proportionally.

Our study showed that harvesting of leaves of the medicinal plant *Plantago major* L. in Ilyinsky district is advisable at a distance of at least 500 m from the highway.

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