

Heavy metal pollution from dust deposits in urban and industrial areas in the Jiu Valley

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Abstract. The aim of this paper was to determine the concentration of heavy metals in dust samples by the method of analysis by inductively coupled plasma optical emission spectrometry (ICP-OES) and to assess the degree of pollution of the studied areas. The dust samples studied and subjected to analytical analyzes were collected from the vicinity of industrial areas and urban areas of localities in the Jiu Valley, a monoindustrial area. The main heavy metals determined were: Cu, Zn, Pb, Ni, Cr, Co etc. Dust particles depending on their origin can be inorganic or organic. The samples were collected from the urban areas and from the vicinity of the industrial areas.

1 Introduction

The main sources of soil and air pollution with dust are associated with the various phases of mining or industrial technological flows that took place in the Jiu Valley: exploitation of useful minerals, transport of minerals or fossil fuels, preparation and storage processes in dumps, which have formed landfills. In recent decades, the share of industrial activities has decreased significantly due to the mine closure process [1]. Soils can be polluted due to physical and chemical factors: change of land use by excavation and processing of ore extraction and transport of ore and tailings, storage of tailings from mining operations in dumps and processes resulting from ore processing. In the vicinity of tailings dumps and tailings ponds, tailings entrainment processes take place through meteorological factors, wind, rain, floods, etc. [2]. The composition of street and surface dust is influenced by the various sources from which it comes: materials transported by water, soil erosion processes, ash and carbon black deposits (soot) resulting from the use of fossil fuels in electricity production, building wear, wear of asphalt and sidewalks, degradation of vehicle tires, wear of brake pads, operation of internal combustion engines, loss of engine oil, etc. [3]. Heavy metals together with other toxic substances have a negative effect even in extremely low concentrations, these effects vary depending on the mode and duration of exposure and metabolism and the detoxification capacity of each body.

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Toxic mechanisms are varied and may include: inhibition of enzymatic processes, damage to cell membranes, as well as changes in transport processes and decreased neuronal function [4]. So, one of these effects are synergistic with other toxic elements or chemicals [5]. Metals can be chemically characterized as elements that conduct electricity, have a metallic luster and are malleable and ductile. Metals will react in different environments and some of them are dangerous for health or for (cadmium, lead, chromium), some can cause corrosion (for example (zinc, lead), and some metals are harmful in other ways [6]. Some of these elements are necessary for people in low amounts (chromium, manganese, copper) while others are carcinogenic or toxic, affecting the central nervous system (lead, arsenic, manganese), kidneys or liver (lead, cadmium, copper) or leather, bones (nickel, cadmium, chromium) [7]. Heavy metals cannot be biologically degraded, and can only be transformed from one state of oxidation or organic complex to another. The ways in which environmental factors are polluted by anthropogenic activities such as mining, purification of zinc, lead and cadmium, burning fossil fuels, burning waste, discharges from industrial effluents, or excessive use of fertilizers in agriculture [8]. By precipitating compounds or by ion exchanges in soils and muds, heavy metal pollutants can be located and left hidden in road dust [9]. Along with heavy metals in dust and street dust deposits can be found other contaminants such as silicon dioxide, [10] various oils such as oils, organic and inorganic compounds, bacteria and viruses [11].

2 Materials and methods

The collection of street dust samples was carried out in March 2021. The street samples were collected in clean polyethylene bags, the GPS system was used to mark the points from which the samples were collected (Table 1, Figure 1).

Table 1. Dust collection sites.

Sampling point	Coordinates
P1 Road E66	N 45°25'38" E 23°22'6"
P2 Petrila main road	N 45°44'16" E 23°37'7"
P3 Petrosani University	N 45°25'9" E 23°22'36"
P4 Station-colony	N 45°25'14" E 23°21'56"
P5 Maleia vicinity	N 45°25'8" E 23°22'20"
P6 Livezeni railway	N 45°24'13" E 23°22'25"
P7 Dacia Square	N 45°23'43" E 23°22'31"
P8 Petrosani Stadium	N 45°23'36" E 23°22'12"
P9 Independentei Street Petroșani	N 45°24'2" E 23°22'36"
P10 Petrosani Carpathians neighborhood	N45°23'51" E23°22'19"
P11 Central ParkCarol Schreter vicinity	N45°24'47" E23°22'24"
P12 Vulcan Main Road	N 45°24'49" E 23°22'11"

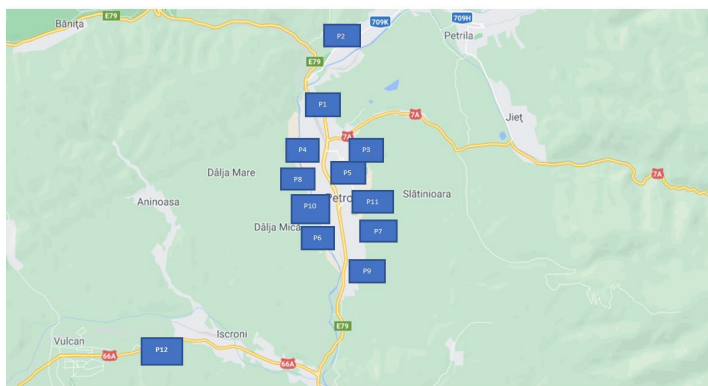


Fig. 1. Dust collection sites.

Street dust samples were taken from three different urban locations, low-traffic streets, high-traffic streets, parks area, residential and industrial areas in Petroșani, Petrila Vulcan, as well as one soil sample collected from Petrosani area, in order to establish background concentrations. Samples were analyzed for As, Co, Cr, Cu, Mn, Ni, Pb, Zn, Ti, Fe using the inductively coupled plasma atomic emission (ICP OES) spectrophotometric technique (Figure 2).



Fig. 2. ICP-OES spectrometer.

3 Results and discussion

One must pay special attention to heavy metal pollution associated with urban dust particles, amid overwhelming concerns about heavy metals could have a considerable impact on the ecosystem and human health.

The main localities in the Jiu Valley are: Petrila, Petroșani, Aninoasa, Vulcan, Lupeni, Uricani. The position of the points used for sampling was determined using the GPS system. Samples of dust particles were taken from urban locations in Petroșani, but also Petrila and Vulcan from different areas, with different characteristics of traffic, heavy and low traffic, areas near industrial perimeters, residential neighborhoods, recreational areas, etc. Soil sample was also analyzed, which was considered a reference in the given situation. The collected street dust samples were analyzed by inductively coupled plasma optical emission spectrometry. The samples were homogenized, crushed, sieved and mineralized using the microwave mineralizer at temperatures between 170°C and 200°C, using high

purity nitric acid, after mineralization and cooling of the resulting solution it was transferred to volumetric flasks of 100ml.

In the Tables 2 and 3 there are the values obtained for heavy metals from the dust samples analyzed.

Table 2. Values obtained for heavy metals.

Sample	As mg·kg ⁻¹	Co mg·kg ⁻¹	Cr mg·kg ⁻¹	Cu mg·kg ⁻¹	Mn mg·kg ⁻¹
P1	8.717	2.213	39.39	38.00	470.2
P2	4.844	1.926	22.13	21.89	331.0
P3	6.195	2.106	13.48	15.08	347.2
P4	9.030	2.489	20.80	16.50	298.1
P5	4.741	2.670	19.65	21.88	265.8
P6	9.519	3.511	28.40	33.88	375.5
P7	2.748	2.975	17.10	14.74	294.5
P8	8.401	3.325	28.66	27.87	347.7
P9	9.324	2.953	14.98	8.986	204.1
P10	5.854	2.634	30.36	33.53	410.1
P11	5.925	3.103	31.41	35.03	429.8
P12	5.843	2.308	23.92	26.39	323.7
Average	6.761	2.684	24.19	24.48	341.48

Table 3. Values obtained for heavy metals.

Sample	Ni mg·kg ⁻¹	Pb mg·kg ⁻¹	Zn mg·kg ⁻¹	Ti mg·kg ⁻¹	Fe mg·kg ⁻¹
P1	11.52	3.091	79.32	463.3	14360
P2	9.517	1.604	79.19	317.0	13840
P3	6.276	5.665	74.11	115.8	6546
P4	9.926	10.11	89.62	414.1	13990
P5	9.509	4.954	81.38	256.2	12620
P6	18.02	9.509	111.4	393.0	14420
P7	10.90	14.06	115.5	271.8	9567
P8	13.63	7.650	78.22	400.0	14560
P9	7.964	9.683	116.8	271.7	7741
P10	14.71	7.964	124.6	396.5	19400
P11	15.70	8.038	128.8	410.9	19920
P12	11.71	6.422	97.30	310.22	15120
Average	11.61	7.39	98.02	335.04	13507

Using the Index Pollution formula (1) [12], it was evaluated the degree of pollution (Table 4) in the analyzed samples (Table 5).

$$IP = C_{det} / C_{refer} \tag{1}$$

where:

C_{det} - concentration of the studied element;

C_{refer} - reference concentration.

Table 4. Pollution index values.

Pollution	Category	IP
Unpolluted	I	IP<1
Slightly polluted	II	1<IP≤2
Moderately polluted	III	2<IP≤3
Heavily polluted	IV	3<IP

Table 5. The range of values for the pollution index in the analyzed samples.

Metals	Range of values
As	0.37÷1.28
Co	0.11÷1.92
Cr	0.67÷1.97
Cu	0.55÷1.42
Mn	0.47÷1.08
Ni	0.15÷0.29
Pb	0.33÷2.95
Zn	0.69÷1.21

In the Table 6 is given the range of determined concentration for the dust samples versus the fond concentration in the analyzed soil sample.

Table 6. Range of determined concentrations.

Metal	Wavelength nm	The concentration range of road dust samples mg.kg ⁻¹	The fond concentration of metals in soil samples mg.kg ⁻¹
As	199.696	2.748÷9.519	7.46
Co	228.802	1.92÷33.325	17.38
Cr	267.716	13.48÷39.39	20.02
Cu	327.393	14.74÷38	26.76
Mn	257.610	204.14÷470	437
Ni	231.604	7.96÷15.7	54.4
Pb	220.353	1.6÷14.06	4.775
Zn	213.857	74.11-128.8	106.8
Ti	334.94	256.2-463.3	484.2
Fe	238.204	6546-19920	21332

In the Figure 3 it can be seen the variation of metal concentrations in the case of the analyzed samples.

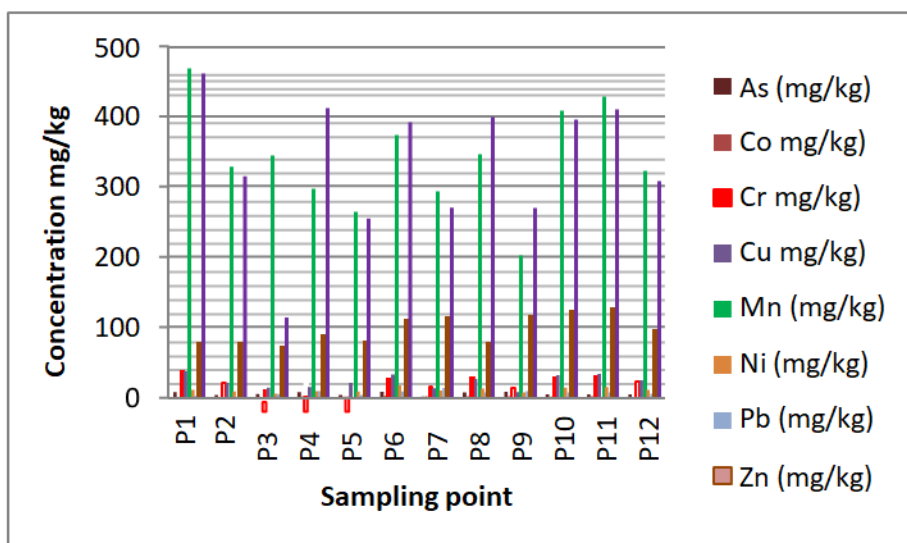


Fig. 3. Variation of metal concentrations in the case of the analyzed samples.

Thus, in the case of manganese, the determined concentrations were between 204.14 and 470.2 mg.kg⁻¹, with an average concentration of 341.48 mg.kg⁻¹. The average concentration determined in the case of chromium is 24.19 mg.kg⁻¹, with values of concentrations between 13.48 and 39.39 mg.kg⁻¹. In the case of manganese samples, a slight concentration was observed compared to the soil sample taken as a reference. In the case of arsenic, values between 2,748 ÷ 8,717 mg.kg⁻¹ were obtained, being observed an enrichment of the dust samples in the arsenic element. In the case of chromium, values between 13.48 ÷ 39.39 mg.kg⁻¹ were determined, higher values could also be observed in the case of some of the samples.

For the copper element, the values determined in the street dust samples were between 14.74 ÷ 38 mg.kg⁻¹, thus an enrichment of the dust in the copper content of the soil taken as reference can be observed. Analyzing the zinc content, it can be seen that compared to the values 74.11-128.8 mg.kg⁻¹ obtained, there was a slow increase in the concentration of some analyzed street dust samples, compared to the soil concentration considered as a reference. In the case of lead, an average value of 7.39 mg.kg⁻¹ was determined and an enrichment of it was observed compared to the lead content of the soil sample taken as reference, the values being in the range 1.6 ÷ 14.06 mg.kg⁻¹. For the nickel concentration, no increase in concentrations was observed in the street dust samples subjected to analyzes compared to the reference concentrations.

4 Conclusions

Urban dust deposits (street dust) represent the image of a wide range of anthropogenic activities and are a useful resource for assessing the level and distribution of heavy metal contaminants in the surface environment. The highest level of metals were found in the samples from the industrial area and the streets where there is heavy traffic and the vicinity of the industrial units the lowest in the areas with low traffic and industrial activity.

Concentrations and levels of contamination of Zn, Cu, Pb, Mn, Cr and Co, Ni, As were studied in the street dust collected in the urban and industrial areas of the Jiu Valley, being evaluated the pollution index.

The concentrations determined for certain samples were higher than their background values, at the indicators As, Co, Cr, Cu, Mn, Pb, Zn.

If we analyze the average values of metal concentrations, we can see that in the case of chromium and lead, the average values of sample concentration were higher compared to their background values. In the case of the other elements (As, Co, Cu, Mn, Zn) the average values obtained had lower values than the background values.

The values of the pollution index varied in the following order: Pb > Cr > Co > Cu > As > Mn > Ni. These values of the pollution index showed that the street dust particles in the Jiu Valley in terms of Pb and Cr concentrations were moderately contaminated, the dust indicated that there is considerable pollution with Pb, which mainly from traffic and industrial activities.

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