Original Scientific paper
UDC: 550.4:552.542(497.6Tuzla)
DOI: 10.7251/afts.2017.0917.027S
COBISS.RS-ID 6817816

LEAD (Pb) CONCENTRATIONS IN SOIL OF TUZLA'S URBAN AREA

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ABSTRACT

The paper presents the results of the geochemical-pedological researches based on the lead concentrations in soil of the Tuzla's urban area. The main goal of the research was to determine to what extent, the urban area of Tuzla was contaminated by lead and to determine the pollutant origin. The 129 soil samples were collected in situ on the of area about 100 km^2. The testing of the lead concentration in soil samples was performed by mass spectrometry (ICP-MS) with detection range of 0.02 to 10.000 ppm. The exceeding of the maximum permissible concentrations of lead (as defined by the „Pravilnik o utvrđivanju dozvoljenih količina štetnih i opasnih tvari u zemljištu i metode njihovog ispitivanja“), was recorded in eight soil samples (samples 108, 170, 171, 182, 187, 189, 195 and 244), 6.20% of the total analyzed. The exceeded lead concentrations range from 114.0 - 190.82 ppm and the average value is 146.72 ppm. The concentration of lead in the soil, which is within the limits of the doses, ranges from 14.14 to 60.74 ppm, and the mean value is 33.68 ppm. Locations of elevated lead concentrations are closely related to the main road, resulting that the contamination is the result of the anthropogenic activities.

Key words: *lead (Pb), soil, concentration, Tuzla, contamination*

INTRODUCTION

The area of the city of Tuzla geographically belongs to the region of north-eastern Bosnia, i.e. to the subregion of the Spreča-Majevica region. Tuzla is located in the valley of the Jala river. From the northeast it's surrounded by the mountain morphostructure of Majevica, and from the south with the Spreča valley. The Tuzla's urban area is located between 18°56' and 18°79' E and 44°48 'and 44°60' N, at an altitude from 202 and 480m. The urban area of Tuzla covers about 98.37 km^2 and is located on the northern slope of the Dinarid mountain system, and generally mildly tilted towards the Gornja Spreča valley. In this area live about 120,000 inhabitants in 66 settlements [1].

The geological structure of soil considers the rock surface, which is changed under the influence of a many factors and from which the soil is evolving and developing. Soil material can provide any rock, if it's on the surface and the subject of physical, chemical and biological impacts, that lead to the decomposition of its surface layer [2].

For a longer period of time, the area of the city and the wider surroundings of Tuzla is marked by the processes of urbanization and deruralization, industrialization and deagrarization, which contributed mostly to the pollution, degradation and soil devastation. The main goal of the research was to determine to what extent, the urban area of Tuzla is contaminated with heavy metals, primarily lead. Lead is scattered into the environment from the oil combustion in motor vehicles, industrial pollution and burning of fossil fuels in thermal power plants, waste, chemicals etc.

GEOLOGICAL STRUCTURE

The oldest structures belong to the Tuzla's lower Miocene formations in which organogenic limestones are prevailing ("slavinovićki" and "tuzlanski" limestones and dolomites) with marls sporadically. Above them, the clasts were deposited with characteristic reddish coloring (sandstones and conglomerates), building the "red" series. The continuation of the sedimentation cycle is made of a "trakasta" series, where the salt formation with accompanying dolomite, anhydrite and tufts are developed. The organogenic limestones, clays, marly clays, sands and subsidiary conglomerates belong to the youngest Miocene products. The development of the lower pliocene is characterized by the deposition of several seams of lignite (main, base and top seams). Vertical development of the Pliocene formation has the characteristics of rhythmicity: quartz sand, clays (slate and alevrite) and lignite. Quaternary formations were developed along the streams in the form of proluvial (debris) and as precipitated terrace and alluvial sediments (sand and pebbles) (Figure 1) [3].

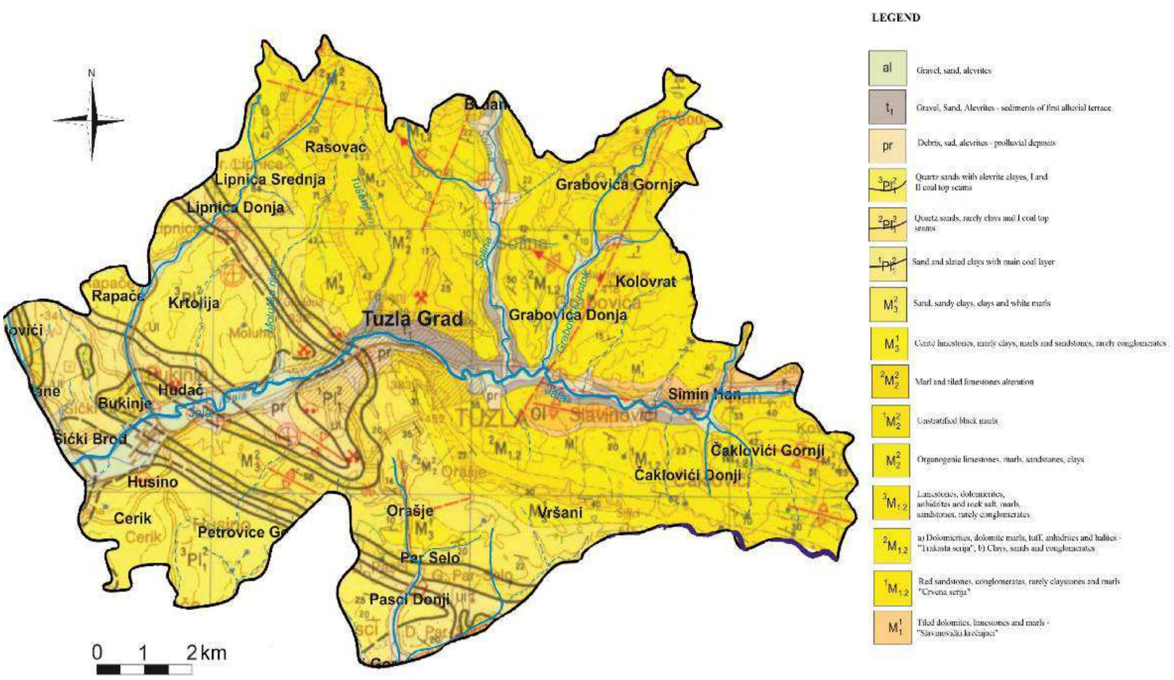

Fig 1: Geological map of the Tuzla's urban area

PEDOLOGICAL CHARACTERISTICS

On the pedological map (R - 1: 50 000) of the Tuzla's urban area, there are 16 (mostly automorphic) soil types [1] (Figure 2). The most common types of soil in the exploration area are yellowish-brown soils on sands and sandstones, brown degraded soil on clays and loams, brown medium deep and deep soil on limestones, grey-brown carbonate soil, grey-brown deeply-soaked soils, pelosols and vertisols [4]. High percentage of this soils is covered with urban infrastructure and isn't used for agricultural purposes.

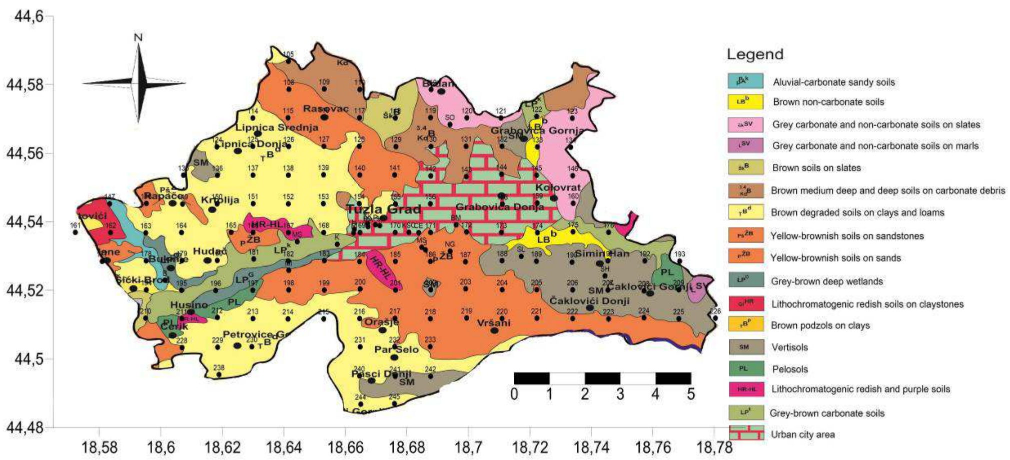

Fig 2: Pedological map of the Tuzla's urban area [4]

METHODS

For a paper purposes, the different methods were used, such as the analysis of the results of previous researches, the defining of the paper concept and the research order, terrain researches, sample preparation for laboratory testing, drafting of thematic maps and tables, etc.

Terrain work was based on the soil sampling from the area of about 100 km^2 (urban part of Tuzla) (Figure 3a). The samples were collected according the composite sampling scheme (Figure 3b), i.e. five subsamples collected from the corners and the center of the square make one sample (Figure 3b). Samples were taken from a depth of about 30 cm and stored in PVC bags with the specified number, location, coordinates and other data.

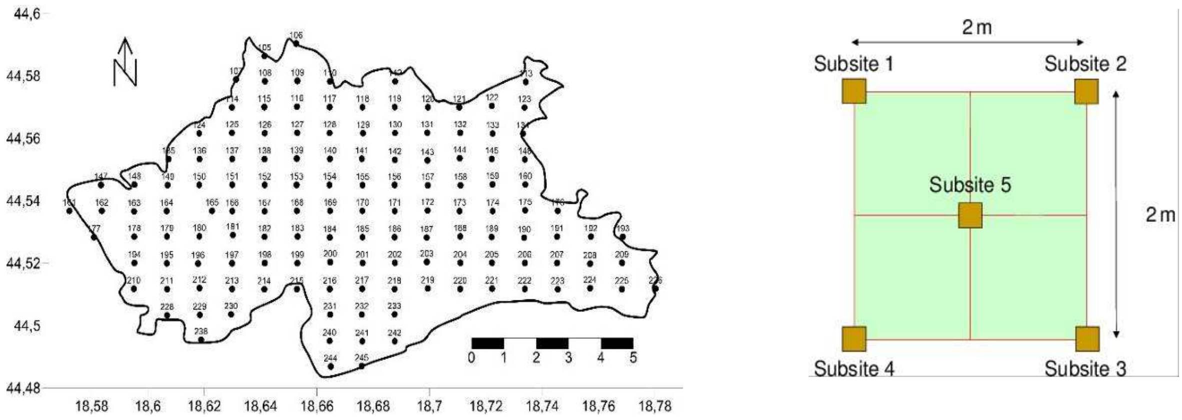

Fig: 3: a) Sample locations and b) soil sampling scheme

Preparation of soil samples for laboratory analysis (sowing, drying, grinding, weighing) was carried out on the Faculty of mining, geology and civil engineering of the University of Tuzla. Laboratory analysis was performed at Bureau Veritas Commodities Canada Ltd., Laboratory in Vancouver - Canada, by Inductively Coupled Plasma - Mass Spectrometry (ICP-MS). The limit detection of this method for lead is 0.02 to 10.000 ppm. The graphical processing of the results was made in the Golden Software Surfer 12 software package.

RESEARCH RESULTS

Lead concentrations were analyzed in 129 soil samples collected in the urban part of Tuzla and shown in Table 1. The lead concentration map of the Tuzla's urban area is shown in Figure 4.

Table 1: Lead (Pb) concentration in Tuzla's urban area soil

Soil sample No.	Pb (ppm)	Soil sample No.	Pb (ppm)	Soil sample No.	Pb (ppm)	Soil sample No.	Pb (ppm)	Soil sample No.	Pb (ppm)
105	29,33	134	24,16	161	31,48	187	170,33	213	37,98
108	131,52	135	24,66	162	34,23	188	32,88	214	37,28
109	28,53	136	26,49	163	26,23	189	147,81	215	43,12
110	32,17	137	22,94	164	44,73	190	32,62	216	39,05
112	24,15	138	23,90	165	15,11	191	37,00	217	25,34
114	24,68	139	23,80	166	22,07	192	17,68	218	23,91
115	28,01	140	49,31	167	48,12	193	40,96	219	37,76
116	19,86	141	33,71	168	25,66	194	33,34	220	23,44
117	36,37	142	49,12	169	26,65	195	128,10	221	32,16
118	24,78	143	31,47	170	114,00	196	24,44	222	42,19
119	45,06	144	40,62	171	120,81	197	22,09	223	28,40
120	31,84	145	39,20	172	28,47	198	39,74	224	31,38
121	27,18	146	31,87	173	40,73	199	47,82	225	23,32
122	15,28	147	39,01	174	43,02	200	28,44	226	37,98
123	25,76	148	51,75	175	25,86	201	30,29	228	41,03
124	26,54	149	31,42	176	33,03	202	23,28	229	40,41
125	17,53	150	25,68	177	14,14	203	33,25	230	60,74
126	30,86	151	27,83	178	34,91	204	32,07	231	37,39
127	26,58	152	19,87	179	36,34	205	25,64	232	32,94
128	45,30	153	35,61	180	28,20	206	29,70	233	32,17
129	34,25	154	21,91	181	45,93	207	22,66	238	33,41
130	34,90	155	33,44	182	158,99	208	23,34	240	24,31
131	36,78	156	33,90	183	48,95	209	28,73	241	38,45
132	41,30	158	35,16	184	35,29	210	38,08	242	42,92
133	49,96	159	38,32	185	37,65	211	29,21	244	190,82
		160	47,32	186	33,01	212	32,23	245	51,06

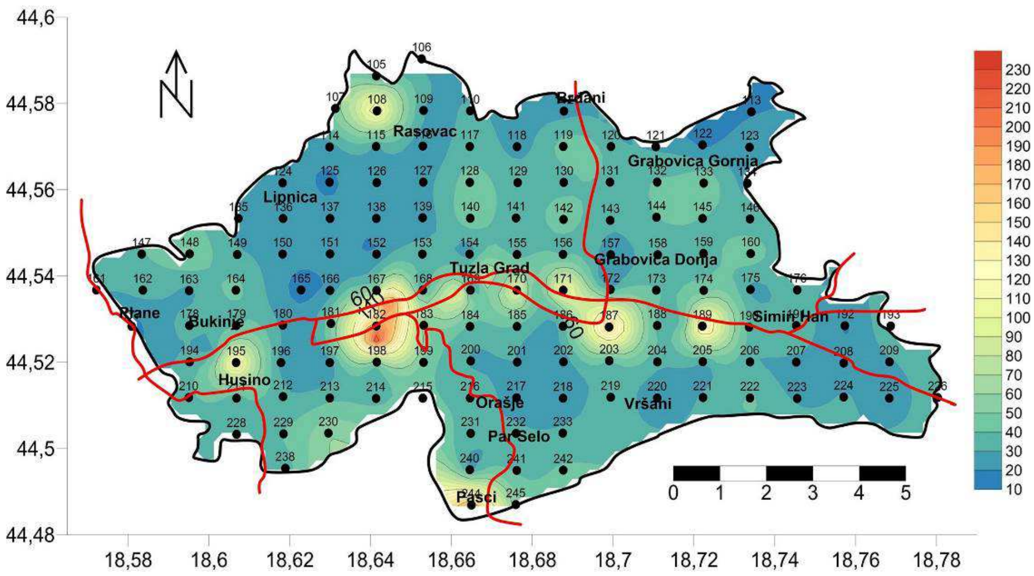

Fig 4: Lead (Pb) concentration in ppm and major roads in Tuzla's urban area

DISCUSSION

Lead is an oxyphilic element in traces and, it's at 36th place by its appearing in the Earth's lithosphere. It is found with potassium and concealed by calcium in aluminosilicate rocks. The average content of lead in magmatic rocks is 12.5 ppm, in sedimentary rocks 20 ppm, while the concentration in soils ranges from 2.6 to 83 ppm, with a mean value of about 14 ppm. The concentrations of lead in soils greater than 100 ppm are considered anomalous and indicate possible contamination [5,6].

The major natural sources include weathering (including erosion and deposition of wind-blown particles), volcanic eruptions, forest fires and biogenic sources [7,8,9]. The major anthropogenic sources of trace elements input to soils are: atmospheric deposition (arising from coal and gasoline combustion, nonferrous and ferrous metal mining, smelting, and manufacturing, waste incineration, production of phosphate fertilizers and cement, and wood combustion), and application of sewage sludge, animal manure and other organic wastes and co-products from agriculture and food industries, land disposal of industrial co-products and waste, fertilizers, lime and agrochemicals (pesticides) use in agriculture [9,10].

Production-oriented policies in the twentieth century, which exploited land for mineral extraction, manufacturing industry and waste disposal have resulted in the input and accumulation of large quantities of TEs in the soils. There are a variety of both natural and anthropogenic input sources of trace elements into soils [8,9]. Because of the frequent use of lead-based paints before the 1970s, leaded gas to the mid-1980s and contamination of various industrial pollutants, urban soils often have much higher concentrations of lead than permitted values. Lead does not degrade and does not disappear over time, but accumulates in soils for thousands of years. Once taken in to the human body, the lead can't be excreted, but accumulates in organism, so the prevention of lead poisoning is the only possible remedy [11].

The limited values of lead concentrations in the soils vary from 50 ppm for sandy soils, 80 ppm for dusty-loamy soils, and 100 ppm for clayey soils [12]. According the pedological map of the Tuzla's urban area, it is evident that all of these three groups of soils are present in the investigated area.
Compared to the total number of analyzed samples (129), eight samples showed elevated concentrations in relation to the maximum permitted concentrations as defined by the „Pravilnik o utvrđivanju dozvoljenih količina štetnih i opasnih tvari u zemljištu i metode njihovog ispitivanja“. Elevated concentrations are recorded in samples 108, 170, 171, 182, 187, 189, 195 and 244. The lead concentration in these samples ranges from 114.0 to 190.82 ppm, with an average value of 146.72 ppm. By inspecting the spatial position of the analyzed samples, it can be specified that the elevated lead concentrations are recorded close to major roads, implying that a source of pollution is anthropogenic.

On all other samples, lead concentrations ranged from 14.14 to 60.74 ppm (average 33.68 ppm), which, from the point of soil contamination rating, represents the concentration that corresponds to the geogenic origin i.e. the natural content of lead in ground. In this way, with the careful evaluation of geological material (lithostratigraphic units, history of terrain creation and exogenous process analysis), the geogenic origin of soil contamination with lead in the examined area was eliminated.

CONCLUSION

Lead is naturally occurring in the soil, but concentrations of lead in soils greater than 100 ppm are considered anomalous and indicate possible contamination. Due to different pollutants in the urban environments, the urban soils often have much higher concentrations of lead than permitted values. Lead does not degrade and does not disappear over time, but accumulates in soils. The humans can intake the lead through water, food or dust inhalation. Lead is carcinogenic and poisonous, even in very small quantities, and eventually accumulates in the body. Because all of this, the regular analyzes and controls have to be carried out and the number of polluters should be reduced, especially in the urban area and in immediate vicinity of schools.

Lead concentrations were analyzed on 129 samples collected in the urban area of Tuzla on (about 100 $km^{2)}$. The maximum concentration of lead is monitored by main roads in the city. These concentrations exceed the values permitted by the „Pravilnik“. The highest concentration of lead was recorded in samples 108, 170, 171, 182, 187, 189, 195 and 244 where limit values were exceeded up to 90%. From all of the above, it can be concluded, that the increase of lead concentration in the soil of the Tuzla's urban area is of anthropogenic origin.

APPRECIATION

We would like to thank to the Office for Scientific Research at the University of Tuzla and to the Federal Ministry of Education and Science for financial support in the realization of a scientifically-research project: "Concentration of heavy metals in the city of Tuzla soils". Project No: 01-7227-1/15 Federal Ministry of Education and Science 05-39-3868-2/15 Faculty of mining, geology and civil engineering of the University of Tuzla.

(Received September 2017, accepted September 2017)

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