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POLLUTION OF SOILS IN URBAN AREAS IN SERBIA

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1.0. INTRODUCTION

Soil pollution is a world-wide problem that affect rural and urban areas of all the continents (Huetal.,2015;Mao et al., 2016; Trujillo-González et al., 2016; Elkhatib et al., 2016; Roy and McDonad, 2015; Mahmoud and Abd El-Kader, 2015; Adamcová et al., 2016). There is a need to develop a program to achieve the sustainability of the soil system as the soils offers goods, services and resources to the human kind (Keesstra et al., 2012; Brevik et al., 2015; Keesstra et al., 2016). The program of systematic monitoring of soil pollution in Belgrade is aimed at testing the concentration of hazardous and harmful substances (Zn, Cu, Ni, Hg, Pb, Cd, As, Cr, PAH, C10-C40, PCB, DDT) including radioactivity in soil (137Cs, 90Sr) at urban areas, interpretation of the results in accordance with current legislation, data processing and updating the database of the degree of pollution and setting up proposal of preventive and remedial measures against pollution in the wider territory of Belgrade.

2.0. SOURCE OF POLLUTION IN BELGRADE

Anthropogenic source of soil pollution: 1. Waste water: industrial, agricultural (fertilizers, pesticides, organic substances of various origin), and municipal waste water from households;

2. The pollutants originating from the atmosphere: emissions from industrial technological processes, fossil fuels, vehicle, burning of many organic compounds; 3. Solid waste: municipal, industrial and agriculture waste.

Natural source of soil pollution: An increased concentration of nickel in the soil is associated with the natural (geochemical) origin from the parent rock on which the soil is formed.

3.0. RESULTS AND DISCUSSION

An overview of the results of systematic monitoring of soil pollution in Belgrade is given for the period 2007-2009 in accordance with the Book of regulation of allowed concentrations of hazardous and harmful substances in the soil, and irrigation water, and methods of their testing ('Official Gazette of Serbia' no. 23/94) and for the period 2010- 2013 pursuant to the Provision on program of systematic monitoring of soil quality, indicators for assessing the risk of soil degradation and methodology for development of remediation programs (Official Gazette of RS 88/2010) including the Law on Environmental Protection (Off. Gazette of RS No. 135/04, 36/09) etc

3.1. Soil pollution analyses results for the period 2007-2009

Monitoring of soil pollution included a total number of 180 samples from 90 sites in the following zones:

1. Sanitary protection zone of Belgrade water supply (60 samples at 30 sites)
2. Large traffic roads (38 samples at 19 sites)
3. Public communal areas (80 samples at 40 sites)
4. Industrial facilities (2 samples at 1 location)

Parameter (mg/kg)	ZONE OF RESEARCH			Prescribed MAC
	1	2	3 /4	
	Range of recorded concentrations in soil samples exceeding the MAC			
Zn	-	3325	537-1929	300
Cu	110.1	148.9	382	100
Ni	53.9-134.6	51.4-87.8	53.3-67.6	50
Hg	-	-	-	2
Pb	120	281.1-451.4	113.8-3010.8	100
Cd	-	4.7	25.64	3
As	-	-	81.2-502.4	25
Cr	-	-	-	100
PAH	-	2.1	1.0-14.4	/
C10-C40	-	-	-	/
PCB	-	-	-	/
DDT	0.015-0.1	-	0.01-0.41	/

Table 1 - Range of recorded concentrations in soil samples exceeding the prescribed MAC

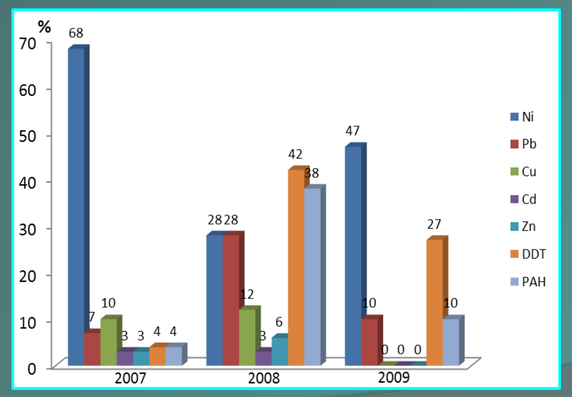


Chart 1 - Soil sample in % with exceeded values of MAC for each parameter

3.2. Soil pollution analyses results for the period 2010-2011

Monitoring of soil pollution included a total number of 146 samples from 73 sites in the following zones:

1. Sanitary protection zone of Belgrade water supply and water objects (18 samples at 9 sites)
2. Large traffic roads (26 samples at 13 sites)
3. Public communal areas (62 samples at 26 sites)
4. Public fountains with drinking water (38 samples at 19 public fountains)
5. Agricultural land (12 samples at 6 sites)

Parameter (mg/kg)	ZONE OF RESEARCH					Limit allowed conc.
	1	2	3	4	5	
	Range of concentration exceeding the limit allowed concentration					
Zn	88.0	92.3-410.0	80.3-222	139-290	96.9	140
Cu	25.8- 30.5	27.4-264	23.0-64.1	36.3-66.9	25.3-31	36
Ni	37.5 – 168	43.4-72.7	35.4-68.3	37.5-87.6	-	35
Hg	-	0.4	-	-	-	0.3
Pb	-	71.3-604	604	290	-	85
Cd	-	0.9-4.6	-	3.2	-	0.8
As	-	22.8-35.6	-	-	-	29
Cr		102.6	-	-	-	100
PAH	-	1.84-45.9	1.1-8.0	1.1-3.0	0.03-0.06	1
C_{10}-C_{40}	-	37.3-497	27.9-270.9	54.6-0.1	-	50
PCB	-	1.1-3.9	-	-	-	0.02
DDT	0.01-0.08	0.02-0.52	0.01-1.18	0.01-0.83	0.01	0.01

Table 2 - Range of recorded concentrations in soil samples exceeding the prescribed MAC

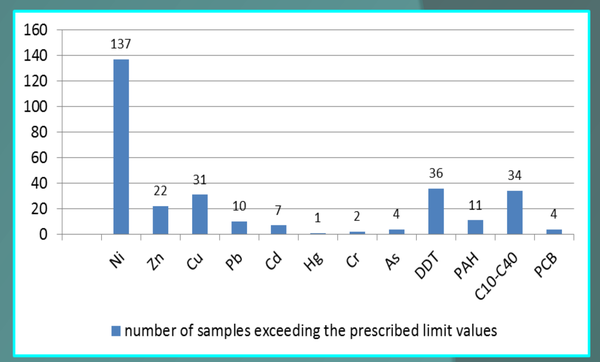


Chart 2 – Number of soil sample with exceeded the limit values for each parameter

3.3. Soil pollution analyses results for the period 2012-2013

In the period 2012-2013, soil pollution monitoring included a total number of 234 samples from 117 sites in the following zones:

1. Sanitary protection zone of Belgrade water supply and water objects (40 samples),
2. Large traffic roads (58 samples),
3. Public communal areas (112 samples),
4. Arable land (22 samples)
5. Industrial facilities (2 samples)

Parameter (mg/kg)	ZONE OF RESEARCH 2012-2013					Limit allowed conc.
	1	2	3	4	5	
	Range of concentration exceeding the limit allowed concentration					
Zn	86.3-2550.0	70.3-410.0	71.8-208	96.9	131-178.0	140
Cu	22.9-65.1	21.6-264.0	21.0-89.2	24.0-32.9	43-1-97.5	36
Ni	13.4-168.0	14.0-148.0	18.5-209	23.3-143.0	69.3-302.0	35
Hg	-	03.-0.7	0.3	-	0.3-0.4	0.3
Pb	81.8	61.4-604.0	74.9-604.0	-	-	85
Cd	0.3-1.3	0.7-4.6	0.7-0.8	-	-	0.8
As	-	20.8-51.0	-	-	-	29
Cr	-	59.7-101.5	-	-	-	100
PAH	1.6	1.2-45.9	1.0-4.1	-	-	1
C10-C40	0.1-3.2	24.55-497.0	8.32-296.9	34.9-61.3	45.3-102.7	50
PCB	0.028-0.110	0.10-3.95	0.05-0.22	-	-	0.02
DDT	0.01-0.07	0.01-0.52	0.01-0.66	0.01-0.03	0.056-0.312	0.01

Table 3 - Range of recorded concentrations in soil samples exceeding the prescribed MAC

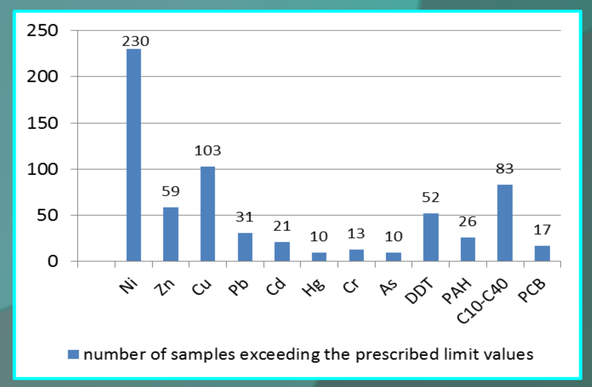


Chart 3 – Number of soil sample with exceeded the limit values for each parameter

3.4. Radioactivity in soil

Average Radioactivity (Bq/kg)	YEAR					
	2007-2009		2010-2011		2012-2013	
	Arable land	Uncultivated land	Arable land	Uncultivated land	Arable land	Uncultivated land
^{137}Cs	0.5-55.8	0.8-113.0	2.8-73.2	0.8-113.0	5.7-108	0.9-95.7
^{90}Sr	0.11-0.98	0.09-1.49	0.08-1.5	0.05-1.29	0.15-1.30	0.15-1.30

The radioactivity of ^{137}Cs and ^{90}Sr in soil was measured at 5 locations (uncultivated and arable land) in the central and wider area of Belgrade. The activity of natural radionuclides is in the range of average values for Serbia.