



## ENVIRONMENTAL HAZARDS RESULTING FROM URBAN SOILS IN BRATISLAVA CITY

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The soil contamination is a special problem in Bratislava resulting from its historical development. An abrupt development of city and intensive immigration tripled the population during the second half of 20<sup>th</sup> century. The governmental and municipal authorities responded by encouraging the development of industries in order to secure the jobs for growing population. Especially the proportion of heavy chemical industry became very large and in 70ties and 80ties Bratislava became one of major centers of chemical industry in the Eastern Europe. During the early stage of the industry development a little attention was paid to soil contamination. In 90ties the situation changed and the contamination start to decrease because more advanced technologies were introduced and some most polluting industries were removed. However, the contaminated soils remained an inherited environmental problem of Bratislava.

Currently the investigation of soil contamination attracts a lot of attention in Bratislava. Since 90ties the approach of Burghardt (1994) was introduced. The recent assessment of environmental hazards related to soil was focused to assessment of contamination of soil and soil parent materials and possible transfer of risk elements to other components of urban environment.

The first step of the soil environmental hazard assessment of Bratislava (Sobocka et al., 2007) was the delineation of so called *pedo-urban complexes* at a scale of 1:25 000. The pedo-urban complexes are understood here as territorial units having specific abiotic, biotic and socio-economic characteristics determining the soils properties. For their delineation mainly orthophotomaps were used. Each pedo-urban complex was further characterized by soil profiles. The legend of the map was based on Slovak Soil Classification System (Collective, 2000). Resulting map of pedo-urban complexes provided a background information for further assessment of environmental hazards resulting from soils.

The second step was the investigation of the contaminated areas. It was based on the soil quality assessment and on analytical characterization of contamination. Soil sampling and sample analysis of surface contamination was focused on most important heavy metals, such as Cd, Pb, Zn, As and Hg. The data on organic pollutants were taken from the database of municipal government where the data from several earlier surveys of organic pollutant contamination are stored and in key areas a new sampling was done. The level of contamination was evaluated in relations to individual pedo-urban complexes and their differentiated functions in urban environment.

The third step was the two-level categorization of pedo-urban complexes. At first level the pedo-urban complexes are divided to those which function as sources of contamination and those suffering from contamination originated in their surrounding. At the second level of the categorization both groups are divided further as follows:

## **I. Pedo-urban complexes functioning as a source of contamination**

This category presents the complexes with soils most heavily affected by anthropogenic activity. These areas are potential contamination sources for the surrounding soils. They can be separated to following subcategories:

1a Chemical and other industry, municipal waste incinerators, stock piles, old environmental loads (Slovnaft, O.L.O, Istrochem, Technické sklo, etc.)

1b Main roads (highways), railway tracks, ports, airports and other traffic areas.

2a Production-commercial and other functional urban systems, commercial-residential zones (the sealed area is more than 60 %)

2b Residential zones with less than 60 % of sealed areas (housing estates, family houses etc.)

The areas in 1a category are strongly contaminated from point sources and can be dangerous also for surrounding soils. The contamination sources are mainly the materials with carcinogenic effect (Cd, Ni, benzene, 1,3-butadiene, and ethylene oxide), solid inorganic materials (Pb), gasiform inorganic materials (NH<sub>3</sub>, HCl) and organic gaseous materials (like naphthalene, vinyl-benzene, ethanolamine, ethyl benzene, chlorine benzene etc.).

The areas in 1b category are contaminated mainly from linear and nodal pollution sources of traffic infrastructure. Mainly the most frequent crossroads and main road lines are loaded by exhaust emissions affecting the soil quality of their surroundings – there are solid inorganic pollutants (Pb, Zn) as well as materials causing carcinogenic effects (Cd). The port and airport belonging to this category show high concentrations of benzene and other organic pollutants.

The areas of categories 2.a and 2.b are less disturbed by anthropic activity than in the category 1.a,b. In spite of this fact it is assumed that these areas are the potential sources of environmental contamination including soils. It is the consequence of excessive waste production, concentration of small industrial parks, hospitals and shopping centers with high energy demands and traffic.

## **II. Pedo-urban complexes suffering by contamination originated in their surroundings**

This category involves the areas where do not occur important sources of contamination, but which are affected by contamination coming from their neighborhood. A special feature of these areas it increased demand on soil quality, because they serve to young population or to recreation and food production. The four subcategories are involved:

A) The most hazardous areas: kindergarten and playgrounds, public playgrounds and sand boxes, school yards used by children. The possible contamination comes from traffic (Pb, Zn, Cd, As, Hg), industrial sources (organic pollutants), trans-boundary contamination (SO<sub>2</sub>, NO<sub>x</sub>), substrata of poor quality etc.). They are the most endangered areas where children health can be significantly influenced by the soil quality.

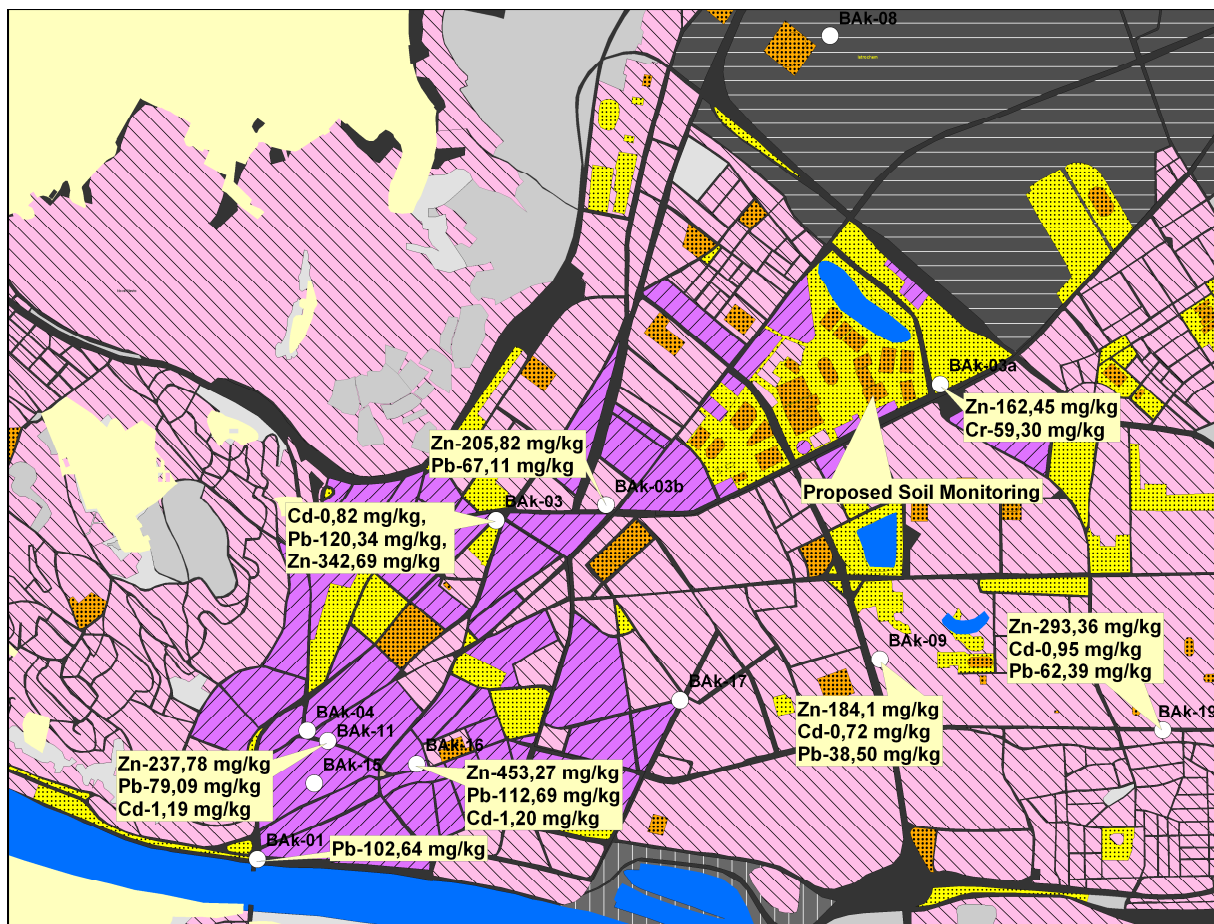
B) The hazardous areas: sport areas, parks, cemeteries, water recreation areas used mainly by adult population. There is possible contamination from traffic (Pb, Zn, Cd, As, Hg), industrial sources (organic pollutants), trans-boundary contamination (SO<sub>2</sub>, NO<sub>x</sub>), substrata of poor quality etc.).

C) Special hazardous areas: gardens, vineyards and orchards. The contamination is coming from traffic (Pb, Zn, Cd, As, Hg), excessive application of inorganic mineral fertilizers (N, P, K, S), manure, sludge from sewage treatment plants, pesticides (persistent chlorine-phenols, aldrines, DDT, hexachlorine benzol etc.), as well as from soil liming (As, Pb).

D Areas potentially slightly endangered by environmental hazards in relation to soil: arable land, grasslands and pastures, urban and suburban forests, protected nature areas. There is possible contamination from traffic (Pb, Zn, Cd, As, Hg) and other sources. The properly managed arable land does not represent the danger of excessive contamination; forests and park-forests as well as protected nature areas are considered as valuable biotopes with significant sanitary function.






The final output is the map of environmental hazards of the city Bratislava resulting from soils at a scale of 1:25 000 covering the whole territory of Bratislava city (367 km<sup>2</sup>). The central segment of this map is shown on Fig. 1. The map of soil environmental risk assessment was provided to municipal government and already now it is used in decision process as a primary input information for urban planning. The investigation of soil contamination resulted also in proposal of contamination monitoring of major risk areas, especially kindergartens, children playgrounds, etc.

Fig. 1. Central segment of the Map of soil related environmental hazards of Bratislava








## Legend:

### I. Pedo-urban complexes functioning as a source of contamination:

-  Chemical and other industry, incineration facilities and landfills or stock piles, old environmental load
-  Highways, major roads and other traffic areas
-  River ports
-  Production-commercial and other functional urban systems, commercial-residential zones (sealed area > 60 %)
-  Residential zones, housing estates, family houses (sealed area < 60 %)

### II. Pedo-urban complexes suffering by contamination originated in their surroundings:

-  Most hazardous areas: nurseries and playgrounds, school yards and playgrounds
-  Hazardous: sport and recreation areas, ornamental gardens and parks, cemeteries and crematoria
-  Special hazardous areas: allotments, vineyards and orchards
-  Potentially and slightly threatened areas: arable land, grasslands and pastures
-  Potentially slightly threatened areas: urban and sub-urban forests, protected nature areas

### Other areas:

-  water

## References:

*Burghardt, W., 1994:* Soil in Urban and Industrial Environment. *Pflanzenrenährung Bodenk.*, 157: 205-214.

*Collective, 2000:* Morphogenetical Soil Classification System of Slovakia (in Slovak), SSCRI-SPS, Bratislava, 74 p.

*Sobočka, J. et al., 2007:* Urban Soils: Example of Bratislava, SSCRI Bratislava, 126 p.