15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. 7 Ext. Abs. GSG2019-076

Urban Geochemical Surveys in Hellas

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Introduction

Urban soil is generally contaminated to a variable degree depending on its proximity to potential contaminating sources. Traffic is one of the main sources of urban contamination, *e.g.*, Pb from the use of leaded petrol, Zn and Cd from tyre wear, Sb from brake pads, and the platinum group elements (PGEs) from the wear of catalytic converters, are some typical elements that often reach high concentrations in the urban environment. Lead was also a key ingredient in white paint, and in towns with a high proportion of white wooden houses very high concentrations were found in soil. Crematoria can or have emitted mercury (Hg). Coal, lignite and heavy oil fired electrical power and heating stations emit S, Ag, V, U, Br and Ba. The use of impregnated wood may have resulted in high concentrations of As, Cr and Cu, especially in kindergartens (nursery schools) and playgrounds. Building materials (plaster and paint) may also contain high concentrations of organic contaminants, especially polychlorinated biphenyls (PCBs), which again end-up in urban soil. Coal and wood burning, the use of diesel fuel, and the production of coke, all lead to the emission of polycyclic aromatic hydrocarbons (PAHs). There exist countless other sources of local contamination in towns, and there is thus every reason to be concerned about the quality of the urban environment, and the suitability of soil for sensitive land uses, such as schools, playgrounds, parks and vegetable gardens. Contaminated urban soil may contaminate indoor dust and, therefore, lead to an increased human exposure to inorganic and organic toxic chemicals. Consequently, the distribution of contaminants in urban soil needs to be documented and made known to city administrations to avoid costly mistakes in land use planning, and further spreading of highly contaminated materials.

Urban geochemistry projects

The Institute of Geology and Mineral Exploration (presently the Hellenic Survey of Geology and Mineral Exploration) realised the significance of carrying out systematic urban geochemical mapping surveys to assist urban authorities and other stakeholders in sustainable land use planning. The first multi-sample media urban survey was carried out in 1989-1992 in Aghios Constaninos (Kamariza) and Lavrion, municipalities to the south-east of Athens, which were centres of mining and smelting activities from ancient to recent times (Hatzigeorgiou-Stavrakis and Vergou-Vichou, 1992). Samples of garden soil (n=187), house dust (n=159) and road dust (n=169) were collected, analysed and studied. The health-related hazards affecting the local population were documented by cross-sectional epidemiological studies.

The second multi-sample media urban geochemical survey was carried out in the Lavrion urban and suburban area (1994-1999), and is considered to be the most comprehensive urban geoscientific project that has ever been carried out, not only in Hellas but globally (Demetriades, 1999; NTUA, 1999). It was a collaborative project between the Institute of Geology and Mineral Exploration and the National Technical University of Athens, and was coordinated by the Municipality of Lavreotiki. Apart from the geochemical results in overburden samples (n=224) and house dust (n=127), different thematic maps were compiled at a scale of 1:5000: (a) metallurgical processing wastes and representative samples (n=62) collected and analysed, (b) parent rocks and representative samples (n=140) collected and analysed, (c) land use, (d) property ownership, and (e) hazard and risk. The geochemistry of the subsurface, and the quality of ground water, were studied by sampling of drill cores and boreholes/wells, respectively. Further, the chemical results of human tissues, such as human blood from 235 children, deciduous teeth (n=82) and 24-hour urine (n=65) showed that the contaminants have entered the human body and affected human health and, especially, of children. The end products were (a) an integrated environmental management plan for the remediation of the different types of metallurgical processing wastes and contaminated overburden, and (b) measures for the protection of the local inhabitants.

As multi-sample media urban geochemical surveys are costly, it was decided to carry out in other towns systematic surface soil (0-10 cm) multi-element geochemical surveys using a regular sampling grid of 500x500 m. Six towns have been mapped up to now, and these are (i) Nafplion (Fig. 1a; Vassiliades, 2008a; Tassiou, 2009a), (ii) Sparti (Fig. 1b; Vassiliades, 2008b; Tassiou, 2009b), (iii) Drama (Fig. 1c; Vassiliades, 2008c; Tassiou, 2009c), (iv) Thrakomakedonaes (Fig. 1d; Vassiliades, 2008d; Tassiou, 2009d), (v) Volos (Tassiou and Kaminari, 2016; Tassiou *et al.*, 2016), and (vi) Igoumenitsa (Gerouki and Liakopoulos, 2016; Gerouki and Sgouros, 2016), with the collection of 144, 206, 176, 173, 205 and 135 soil samples, respectively. In order to produce compatible and harmonised urban geochemical databases all samples were analysed by the same hot *aqua regia* analytical method at the same commercial laboratory.

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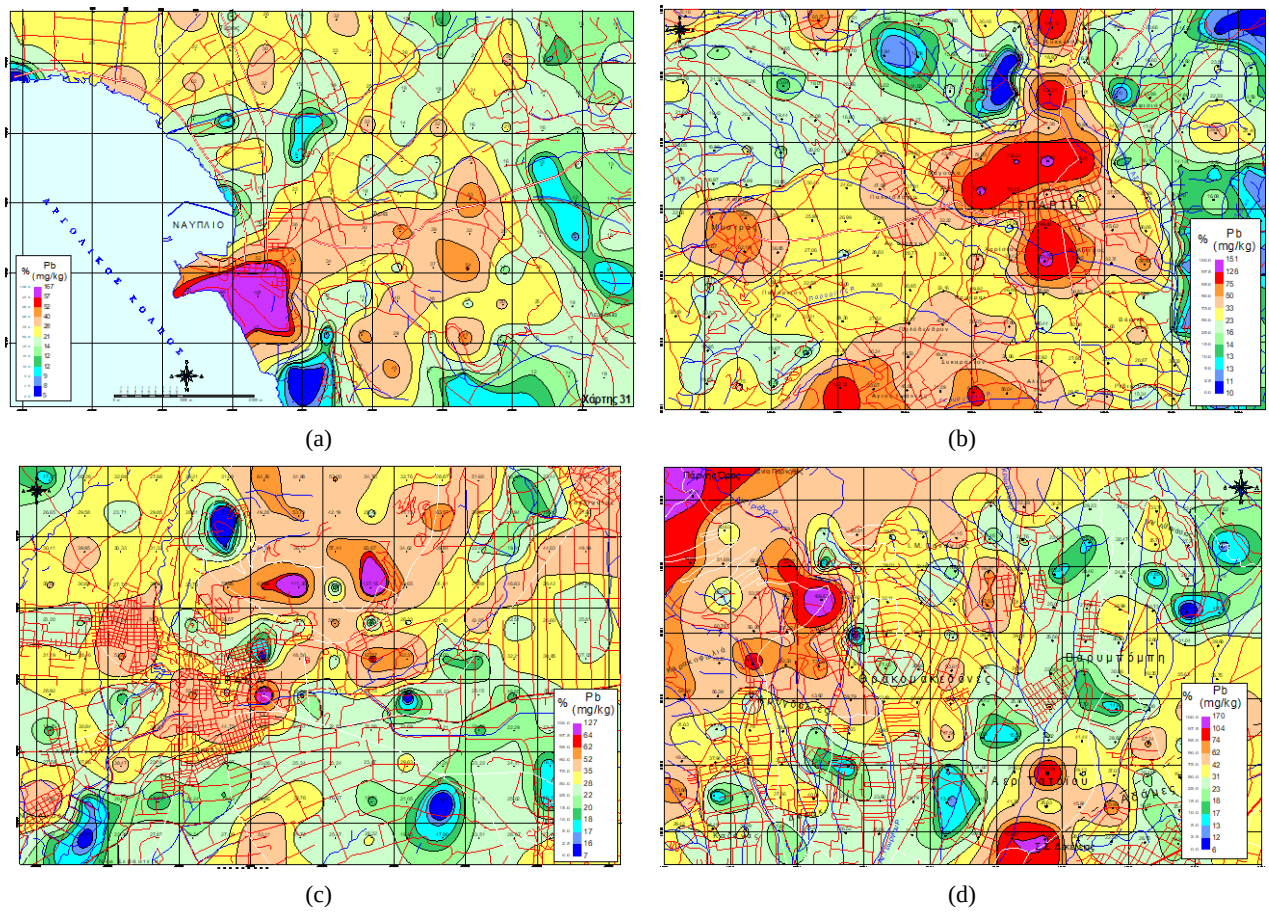

(a) (b)

(c) (d)

Figure 1. (a) Geochemical distribution maps of Pb in surface soil (0-10 cm) in (a) Nafplion (Vassiliades, 2008a); (b) Sparti (Vassiliades, 2008b); (c) Drama (Vassiliades, 2008c); (d) Thrakomakedhonaes (Vassiliades, 2008d).

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