Long-term airborne contamination studied by attic dust in an industrial area: Ajka, Hungary

petervolgyesi11@gmail.com, http://lrg.elte.hu

[1]Péter Völgyesi, [2]Győző Jordán & [1]Csaba Szabó

[1]Lithosphere Fluid Research Lab, Eötvös University, Pázmány Péter sétány 1/C, H-1117, Budapest, Hungary, [2]Geological and Geophysics Institute of Hungary, Environmental Geology Department, Stefánia út 14., H-1143, Budapest, Hungary

Poster presented at the EUROPEAN GEOSCIENCES UNION General Assembly, 22-27 April 2012, Vienna, Austria

1. Introduction

Heavy industrial activities such as mining, metal industry, coal fired power plants have produced large amount of by-products and wide-spread pollution, particularly in the period of centrally dictated economy after WWII, in Hungary. Several studies suggest that significant amount of these pollutants have been deposited in the urban environment. Nowadays, more than half of the world's population is living in urban areas and people spend almost 80% of their lives indoors in developed countries increasing human health risk due to contamination present in urban dwellings. Attic dust sampling was applied to determine the long-term airborne contamination load in the industrial town of Ajka (Hungary).

2. Study Area

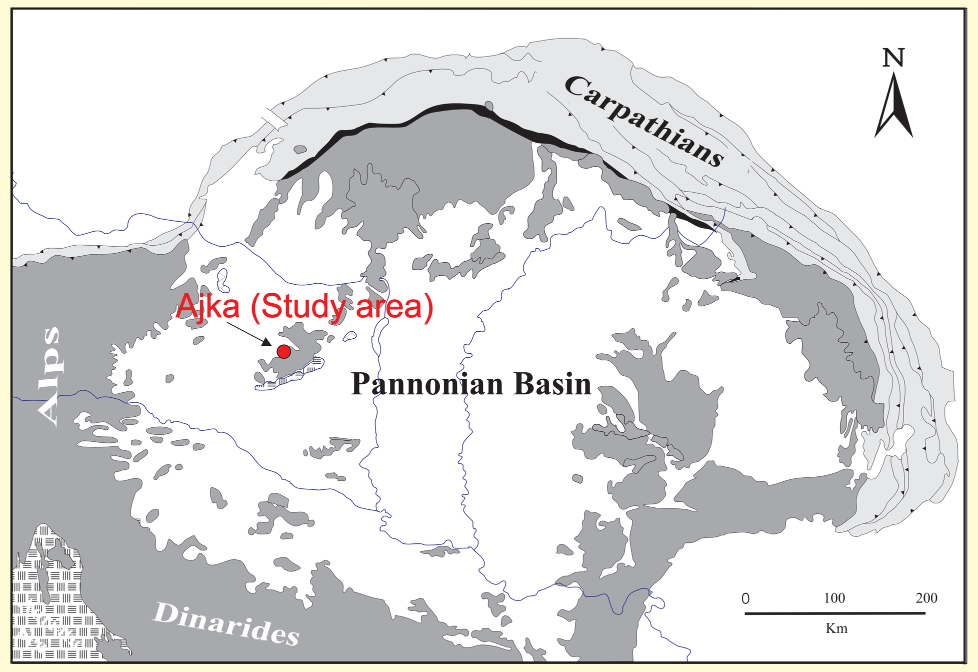

Fig. 1 Map of the Carpathian-Pannonian region. The red point indicates the locality (Ajka) of the studied attic dust samples.

Ajka town is located in western Hungary *(Fig. 1)*. There has been a high industrial activity in Ajka since the end of the 19th century. In addition to aluminum and alumina industry, coal mining, coal fired power plant and glass industry sites, generated numerous waste heaps, which act as multi-contamination sources in the area. In October 2010 the Ajka red mud tailings pond failed and caused an additional accidental regional contamination of international significance.

3. Sampling and analytical methods

At 27 sampling sites 30 attic dust samples were collected in Ajka town *(Fig. 1)*. Sampling strategy followed a grid-based stratified random sampling design *(Fig. 2)*. In each cell a house for attic dust sample collection was selected, which was located closest to a randomly generated point in the grid cell *(Fig. 2)*. The project area covers a 6x8 grid of 1x1 km cells with a total area of 48 km^2. In order to represent long-term industrial pollution, houses with attics kept intact for at least 30-40 years were selected for sampling. Sampling included the collection of background samples remotely placed from the industrialized urban area *(Fig. 2)*. The concentration of the major and toxic elements (Al, Ca, Fe, K, Mg, Mn, Na, P, S, and As, Ba, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, Se, Sn, Sr, Ti, V, Zn) were measured with ICP-OES and the mercury content was determined with atom absorption spectrometry. On this poster the concentration ranges and the spatial distributions of the As, Cd, Cu, Hg and Pb toxic elements can be seen. The concentration data were partitioned into populations by using STATGRAPICS Centurion program.

4. Goal

The major objective of this research was to study and map the spatial distribution of toxic element contamination in airborne attic dust samples.

5. Results

From the measured 27 elements, As, Cd, Cu, Hg and Pb concentrations are presented. To better understand the study area, *Fig. 2.* demonstrates all additional information about the sampling design, the main contamination sources, living areas and major traffic lines. Arsenic, Cd, Cu, Hg and Pb concentration of the attic dust samples and the spatial distribution of the populations, based on the concentration ranges, are presented on separate maps on elements *(Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7)*. Because there are no limit values for this type of dusts, our results were compared to other studies using attic dust as a sampling media (Czidziel and Hodge, 2000; Davis and Gulson, 2006 and Gosar et al., 2006). Below map short summaries aggregate principal information such as spatial distribution of the given attic dust toxic element concentration compared to publications mentioned above, their potential sources and geochemical behaviours.

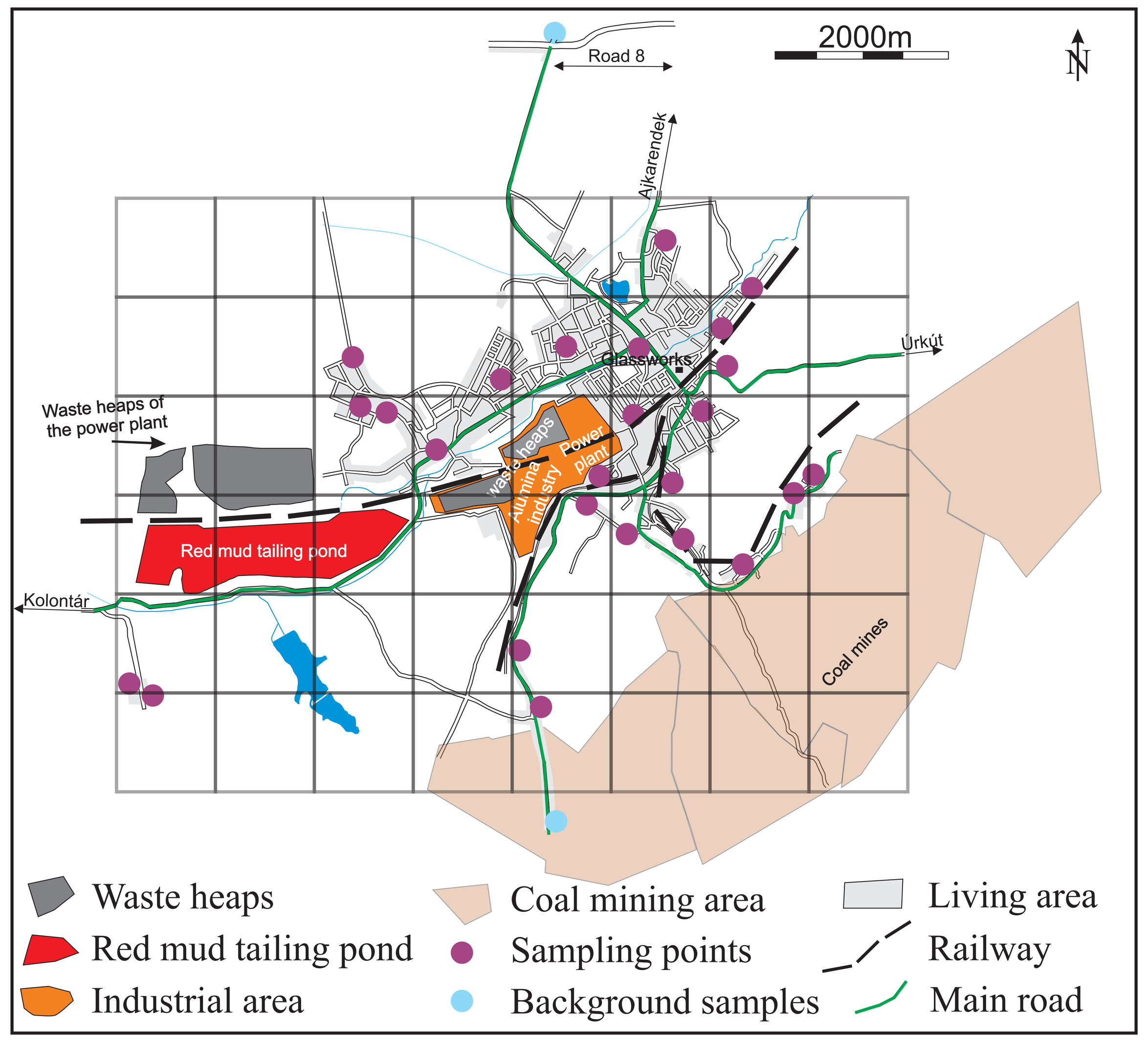

Fig. 2 Grid sampling design and main contamination sources in the studied area (Ajka).
Purple points indicate the attic dust samples, blue points illustrate the attic dust background samples. Green line and dashed black lines indicate main roads and train tracks.

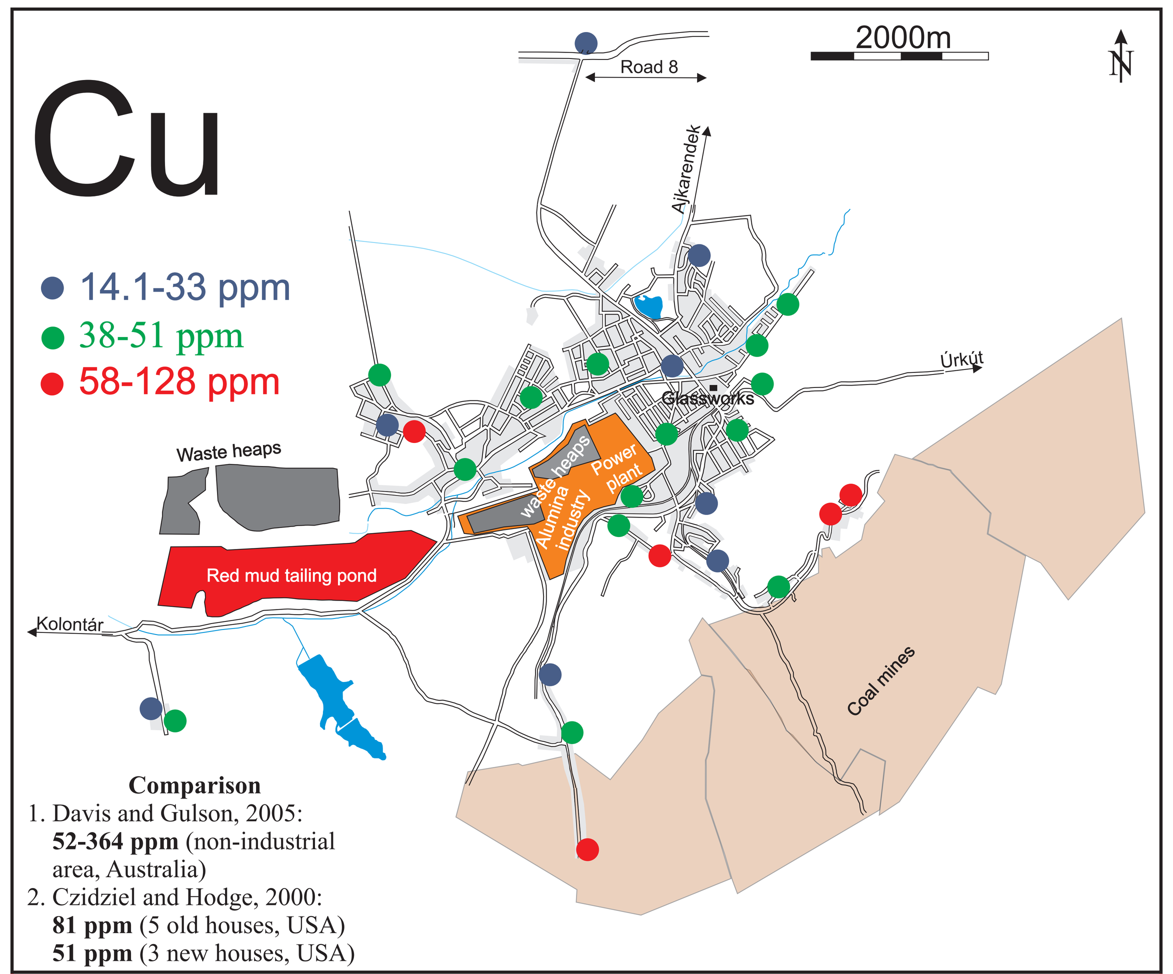

Fig. 3 Cu concentration in attic dust samples from Ajka.

Summary: Good spatial correspondence can be observed to the main roads and train tracks *(Fig. 3, Fig. 2-main roads and railway)*. Based on other studies (Davis and Gulson, 2005 and Czizdiel and Hodge, 2000), it is clear that the copper concentration in the attic dust samples from Ajka (14.1-128 ppm, *Fig. 3*) show the same values as the attic dust from Nevada and Utah (USA) and a bit lower than those from a non-industrial area in Sydney (Australia).
Our attic dust data indicate good correlation to potential Cu sources like copper wiring, brake and thrust bearings from motor vehicles (Fuge, 2005).

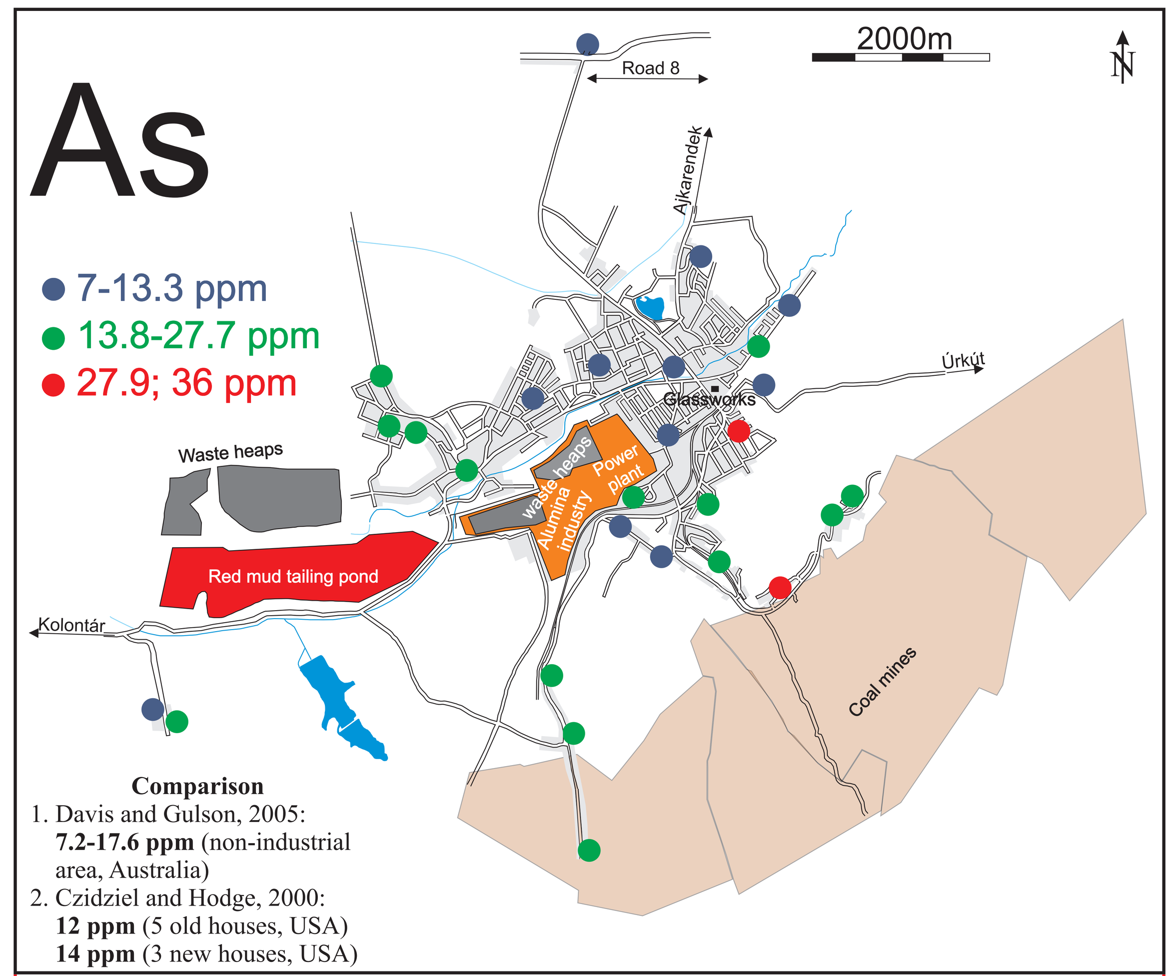

Fig. 4 As concentration in attic dust samples from Ajka.

Summary: High concentration can be found around the coal mining area and the waste heap of the power plant *(Fig. 4, Fig. 2)*.
To compare these data with those in other publications, it is obvious that arsenic concentration in Ajka (7-36 ppm, *Fig. 4*) is a bit higher than in the attic dust samples from the non-industrial area of Sydney (Australia) and Nevada and Utah states (USA).
The effect of the coal mining and coal combustion is recognizable in our sampling medium as coal can contain appreciable amounts of As (e.g. Fordyce et al., 2005).

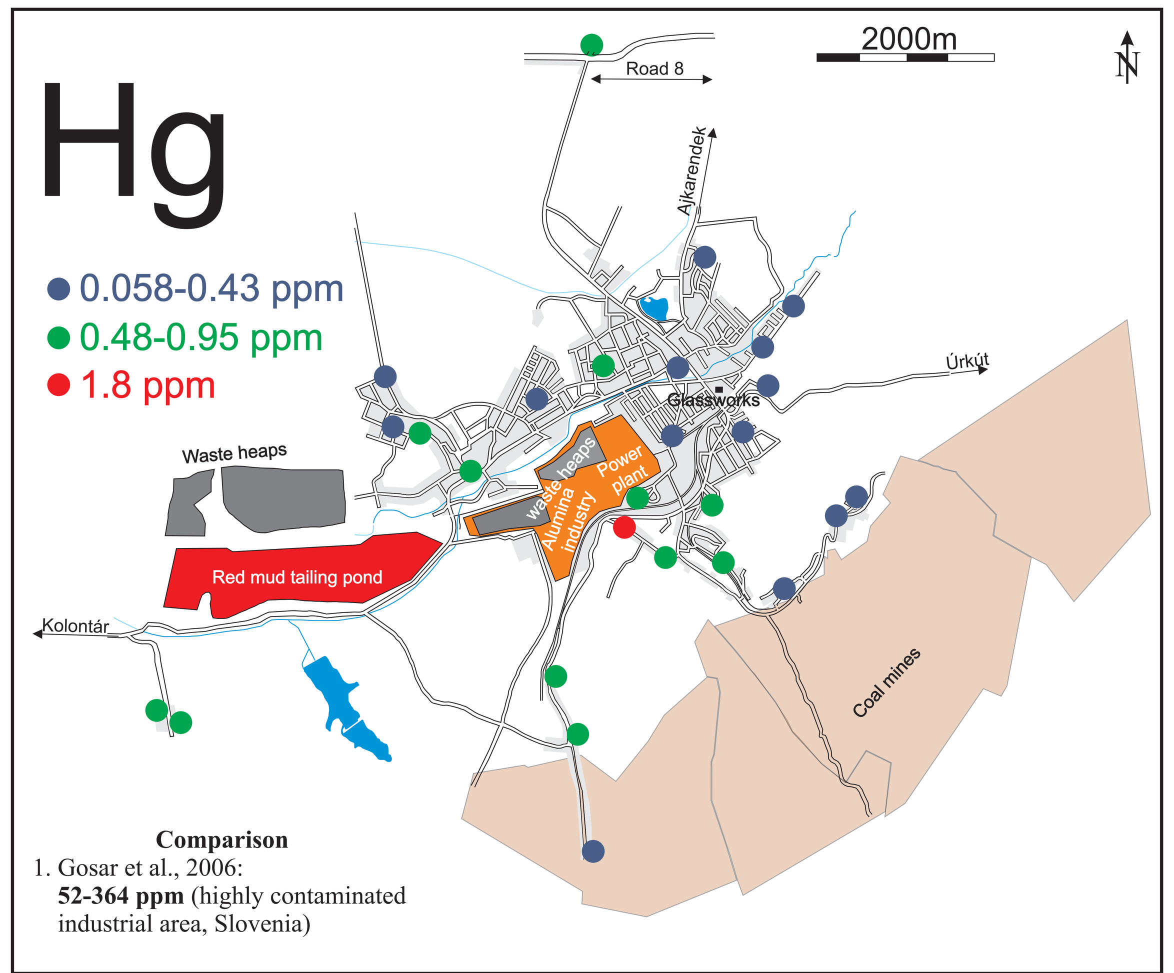

Fig. 5 Hg concentration in attic dust samples from Ajka.

Summary: Significantly high concentrations were measured around the power plant and the mining area *(Fig. 5, Fig. 2)*. An approx. N-S spatial trend occures in the Hg distribution, mostly due to the prevailing wind direction. One outlier sample can be seen around the industrial area (red point on the *Fig .5*).
The impact of the power plant is significant on distribution of the mercury concentration in the studied attic dust.
Our data (0.058-1.8 ppm) on the *Fig. 5* is much more lower than those in the industrial area of Idrija (52-364 ppm), Slovenia (Gosar et al., 2006). Note that Idrija area is of highly contaminated due to the mercury industry operated for many decades.
The attic dust can be useful to map the atmospheric transport of Hg (Gosar et al., 2006).

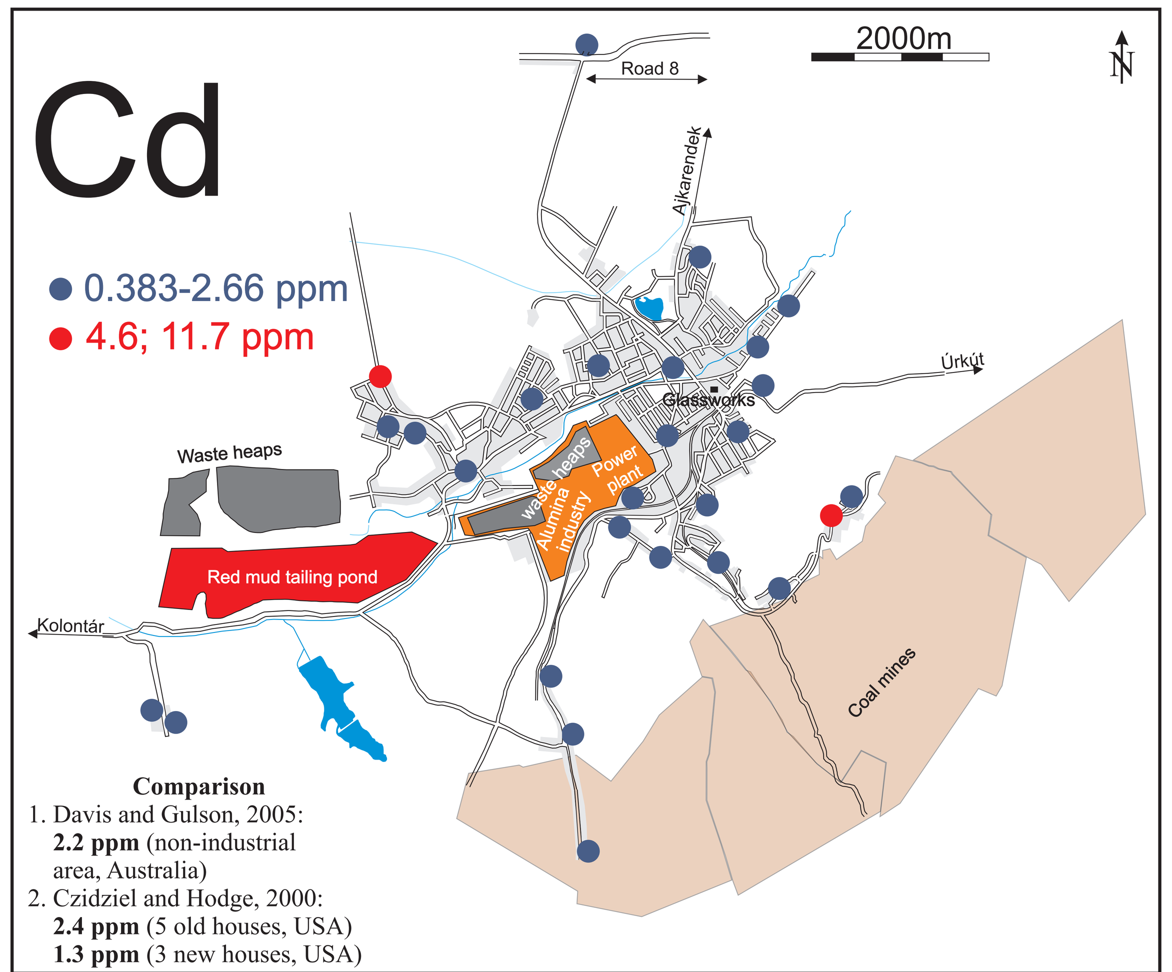

Fig. 6 Cd concentration in attic dust samples from Ajka.

Summary: No spatial trend was recognized in the distribution of cadmium concentration, except two samples near the coal mining area and the vicinity of the waste heap of the power plant *(Fig. 6, Fig. 2)*. Cadmium contents of attic dust samples from Ajka are equal to the concentration range in Sydney (Davis and Gulson, 2005) and Nevada and Utah (Czizdiel and Hodge, 2000), exept the two outliers (red points on the *Fig. 6*).
It is possible that high concentration in these two attic dust samples is related to the coal mining area and the waste heap of the power plant. Because of the selective adsorption and complexation by humic compounds, coal and peat can contain relatively high Cd (Salminen et al, 2005).

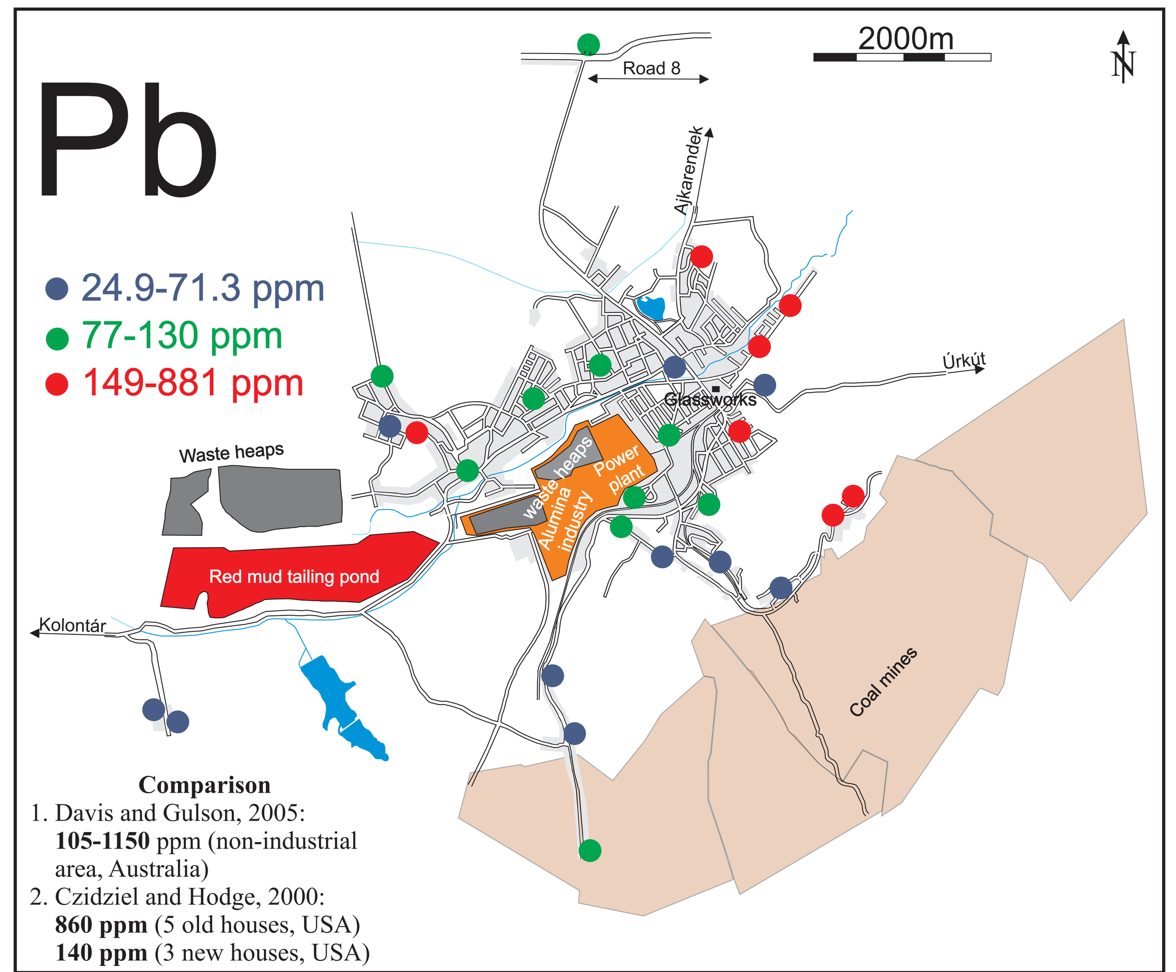

Fig. 7 Pb concentration in attic dust samples from Ajka.

Summary: High concentrations can be observed in the city centre relative to other sampling sites. Enrichment also detected in the eastern part of the city including the highest concentration of Pb *(Fig. 7)*, which can be related to the presence of old houses in this area. To compare these results (24.9-881 ppm) to those of other studies, the lead concentration in attic dust samples from Ajka show the same values as those in Sydney, Australia and Utah and Nevada, USA published by Davis and Gulson (2005) and Czidziel and Hodge (2000), respectively. Note that Czidziel and Hodge (2000) reported higher concentrations of Pb in old houses than in new ones. The spatial distribution of the attic dust samples is quite homogeneous, however an enrichment can be seen in the old houses of the eastern region representing probably the long-term Pb usage as fuel additive.

6. Conclusions

1. It was difficult to identify exactly the major sources of the selected elements because of the complex anthropogenic activity including alumina industry, coal mining and combustion and traffic. Despite of these potential sources, the impact of coal mining and the coal-fired power plant can be clearly recognized in the distribution of the studied elements (As, Hg).
2. In case of Cd concentrations only the two outlier data indicate the coal mining and combustion.
3. The Cu concentrations show good correspondence to the traffic. The spatial distribution of the Pb concentrations is quiet homogeneous. Only a slight enrichment can be found in the city centre and higher data in the older houses of the eastern part of Ajka representing probably the long-term Pb usage as fuel additive.
4. Attic dust preserve the influences of the past industrial activities, therefore it is a useful method to study the long-term environmental geochemical behaviour and spatial distribution of toxic elements.
5. Attic dust study can be useful and powerful tool to study the past atmospheric exposure of inhabitants.

References

Czidziel, V.J. & Hodge, F.V. (2000): Attics as archives for house infiltrating pollutants: trace elements and pesticides in attic dust and soil from southern Nevada and Utah, Microchemical Journal, 64, 85-92.

Davis J.J. & Gulson L.B. (2005): Ceiling (attic) dust: A "museum" of contamination and potential hazard. Environmental Research, 99, 177-194.

Fordyce, F.M., Brown, S.E., Ander, E.L., Rawlins, B.G., O'Donnell, K.E., Lister, T.R., Breward, N., Johnson, C.C., GSUE (2005): urban geochemical mapping in Great Britain, Geochemistry: Exploration, Environment, Analysis, 4, 325-336.

Fuge, R., (2005): Anthropogenic sources. Essentials of Medical Geology, 43-60.

Gosar, M., Šajn, R., Biester, H. (2006): Binding of mercury in soils and attic dust in the Idrija mercury mine area (Slovenia). Science of The Total Environment, 69, 150-162.

Salminen, R. (Chief-editor), Batista, M.J., Bidovec, M., Demetriades, A., De Vivo, B., De Vos, W., Duris, M., Gilucis, A., Gregorauskiene, V.,Halamic, J., Heitzmann, P., Lima A., Jordan, G., Klaver, G., Klein, P., Lis, J., Locutura, J., Marsina, K., Mazreku, A., O'Connor, P.J., Olsson, S.A., Ottesen, R-T., Petersell, V., Plant, J.A., Reeder, S., Salpeteur, I., Sandström, H., Siewers, U., Steenfelt, A., Tarvainen, T. (2005): FOREGS Global Geochemical Baselines Programme. Geochemical Atlas of Europe. Available at :http://weppi.gtk.fi/publ/foregsatlas.

Acknowledgements

The authors thank to the members of the LRG, especially to Dóra Zacháry, Csilla Király and Viktória Forray, local people of Ajka, especially Oszkár Illési, Dezső Csóka and Lívia Kulcsár, Laboratory of the Geological and Geophysics Institute of Hungary, Eötvös University, Doctoral School of Environmental Science, Hungarian Developement Bank Ltd.