Can the reactive pool of potentially toxic elements in urban soils give an indication of human exposure?

[a]Coelho C, [b]Rodrigues S, [b]Cruz N, [c]Carvalho L, [b]Duarte A C, [b]Pereira E, [4]Römkens P F A M

Urban soils play an important role in the quality of life in cities and are permanently subject to changes in geochemical characteristics due to diverse anthropogenic activities. Such activities are responsible for emissions of potentially toxic elements (PTEs). People living in cities may therefore be exposed to these PTEs in soils through dermal contact, inhalation of soil particles and oral ingestion [1, 2].

Soil extraction procedures have been widely used to provide information on the concentrations of PTEs that are reactive in soils and thereby may become soluble or available to living organisms. In particular, soil extraction with 0.43 M HNO_3 has been commonly used to assess this geochemically reactive pool [3]. Various "in-vitro" extraction procedures have also been developed to mimic the effects of the human-digestion process on soils. These generally include extraction tests with solutions similar to gastric juice such as the simple bioaccessibility extraction test (SBET) [4]. Both approaches take into consideration that changes in pH and soil conditions control the release of PTEs from the soil matrix. Hence, the objective of this study was to compare the results obtained by soil extraction with 0.43 M HNO_3 with those of the SBET method in order to assess if the reactive pool of PTEs in urban soils can also give an indication of the potential for human exposure.

For this study, both "clean" and contaminated sites from Portugal were studied and a total of 73 samples were collected. These included 33 samples from the "Grande Porto" urban area. Pseudo-total (aqua regia digestion), reactive (0.43 M HNO_3 extraction) and bioaccessible pools (SBET method) of As, Ba, Cd, Cr, Cu, Ni, Pb and Zn were determined in all soils.

The reactive pool of PTEs in soils decreased in the following order: Cd>Pb>Cu≈Ba>As>Zn>Ni≈Cr with median reactive pools varying from 82 to 14% of the pseudo-total contents of Cd and Cr, respectively. A similar distribution was observed for the percentage of bioaccessibility of PTEs in soils: Cd>Pb>Ba>Cu>Zn>As>Ni>Cr with median bioaccessible pools varying from 67% (for Cd) to 6% (for Cr) of the respective pseudo-total contents.

For Ba, Cd, Cu, Ni, Pb and Zn no statistically significant differences ($p<0.05$) were found between the 0.43 M HNO_3 soil extraction and the SBET method. Furthermore, $R^2>0.94$ ($p<0.001$) were obtained in the comparison of the two methods for all PTEs analysed. This indicates that the reactive pool can be useful in the prediction of the impact of chemical factors affecting the bioaccessibility of PTEs in soils and can also be used as an indicator of the oral bioaccessible pool.

References

[1] Abrahams, P.W., 2002. Soils: Their implications to human health. Sci. Total Environ. 291, 1 – 32.

[2] Poggio, L., Vrščaj, B., Schulin, R., Hepperle, E., Ajmone Marsan, F., 2009. Metals pollution and human bioaccessibility of topsoils in Grugliasco (Italy). Environ. Pollut. 157, 680 – 689.

[3] Rodrigues, S.M., Henriques, B., Ferreira da Silva, E., Pereira, M.E., Duarte, A.C., Römkens, P.F.A.M., 2010. Evaluation of an approach for the characterization of reactive and available pools of twenty potentially toxic elements in soils: Part I – The role of key soil properties in the variation of contaminants' reactivity. Chemosphere 81 (11), 1549 – 1559.

[4] Kim, J., Kim, K., Lee, J., Lee, J., Cook, J., 2002. Assessment of As and heavy metal contamination in the vinicity of Duckum Au-Ag mine, Korea. Environ. Geochem. Health. 24, 215 – 227.

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[a] *CESAM & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal (claudiafilipa@ua.pt)*
[b] *CESAM & Department of Chemistry, University of Aveiro, 3810-193 Aveiro, Portugal*
[c] *Laboratório Central de Análises, University of Aveiro, 3810-193 Aveiro, Portugal*
[d] *Alterra – Wageningen University and Research Center, PO Box 47, Wageningen, 6700 AA, the Netherlands*