Factors controlling the bioaccessibility of Pb in polluted soils

N. WALRAVEN[1], S.P. VRIEND[1], B.J.H. VAN OS[2], G.TH. KLAVER[2] AND A.G. OOMEN[3]

[1]Utrecht University, P.O.Box 80021, 3508 TA Utrecht, The Netherlands (n.walraven@geo.uu.nl)
[2]TNO-NITG, P.O.Box 80015, 3508 TA Utrecht, The Netherlands, (b.vanos@nitg.tno.nl)
[3]RIVM, P.O.Box 1, 3720 BA Bilthoven, The Netherlands (agnes.oomen@rivm.nl)

The negative health effects of Pb pollution are long-known. However, it lasted until the 1970's before legislative measures were taken to reduce the input of Pb and related heavy metals in the environment. Despite these measures, many sites in the world are, as remnant from the past, heavily polluted with Pb. These sites are unsuitable for agriculture and residential building and, if they remain unattended, pose a threat to human health.

In human risk assessment, ingestion of soil is considered a major route of Pb, especially for children. A large body of research has focused on the measurement of the 'total' Pb content in sediment, soil and dust to determine the potential risk of the Pb polluted environment. However, we found that Pb bioaccessibility, determined with an in-vitro test [1], does not necessarily depend on the total Pb content, but also on the Pb source, chemical speciation and soil characteristics.

Initially the Pb bioaccessibility is largely controlled by the chemical form of the Pb source, which determines its solubility. However, when anthropogenic Pb enters the soils, it forms new, more stable, minerals and/or binds to organic matter, clay, iron or other reactive phases.

The Pb bioaccessibility of 30 soils, polluted with various Pb sources (o.a. gasoline Pb, gun shot, Pb based paint, Pb glazed ceramics and coal ashes), was determined and varied from 0.5% to 61%. The highest Pb bioaccessibility (56% to 61%) was measured in Pb polluted soils from shooting ranges (native lead). The soils of the shooting ranges are, in contrast to the other studied soils, acidic and contain negligible amounts of reactive phases, such as organic matter, clay, calcium-carbonate and reactive iron. The lowest Pb bioaccessibility (0.5%-8%) was measured in Pb polluted soils from a village already inhibited since Roman times. These soils are characterized by a high clay and intermediate organic matter content.

Multiple regression analysis shows that Pb bioaccessibility strongly relates to the content of reactive phases present in soil samples. These results indicate that it is possible to predict Pb bioaccessibility, as determined with the in-vitro digestion model [1], if the content of the reactive phases in Pb polluted soils is known

Instead of basing human risk assessment only on total heavy metal contents we propose to base it also on in-vitro bioaccessibility tests, taking factors such as organic matter, clay and reactive iron into account.

References

[1] Oomen *et al.*, (2002). Environ. Sci. Technol. **36**: 3326-3334.

A soil geochemical transect in northern California – Links to human health issues

M. B.GOLDHABER[1], J.M., MORRISON[1], R. L. REYNOLDS[2], AND D. B. SMITH[1]

[1]USGS, MS 973 Denver Federal Center, Denver CO, 80225, USA (mgold@usgs.gov, jmorrison@usgs.gov, dsmith@usgs.gov)
[2]USGS, MS 980 Denver Federal Center, Denver CO, 80225, USA (rreynolds@usgs.gov)

Soil is literally and figuratively a foundation of human society and may directly affect human health through its ingestion, inhalation, and dermal absorption. This study examined soil samples in a latitudinal transect crossing California from Marin County north of San Francisco to the Nevada border. Soil-related human health issues in the study area center on potentially carcinogenic Cr, Ni, and V enrichments in soil derived from ultramafic belts. We have chemically analyzed and measured magnetic susceptibility (ms) on nearly 2000 soil samples including 1300 shallow soils in the central and eastern portion of the study area (El Dorado, Placer, Sutter, Sacramento, Yolo, and Solano Counties), and 100 soil depth profiles across the transect. Cr, Ni, and V in these samples display distinctive patterns reflecting the underlying geology. Elevated concentrations of Cr, Ni, and V in soil with high ms values (high magnetite abundance) overlie ultramafic rocks and Mesozoic volcanic and metavolcanic rocks in the foothills of the Sierra Nevada. Soils with Tertiary volcanic and granitic parent material had lower Cr, Ni, and V concentrations with high ms. Surprisingly, Cr, Ni, and V enrichment is associated with low ms values in soil from the west side of the Sacramento Valley. The valley alluvial fill was derived in part from sediments transported from the Sacramento River headwaters in the Klamath Mountains and from ultramafic rocks in the Coast Ranges to the west of the valley. Low ms values are attributed to post-depositional alteration of detrital magnetite. We cannot confirm a link between soil geochemistry and human health in the study area. However, breast cancer rates are elevated, ranking near the top for California counties, where elevated Cr, Ni, and V concentrations occur in soils. We are investigating a potential environmental link between soil geochemistry and these high cancer rates through 'bioaccessibility' (selective leach) studies and through collaboration with researchers studying the potential for these high Cr soils to cause mutagenesis.