# Ecotoxicological and Chemical Considerations in Assessing Background Concentrations of Metals in Risk Assessments for Terrestrial Environments

Mike J. McLaughlin[1,2], Rebecca E. Hamon[1], and Kris Broos[1]

[1]CSIRO Land and Water, Centre for Environmental Contaminant Research, PMB2, Glen Osmond, 5064, AUSTRALIA
[2]Soil and Land System, School of Earth and Environmental Sciences, The University of Adelaide, PMB1, Glen Osmond, 5064, AUSTRALIA

## INTRODUCTION

Unlike anthropogenic chemicals, detection of metals in terrestrial environments does not necessarily indicate that contamination or pollution has occurred. Hence advances in analytical chemistry with regard to limits of contaminant detection are unlikely to drive regulatory approaches to assessment and control of metal pollution, as they continue to do with organic contaminants. As metals are naturally ubiquitous in soils at concentrations easily measurable, assessment of anthropogenic contamination is problematic. Established regulatory guidelines struggle to provide a clear rationale for assessing metal background concentrations against which contamination can be measured.

A second factor which needs to be considered with metals, is that due to their widespread occurrence at variable concentrations, ecosystems have developed “in tune” with these conditions. Adaptation to background metal concentrations by indigenous flora and fauna, widely recognised in ecology, has only recently been recognised in risk assessment procedures, and further advances are needed to incorporate this phenomenon into our risk assessment frameworks for metals.

## MEASURING BACKGROUND METALS

Metal concentrations in soils can vary geographically by orders of magnitude (Fig. 1), so choosing a single concentration for “background” for any element only becomes feasible if the areal extent under examination reduces to a scale that is less than that governing variation in parent material and pedogenic processes. Hence, risk assessment of metals in soil at a contaminated urban or industrial site would require site specific background values to be determined on uncontaminated land adjacent to the site, rather than use of a blanket regional or continental value. In urban areas, the availability of uncontaminated “control” sites is often limited.

For continental scale risk assessments, application of background values in one region may be inappropriate in other regions, due to variation in geology, pedogenic processes and hence background concentrations.

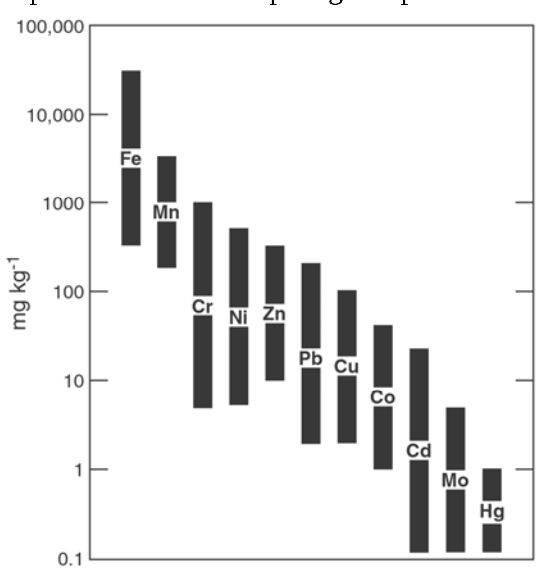


**Fig. 1. Variability in background concentrations of metals in soil (from McLaughlin 2002)**

Recently, a unifying approach to assess background concentrations in soil was suggested by Hamon et al. (2004). This relies on the observation that the concentrations of many metals in uncontaminated soils vary according to the iron (Fe) concentration. Thus, background concentrations can be "normalised" to Fe concentrations to produce a sliding scale of background concentrations dependent on Fe concentration in soil (Table 1).

**Table 1. Expected background concentrations of elements in soil given different concentrations of soil Fe. Current Australian Ecological Investigation Levels are shown for comparison (from Hamon et al. 2004).**

| | *Background Concentration of HMs in Soil (mg kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| Soil Fe % | As | Cr | Cu | Ni | Pb | Zn |
| 0.1 | < 3 | < 15 | < 4 | < 5 | < 0.3 | < 9 |
| 0.5 | < 8 | < 50 | < 10 | < 15 | < 2 | < 25 |
| 1 | < 10 | < 80 | < 15 | < 25 | < 4 | < 35 |
| 5 | < 30 | < 275 | < 45 | < 75 | < 20 | < 85 |
| 10 | < 45 | < 465 | < 70 | < 120 | < 40 | < 130 |
| 15 | < 55 | < 630 | < 90 | < 160 | < 60 | < 165 |
| 20 | < 65 | < 780 | < 105 | < 195 | < 80 | < 195 |
| 25 | < 75 | < 925 | < 120 | < 230 | < 100 | < 225 |
| Australian EILs | 20 | 400 | 100 | 60 | 600 | 200 |

## ADAPTATION OF INDIGENOUS FLORA AND FAUNA

Given the wide range in soil metal concentrations (Fig. 1), it is not surprising that microorganisms, plants and animals have adapted to different background metal concentrations, to give "metalloregions" (McLaughlin and Smolders 2001). This inherent tolerance, or adaptation, is well known. In microbial ecotoxicology, it has even been suggested that we can use tolerance to identify metal contamination ("pollution-induced community tolerance", or PICT). However, just as with background concentrations of metals in soil, the difficulty for risk assessors is how to distinguish between what we would call "inherent community tolerance" (ICT) (presumably acceptable) and PICT, which is potentially unacceptable, particularly if it results in an adverse effect on the community, such as loss of functional resilience. We propose that the combined concepts of community tolerance and resilience, as shown in Fig. 2, could be helpful in defining the distinction between ICT and PICT, and thus aid decisions on "acceptable" adaptation.

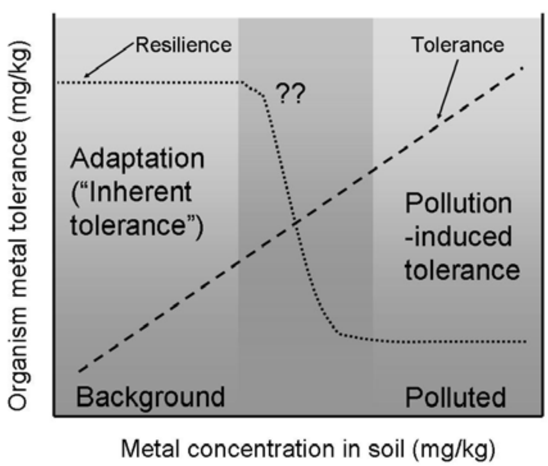


**Figure 2. Range in organism tolerance to metals as a function of concentration in soil.**

## REFERENCES

1) Hamon R.E., McLaughlin M.J., Gilkes R.J., Rate A.W., Zarcinas B., Robertson A, Cozens G., N. Radford N. and L. Bettenay. 2004. Geochemical indices allow estimation of heavy metal background concentrations in soils. Global Biogeochem. Cycl. 18 (1) Art. No. GB1014.
2) McLaughlin, M.J. 2002. Heavy metals. In "Encyclopedia of Soil Science", Ed. R. Lal, Marcel Dekker Inc., New York.
3) McLaughlin, M.J. and Smolders, E. 2001. A rationale for the metalloregion approach to risk assessments for metals in soil – a case study for effects of zinc on microbial functions in soil. Environ. Toxicol. Chem. 20: 2639-2643.