Urban Agriculture: Bioavailability as a tool to improve Risk Assessment?

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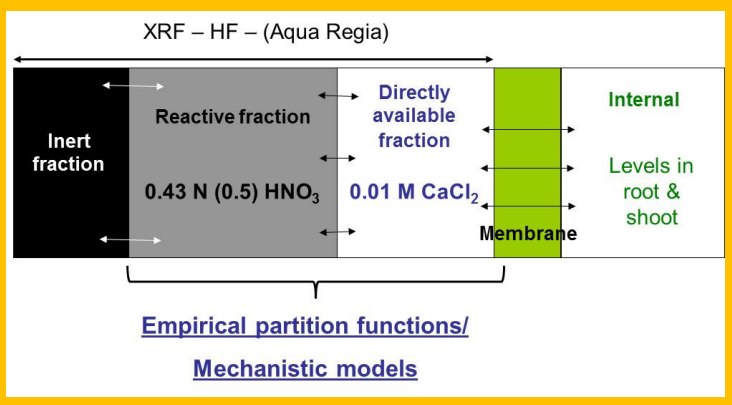
Background

The quality of soils in and near urban areas is affected by emission of potentially harmful substances including heavy metals and metalloids (Pb, Hg, Cd, As etc.). Important sources of metals include atmospheric deposition from on-going industrial activities, traffic and the use of polluted irrigation water. The latter source is highly relevant for paddy fields in industrialized areas/countries like Taiwan, Japan, or China. At present, the quality of urban soils affected by urbanization or industrialization is often assessed solely by the *total level* of contaminants in the soil. This, however, is often insufficient to address the risk of contaminants in view of transfer of contaminants from soil to crops. For most (heavy) metals the availability in the soil strongly depends on soil properties including the acidity (pH), soil organic matter content and redox potential. Obviously tools to assess soil quality on a national, regional or even local scale need to be practical on one hand but should include essential aspects that regulate the availability and risk on the other. Here we present several examples of how the determination of the availability of contaminants has been used successfully to derive more meaningful, i.e. realistic, risk assessment frameworks. The examples include strongly contrasting forms of land use and soil type illustrating a rather wide range of validity.

Geochemical Availability: The concept

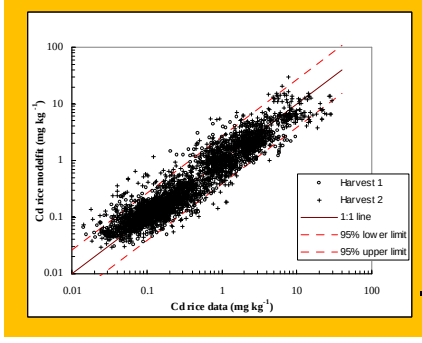
The concept: uptake of metals by crops can be related to the chemical availability in soils. This availability can be characterized by selected chemical extractions.



Derivation of soil quality standards for rice cropping: Uptake of Cadmium by rice in Taiwan (ROC)

Case: In paddy fields in Taiwan numerous industries have emitted chemical waste into surface waters. Levels of cadmium (and other metals) in rice now exceed food quality standards. Current soil quality guidelines are unable to detect the soils which are at risk since no correction for soil type is made.

Approach: in cooperation with TARI, cadmium availability can be modelled and linked to uptake by Japonica and Indica rice (left graph). The model then is used to derive soil standards that take into account soil pH and CEC.



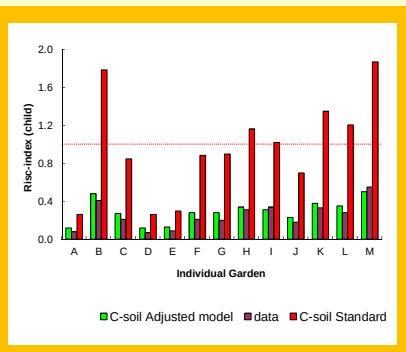
Soil Quality Standards for Cd (mg kg^{-1})

Cultivar:	Japonica		Indica	
pH:	5	7	5	7
Soil type				
Sand	1	3	0.5	1.5
Clay	2	3	0.5	2

Availability as a tool to improve Risk Assessment in view of food safety

Suitability of polluted urban gardens for food production: Heerenveen

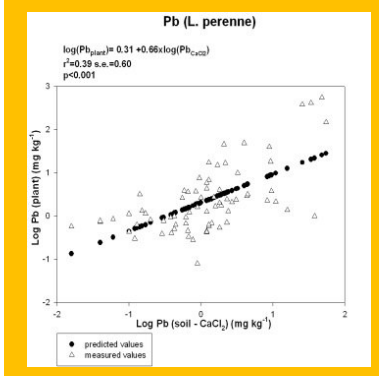
Parameter in regression model	Model to predict BioConcentration Factor (BCF) R^2	se
Pb in soil	54.7	0.41
Pb+pH	71.7	0.30
Pb+pH+OM	73.8	0.29
Pb+pH+clay	71.9	0.30
Pb+pH+OM+clay	74.1	0.29



Case: in urban areas elevated levels of lead in soil restrict the use of the gardens for crop production.

Approach: a new soil – plant transfer model has been developed to improve the risk assessment framework (model performance to predict the BioConcentration Factor in CSOIL for lead in the table on the left). Application of this model (graph on the right) leads to realistic assessments of the Risk-Index (RI) calculated by the 'CSOIL-adjusted' model compared to data, and a significant improvement compared to the performance of the current model.

Transfer of lead from soils into the food chain: Portugal



Land use	Soil standard for Lead (depending on Al-content) Al_{ox}=50 mmol kg^{-1}	Al_{ox}=100 mmol kg^{-1}	Al_{ox}=150 mmol kg^{-1}
Fodder production	411	618	789
Food safety (cow-kidney)	51	70	82
Food safety (cow-liver)	113	152	179
Animal health (cow-kidney)	332	446	524

Case: In Portugal soil policy is starting to be developed. Both for uncontaminated and contaminated soils, standards are needed to protect animal health, crop quality and human health.

Approach: Soil – plant transfer functions (left part of the graph) that consider differences in availability are developed to derive meaningful standards for different forms of land use (table on the right).

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