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Risk assessment of emission from (secondary) construction products and contaminated soil, an example of a general approach applied in the Netherlands

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Abstract

We are modelling the leaching of contaminants from the unsaturated soil towards shallow groundwater in soils exposed to emission from construction products or contaminated soil. Using a solute transport model in combination with a geochemical speciation model we will estimate the concentration in the shallow groundwater over time for the elements As, Ba, Cd, Cr, Co, Cu, Hg, Pb, Mo, Ni, Sn, V and Zn.

With this study we investigate the relation between sustainable soil management, including the application of construction products and contaminated soils, and the effects for shallow groundwater quality. Using knowledge and models from current and future work we will be able to (1) assess the mobility of present contaminants in soil and (2) the mobility of input of contaminants due to (diffuse) emission from construction products. In this year, our study will provide instruments to predict leaching from either soils under ambient conditions, or soils which are displaced or applied in construction works. Based on these predictions a risk assessment will be carried out incorporating current soil and groundwater quality and existing risk levels.

1 Introduction

The European Construction Regulation (CPR) regulates the performance criteria and testing of secondary products using standardised tests. The CPR acknowledges criteria for the protection of health and the environment. However, the CPR does not set limits or criteria to determine if this essential requirement is met. Also, for the revised Waste Framework Directive so called 'End of Waste' criteria will be developed which include criteria to protect the environment and human health. For contaminated soil several national regulations are in force, also setting criteria for health an the environment.

Within the EU several other directives are in force to protect the environment and human health. For example for the Groundwater Directive demands that the release of dangerous substances to groundwater should be evaluated. This release of dangerous substances implicitly includes the release of construction products or from contaminated soils and can be part of local soil policy. But how do we harmonise the risk assessment and criteria needed for the many EU and national regulations?

Luckily, from the broad field of environmental risk assessment much knowledge and many methods are available to determine the risk of dangerous substances released to our environment. But how do you apply this knowledge to construction products? During a workshop at WASCON 2009 the barrier most mentioned for use and reuse of (waste) material was the need for new approaches towards risk assessment based on standardised test. The conclusion was that these approaches needed the combination of different scientific disciplines, knowledge and data.

Each different scenario for the application of (secondary) construction products or contaminated soils has a common fundamental approach for risk assessment and follows tree steps: First there is a source term, mostly the mechanism describing how dangerous substances are released from the material. Next there is a transport mechanism often related to transport through the unsaturated soil. And finally there is the impact for were a criteria is set,

For large parts of the Netherlands, groundwater levels are generally shallow, about one meter below the surface. This means that emission to soil, and downward transport, may result in undesired impacts on groundwater. For our case, this relates the basic requirement of the CPD considering protection of the environment with groundwater quality. In general, every emission to the soil might influence the input into shallow groundwater, so it should be judged in relation with measures to protect groundwater quality. Groundwater can be used as common endpoint for risk assessment underpinning the criteria for the many aforementioned regulations.

During the last years an extensive interdisciplinary research has been carried out in the Netherlands, which combined the knowledge from fields like geochemistry, soil sciences material sciences and environmental risk assessment. The aim of the research was to assess the environmental risk of the use of construction products, aggregates and contaminated soils for soil and groundwater. Using a modelling approach based on the source - path - receptor steps mentioned above.

2 Method

The model is set up as a soil profile of 1 m, the top soil (first 0.5 m) is diffusely polluted. The sub soil (second 0.5 m) is uncontaminated, followed by a 1m thick groundwater layer underneath the soil profile. The modelling is based on 1) a release scenario which determines the release of contaminants from the soil, 2) the geochemical speciation which determines the mobility of the substances in the soil column, and, 3) a transport scenario which transports the mobile fraction towards the groundwater.

The geochemical modelling of release, speciation, and transport was performed with the ORCHESTRA framework and the modelling endpoints are time-average element concentrations in the groundwater column. Exposure levels are predicted in groundwater, and an effect assessment is performed using limit values, based on (eco)toxicological data, and ambient soil- and groundwater concentrations.

For the transport scenario we use three representative soil profiles (sand, peat, and clay) from a nation wide schematisation of soil profiles in the Netherlands. Additionally we aim to extend the number of soil profiles to obtain a better spatial overview, using mentioned schematisation, of risks of leaching of contaminants towards groundwater.

3 Preliminary results

The chemical reactive fraction (0.43 M HNO_3 extractable metal concentrations) of contaminants in the top soil is considered to be available for leaching. It is assumed that anthropogenic input or enrichment of metals to soil will be part of the chemical reactive fraction, i.e. are fully available for leaching. This assumption was tested based on a nation wide geochemical survey and appeared to be valid for Pb, Zn, Cu and Cd. For Sn and Sb the model overestimates the availability. For other elements the assumptions have not yet been validated due to the fact that these are not generally enriched in soils. (see Figure 1).

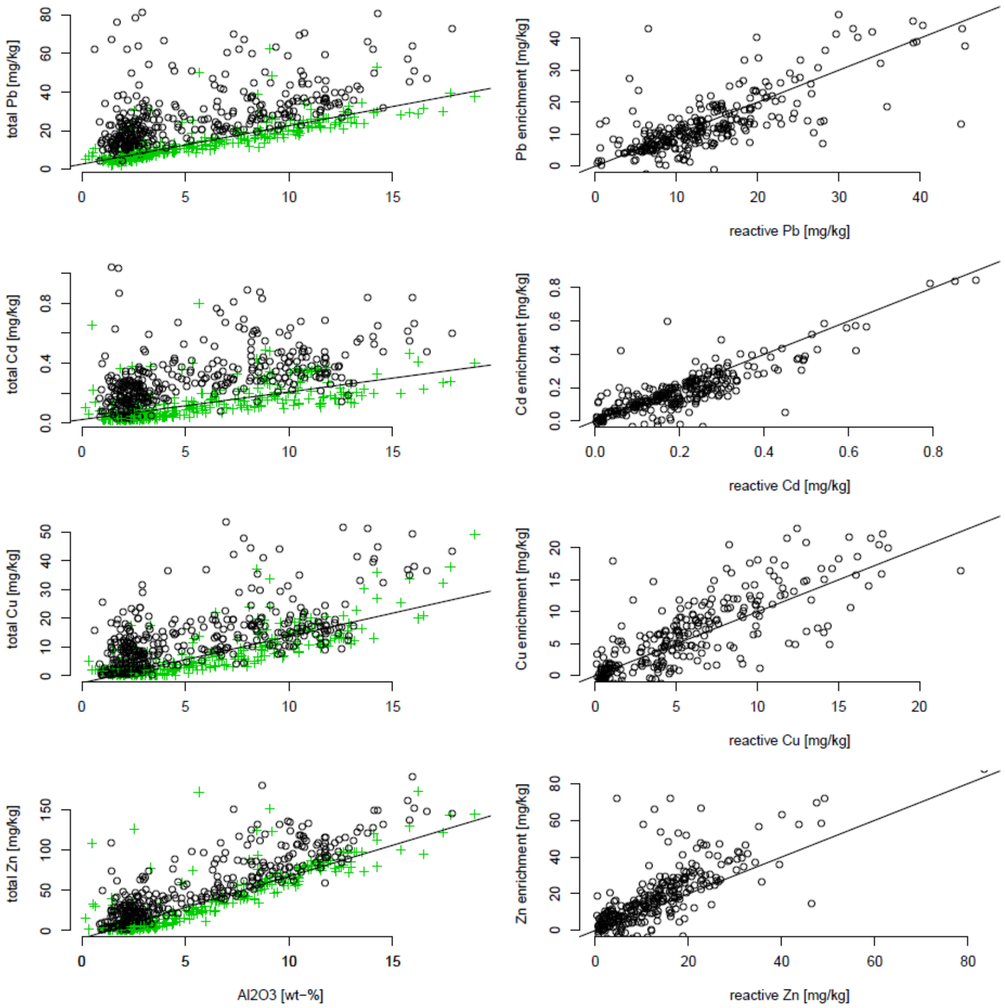

Figure 1. *(Left)* Scatter plots depicting the way in which metal enrichments in the topsoil are estimated with a geochemical baseline model; *green crosses* subsoil sample metal concentrations; *lines* Al_2O_3 baseline models; *black circles* topsoil sample metal concentrations. *(Right)* Linear relationships between reactive metal concentrations (0.43 M HNO_3 extractable metal concentrations) and enrichments (topsoil concentrations minus baseline-estimate concentrations. The *line* depicts the 1:1 relation (Figure from Spijker e.a, 2011).

Using the chemical reactive fraction the geochemical speciation was estimated and the mobile fraction, i.e. dissolved metals, was transported through the soil column. Validation of the model occurred in two ways: by 1) a validation of the estimation of pore water concentrations and 2) by field validation of the transport model using historical data.

Concentrations in the pore water were calculated from the available concentrations. The used model was validated for elements including As, Ba, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, Se, V, Zn by comparing modelled pore water concentrations with measured concentrations from a large set of soil samples. The result of this validation is that there is a good relation between modelled and observed porewater concentration.

The modelling of the metal transport was evaluated by retrospective modelling of a historical waste water infiltration site. Based on historical data and actual field measurements the predicted metal concentrations in the soil profile were compared with the measured data (see Figure 2)

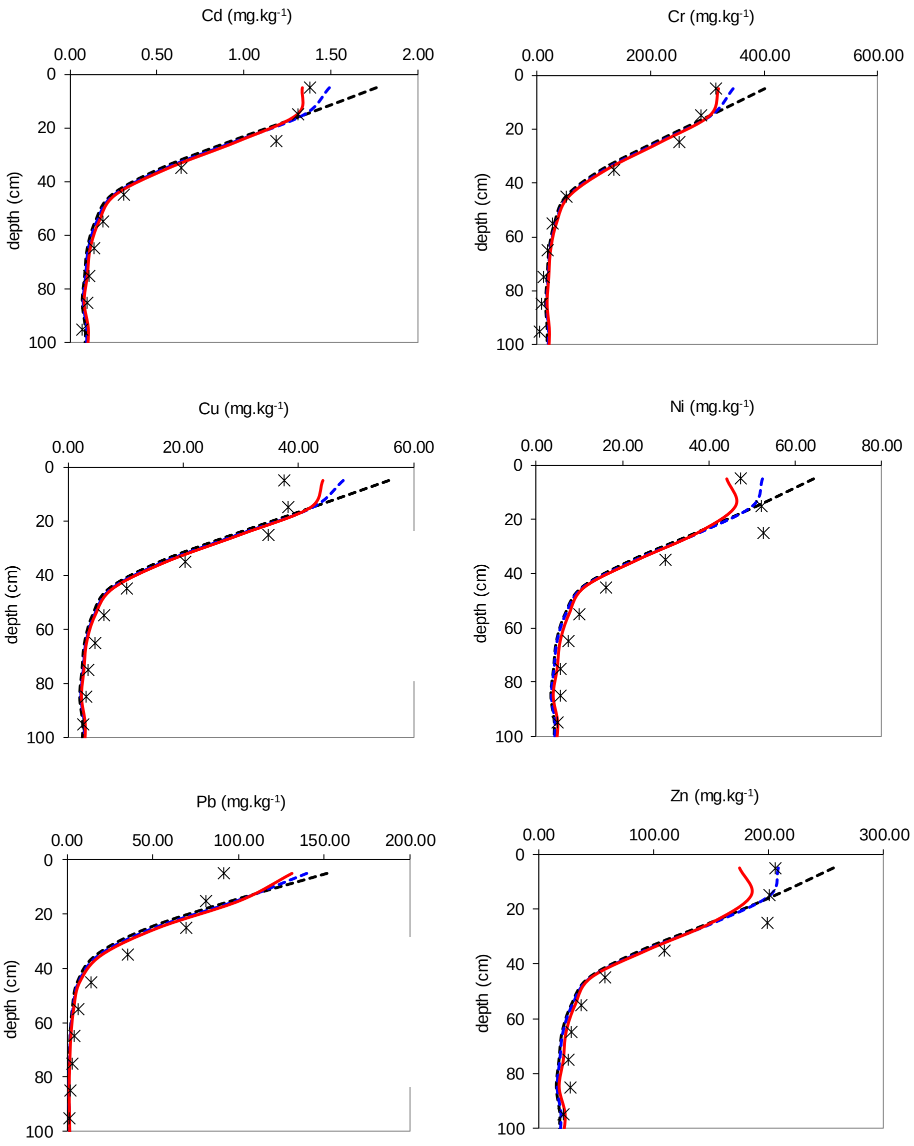

Figure 2. Measured (symbols) and simulated concentrations of the metals in the non-treated plot. The results of the simulation are given at the end of the three distinguished time periods: waste water infiltration field (black dashed line), meadow (blue line) and forest (red line). (Figure from Groenenberg et al., subm).

A sensitivity analyses of the model showed that, besides the release scenario and soil type, pH and the concentration of dissolved organic carbon (DOC) are the most important parameters which determine the transport to and concentration ranges in shallow groundwater. Currently, research is carried out to reduce the uncertainties in the model by doing field and laboratory experiments. These experiments are focussed at understanding the relation between solid and dissolved concentrations, transport and the composition of DOC.

4 Outlook

This year the project enters its final stage. Currently we are combining the knowledge of past years research and we are setting up the final model. This year we expect to have a complete set of tools and models for risk assessment for emissions into soils and to provide an overview of the impact of sustainable soil management, and the application of construction products and contaminated soil, on groundwater.