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Transfer of cadmium from rock substratum to the soil and associated vegetation under natural and experimental conditions

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As a result of soil-surveying studies carried out in the Swiss and French Jura Mountains during the early 1990's, anomalous cadmium (Cd) concentrations were identified in soils developed mostly on Bajocian and Oxfordian limestone. Measured Cd concentrations are as high as 22 mg kg-1 and exceed as such the Swiss official tolerance guideline concentration for non-polluted soils established at 0.8 mg kg-1 (Osol, 1998). Benitez et al. (1999) and Dubois et al. (2002) determined the geogenic origin of Cd in these soils, which are mainly derived from the weathering of carbonate substrata, being also enriched in this element. Cd is a highly toxic trace element and the physico-chemical conditions leading to its transfer from weathered Cd-enriched rocks to soils and its potential bioavailability to plants are still in need of a detailed geochemical assessment. As this phenomenon of natural pollution of soils is suspected to have a widespread occurrence as a function of frequent outcrops of Cd-enriched carbonate rocks in the Jura Mountains, we study rock-soil-plant interactions with regard to this element both under natural as well as under experimental conditions (microcosm set-up).

A first study of rock-soil interaction was carried out determining Cd-bearing phases in a soil developed on top of a road-cut section outcropping at the SW-facing slope of the Schleifenberg hill (canton Basel-Land, Switzerland). This section consisting of an oblique succession of Bajocian oolitic carbonate includes several horizons which are anomalously enriched in Cd (0.03 – 2.30 mg kg-1) (Rambeau, 2006). Total Cd contents in this soil range from 0.21 to 1.64 mg kg-1. Vertical pedogenetic processes (weathering of underlying bedrock) as well as lateral colluviums (weathering of up-

hill carbonates) are responsible for the origin of Cd in the soil. The mean percent distribution of each Cd species followed the order: carbonate-bound (49.3%) > crystalline Fe oxides-bound (31.7%) > organic matter-bound (12.7%) > amorphous Mn oxides-bound (3.8%) > residual (2.4%). The first three phases are the strongest to fix cadmium as no exchangeable Cd was found. Adsorption of a low percentage of Cd on clays is of less importance since Pb, Zn, Cu and Cr ions will compete with Cd to gain adsorbed sites on clays. Where developed on steep slopes at this site, a soil will hardly accumulate and colluviums will constantly renew it.

Cadmium transfer from soils to plants under natural conditions is studied at a second site called Le Gurnigel (canton Neuchâtel, Switzerland). Soils from this site present concentrations of geogenic Cd reaching up to 22 mg kg-1. The simultaneous effects of five variables on Cd behaviour are studied. The chosen variables are: 1) type of soil, 2) spatial variability of Cd concentrations in soils, 3) physicochemical properties of soils, 4) differential Cd accumulations in six species of plants (analyzing roots and aerial parts separately). The first results reveal preferential accumulations of Cd in roots and/or aerial parts varying from one species to another. Plants of the same family are also shown to behave in a different way. The obtained results will complete previous geochemical data and multivariable analyses will be used to thoroughly assess Cd bioavailability and potential environmental risks.

As a third axe in this research work, a laboratory experiment is used to study Cd transfer from rock to soil and then to plant using microcosms under controlled temperature, light and humidity conditions. Microcosms are filled with a Cd-depleted soil containing small pieces of Cd-enriched carbonate rocks. Then, seeds of *Lupinus albus* are sown and the experiment is set up over a 1-year and a 3-year period. The first results after one year reveal Cd accumulation in the cluster roots. Cd availability would be favoured by its complexation with the excreted organic acids. The aerial biomass of lupine did not show a significant Cd accumulation. Surface weathering was observed on carbonate slices by root activity. More definitive conclusions will be established with the results of the 3-year modality. However, it is assumed that lupine may eventually favour the Cd mobilisation by means of increasing the rhizosphere soil acidity and may thereafter directly incorporate this trace element. This experiment forms part of a multi-proxy investigation which studies plant health under stressful conditions carried out in collaboration with the National Centre of Competence in Research NCCR “Plant survival” of the University of Neuchâtel.