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Geochemical Transformation of Cadmium (Cd) from Creek to Paddy Fields in W Thailand

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Extensive Cd contamination of paddy soils in Tak Province, western Thailand, a consequence of Zn mining activities, was first established in 2005 and medical studies showed that the health of local communities was being impaired. Mae Tao, Tak Province, comprising many paddy fields and irrigation canals, has been selected for this study of the geochemical transformation of Cd from the contamination source in the mountainous region to the east of the study site through the community irrigation system to the paddy soils. The aim of this research is to (i) investigate the geochemical transformation of Cd as it is transported from the main irrigation creek through the canals and to the paddy fields, (ii) assess the availability of Cd to rice plants, which may be affected by both chemical and physical factors, and (iii) trial some practical treatments to minimise Cd concentrations in rice grains.

Soils, irrigation canal sediments and water samples were collected during the dry season and at the onset of the rainy season. Rice samples were collected at harvesting time and samples of soil fertiliser were also obtained. Water samples were filtered, ultrafiltered and analysed by ICP-MS whilst sub-samples of dried, ground soils and sediments were first subjected to micro-wave assisted acid digestion (modified US EPA method 3052). XRD and SEM-EDX methods were used for mineralogical characterisation and selective chemical extractions have assisted in the characterisation of solid phase Cd associations.

Soil Cd concentrations were in the range 2.5-87.6 μg g-1, with higher values being obtained for fields furthest from the main creek. Although current irrigation water Cd inputs are low (mean 1.9 μg L-1; flood period), high loads of suspended particles still contribute additional Cd (4.2-9.8 μg L-1) to the paddy fields. For bioavailability assessment by a 3-step BCR sequential extraction, 70-90% Cd was in the exchangeable; HOAc-extractable fraction. That indicated that most of the Cd was in water soluble, exchangeable and carbonate-bound forms. For the fields with highest Cd concentration, SEM-EDX analysis identified two forms of Cd, i.e. Cd-Clay and Cd-$CaCO_3$, in good agreement with the sequential extraction data. The predominance of easily extractable forms in the paddy field soils suggests that Cd may be readily absorbed by the rice plants. After harvesting, the Cd concentration in rice grains ranged from 0.05-4.0 μg g-1 and the concentration trends across the group of 18 fields matched well with the soil Cd data. Rice from nine out of the 18 fields contained Cd at greater than the safe level of 0.4 μg g-1.