Open-pit coal mining effects on rice paddy soil composition and metal bioavailability to *Oryza sativa* L. plants in Cam Pha, northeastern Vietnam

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This study quantified Cd, Pb, and Cu content, and the soil-plant transfer factors of these elements in rice paddies within Cam Pha, Quang Ninh province, northeastern Vietnam. The rice paddies are located at a distance of 2 km from the largest Coc Sau open-pit coal mine. Electron microprobe analysis and energy-dispersive spectroscopy revealed a relatively high proportion of carbon particles rimmed by an iron sulfide mineral in the quartz-clay matrix of rice paddy soils at 20-30 cm depth. Bulk chemical analysis of these soils revealed Cd, Pb, and Cu in concentrations exceeding calculated background concentrations by 2500, 1226, and 979 %, respectively. Metals and metalloids in Cam Pha rice paddy soils, including As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, and Zn, ranged from 0.2 ± 0.1 to 140 ± 3 mg/kg, in close agreement with toxic metal contents in mine tailings and Coc Sau coal. Native and model Oryza sativa L. rice plants were grown in the laboratory in presence of 1.5 mg/kg of paddy soil from Cam Pha to investigate its effects on plant growth. A decrease in growth of 60% with respect to a control was found for model plants, whereas a decrease of only 10% was observed for native rice plants. This result suggests an adaptation of native Cam Pha rice plants to toxic metals in the agricultural lands. The Cd, Cu, and Pb contents of the native rice plants from Cam Pha paddies exceeded permitted levels in foods. Cadmium was highest in the rice-grain endosperm at 0.09 ± 0.01 mg/kg, compared to the allowed content in foods of 0.05 mg/kg. Along with rice plant adaptation to contaminated soils, bioaccumulation of trace metals, such as Cd and Pb, poses a severe health risk to the population of Cam Pha. The adaptation of native rice plants, combined with bioaccumulation ratios of 1 ± 0.6 to 1.4 ± 0.7 calculated for Cd transfer to the rice-grain endosperm, strongly suggest a continuous input of toxic metals from coal-mining to agricultural lands in Cam Pha. In addition, our results imply a sustained absorption of metals by native rice plant varieties, which may lead to metal accumulation (e.g. Cd) in human organs and in turn to severe disease.

Sectoral contributions to black carbon concentrations and radiative forcing in Delhi

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In this study we evaluate the air pollution levels in Delhi and their impacts on weather and climate. The two way interactions between pollution and meteorology are evaluated using the WRF-Chem model. The analysis period is focused on October 2010, the time period of the Commonwealth Games. The model is compared to BC and PM2.5 measurements at 11 sites. A sector based analysis is performed to assess the contributions to pollution and direct radiative forcing from transport, residential, power and industrial emissions. The contributions from emissions outside of Delhi are also evaluated to see the extent that regional emissions need to be controlled to meet air quality targets in Delhi. Results of simulations for emission scenarios for 2030 generated by the GAINS model that address air quality and climate strategies are also discussed.

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DOI:10.1180/minmag.2013.077.5.13