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Relationships between soil heavy metal pollution and enzyme activities in mining areas of northern Hunan province, Central South China

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Hunan province, Central South China, is a well-known nonferrous metal base in China. Mine exploiting and processing there, however, often lead to heavy metal pollution of farmland. To study the effects of mining activities on the soil environmental quality, four representative paddy fields, the HSG, SNJ, NT and THJ, in Y county, northern Hunan province, were investigated. It was found that the streams running through the HSG, SNJ and NT are severely contaminated due to the long-term discharge of untreated mineral wastewater from local indigenous mining factories. The stream at the HSG, for example, is brownish red in color, with high concentrations of Cu, Zn, Cd, Fe and Mn. The concentrations of Cu, Zn and Cd in all the stream water of the HSG, SNJ and NT exceed the maximum allowable levels of the Agricultural Irrigation Water Criteria of China. Correspondingly, the HSG, SNJ and NT are heavily polluted by Cu, Zn and Cd due to the long-term irrigation with the contaminated stream water. In comparison, both stream water and paddy fields of the THJ, far away from mining areas, are not contaminated by any heavy metals and hence regarded as a control in this study. The rice grain produced at the HSG, SNJ and NT has a high risk of Cd contamination. The rate of rice grain produced in the four paddy fields in Y county with Cd exceeding the safe level (Cd, 0.2 μg g^{-1}) specified by the National Standards for Rice Quality and Safety of China reaches 90%. Cd content in the rice grain is positively significantly correlated with that in the paddy fields, especially with the content of diethylenetriaminepentaacetic acid (DTPA) - extracted Cd, suggesting that the heavy metal pollution of paddy fields has already posed a high risk to rice safety and human health. Soil enzyme activities and microbial biomass are significantly inhibited by the heavy metal pollution of the paddy fields. Microbial biomass C and N (MBC and MBN) at a severely contaminated site of the HSG are only 31.6% and 64.4% of the controls; the activities of dehydrogenase, urease, catalase, acid and neutral phosphatase and sucrase are only 25.2%, 49.3%, 52.4%, 94.7%, 53.2% and 87.8% of the controls. These microbial parameters are mostly negatively significantly correlated with the contents of Cu, Zn, Cd and Ni in the paddy fields, suggesting the toxic effects of the heavy metals on microbial processes. Both the Principal Component Analysis (PCA) and Cluster Analysis (CA) indicated that DH activity and MBC are the most sensitive to the heavy metal pollution and could be used as eco-indicators of the environmental quality of the paddy fields in the study areas. Acknowledgements: This work was supported by the National Natural Science Foundation of China (No. 41130526).