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Evolution of redox properties and trace metal solubility in soil during incubation

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Soil is a complex, heterogeneous and ever-changing material. Redox conditions may change as a result of fluctuating soil moisture content or decaying organic matter or due to biological activity, particularly in the rhizosphere. Rather little is known about the effects of such changes on the mobility of trace metals. In this study we have followed the changes in soil properties (pH, Eh, dissolved organic carbon), the solubility of metal oxides (Mn and Fe) and the solubility of added or native Cu and Zn over a period of 5 months in a soil that was either kept well aerated or flooded to induce strongly reducing conditions.

The aerated soil remained oxidized throughout the incubation period. Its pH fell slightly over the first two weeks, then remained constant. During the first month there was a flush of dissolved organic carbon, and an even shorter lived flush of water soluble manganese (one day) but little change in the water soluble Fe. The flooded soil became rapidly strongly reduced, with an accompanying increase in pH and a very large solubilisation of Mn. There was always more dissolved organic carbon and soluble Fe in the flooded soil than in the moist soil.

Soluble copper was always greater in flooded soils than aerated soils, but for each series the evolution with time was complex. Added copper was strongly immobilised and its solubility followed a similar pattern to native Cu. There was a good positive relationship between Cu solubility and pH, contrary to the usual observation in this pH range. Cu solubility did not appear to be enhanced by increasing concentrations of organic carbon in solution, as would be expected if the driving force were complex

formation in solution. There was a good positive correlation between Cu and Fe solubility, suggesting that Cu was released as iron oxides were dissolved due to changing redox and pH conditions.

It was not possible to measure the water extractable native soil Zn, and so only data for Zn enriched soil will be presented. Soluble Zn fluctuated over the 5-month period and was initially greater in moist soil than flooded soil, but somewhat smaller after 4 months. As expected, since Zn has little affinity for organic matter, there was no relation between Zn solubility and dissolved organic carbon. The correlations between Zn solubility and other soil parameters were very different for aerated and flooded soils, suggesting that different processes are determinant. None of the soil properties monitored helped to explain changing Zn solubility in moist soils. For flooded, reduced soils, Zn solubility decreased with increasing pH as is usually observed and increasing Fe solubility, suggesting that iron oxides constitute an important adsorption phase. There was also a slight decrease in Zn solubility with increasing Mn dissolution, but there is probably not a causative link.

To conclude, the changing redox conditions induced by soil moisture conditions did have some effect on the solubility of Cu and Zn and these changes could be partially related to changing pH and the solubility of soil metal oxides.