Vertical distribution of Copper in soil microcosms - Influence of the experimental modalities in the Copper distribution

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Vertical Distribution of copper added in soil microcosms used to mimick fields : Influence of experimental modalities.

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Introduction / Objective

This study is a part of a project that aims at developing an index of soil biological status in order to define a reference status and assess a biological quality of soil. Among the factors affecting the soil biological status, the presence of a metallic pollutant, like copper had to be taken account. The main physico-chemical and biological parameters of the soil were measured in 2005 in the field, then the soil was polluted by copper into the year after and the same parameters were further measured. We set up an experimental approach using columns of soil called microcosms, which allowed us to mimick real agricultural practices.

Our objective is to show results concerning the way we have polluted the soil *in situ* and the influence of experimental modalities on the copper distribution in soil.

Experimental / Modalities

The total study was carried out in north western France (Normandy), in loamy soil including intensive crop and permanent pasture, with mild climate and low seasonal ranges. Five replicates per soil management, per date of kinetics (7, 35 and 70 days) with undisturbed soil and 2mm-sieved soil, allowed statistical treatments. Copper was determined after total mineralisation and after EDTA extraction. We tested the following modalities :

1-Samples

Soil management : Intensive crop (photo) or permanent pasture (SOM, pH…)

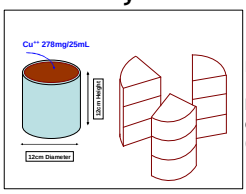
State of the soil: undisturbed or 2mm-sieved soil (photo)

2-Way of contamination

Contamination of 200 ppm Cu^{++} with a test tube (photo) or a coarse sieve

Date of kinetics *in situ* (7, 35 and 70 days).

3-Analyses



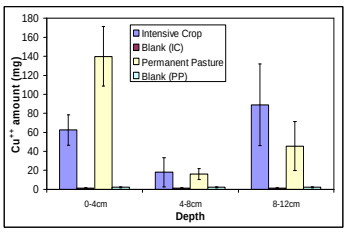
Homogeneity of the horizontal distribution (see drawing)

Impact of soil management

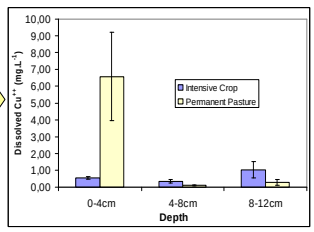
◆ Soil management impacts the vertical distribution of Cu^{++} in the undisturbed-soils microcosms. 60 % of Total copper descended below the level of 5 cm in the intensive crop and only 30 % of Total copper shifted below 5 cm in the permanent pasture. The macroporosity of the permanent pasture is higher than the crop soil.

◆ A semi-mechanistic model based on the competitive adsorption of metal and H^+, dependent on soil pH, total metal content and SOM (soil organic matter), was used to predict dissolved Cu^{++} concentration (Sauvé et al., 2000). The predicted dissolved Cu^{++} concentrations were distributed along the depth for the intensive crop but they were concentrated in the 0-4cm layer in the permanent pasture. The discrepancy between the two copper behaviors is demonstrated in the model but underestimated in the sub-surface.

Vertical distribution of Copper
T = 70 days
Experimental



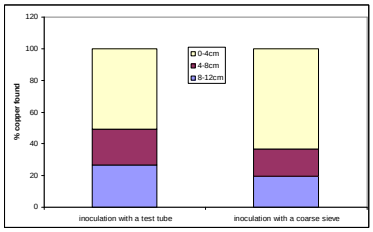
Vertical distribution of dissolved Cu^{++}
T = 70 days
Theoritical (Sauvé Model)



◆ EDTA extraction is a measure of Cu availability. In our terrestrial ecosystem, the ratio mainly ranged from 0.7 to 0.8, except in the 4-8 cm soil layer where this ratio is low.

Impact of the state of the soil

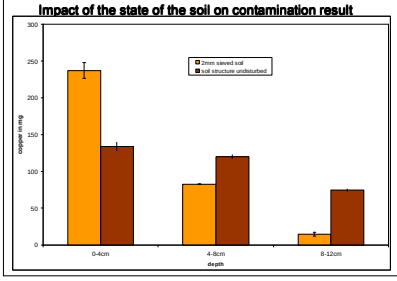
Vertical distribution copper versus contamination method



◆ Inoculation of copper modalities

The different modalities of contamination by test tube or by a coarse sieve (or watering "rose" spout attachment) have little impact on copper vertical distribution. The second method seems more homogeneous at the surface of soil. In the first mode, copper solution quickly follows the cavities, cracks and holes in the soil; a significant amount percolating up to the outside of the microcosm.

Impact of the state of the soil on contamination result



◆ The state of the soil impacts the vertical distribution of Cu++. Freshly sieved soil appears able to capture more solution and copper than normal soil on the surface. Destructuring of aggregates and organic matter availability are probably responsible for this retention.
Undisturbed soil allows a homogeneous distribution of contamination and represents a typical process for real contamination.

Conclusion

First, the miniaturized terrestrial ecosystems, microcosms, can be a realistic experimental model to study the biological soil properties in soil. However, some modalities need to be considered before experimental planning.
Secondly, after 70 days, the vertical distribution of copper is localized, indicating that the potential impact of copper on the soil microorganisms could be restricted to the upper cm of the soil horizon.

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