ROLE OF FERRI-REDUCING BACTERIA IN TRACE ELEMENT MOBILITY IN SOIL AND RIVER SEDIMENT

QUANTIN C. [1], BECQUER T. [2], BELGY G. [1], MUNIER-LAMY C. [1] and BERTHELIN J. [1]

[1] Centre de Pédologie Biologique, U.P.R. 6831 du CNRS associée à l'Université Henri Poincaré, Nancy I, 17, rue Notre-Dame des Pauvres, B.P.5, F-54501 Vandoeuvre les Nancy Cedex

[2] ORSTOM c/o Centre de Pédologie Biologique, U.P.R. 6831 du CNRS associée à l'Université Henri Poincaré, Nancy I, 17, rue Notre-Dame des Pauvres, B.P.5, F-54501 Vandoeuvre les Nancy Cedex

quantin@cpb.cnrs-nancy.fr

1. Introduction

Ferric oxihydroxides are present in most soils and sediments and are very often associated with trace elements. Otherwise, some cations other than Al or trace elements such as Ni, Cr, Co, Pb, may be adsorbed or substituted in iron oxides and their behaviour can be linked with iron. The iron oxides are generally stable but can be solubilised by biological and chemical processes like reduction.

Several studies show that reduction processes of ferric oxides influence metal mobility and availability. A major influence of bacterial reduction in both waterlogged or temporary waterlogged environments can be suspected. Bacterial reduction involves anaerobic bacteria which use organic matter as an energy source and ferric iron as a direct or indirect electron acceptor (Berthelin, 1982, 1988). So the iron cycle is partially linked with the carbon one and has a drastic influence on the solubility and mobility of trace elements.

The aims of this study are i) to determine the role of ferri-reducing bacteria in iron and associated metal solubilisation, ii) to relate the ferri-reducing activity to the organic matter biodegradation.

2. Materials and Methods

Two types of material were studied (Table 1) : a surface soil sample of a Gerric(?) Ferralsol from the Ouenarou station (South of New Caledonia, Becquer et al, 1995) and a river sediment from Lorraine (France). The soil sample is originated from an oxisol in an alluvio-colluvial position with temporary waterlogged phases. It is very rich in iron (up to 50 % Fe_2O_3), with high contents of Ni and other transition metals like Cr, Co, Mn... and about 5 % of organic matter. The river sediment was collected down-river from a petrochemical complex. This sediment is rich in natural and anthropogenic organic matter and contains high levels of trace elements like Zn, Pb, Cr, Cu, Cd.

Both samples were characterised by elemental mineral analysis after diacid digestion. The organic content (C, N, FA, HA and humin) was determined. Total, cellulolytic and ferri-reducing microflora were enumerated using specific media and agar plates methods (Bromfield, 1954 ; Alef and Nannipieri, 1995).

Batch experiments were performed as reactor studies to determine the rates of carbon mineralisation, ferric oxides dissolution and the concomittant metal release in solution. The CO_2 evolved from organic matter decomposition was determined using an IR Gas analyser and several parameters like pH, Eh, dissolved organic carbon and metals in solution were followed .

Table 1.- Characteristics of Ouenarou soil sample and river sediment

	orgC %	orgC/N	Fe_2O_3 %	Ni mg/kg	Cr mg/kg	Co mg/kg	Zn mg/kg	Pb mg/kg	Cd mg/kg	Cu mg/kg
Ouenarou	2.60	21.7	56.8	7750	10850	720	580	156	81	47
Sediment	4.97	27.6	3.3	21	30	7	525	100	6	74

3. Results and Discussion

The organic matter decomposition rates for both samples are relatively high. The mineralisation is greater under aerobic conditions than anaerobic one. The supply of an easily-biodegradable organic matter (cellulose) stimulates the biodegradation activity mainly for the river sediment. This stimulation does not appear as well for the oxisol sample although cellulolytic microflora is present too.

During experiments, a lower Eh is observed in biotic anaerobic conditions for both samples combined with Fe^{2+} solubilisation. Comparison with abiotic experiments shows that this reduction of Fe(III) to Fe(II) is mainly due to bacterial activity. Metal mobilisation is observed but some precipitation and coprecipitation phenomenons occured. The metal mobilisation is greater in conditions stimulated by cellulose addition. The data for Fe(III) to Fe(II) reduction along with trace element concentrations are illustrated as a function of incubation time, redox status and in fact bacterial activity.

Such mobilisation of trace elements in soils and river sediments is of major importance with regard to their bioavailability to fauna and flora, their transfer in river and soils, the risks of toxicity, the potential for leaching down the soil profile to the groundwater and their removal from polluted sites.

4. References

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