The Role of Microorganisms in the diversity and distribution of siderophores in Podzolic Forest Soil

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Iron is a key component of the chemical architecture of the biosphere. Due to the low bioavailability of iron in the environment, microorganisms have developed specific uptake strategies. The most important one is the production of siderophores, which are operationally defined as low-molecular-mass biogenic Fe (III)-binding compounds which may greatly increase bioavailability of Fe [1]. One of the primary biogeochemical functions of siderophores is therefore to increase Fe bioavailability by promoting the dissolution of iron-bearing minerals [2]. This study aims to understand the role of microorganisms in the chemical diversity and distribution of siderophores in podzol soil and how this diversity can contribute to the bioavailability of Fe in forest soil.

Soil samples were collected from an experimental site in the area of Bispgården in central Sweden (63°07′N, 16°70′E) from the O (organic), E (eluvial), B1 (upper illuvial), and C (mineral) horizons. Concentration and chemical composition of dissolved and adsorbed siderophores in the soil samples were determined using colorimetric assays and high-performance liquid chromatography.

The highest siderophore concentrations were found in the O layer and thereafter decreased by depth. Concentrations of dissolved hydroxamate, catecholate and carboxylate siderophores were up to 84, 17 and 0.2 nmol/ g soil, respectively. In contrast, concentrations of adsorbed hydroxamates, catecholates and carboxylates were only up to 1.8, 3 and 0.2 nmol/ g soil, respectively.

Siderophore-producing microorganisms were isolated from the same soil samples. Viable fungi, bacteria and actinomycete counts ranged from 7 to 300, from 300 to 1800, and from 0 to 5 cfu/gm, respectively. The highest counts were found in the O and E layers. Only the E layer contained the three types of siderophore-producing microorganisms investigated in this study. Siderophores were extracted from culture filtrates of the isolated microorganisms when grown under iron-limited conditions. These extracts varied considerably in siderophore composition. Fungal isolates produced up to 183 μM of hydroxamates, especially those isolated from the O layer, whereas bacteria and actinomycete isolated from the O and E layers of the soil produced high amounts of carboxylate, catecholate and hydroxamate siderophores. Actinomycete produced up to 93 μM of hydroxamates and 47 μM of catecholates, while bacteria produced up to 34 μM of carboxylates and up to 14 μM of catecholates.

The depth variability in concentration and chemical composition and the good correlation between abundance of siderophore-producing microorganisms and siderophore soil concentrations strongly suggest that these siderophore-producing microorganisms play an important role in the mobilization of iron in the podzol soil that may be important in iron availability to plants in forest environment.

[1] Clay *et al.* (1981) Biochemistry 20, 2432-2436. [2] Duckworth *et al.* (2009) ChemGeol 260, 149-158.

Adsorption of fecal microorganism on soils

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Mobility of virus and microorganism through earth materials need to be investigated for evaluating soil and groundwater contamination. Surface charges of minerals or organic matters can vary with pH. When the surface charge polarity of soil particle is opposite to that of virus or microorganism, the virus or microorganism is adsorbed onto the soil particle by the electromagnetic attraction force [1]. Therefore, pH affects sorption characteristics of fecal virus or microorganism on the soil. This study investigated sorption characteristics of MS2 bacteriophage and E. coli on sorbents (i.e., quartz sand, iron oxide, and kaolinite) in aqueous solutions.

DI water was sterilized by filtering and then adjusted to pH 6~7 by adding the concentrated NaOH solution. Concentrated MS2 bacteriophage or E. coli was added to the pH adjusted solution. 1 g or 3.3 g of sorbent and the 10 ml of virus solution (10^3~10^8 PFU/ml) was reacted for 1~16 hours at 50 rpm and 15 ℃. After the reaction, the leachate was obtained by filtering the mixture of sorbent and virus solution using 0.22 ㎛ membrane filters. MS2 bacteriophage and E. coli concentrations of the leachate s were measured.

Sand and iron oxide adsorbed more MS2 bacteriophage than kaolinite. 1 g of sand or iron oxide removed almost completely MS2 bacteriophage from the 10 ml solution with 10^4~10^5 PFU/ml of MS2 bacteriophage. However, appromimately 20 % of MS2 bacteriophage was removed by kaolinite at the same condition. Iron oxide adsorbed more E. coli than sand and kaolinite. 1 g of iron oxide adsorbed 43~96 % of E. coli in the 10 ml solution with 10^3~10^5 PFU/ml for 1~16 hours, whereas no adsorption onto sand and kaolinite occurred. These results suggest that moblity of virus or mirooragnism can be affected by the soil constituents.

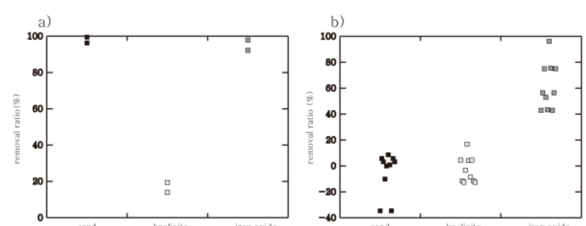

Figure 1: Removal ratio of a) MS2 bacteriophage and b) E. coli

[1] Redman et al (1997) *Environ. Sci. Technol.* **31,** 3378-3383.