Nutrient limiting factors for bacterial and fungal growth in soil differing in nutrient availability

ABSTRACT
Nutrient limitation for microbial growth in soil is an important factor regulating growth, efficiency and competitive strength of different organism groups in soil. In present study nutrients limiting bacterial and fungal growth in soil differing in nutrient availability has been studied. The effect of substrate addition on bacterial growth and the effect of environmental factors like pH and salinity on the bacterial community. Leucine and acetate incorporation to estimate bacterial and fungal growth, respectively, and phospholipids fatty acid (PLFA) analysis to analyze the community structure were used.

In these soils bacteria were limited by carbon, followed by nitrogen. By adding carbon-rich substrate, like starch and straw, the soil could, however, be switch to become primarily nitrogen limited. Alleviating the nitrogen limitation in starch amended soils mainly resulted in increased bacterial growth, while in the straw amended soil only fungal growth increased after adding extra nitrogen.

Comparison has been made for bacterial and fungal growth rates and nutrients limiting bacterial growth in a boreal forest with experimentally long-term increasing nitrogen amendments to mimic increasing anthropogenic nitrogen deposition (the Chronic N Amendment Study at Harvard Forest Long Term Ecological Research Network, USA). In the organic soil horizon bacterial growth (measured using leucine
incorporation) decreased 5 times in the High N treatment, while in the mineral soil only the Low N treatment differed from the Control and High N treatment. Fungal growth (measured using acetate incorporation into ergosterol) was unaffected in the organic horizon, but increased marginally in the High N treatment in the mineral soil. Lack of carbon (C) limited bacterial growth in all soils, although in the unfertilized control soil adding carbon (as glucose) without other nutrients only resulted in a minor increase in bacterial growth compared to adding C in combination with nitrogen. More extensive bacterial growth after adding only C was found with increasing nitrogen application levels, indicating increased availability of nitrogen for the bacteria.

In the same soils (3 levels of nitrogen availability: Control, Low N, High N), studied bacterial growth after amending with C-rich substrate (starch & straw) at different rates to induce N limitation. In non-amended soils bacterial growth was limited by C. Soils amended with low amounts of substrates were still limited by C, especially in the High N soil. At higher levels of substrate amendment, neither and effect of C or N was found, suggested co-limitation. At the highest level of substrate amendment there appeared to be a switch from carbon to nitrogen limitation for bacterial growth, although the effect was week.

Also compared respiration rate, bacterial and fungal growth in soils with a range of C to nitrogen limitation (experimentally induced by amending with starch or straw) after the limitation was alleviated by adding easily available C and N. Unamended soils were limited by C. After substrate amendment respiration rate, bacterial and fungal growth was switched from being C limited to being N limited. All techniques had shown similar results. However, starch addition favored bacterial growth while, straw
addition favored fungal growth, suggesting that under N limitation the type of C-rich substrate determined which organism group that would benefit from extra N.

Twelve soils from Pravaranagar (India), having high pH, salinity and nutrient availability, were microbial characterized and nutrient factors limiting growth was determined. The PLFA pattern was typical for a microbial community characteristic of high pH soils, which was corroborated by the bacterial community being adapted to high pH conditions. The optimum pH for bacterial growth was equal to in-situ soil pH. The high pH had resulted in soils with high bacterial but low fungal growth. However, adding substrate conducive for fungal growth, like straw, could induce fungal growth. Some soils had high electric conductivity, indicating salinization. These soils differed slightly in PLFA pattern, suggesting that the saline soils had more fungi. The bacterial community tolerance to NaCl also increased in these high saline soils, suggesting a bacterial community adapted to high saline conditions. Bacterial growth in all soils was limited by C, while N addition had a negative impact on bacterial growth. P addition had no effect on bacterial growth.