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Anaerobic N mineralization in paddy soils in relation to inundation management, physicochemical soil fractions, mineralogy and soil properties

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Anaerobic N mineralization measured from (saturated) repacked soil cores from 25 paddy fields in Bangladesh and was previously found to negatively related to soil N content on a relative basis. This suggests that other factors like soil organic matter (SOM) quality or abiotic factors instead control the anaerobic N mineralization process. We therefore assessed different physical and chemical fractions of SOM, management factors and various soil properties as predictors for the net anaerobic N mineralization.

1° First, we assessed routinely analyzed soil parameters (soil N and soil organic carbon, texture, pH, oxalate- and pyrophosphate-extractable Fe, Al, and Mn, fixed-NH4 content). We found no significant influences of neither soil mineralogy nor the annual length of inundation on soil N mineralization. The anaerobic N mineralization correlated positively with Na-pyrophosphate-extractable Fe and negatively with pH (both at $P<0.01$). At this stage it is, however, not known if these relations between net evolution of NH4 and pH and Fe content are causal or indirect.

2° Second, the 25 samples collected from farmers' fields were physically fractionated into particulate OM and silt and clay associated OM. The silt and clay sized OM was further chemically fractionated by oxidation with 6%NaOCl to isolate an oxidation-resistant OM fraction, followed by extraction of mineral bound OM with 10%HF thereby isolating the HF-resistant OM. None of the physicochemical SOM fractions were found useful predictors anaerobic N mineralization. The linkage between these chemical soil N fractions and N supplying processes actually occurring in the soil thus appears to be weak. Regardless, we hypothesize that variation in strength of N-mineral and N-OM linkages is likely to explain variation in bio-availability of organic N and proneness to mineralization. Yet, in order to separate kinetically different soil N fractions we then postulated that an alternative approach would be required, which instead isolates soil N fractions on the basis of bonding strength. In this respect bonding strength should be seen as opposite of proneness to dissolution of released N into water, the habitat of soil microorganisms mediating soil N mineralization. We hypothesize that soil N extracted by water at increasing temperatures would reflect such N fractions with increasing bonding strength, in turn equivalent to decreasing bio-availability. Although water has frequently been used to extract labile SOM, its use has mostly been limited to 100°C.

3° Third we developed sub critical water extraction (SCWE) at 100°C, 150°C and 200°C to isolate SOM fractions from the set of 25 paddy soil samples. In all cases, SCWE organic carbon (SCWE-OC) and N (SCWE-N) increased exponentially with the increase of temperature. SCWE preferentially extracted N over OC with increasing temperature. The efficiency of SCWE and the selectivity towards N were both lower in soils with increasingly reactive clay mineralogy. No correlations were found between the SCWE fractions and anaerobic N mineralization rate.

In conclusion, SOM quantity and SOM quality, here represented by C and N distribution over physicochemical fractions, don't seem to dominantly determine anaerobic N mineralization in primarily young floodplain paddy soils. Other factors with exceeding control (pH and pyrophosphate extractable Fe) appear to exist. Possibly, the specific young genesis stage of most of the soils included (termed 'floodplain' soils) results in a limited availability of readily reducible Fe. Being an important alternative electron acceptor under submerged conditions, the availability of Fe, which is also controlled by pH, may be a bottleneck in the anaerobic N mineralization process. This needs to be further investigated by controlled incubation experiments with detailed follow-up of pH, redox potential, Fe in solution and mineral N.