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Nitrite accumulation in the soil profile of semi-arid ecosystems in response to seasonal changes in environmental conditions

I. Gelfand and D. Yakir

Weizmann Institute of Science, Israel (ilia.gelfand@weizmann.ac.il, phone +972-8-9342072)

The factors controlling ecosystem nitrogen (N) dynamics and availability are still poorly understood in general and in semi-arid ecosystems in particular. Specifically, the production of nitrate via nitrification in soils influences both the availability of nitrogen for plant uptake, and possible N losses via nitrate leaching and gas emission (N_2 and N_20). We investigated different aspects of the nitrogen cycle in a semi-arid forest and surrounding shrubland in southern Israel (mean annual precipitation 280 mm). Three years of continues soil sampling from the investigated sites revealed an unexpected fast increase in nitrite concentration in the soil profile after soil rewetting by the first winter rains, following 6-8 month rain-free period. At the same time, a reduction in ammonia concentration (from up to 5μg/g soil DW to zero), and only a slight increase in nitrate (less than 1μg/g soil DW) concentration were observed. Nitrate concentrations in wet deposition could completely explain the slight increase in nitrate concentration, but not that in the nitrite. Laboratory incubations of soil slurries under favorable conditions for nitrification showed nitrite accumulation rates up to five times those for nitrate. This clearly indicated different rates of ammonia and nitrite oxidation, and likely presence of different microbial populations responsible for oxidation of ammonia and nitrite. Similar results were observed in a preliminary study in a pine forest in Judean Hills that receive more than twice the amount of precipitation (600-750 mm year^{-1}). We hypothesize that the initial ammonia to nitrate oxidation process upon soil rewetting in semi-arid environments occurs as an uncoupled two-step process, as opposed to a rapid, continuous one in wetter environments. Initiation of the second step (nitrite oxidation) requires a particular stimulus (e.g. a critical nitrite concentration). This is, to our knowledge, the first report of nitrite accumulation in soils under natural conditions, which likely reflects temporary de-coupling between

two steps of nitrification (analogous to the situation commonly observed in artificial aquatic systems). Nitrite is toxic to living organisms, including bacteria, even at low concentrations, and the implications of observed nitrite accumulation (up to 3μg/g soil DW) on the soil biota in the semi-arid ecosystem require further study. Irrespectively, the nitrite accumulation may have influence on intracellular signaling in plants, since nitrite is precursor of nitric oxide (NO). Finally, the observed delay in nitrite oxidation may also have implications for synchronization of nitrate availability and plant activities in a forest ecosystem that has a very limited active period.