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A functional approach to assess soil quality parameters for ecosystem services of soils

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Environmental stress by human activities may have promoted soil degradation in such a way that ecosystem services of soils might not longer support ecosystem biodiversity in the near future. Therefore we focus on soil quality parameters that can be linked to ecosystem functioning. Knowledge of these relationships is required for soil rehabilitation and ecological restoration programs.

Ecosystem services of soils rely upon functional groups of soil organisms controlling nutrient availabilities for primary production. We suppose that production is linked to biodiversity according the well known 'hump-shaped' relationship. We studied the role of different functional groups of soil biota in nitrogen cycling on sites with different degrees of soil degradation. We selected a toposequence along a landscape gradient from dry, acid podsolic soils to moist slightly acid, gley soils. We investigated 7 sites in 3 natural areas. In two areas nature restoration after agriculture land use was started thirty five years ago, which resulted in soil acidification and loss of organic matter. The third area provided reference sites for long time undisturbed nature development. Humus profiles and general soil characteristics were determined. Three groups of soil biota, functioning on different trophic levels of the soil food web were analyzed: i) bacteria and fungi, ii) microarthropod fungivorous grazers and browsers iii) general and arthropod predators and earth worms. Both the amount (biomass) and activity of bacteria and fungi were measured. Activity was measured as incorporation of [^{14}C] leucine into bacterial proteins (bacterial growth, biomass production) by CO_2 respiration (C mineralization, respiration) and by potential net and gross N mineralization through aerobic and anaerobic incubation (6 weeks at 20^{o}C and 1 week at 40^{o}C respectively). Soil fauna was analyzed by counting techniques.

Bacterial and fungal biomass correlated positively with C mineralization but negatively with net N-mineralization. The lower the ratio of net over gross N mineralization, the higher [^{14}C] leucine incorporation was. This suggests a high bacterial growth rate and N immobilization, resulting in N limited primary production. These conditions prevailed at gley soils with an active earth worm population and a diverse low productive vegetation. In contrast, low bacterial growth coincided with a high ratio of net over gross N mineralization, high levels of primary production and low plant biodiversity. This occurred at the degraded and acidified sites with accumulation of organic matter and without earth worms. The results suggest that fungal growth and biomass was controlled by browsing and grazing mites through a top down relation, whereas bacterial growth was stimulated by earth worm activity. Concerning microarthropods, the fungivorous browsers and grazers are supposed to stimulate predators through a bottom up relation. Predators finally were positively and earth worms negatively correlated with the ratio of net over gross N mineralization.

We conclude that i) different functional groups are involved in balancing nitrogen mobilization and immobilization, ii) a changed activity of a specific group by environmental stress might shift this balance and iii) a decline in microbial growth resulted in an increased net nitrogen mineralization in favor of primary production but a decreased biodiversity of ecosystems. Results suggest that soil rehabilitation by managing specific soil biota may be a promising tool in restoring ecosystem services of soils.