尕海湿地退化过程中土壤氮矿化变化特征及驱动因素

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摘 要:【目的】探究退化湿地土壤氮矿化速率、土壤温湿度及相关酶活性的时空变化规律，分析土壤氮矿化随时空的变化特征及内在驱动因素。【方法】以尕海湿地未退化、轻度退化、中度退化、重度退化的沼泽草甸为研究对象，采用野外树脂芯原位培养方法，在 2020 年通过对植物生长初期（6-7 月）、生长盛期（7-9 月）、枯萎期（9-10 月）的土壤氮素矿化作用的研究，探讨湿地沼泽草甸退化过程中土壤氮矿化时空变化特征及其与土壤酶活性及环境因素之间的关系。【结果】1）随退化程度的加剧，土壤温度、硝酸还原酶和脲酶活性逐渐增大，土壤含水量、亚硝酸还原酶和蛋白酶活性与之相反。随生长季的推移，土壤温度、脲酶、亚硝酸还原酶和蛋白酶呈现先增大后减少的趋势，在 7、8 月达到峰值；硝酸还原酶逐步增大，于 10 月达到峰值。2）随退化程度加剧，较未退化阶段，培养前后的土壤铵态氮含量分别降低了 12.9% - 52.4%和 13.8% - 55.5%; 净氨化速率降低 18.6% - 61.1%。随时间推移，各退化阶段的氨态氮含量及净氨化速率均在 7、8 月达到峰值，枯萎期较小。3）与未退化相比，培养前后的土壤硝态氮含量分别增加了 40.2% - 53.5%和 32.7% - 69.5%；净硝化速率增加了 26.73% - 80.0%；且均在 7、8 月达到峰值。4）尕海沼泽草甸退化对土壤氮矿化存在显著的抑制作用，与未退化阶段相比，轻度、中度、重度退化分别降低了 12.4%、17.4% 、17.9%，三者均在 7 月出现最大值，未退化阶段在 8 月出现最大值。5）冗余分析表明，净硝化速率与硝态氮、硝酸还原酶活性、脲酶活性及温度呈显著正相关，与铵态氮、蛋白酶、亚硝酸还原酶、含水量呈显著负相关。净氨化和净氮矿化速率与其恰好相反，土壤铵态氮含量是影响土壤氮矿化作用的关键驱动因素，贡献率达到 66.5%。【结论】尕海沼泽草甸退化显著降低了净氨化速率和净氮矿化速率，提高了净硝化速率，且生长季对土壤氮矿化速率、酶活性以及土壤温湿度也有显著影响。土壤铵态氮是影响土壤氮矿化作用的关键驱动因子，研究结果为气候变化背景下高寒湿地氮过程机理模型的发展提供基础数据。

关键词: 湿地；氮矿化；退化；时空变化

Characteristics and propelling forces of soil nitrogen mineralization in the Gahai wetland degradation process

Abstract: 【Objective】To investigate the spatial and temporal variations of soil nitrogen mineralization rate, soil temperature and humidity, and related enzyme activities in degraded wetland ecosystems. To analyze the spatial and temporal changes of soil nitrogen mineralization rate, soil temperature and humidity, related enzyme activities in degraded wetlands, and the characteristics and internal driving factors of soil nitrogen mineralization change. 【Methods】 The non-degraded, slightly degraded, moderately degraded, and heavily degraded marsh meadows in Gahai wetland served as the research object, and in-situ cultivation of resin cores in the field was used to examine soil nitrogen mineralization in the early growth stage (June-July), peak growth stage (July-September), and wilting stage (September-October) in 2020. During the degradation of wetland marsh and meadow, examine the temporal and spatial changes of soil nitrogen mineralization and its relationship with soil enzyme activity and environmental factors. 【Results】 1) Temperature, nitrate reductase, and urease activities increased proportionally with the degree of soil deterioration, whereas soil water content, nitrite reductase, and protease activities decreased. July and August are the prime months for soil temperature, urease, nitrite reductase, and protease. Nitrate reductase levels increased progressively and peaked in October. 2) Before and after cultivation, the soil's ammonium nitrogen content decreased by 12.9%-52.4% and 13.8%-55.5%, respectively, compared to its non-degraded state. The net ammoniation rate decreased between 18.6% and 61.1%. Each degradation stage's ammonia nitrogen content and net ammoniation rate peaked in July and August, while the wilt stage shrank over time. 3) Before and after cultivation, the soil's nitrate nitrogen content increased by 40.2% to 53.5% and 32.7% to 69.5%, respectively, compared to when no degradation occurred. The nitrification rate increased by 26.73 to 80.0%. Each peaked between July and August. 4) slightly, moderately, and heavily degradation inhibited soil nitrogen mineralization by 12.4%, 17.4%, and 17.4%, respectively, compared to the non-degraded stage. In July and August, respectively, the utmost values for the three categories were recorded. 5) Net nitration rate was significantly positively correlated with nitrate nitrogen, nitrate reductase activity, urease activity, and temperature, and significantly negatively correlated with ammonium nitrogen, protease, nitrite reductase, and water content. The rates of net ammoniation and net nitrogen mineralization were opposites. The ammonium nitrogen content of the soil was the most influential factor in soil nitrogen mineralization, with a contribution rate of 66.5%. 【Conclusion】 The degradation of Gahai marsh meadow significantly decreased the net ammoniation rate, increased the net nitrogen mineralization rate, and decreased the net nitrification rate. The growth season significantly affected soil nitrogen mineralization rate, enzyme activity, temperature, and humidity. Soil ammonium nitrogen is a key factor influencing soil nitrogen mineralization, and the research findings provide fundamental data for the development of nitrogen process mechanism models in alpine wetlands against a climate change backdrop.

Key words: Wetland; Nitrogen mineralization; Degeneration; Spatiotemporal variation