Below- and Above-Ground Microbial Carbon and Nitrogen Cycles in Congo Basin Peatland Forests and Grazed Savannas

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In the Congo Basin's peatland ecosystems, carbon (C) and nitrogen (N) cycles are crucial for sustaining biodiversity, productivity, and greenhouse gas balance. These peatlands act as significant carbon sinks and play a key role in nutrient availability, influencing plant growth, soil fertility, and microbial activities that support ecosystem health. Microbes driving biogeochemical processes control the distribution and quantity of C and N; however, limited knowledge of the microbial mechanisms behind CH_4 and N_2O emissions — especially the poorly understood aboveground roles in these forests — hampers accurate assessments of tropical peatlands' climate change impacts. This study aimed to identify the key processes in soil and plant microbial communities that control gaseous fluxes (CH_4, N_2O, and N_2) in the tropical peatlands of the Congo Basin. In March (dry season) and November (wet season) 2024, peat samples from the soil column (0–10 cm and 10–20 cm) and plant leaf (*Raphia hookeri* (palm), *Macaranga spinosa* (tree), *Guibourtia demeusei* (tree)) samples were collected along a tropical peatland forest transect and a grazed alluvial savanna in the Congo Basin. Quantitative real-time PCR and sequencing were used to assess the abundance and structure of bacterial and archaeal communities. Additionally, functional genes associated with N cycle processes— including denitrification (*nirK*, *nirS*, *nosZI*, *nosZII*), nitrification (bacterial, archaeal, and COMAMMOX *amoA*), dissimilatory nitrate reduction to ammonium (*nrfA*), and N fixation (*nifH*) — were measured. Methane cycle-related processes, such as nitrate/nitrite-dependent anaerobic CH_4 oxidation (n-DAMO-specific 16S rRNA), methanogenesis (*mcrA*), and methanotrophy (*pmoA*), were also analyzed. Furthermore, in situ soil CH_4 and N_2O emissions, potential N_2 emissions, and physicochemical parameters were measured. Soil total C and N concentrations, including nitrate and ammonium, were higher in forests, indicating more active nutrient cycling. This was reflected in soil gas emissions, with elevated N_2O emissions from forests and high CH_4 emissions in certain forest areas associated with high soil moisture. All sites displayed low potential N_2 emissions from soil. Soil microbial communities were influenced by pH, which was notably higher in savannas (around 5) than in forests (around 3.5). Preliminary gene analysis showed high abundances of archaeal nitrifiers and denitrifiers in forest soil, while bacterial nitrifiers were entirely absent. Fungal denitrifiers were abundant in both ecosystems. Regarding aboveground microbial activity, the most active community was found on the leaves of *Raphia hookeri*, while relatively the smallest microbial activity in nutrient cycles was observed on the leaves of *Guibourtia demeusei*.