Nitrogen budget and critical load estimate in a semi-arid grazed ecosystem

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Abstract

A nitrogen budget was calculated in a semi-arid grazed ecosystem in Senegal (Dahra site), including nitrogen inputs (wet and dry deposition, biological nitrogen fixation (BNF)) and outputs (natural emissions of NO, N_2O, volatilization of NH_3 from animal excreta, anthropogenic emissions of NO and NH_3 from fires, nitrogen uptake by trees and animals, soil leaching). Nitrogen soil leaching was measured *in situ* for the first time in the Sahel. Calculated nitrogen inputs did not exceed the critical load estimated for this specific ecosystem.

Keywords: Nitrogen budget, Sahel, critical load, Africa

1. Introduction

In the Sahel, very low nitrogen (N) concentrations are observed in the soils, making the ecosystems vulnerable to increases of nitrogen deposition due to large scale anthropogenic activity development. In this study, a nitrogen budget (Fig. 1) was calculated for a semi-arid grazed ecosystem located in Dahra (Senegal, 15◦24 N, 15◦ 25 W). The nitrogen critical load was estimated with a steady-state mass balance method, and compared to nitrogen inputs.

2. Budget calculation

Inputs: Wet and dry deposition fluxes were measured in Dahra according to International Network to study Deposition and Atmospheric chemistry in AFrica (INDAAF) protocols. BNF was estimated from literature data.

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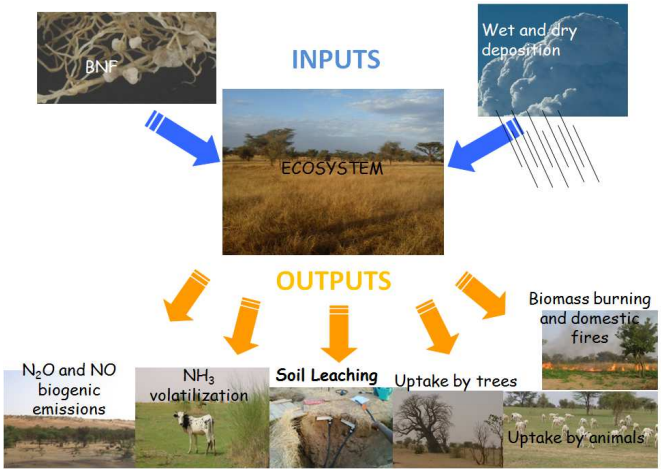

Fig. 1: N inputs and outputs to the ecosystem of Dahra

Outputs: N_2O and NO biogenic emissions were measured from static and dynamic chambers. NH_3 and NO emissions from biomass burning and domestic fires were calculated from satellite data. NH_3 volatilization was calculated from N concentration in animal excreta and herb mass, animal density, and ingestion. Uptake by trees was calculated from tree density, % occupation, N concentration in trunks, and N uptake by animals was calculated from the same parameters as for NH_3 volatilization. Soil N leaching was calculated from N concentration measured in soil solutions collected by two zero-tension lysimeters plates inserted in the soil and the corresponding intercepted water volumes.

3. Budget results and critical load estimation

N inputs = 9 kgN ha^{-1} yr^{-1}, whereas N outputs range from 10 to 20 kgN ha^{-1} yr^{-1}, with a large uncertainty on animal dependant data.

The nitrogen critical load was calculated by adding all outputs, including a critical leaching flux obtained with a critical concentration (N concentration from which the ecosystem may encounter a change in biodiversity). N critical load ranged between 11 and 24 kgN ha^{-1} yr^{-1}. N inputs are lower than the critical load, hence the ecosystem was not yet endangered by the nitrogen load at steady-state.

4. Discussion and conclusion

The impact of nitrogen deposition in the Sahel region is unknown and nitrogen critical loads are poorly assessed. Due to low N concentrations in soils, and to the increasing anthropogenic pressure, the ecosystems may be damaged by an excess of nitrogen at a shorter time scale than initially thought. For the first time, this study estimated the N critical load and N budget, based on measured data of the various N fluxes in semi-arid Sahel, showing that at steady-state, the ecosystem in Dahra is not yet threatened by an excess of N deposition.

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