Nitrous Oxide (N2O) emissions in a continuum plot-groundwater-wetland-river in a farming catchment area

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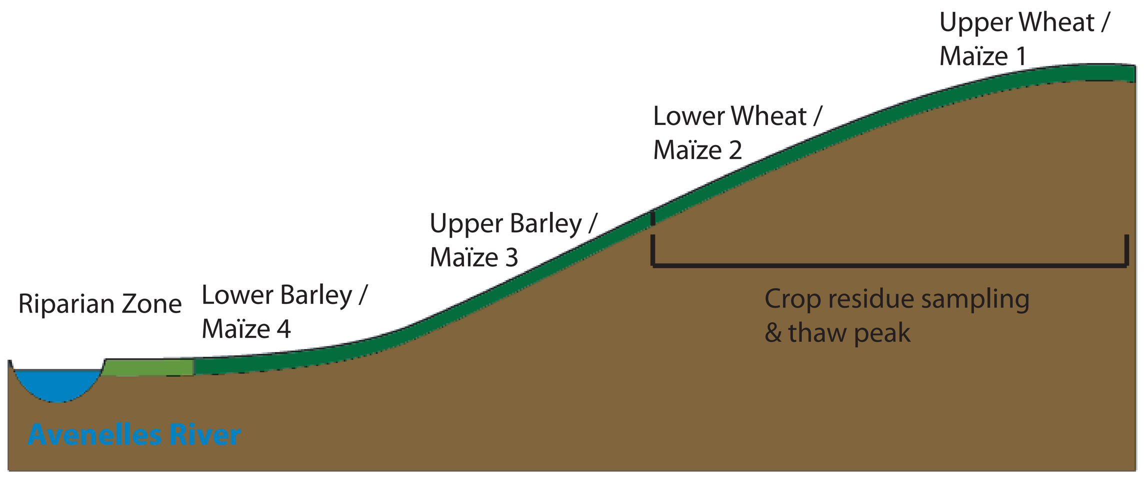
1 Scope of the study

Nitrous oxide (N_2O) has an important role in the atmosphere; it is a greenhouse gas with a 296 times larger global warming potential than carbon dioxide over a 100 year time period (IPCC, 2001). Soil contribution of global emission of N_2O is 70% (Conrad and Smith 1995) with a major contribution of agricultural soils, responsible for 67% of anthropogenic N_2O emissions (UNFCCC, 2003).
The purpose of this study was to analyse environmental factors (texture and organic matter content of soil, crop management and fertilizer application) in a continuum from an agricultural plateau to the riparian zone, in order to quantify emissions of N_2O (IPCC 2006).

3 N_2O emissions by soils

Material & Methods



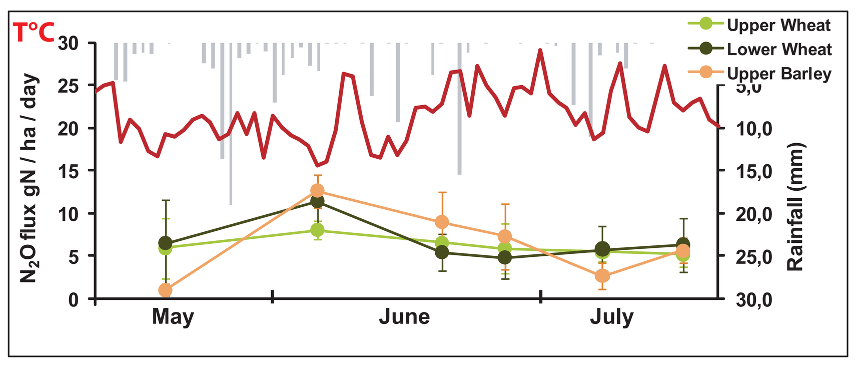
Nitrous oxide (N_2O) gas emission is measured with the "closed chamber technique" with 5 sampling plots at each site.

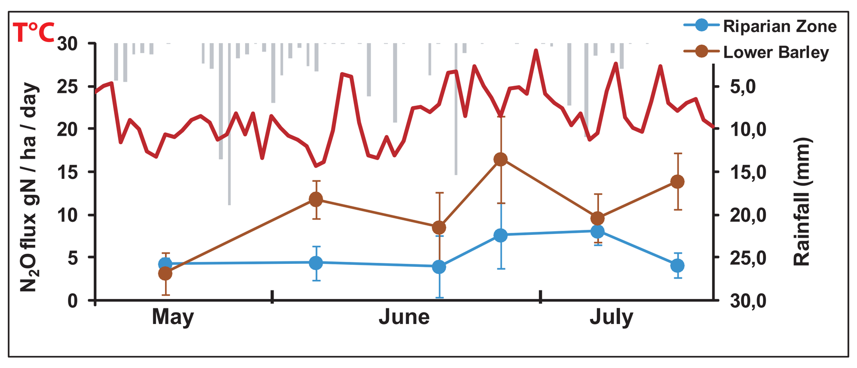
N_2O concentrations in the gas sample is analyzed using a gas chromatograph (GC) coupled with electron capture detector (ECD).

N_2O fluxes are determined by measuring N_2O concentration increases in the chamber headspaces and calculating the slope of linear regression of N_2O concentrations in function of time.

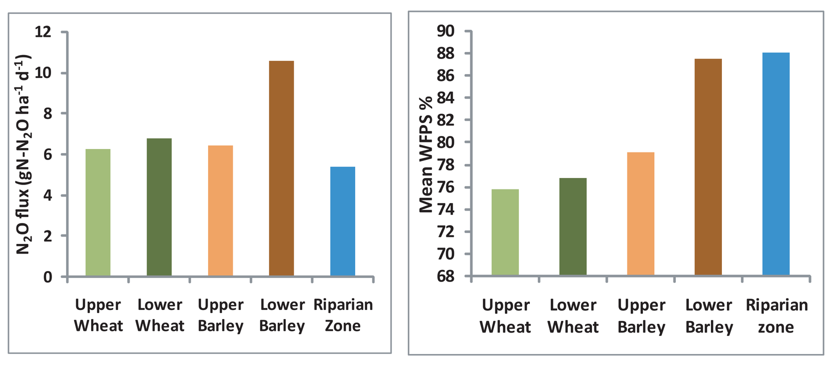
Soil and air temperature are measured around each chamber as well as soil moisture and organic matter content.

SPRING - SUMMER 2008 : Wheat and Barley





N_2O emissions during sampling campaign. Plots in slope (a) and backslope (b)



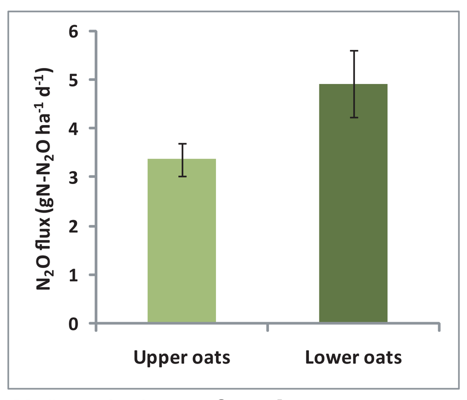
Mean N_2O emissions (a) and mean soil humidity (WFPS) (b)

Mean N_2O emissions, from 6 to 10 gN-N_2O ha^{-1} day^{-1} for croplands are well in the range of those found in other regions of the world (Bouwman, 1996; Garnier et al., 2009).

Mean N_2O emissions show a distinct landscape pattern. The mean fluxes of the footslope level (LB) are significantly higher than the fluxes in shoulder position (UW) or midslope position (LW and UB).
The same relationship with landscape position is observed with WFPS.

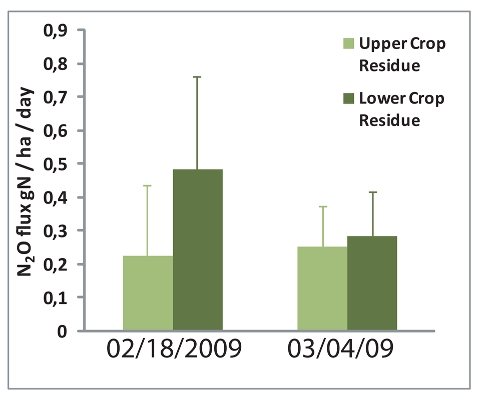
Topographic factor, to which water content is closely linked, seems to be a major controlling factor of N_2O emissions at the microscale level.

WINTER 2008-2009 : Thaw peak & N_2O emissions by crop residue



N_2O emissions after thaw

N_2O thaw peaks (from 3.3 to 4.9 gN-N_2O ha^{-1} d^{-1}) were observed on 01/20/2009 and were 10 times higher than fluxes observed for winter covert (from 0.26 to 0.37 gN-N_2O ha^{-1} d^{-1})



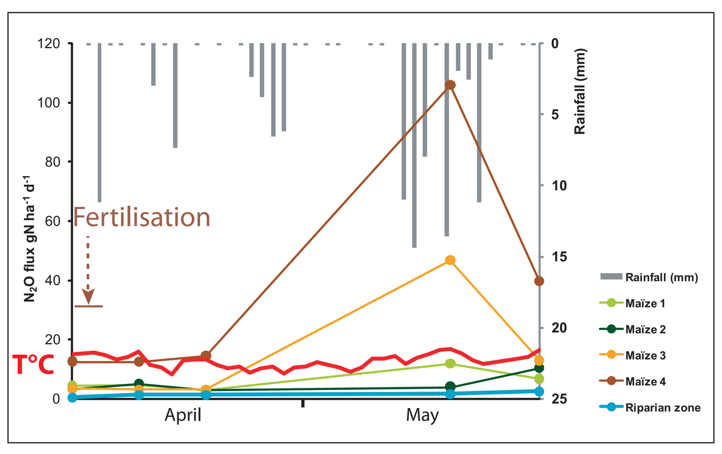
Background winter N_2O emissions by crop residue

Crop residue Sampling strategy consisted in two measurements after burying of oats covert.

Mean N_2O flux by crop residue (0.31 ± 0.12 gN-N_2O / ha / day) was significantly lower than flux measured in fields with wheat, barley or maïze.

This can de due to very low temperature at this period.

SPRING - SUMMER 2008 : Maïze (in progress)

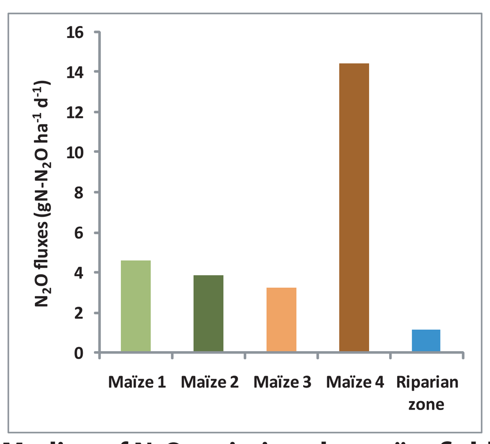


N_2O emissions by maïze field during sampling campaign

First results show the same landscape pattern with highest N_2O emissions in footslope position.

N_2O emissions are in the same range than those found for wheat and barley.

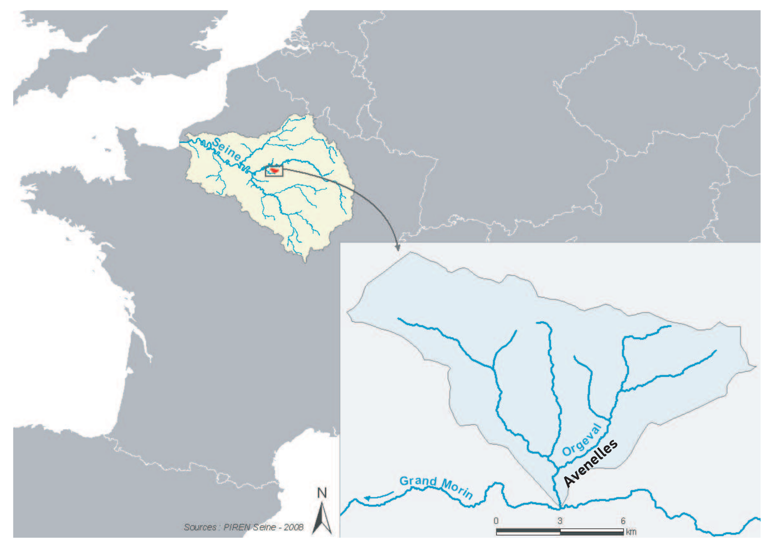
N_2O peak after first post-fertilisation high rainfall particullary marked in footslope position (Maïze 4).



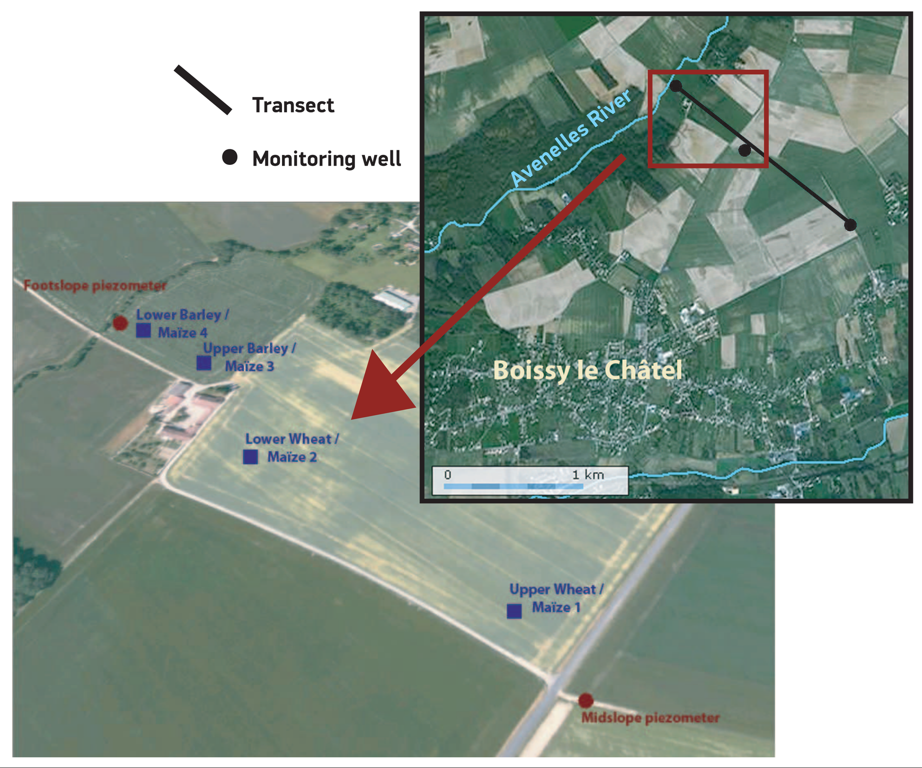
Median of N_2O emissions by maïze field

2 Study site : The Orgeval sub-basin

The study site is a north-westward falling slope reaching the Avenelles River with an average inclination of 2.2%.



The study area is located in the Orgeval sub-basin (Seine basin, France), about 60km east of Paris (48°50'N, 03°08'E). The mean annual precipitation is 700 mm and the mean ambient temperature is 4°C in winter and 19°C in summer.

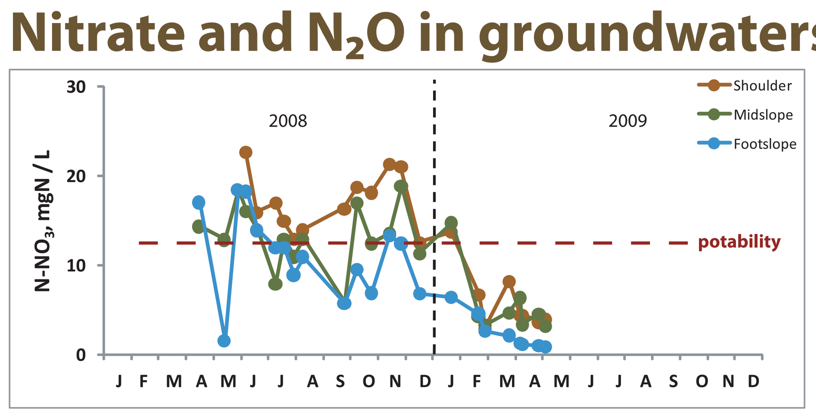


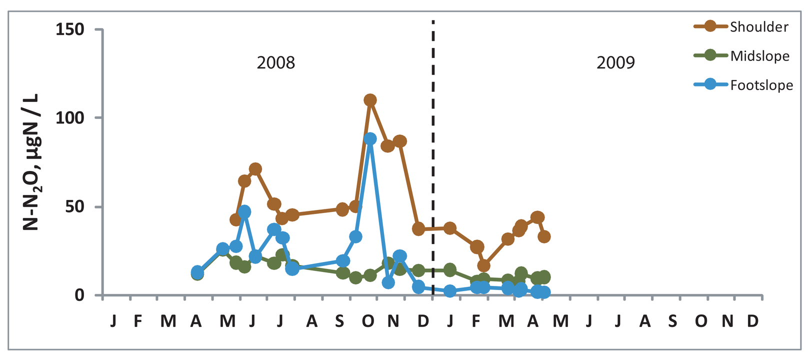
4 NO_3 and N_2O in groundwater and rivers

DIssolved N_2O and nitrate in the groundwater and rivers are sampled with a submersible pump. Dissolved nitrous oxide is analyzed, following desorption, with a gas chromatograph (PERICHROM ST200) with an electron capture detector (ECD).

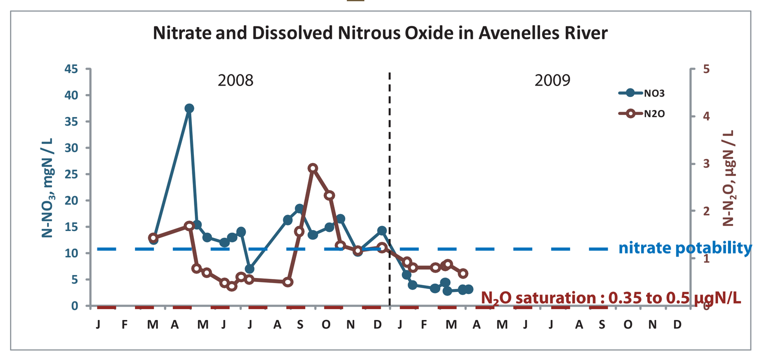
Nitrate is measured on filtered water (GF/F 0.7µm of porosity) with an autoanalyser (Quaatro), after cadmium reduction into nitrite with the sulphanilamide method.

Nitrate and N_2O in groundwaters





Nitrate and N_2O in rivers



Dissolved N_2O in groundwater and rivers always above saturation with very higher concentrations in groundwater.

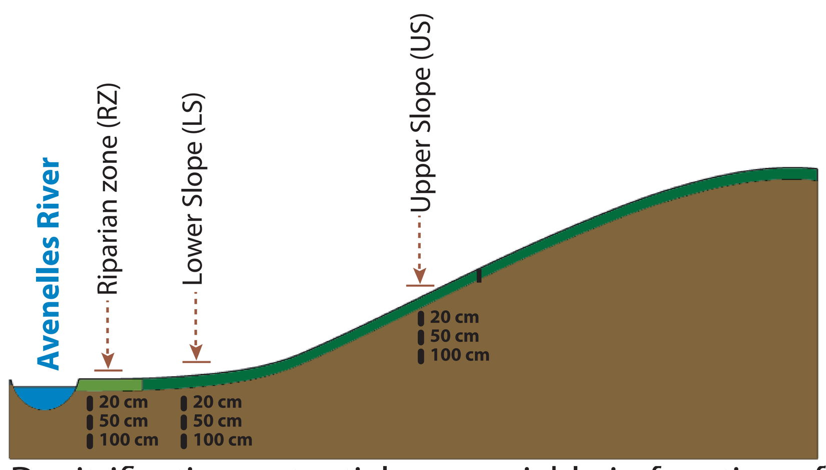
N_2O concentration gradient along the slope with highest concentrations in upper position (more marked for N_2O).

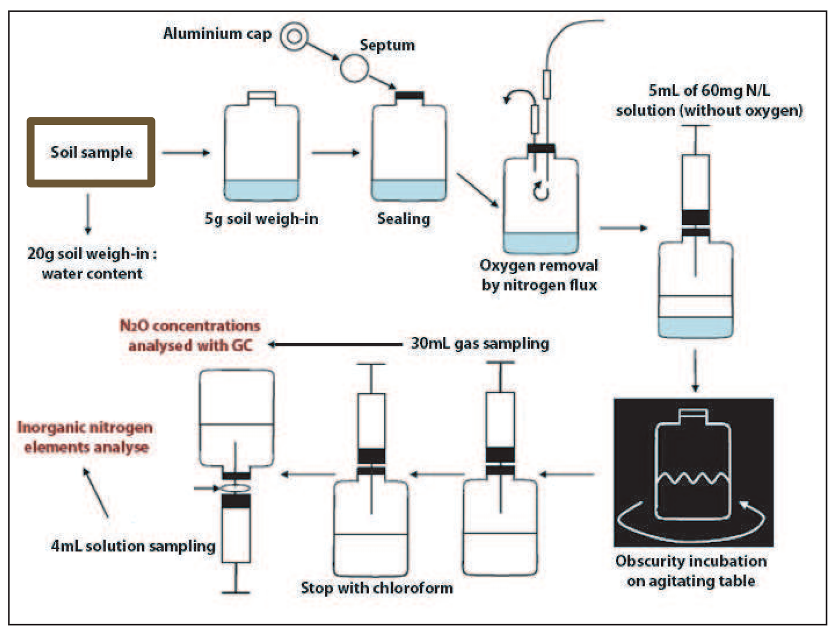
In 2009, nitrate concentrations is in the same order in groundwater and rivers.

Two key periods for highest concentrations of nitrate and dissolved N_2O : spring (2008 & 2009) after fertilisation and fall (after first post-summer rainfalls)

5 Soil potential denitrification : a lab study

Sampling strategy & Experiment protocol

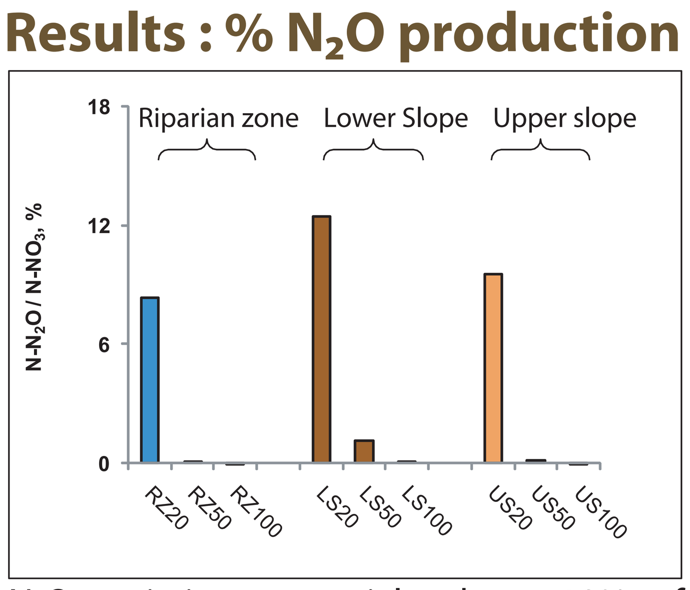




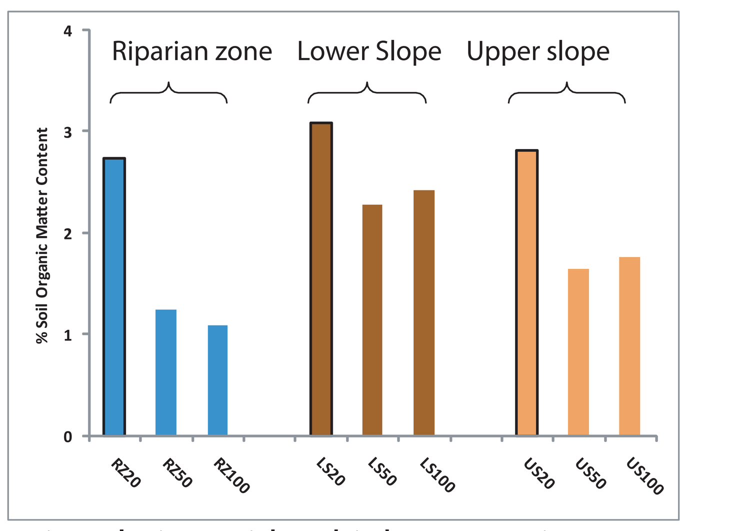
Denitrification potentials are variable in function of depth, about 2 µg N / g dry soil / h

N_2O emission potentials are much higher in surface, about 0.12 µg N / g dry soil / h

Results : % N_2O production



N_2O emission potentials about 10% of surface denitrification potential...



... in relation with a higher organic matter content

Conclusion

This study has permitted to show that landscape position affects N_2O emissions as well as soil characteristics like WFPS.

Values from 6 to 10 gN-N_2O ha^{-1} day^{-1} for croplands are well in the range of those found in other regions of the world (Bouwman, 1996; Garnier et al., 2009). Laboratory experiments show that N_2O production are potentially higher at the surface, so that besides being emitted N_2O could reach the groundwaters by infiltration. During the water transfer from aquifer to surface water, N_2O could be further reduced or emitted.

N_2O concentrations in groundwaters are clearly higher than concentrations found in rivers and huge compared with that of the saturation, with a clear gradient along the slope. Soils appear to be a real source of N_2O for the river water.

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