DOCTORAL SCHOOL IN ENVIRONMENTAL ENGINEERING

Department of Civil and Environmental Engineering

University of Trento – Italy

XXI cycle

Simonetta Rubol

The influence of redox dynamics on nitrogen cycling and nitrous oxide emissions from soils

Supervisors:

Prof. Alberto Bellin (University of Trento)

Prof. Gianni Andreottola (University of Trento)

Prof. Whendee Silver (UC Berkeley, USA)

Abstract

Soils are a dominant source of nitrous oxide (N2O), a potent greenhouse gas. The complexity of drivers of N2O production and emissions has hindered our ability to predict the magnitude and spatial dynamics of N2O fluxes. Soil moisture can be considered a key driver because it influences oxygen supply, which feeds back on N2O sources (nitrification versus denitrification) and sinks (reduction to dinitrogen). Soil volumetric water content is directly linked to dissolved oxygen and to redox potential, which regulate microbial metabolism and chemical transformations in the environment.

The relationship between soil moisture and N2O is usually based on incubations of soil at different soil moisture levels.

Few studies have focused on the interaction between soil moisture and nitrogen dynamics in the vadose zone.

In this thesis soil column and chamber experiments were performed in order to investigate the relationship of soil moisture dynamics to redox sensitive nitrogen dynamics in the organic matter layer of a pasture peatland in Sacramento, Bay Delta area, California.

Field data has been analyzed and statistics has been used to evaluate the influence of irrigation practices on spatial pattern of measurements.

Data indicate that organic peatland might be an important source of nitrous oxide emissions.

The comparison of rainfall, saturation and deposition shown that trace gases emissions, dissolved nitrate and ammonium changed considerably along the soil column profile as a response of the microbial community to the high variability in

redox, soil moisture, oxygen experienced by the soil at different depth. Water movement favored the formation of zones at different redox condition, redistributed the nutrient along the soil profile, and considerably changed mineralization, nitrification and dissimilatory reduction to nitrate (DNRA) rates.

It was observed an asymmetrical behavior between nitrogen and ammonium profiles. Experiments shown that this assimetry is a function of the degree of saturation (as well as its duration). Also the fraction of the total N2O that is actually emitted to the atmosphere depends heavily on the structure and wetness of the soil.

The nitrous oxide dynamic is therefore a function of the antecedent wetness condition, the nutrient content of the peat-land, the physical characteristics of the peat-land and the vertical stratification of layers at different redox and oxygen condition, which may affect the annual N budget.

In addition, the combined use of soil column and chamber experiments suggest a negative correlation between soil moisture and N2O in dynamic condition and a functional dependence of N2O emissions from the oxygen concentration. We found that the time scale of water dynamic was faster than the biological scale of trace gas emissions.

Finally, the relationship of nitrous oxide versus water content was reproduced by using a lumped model which include oxygen dynamic.

Preliminary results suggest that by accounting for oxygen dynamic, it is possible to reproduce the functional behavior observed in the experiment and that the latter is depending on the physical and biological properties of the soil.

Keywords: water dynamics, nitrous oxide emissions, nitrate ammonification, feammox, denitrification, soil heterogeneity, oxygen, redox.