Nitrous Oxide from Irish Agricultural Grasslands: Current Emissions and Future Trends

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Introduction

The emission of the greenhouse gas (GHG), nitrous oxide (N_2O) from human activities are contributing to global climate change. An estimated 29% of Ireland's GHG emissions are from the agricultural sector and N_2O make half of these [1]. The Intergovernmental Panel on Climate Change (IPCC) has prescribed limits on national GHG emissions and provides a method for estimation derived from IPCC "Tier I" which may be an overestimate. Therefore Irish Agriculture requires an accurate estimation of N_2O in order to avoid overestimation in future. N_2O emissions are being measured at eight grassland different sites in South Ireland over a period of 2 years. The main site is Dripsey (Co, Cork) and the emissions are being measured both by eddy covariance and chambers. The other seven sites are spatially dispersed throughout the south western region to represent the most prevalent soil properties and grassland management practices. This approach will capture both temporal variation at the main site and spatial variation at the seven satellite sites. This project aims for an improved understanding of N_2O emissions controlling parameters, its spatial and temporal variation and a robust estimate of N_2O emission [2].

Objectives

- To create a representative set of field data on N_2O emissions from agricultural grassland in the southwest of Ireland
- To assess two N_2O modelling approaches: empirical and process based modelling
- Upscale the N_2O emission to the regional scale

Site Description

Total of eight sites are being analysed for soil N_2O emissions. These sites are dispersed throughout the south west part of the country. These sites are shown in (Fig. 1):

Ballinhassig (BH), Kiloworth (KW), Clonakilty (CK), Dripsey (D)

and Carrig na Bh fear (CF) (Co, Cork),

Palliskenry (PK) (Co, Limerick) , Solohead (SH) 1 & 2 (Co, Tipperary)

A basic weather station at each site records continuously temperature, rainfall and soil moisture contents (Fig. 2). Soil analysis has been carried out from all sites which comprises bulk density, texture (silt/sand/clay), organic matter, pH and available nitrogen. An Eddy Covariance (EC) station is fixed on dripsey site to measure the temporal variations of N_2O flux. (Fig. 3).

Fig 1: Location of sites


Fig 2: Weather sensor


Fig 3: Eddy Covariance

Methods

Chamber Design

Chambers are made up of Polyvinyl Chloride (PVC) pipe with 300 mm diameter and 450 mm height (Fig. 4). An aluminium ring at the end of each chamber is fixed to penetrate in soil during sampling (Fig. 5). A thermocouple measures the internal temperature. A vent tube is used to reduce the pressure inside the chamber and there is one sampling port fitted with a valve.

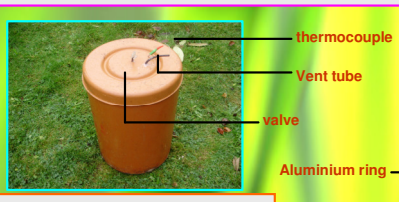

Fig 4: PVC sampling chamber


Fig 5: The inner side of chamber

Gas Sampling Method

The samples are drawn with a syringe. Gas samples are collected at 0, 20, 40 and 60 minutes intervals (Fig. 7). These samples are transferred into vials and returned to lab for chemical analysis (Fig. 8). During sampling the internal chamber temperature, the soil moisture content, soil temperature and air temperatures are recorded. The sampling frequency is once per week from April to October and once per month from October to March.


Fig 6: Chambers placement


Fig 7: Sample Extraction


Fig 8: Sample transferring

References

[1] Ireland`s Environment 2008, report, Environmental Protection Agency, 2008.
[2] Green House Gas Mitigation in Agriculture, Fourth Assessment Report, Intergovernmental Panel on Climate Change.
[3] Chamber-based Trace Gas Flux measurement Protocol, GRACEnet, 2004.

Chemical Analysis

Gas samples are analysed using a Varian 3800 Gas Chromatograph (Fig. 9). The CombiPal Auto sampler is used to retrieve and inject the samples from the gas vial to GC injector and then it is pushed through the fitted GC packed column (Porapak QS 80-100 MESH) which is suitable for N_2O.


Fig 9: Gas Chromatograph

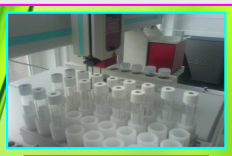
Fig 10: Sample vials

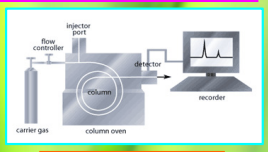

Fig 11: GC diagram

N_2O Flux Calculation

The N_2O flux is calculated by a regression model and the equations used are [3]:

$Cm=(Cv*M*P)/(R*T)$; where, T= Temperature ($^0K= {}^0C + 273.15$) , M = Molecular wt of N_2O ,
Cm = mass/volume concentration (µg N_2O-N/L), P = barometric pressure ,
Cv = volume/volume concentration (ppm or ppb)

$F= V*(dC/dt)/A.$ Where, V = volume of chamber (m^3), A = soil area covered (m^2)
dC/dt = Change in concentration of gas over the enclosure period

Eddy Covariance (EC)

EC is a micrometeorological technique used to assess fluxes of heat, water and gases on ecosystem scale. The 3-D anemometer and TGA-100A system are being used to measure u, v, w wind speed components at 10 Hz and the concentration of N_2O at 10 Hz respectively .A custom created algorithm is then used to calculate the 30 minutes N_2O flux.

Emission Upscaling

The extrapolation of the emission from plot and farm scale to the regional scale will be done:

- Using existing soil, meteorological and emissions measurements to validate models at a small number of sites.
- Running these models with inputs from extensive soil, meteorological and land cover databases and aggregating the results.

Scenario Modelling

The prediction of regional N_2O emissions under a set of scenarios based on current and projected land use and management and climate trends will be performed by:

- Using a stochastic weather generator to simulate daily weather patterns under climate change scenarios
- Running the process based N_2O flux models under each scenarios and collating, analysing and interpreting the results.

Questions for Audience

1- What kind of regression models (i.e. linear or non-linear) are available for N_2O flux calculation ?

2- what Value of R^2 (0.7, 0.8, 0.9 > R^2) from chambers are expected in regression model?

3- Which process-based model is best for Irish grassland sites e.g. DNDC, DAYCENT etc ?

4- Which is better: random or systematic sampling plot design?

5- How can we use the 4-5 months old gas samples ?

6- What should be the minimum detection limit?

Future Goals

To continue the flux measurements for at least one year more, collect all the required data, start process based modelling, up scaling and scenario analysis. It is also aimed to start the Eddy Covariance (EC) and Chamber method comparison campaign and find the answers of above questions

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