Ammonia and nitrous oxide emissions following land application of high and low nitrogen pig manures to winter wheat at three growth stages

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Background

• **Agriculture in Ireland - 26.8% of GHG emissions**
  - GHG almost transparent to solar radiation but absorb & emit infrared radiation. Thus, GHG trap heat within the surface-troposphere system causing global warming
  - N\textsubscript{2}O, CH\textsubscript{4}, CO\textsubscript{2}, sulphur hexafluoride, HFC’s, PFC’s

• **Kyoto Protocol - reduction of GHG emissions**
  - Europe has chosen to reduce emissions by 8%
  - Ireland has to be within +13% of 1990 levels by 2012
  - Beyond 2012, 20% reduction of GHG on 1990 levels by 2020

• **Agriculture in Ireland - 98% of ammonia emissions**
  - Atmospheric deposition causing eutrophication & acidification of sensitive eco-systems
  - Gothenburg Protocol to reduce NH\textsubscript{3} by 8% based on 1990 levels for 2010
Background to this Project

Manure Disposal → Wheat Production

Pig Production → Animal Feed

Animal Feed → Wheat Production

Wheat Production → Manure Disposal
Introduction

- Pig manure can be a valuable nutrient source in tillage crop production
  - Benefits include:
    - Increased soil organic matter content
    - Reduced N, P, K costs
    - Reduced trace element deficiency problems

- Significant loss through leaching, denitrification and volatilisation can reduce beneficial effects

- Need to quantify the losses of nitrogen as ammonia and nitrous oxide for meeting Kyoto & Gothenburg targets but also to quantify N losses for farmers
Nitrous Oxide & Ammonia Emissions

- Denitrification: Microbial reduction of nitrate to di-nitrogen gas
  - Anaerobic conditions - Denitrifying bacteria (e.g. *Pseudomonas*)
- Nitrification: Oxidation of ammonium to nitrate
  - Aerobic conditions - Nitrifying bacteria (e.g. *Nitrosomonas*, *Nitrobacter*)

- Current nitrous oxide content in the air is 319 ppb
- Increasing at a rate of 0.25% per year
- 300 times greater global warming potential than CO₂
- Estimated 16.8kg N/ha/yr lost as N₂O in Ireland

- With ammonia the key issue is the loss of NH₃ to the air after manure application
- Rate of ammonia volatilisation depends on:
  - Weather conditions, Soil characteristics, Mode of application, Manure characteristics
Hypothesis

Pigs fed low CP diet

Low Urea Pig Manure

Applied by band spreader

Applied to wheat at later growth stages

Canopy more dense/ increased N requirement

Ammonia/Nitrous Oxide emissions reduced

Reduced global warming

Environmental Benefits
Diets for Manure Production

• Ideal protein concept
  • Feed that yields all of the essential A.A in proper proportions for growth & maintenance after digestion

• 2 pig diets 16% vs. 23% CP
  – HCP = 65% wheat, 31% soya
  – LCP = 83% wheat, 12% soya

• Low protein diet – meeting protein requirements
  • Added synthetic A.A to prevent deficiency (1%)

• High protein diet – supplying excess protein
  • Nitrogen excreted in urine – more N available for volatilisation
2 groups of 85 pigs were housed in a grower/finisher house with 2 separate manure storage tanks. Pigs entered the house at 35kg and were fed for approximately 12 weeks.

Manure applied at 3 spread dates (SD):
- **SD 1** - Mid tillering – GS 25
- **SD 2** - Stem extension – GS 31-32
- **SD 3** - Flag Leaf – GS 37-39

Manure was applied by use of band spreading equipment.

Crop canopy as G.S increases.

Micro-climate created.

Increased requirement for N.
Micrometeorological Technique

- Use of passive flux samplers to measure the ammonia concentration in air
- Manure spread & mast immediately erected in the centre of plot
- Shuttles place at 5 heights 0.2m, 0.4m, 0.8m, 1.5m and 3.0m
- 7 sampling times 1, 3, 6, 24, 48, 96 & 168 hours post spreading
- Background mast for measuring the background levels of ammonia in the area surrounding the trial plots
Nitrous Oxide Measurement

- Static chamber technique
- Stainless steel chambers 0.41m*0.41m
- Measure flux of N$_2$O over a given time period
- Sampled at 0, 15 & 30mins
Results
Results – Nitrous Oxide

N$_2$O (µg N$_2$O/m$^2$/hr)

<table>
<thead>
<tr>
<th>Application Timing</th>
<th>HCP</th>
<th>LCP</th>
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</thead>
<tbody>
<tr>
<td>SD 1</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>SD 2</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>SD 3</td>
<td></td>
<td>B</td>
</tr>
<tr>
<td>Av.</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

Spread: P<0.0053  Manure: P<0.0184
Nitrous Oxide - SD 1

Sample time P<0.0001

Days After Spreading

N₂O (µg N₂O/m²/hr)
Nitrous Oxide - SD 2

Sample time P <0.0001

Days After Spreading

N₂O (µg N₂O/m²/hr)
Nitrous Oxide - SD 3

Sample time $P<0.0001$

Days After Spreading

$N_2O$ (µg $N_2O$ /m²/hr)
Ammonia Volatilisation

Cumulative N Lost (kgN/ha)

<table>
<thead>
<tr>
<th>Spread Date</th>
<th>Cumulative N Lost (kgN/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD 1</td>
<td>9</td>
</tr>
<tr>
<td>SD 2</td>
<td>7</td>
</tr>
<tr>
<td>SD 3</td>
<td>6</td>
</tr>
<tr>
<td>Av.</td>
<td>7</td>
</tr>
</tbody>
</table>

Spread P<0.0005 Manure P<0.0240

HCP
LCP
Ammonia Volatilisation

Sample Time P<0.0001
Ammonia Volatilisation

Ammonia Emissions (kg N/ha/hr)

Hours Post Manure Application

Sample Time P<0.0001

Amonia Emissions 6.24 kgN

Amonia Emissions 0.33 kgN
Ammonia SD 1-3

Cumulative N lost (kgN/ha)

- SD 1: 8.66
- SD 2: 6.31
- SD 3: 6.30

Hours post spreading

- SD 1: 96%
- SD 2: 95%
- SD 3: 93%
Overview – Results

- Manure application increased crop yield & crop nitrogen uptake
- HCP manure had consistently higher emissions than the LCP manure
- Ammonia and nitrous oxide emissions decreased as the crop advanced
- 93-96% of ammonia emissions occurred in the first 24hrs
- Total nitrogen lost as ammonia ~6.5kgN/ha over the 1 week measurement period
- Total nitrogen lost as nitrous oxide ~0.626kgN/ha in 30 days