Manure Storage, Handling and Application Practices which Mitigate GHG Emissions for Hog Operations

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on Manure Management

Workshop on
Climate Change Strategy in the Hog Industry

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A Few GHG Statistics

- Agriculture accounts for 10–12% of GHG emissions in Canada. With no mitigation, agriculture emissions expected to be 18% above 1990 levels by 2010
- Relative importance in Agriculture
  - Carbon dioxide – 11%
  - Methane – 36%
  - Nitrous oxide – 53%

From:

GHG Mitigation Strategy for Can. Hog Industry

– June 2002

- 82% (est.) of GHG emissions for hogs comes from manure management
  - 62% from methane
  - 20% from nitrous oxide
  - 9% from enteric fermentation (55 – 73% for ruminants)

Manure Management Objectives

- Odour control
- Nutrient retention / re-use (recycling) (ammonia loss)
- Pathogen reduction
- Greenhouse gas emissions (CH_4, N_2O)
- Land, labour or capital requirements
- Energy efficiency
- Animal / human health and performance considerations

Relative importance of these objectives is farm-specific

Optimizing only 1 objective at a time will negatively impact on others – must use system approach

Factors Affecting GHG Emissions from Manure

GHG production largely due to microbial processes

- Factors affecting microbes
  - Aeration, moisture, temperature, nutrient sources
- Livestock type (beef manure > swine > dairy)
  (ruminants – enteric (direct) methane emissions)
- How it is stored (slurry vs solid - aeration)
  - Closed / open containment
- How it is applied on the field (surface, injected)
  - Timing, amount, compaction
- Animal diets (ionophores - suppress CH_4 production)

Ammonia Emissions from Manure

Include ammonia in ghg management strategy

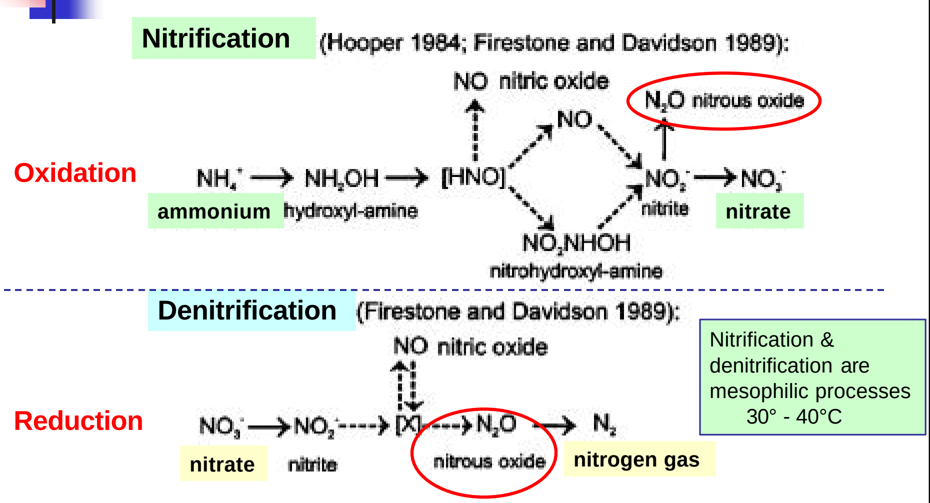
- Valuable nutrient
- Toxic substance (CEPA)
- Links to nitrous oxide production

$NH_4^+ \quad NH_3 + H^+ \qquad K = [NH_3]\,[H^+] / [NH_4^+]$

Factors

- Slurry pH (pK = 9.3; 50% NH_3, 50% NH_4^+)
- Temp.-dependent If T more NH_3
- Air Flow
- C/N ratio
- Supply of NH_4^+ ions, urea or organic N

Nitrification & Denitrification
Nitrous Oxide Production



1. MANURE COLLECTION & STORAGE

Manure Collection & Storage to Minimize GHG Emissions

Remove manure from barn when fresh
…. minimizing water volumes … and
… transfer into a closed vessel / tank

BENEFITS

- **Minimize odour production** **(NH_3, VOCs)**
  - Minimize ammonia losses (toxic substance – CEPA)
  - Improve air quality in barn – healthier for hogs and for humans.. Improved performance

Manure Collection & Storage to Minimize GHG Emissions

Remove manure from barn when fresh
…. minimizing water volumes … and
… transfer into a closed vessel / tank

BENEFITS

- **Minimize GHG emissions from closed storage**
  - Little losses of CH_4 or N_2O
- **Conserve nutrients & organic matter (carbon)**
  - Methane capture & energy recovery
  - Minimize N losses (NH_3, N_2O) (closed systems)

Manure Collection & Storage to Minimize GHG Emissions

Remove manure from barn when fresh
…. minimizing water volumes … and
… transfer into a closed vessel / tank

BENEFITS

- **Avoid gas accumulations below pens** – **explosions**
- **Avoid deterioration of cement**
  - H_2S becomes sulfurous acid vapour in presence of moisture

Innerkip - Summer 2001 - 12- year old deep-pit barn
Severe corrosion of cement pillars above liquid

Ammonia Losses Influenced by the Retention Time in Swine Housing

Management System	Retention on Barn Floor	NH_3 Loss
Slotted floor over pit	**~ 1 hour**	**5 - 9%**
Daily scraping to pit	**~ 1 day**	**19 - 21%**
Gravity incline to pit	**~ 1 week**	**27%**

(Burton and Beauchamp, 1986)

Prompt removal to storage conserves N (ammonia)

Solutions For Existing Lagoon Storages

- **Negative Air Pressure Covers can reduce:**
  - GHG & ammonia emissions
  - Odour release (does not change odour production)

    BUT - doesn't stop anaerobic processes in lagoon

- **Uncovered Lagoon**
  - Can keep surface aerobic – difficult to stop anaerobic generation of N_2O & CH_4 at greater depths
  - NH_3 loss reduced if pH 7.0 (neutral).. BUT H_2S production will increase as pH decreases.

2. MANURE TREATMENT

Manure Treatment to Minimize GHG Emissions

Two Choices

- **“Dry” Systems –> Composting**
  - > 65% moisture - de-water or add bulking agents
  - Nitrification/Denitrification inhibited in 50° - 65°C range
- **“Wet” Systems –> Anaerobic Digestion**
  - < 10% solids (> 90% moisture) – hog manures

Manure Treatment to Minimize GHG Emissions

Dry System – In-vessel Composting

- Inside closed vessel, or inside building
  - Reduce gaseous losses, odour (incl. NH_3)
- Large volume reduction (40 – 60% reduction)
- Effective for killing pathogens (60° - 65°C)
- Product less likely to produce N_2O when land applied
  (Dr. John Paul, Transform Composting)

Manure Treatment Composting

Dry System – In-vessel composting

Rotating Cylinder (8' x 24')
– Texas A&M Univ.

Tested in early 1990's before ghg's

Transform Composting – Abbottsford, BC

Covered building - controlled

Manure Treatment
Rotary Vessel Composting

- Rapid initial treatment (3-4 days) @ 3-4 revs/hour
- Control airflow
  - Keep aerobic – prevent CH_4 or N_2O production
  - Minimize NH_3 losses – minimize odour
- Moisture content < 65% (pre-dry or add bulking agent)
- 8' x 24' vessel for 400 cow herd (continuous flow)
- Also Canadian developer of rotary composting technology

- **Concerns**
  - Static outdoor curing – CH_4 emissions (anaerobic zones) can increase several fold!

(Dr. C. Wagner-Riddle, pers. Comm, 2002)

Manure Treatment
Composting

Open-air composting - several problems

- Considerable N losses (ammonia, odour)
- CH_4 & N_2O emissions if anaerobic zones in pile – turn pile on regular basis until curing completed
- Runoff losses if not covered (crust formation)

BEST to compost on covered cement pad to minimize leaching & volatilization losses

Manure Treatment
Anaerobic Digestion

Liquid Systems

- Load daily from barn – no intermediate storage
- Closed system – no nutrient, gaseous losses
- Capture CH_4 – generate electricity, heat
- Odours, pathogens greatly reduced

Manure Treatment
Anaerobic Digestion

Methane collected inside air-tight plastic cover

- Low Tech

German GBU mixed manure-waste digester
3,000 cu.m./yr - hydraulically operated, continuous flow
(Canada - Rentec Renewable Energy)

- High Tech

Manure Treatment
Anaerobic Digestion

Benefits

- **Reduce odours & pathogens** by 90% (mesophilic)
- **All nutrients preserved** during treatment (GHGs, NH_3)
- **Co-generation** (electricity, heat)
  - **Energy independence** (costs, brown-outs)
  - **Green credits** (emission trading)
- **N** is conserved.. Closer **N:P ratio** for crop utilization

Manure Treatment
Anaerobic Digestion

Additional Benefits

- **Homogeneous product**
  - More N in mineral form (50% C to methane)
  - More predictable plant availability
  - More uniform land application
  - **Increased flexibility** for further treatment & managing nutrients

– **IF** have excess nutrients, separate solids → organic amendments / org. fertilizers
(**off-farm value-added products, pellets, granules**)

3. LAND APPLICATION

Land Application Practices to Minimize GHG emissions

Liquid manure

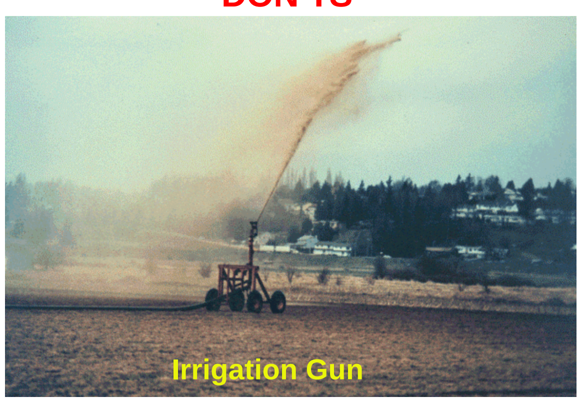
- **Inject in upper root zone**
  - Minimize exposure with air
- **Match applied nutrients to crop needs**
  - Amounts & Timing
- **Apply uniformly -** moderate volumes
- **Apply under well-aerated conditions**
  - Minimize compaction
  - Avoid application just before/after rain

Land Application Practices to Minimize GHG emissions

- Nitrous oxide can be produced by
  - Oxidation of ammoniacal N (NH_4^+, NH_3)
  - Reduction of nitrate (NO_3) – avoid anaerobic
- Sources
  - N fertilizers
  - Livestock manures
- Tillage Systems – no clear differences

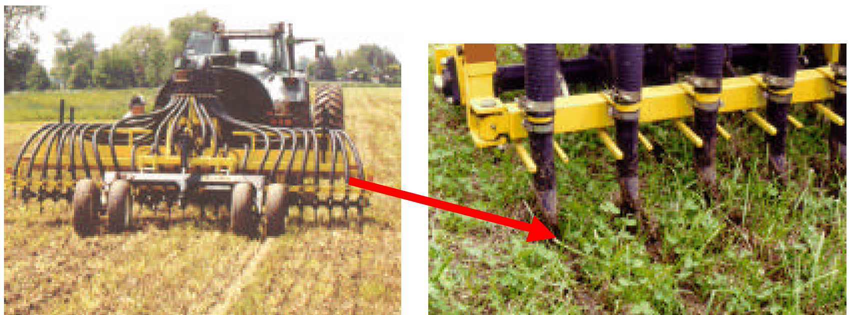
Land Application Practices to Minimize GHG emissions

DON'TS



S. Bittman, AAFC 2002

Land Application Practices to Minimize GHG emissions

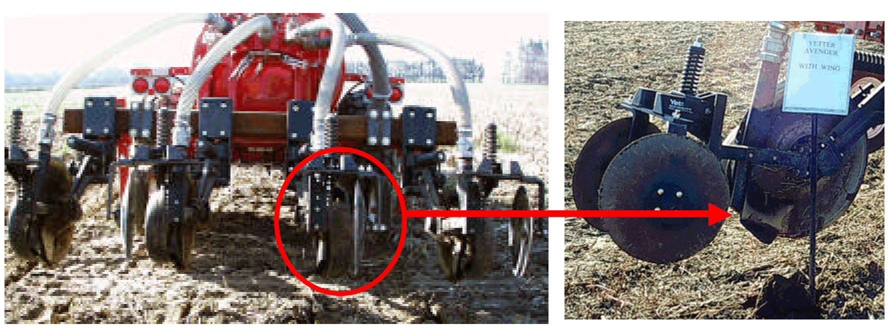


AERWAY
Sub-Surface Deposition
(SSD) manure applicator

S. Bittman, AAFC 2002

Land Application Practices to Minimize GHG emissions

Yetter Avenger injector with wings



- Injection slot backfilled, reducing N volatilization losses

Bonnie Ball-Coelho, AAFC, 2002

Land Application Practices to Minimize GHG emissions

Solid Manures (incl. composts)

- **Apply uniformly**
  - Avoid clumps – possible anaerobic zone
- **Incorporate promptly**
  - Minimize volatilization
- **Match applied nutrients to crop needs**
  - Amounts & Timing
- **Apply under well-aerated conditions**
  - Minimize compaction
  - Avoid application just before/after rain

Some General Principles

Conserve & re-cycle nutrients

- Don't promote N losses (NH_3, reduction to N_2) to solve other management issues
- Manage nutrients on **entire system basis**
  - incl. energy / ghg impacts of producing new fertilizers

Recycling livestock nutrients reduces need for new mineral fertilizers

Minimize water additions for handling manure

- Reduce odour problems
- Reduce storage/handling/transportation costs
- Reduce environmental risks at application time

Summary

Collection/ Handling/Storage

Remove quickly from barn to separate storage

- Reduces odour production (ammonia losses)
- Reduces chances for explosions or corrosion
- Improves air quality – health, productivity
- Conserves nutrients

Cover Lagoons

- Reduces odour & ghg emissions

Summary

Treatment

- **Use enclosed vessels**
  - Minimize nutrient losses
  - Minimize ghg & odour emissions
- Keep pH near 7.0 – minimize ammonia losses
- **Best** - **Composting or anaerobic digestion**
  - Minimize ghg and ammonia emissions
  - Reduce pathogens
  - Consistent end-product

Summary

Land Application

- **Match applied nutrients to crop needs**
  - Amounts & Timing
- **Apply uniformly, inject liquid manures**
- **Apply under well-aerated conditions**
  - Minimize compaction
  - Avoid application just before/after rain

Thank you