

Non-CO₂ Greenhouse Gases: Nitrous Oxide

Source/Sectors: Agriculture/Manure Management

Technology: Options for emission reduction related to manure management (B.1.2)

Description of the Technology:

Livestock manure can produce N₂O emissions, as part of the nitrogen cycle through nitrification and denitrification of organic nitrogen compounds in manure and urine. With regards to reducing N₂O emission from manure management systems, there are several technological options and practices mentioned in the literature. Below are a list and a brief description of the technological options and practices found from the literature search:

- Optimizing the crude protein/energy ratio in animal diets – Some exploratory work has been performed on altering quantity of nitrogen excreted by domestic livestock by changing feed in such a way as to reducing nitrogen intake (Bates, 2001; IEA, 2000). One approach is to feed high quality diets which are low in protein. In one experiment it was found that the reduction in urinary nitrogen was 24% (O'Hara *et al.*, 2003). An attractive forage for cattle in this respect is corn silage, which reduces nitrogen intake, but improves utilization of the ingested nitrogen (de Jager *et al.*, 2001). Dairy cows fed with grasses high in water-soluble carbohydrate excreted 24% less nitrogen than those with normal diets (O'Hara *et al.*, 2003). Reduction of nitrogen output by pigs can be achieved by matching dietary protein concentration to physiological requirement. Other options include reduction of protein content, improvement of amino acid profile by amino acid supplementation, breeding and gene technology, and the use of feed additives (de Jager *et al.*, 2001).
- Nitrification and urease inhibitors – Nitrification and urease inhibitors can be used to reduce N₂O emissions from livestock manure. This option appears to be rather expensive (IEA, 2000).
- Waste storage – A shift towards anaerobic storage rather than aerobic storage of manures may reduce N₂O losses by a factor of 10 (Cole *et al.*, 1997; Kroeze and Mosier, 2000). However, it may also increase methane emission by a factor of 10, unless measures to capture and destroy methane are implemented (Bates, 2001).
- Use of cattle feed-pads during winter months – By keeping cattle on feed-pads during autumn/winter period, excretes can be collected and utilized as fertilizer later (Branosky & Greenhalgh, 2007; O'Hara *et al.*, 2003).
- Reducing the number of animals by increasing their productivity (Lucas *et al.*, 2006)
- Optimizing manure management and limiting grazing (Lucas *et al.*, 2006)

Effectiveness: Low

Implementability: Low

Reliability: Low

Maturity: Low

Environmental Benefits: It reduces nitrous oxide emission.

Cost Effectiveness: Low

Industry Acceptance Level: Low

Limitations: Some options may affect the yield of livestock.

Sources of Information:

1. Bates, J. (2001) "Economic Evaluation of Emission Reductions of Nitrous Oxide and Methane in Agriculture in the EU: Bottom-up Analysis", A final report to European Commission.
2. Blok, K.; de Jager, D. (1994) "Effectiveness of Non-CO₂ Greenhouse Gas Emission Reduction Technologies", *Environ. Monitoring & Assessment*, 31, 17-40.
3. Beach, R.H.; DeAngelo, B.J.; Rose, S.; Li, C.; Salas, W.; DelGrosso, S.J. (2006) "Mitigation Potential and Costs for Global Agricultural Greenhouse Gas Emissions", *Proc. International Association of Agricultural Economists Conference*, Gold Coast, Australia, August 12-18.
4. Branosky, E.; Greenhalgh, S. (2007) "Agriculture and Climate Change: Greenhouse Gas Mitigation Opportunities and the 2007 Farm Bill, Water Resource Institute, Washington, D.C., March 2007.
5. California Energy Commission (2005) "Emission Reduction Opportunities for Non-CO₂ Greenhouse Gases in California", a report prepared by ICF Consulting for California Energy Commissions, CEC-500-2005-121, July 2005.
6. California Energy Commission (2006) "Inventory of California Greenhouse Gas Emissions and Sinks: 1990 to 2004", final staff report, December 22, 2006.
7. Cole, C.V.; Duxbury, J.; Freney, J.; Heinemeyer, O.; Mosier, A.; Paustian, K.; Rosenberg, M.; Sampson, N.; Sauerbeck, D.; Zhao, Q. (1997) "Global Estimates of Potential Mitigation of Greenhouse Gs Emissions by Agriculture", *Nutrient Cycle in Agroecosystems*, 52, 221-228.
8. Dalal, R. C.; Wang, W.; Robertson, G.P.; Parton, W. (2003) "Nitrous Oxide Emission from Australian Agricultural Lands and Mitigation Options: a Review", *Australian J. Soil Res.* 41, 165-195.
9. de Jager, D.; Hendriks, C.A.; Byers, C. ; van Brummelen, M.; Petersdorff, C. ; Strucker, A.H.M.; Blok, K.; Oonk, J ; Gerbens, S.; Zeeman, G. (2001) "Emission Reduction of Non-CO₂ Greenhouse Gases", Dutch National Research Programme on Global Air Pollution and Climate Change, Report no. 410-200-094.
10. DeAngelo, B. J., de la Chesnaye, F. C., Beach, R. H., Sommer, A. and Murray, B. C. (2006) "Methane and Nitrous Oxide Mitigation in Agriculture", *The Energy Journal*, Multi-Greenhouse Gas Mitigation and Climate Policy Special Issue, pp. 89-108.
11. European Commission (2001) "Economic Evaluation of Sectoral Emission Reduction Objectives for Climate Change", Brussels. (Document can be found at http://ec.europa.eu/environment/enveco/climate_change/sectoral_objectives.htm)
12. Gale, J.J.; Freund, P. (2002) "An Assessment of the Costs and Global Impact of Nitrous Oxide Abatement Measures", in *Non-CO₂ Greenhouse Gases: Scientific Understanding, Control Options and Policy Aspects*, edited by J. van Ham *et al.*, Millpress, Rotterdam, the Netherlands.
13. Graus, W., Harmelink, M. and Hendriks, C. (2004) "Marginal GHG-Abatement curves for agriculture", Ecofys, Utrecht, the Netherlands.
14. Hendriks, C.A.; de Jager, D.; Blok, K. (1998) "Emission Reduction Potential and Costs for Methane and Nitrous Oxide in the EU-15", ECOFYS Interim Report, Utrecht, the Netherlands.
15. International Energy Agency (2000) "Abatement of Emissions of Other Greenhouse Gases – Nitrous Oxide", Report Number PH3/29, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, September 2000.

16. International Energy Agency (2003) "Building the Cost Curves for the Industrial Sources of Non-CO₂ Greenhouse Gases", Report Number PH4/25, IEA Greenhouse Gas R&D Programme, Cheltenham, United Kingdom, October 2003.
17. Intergovernmental Panel on Climate Change (2000), Climate Change 2000 - The Third Assessment Report - Working Group 3, Final Draft, October 2000.
18. Kasper, G.J.; Holshof, G.; van den Pol-van Dasselaar, A. (2002) "Reduction of N₂O Emission by Introduction of Precision Fertilization", in Non-CO₂ Greenhouse Gases: Scientific Understanding, Control Options and Policy Aspects, edited by J. van Ham *et al.*, Millpress, Rotterdam, the Netherlands.
19. Kowalenko, G. (1999) "Assessing Nitrous Oxide Emissions from Farming Practice", *Proc. International Workshop on Reducing Nitrous Oxide Emissions from Agroecosystems*, Banff, Alberta, March 1999.
20. Kroeze, C.; Mosier, A.R. (2000) "New Estimates for Emissions of Nitrous Oxide", in Non-CO₂ Greenhouse Gases: Scientific Understanding, Control and Implementation, edited by J. van Ham *et al.*, Kluwer Academic Publisher, Dordrecht, the Netherlands.
21. Lemke, H.; Janzen, H.; Rochette, P. (1999) "Processes of Nitrous Oxide Emissions from Canadian Agroecosystems", *Proc. International Workshop on Reducing Nitrous Oxide Emissions from Agroecosystems*, Banff, Alberta, March 1999.
22. Lucas, P.L.; van Vuuren, D.P.; Jos Oliver, G.J.; den Elzen, M.G.J. (2006) "Long-term Reduction Potential of Non-CO₂ Greenhouse Gases", Netherlands Environment Assessment Agency (MNP), published on line November 28, 2006.
23. McTaggart, I. P.; Clayton, H.; Smith, K.A. (1994) "Nitrous Oxide Flux from Fertilized Grassland: Strategies for Reducing Emissions", in Non-CO₂ Greenhouse Gases: Why and How to Control, edited by J. van Ham *et al.*, Kluwer Academic Publisher, Dordrecht, the Netherlands.
24. Moritomi, H.; Mochida, I. (2000) "N₂O Emission Inventory and the Abatement Technologies in Japan", in Non-CO₂ Greenhouse Gases: Scientific Understanding, Control and Implementation, edited by J. van Ham *et al.*, Kluwer Academic Publisher, Dordrecht, the Netherlands.
25. Mosier, A.R.; Duxbury, J.M.; Freney, J.R.; Heinemeyer, O.; Minami, K. (1998) "Assessing and Mitigating N₂O Emissions from Agricultural Soils", *Climatic Change*, 40, 7-38.
26. O'Hara, P.; Freney, J.; Ulyatt (2003) "Abatement of Agricultural Non-carbon Dioxide Greenhouse Gas Emissions – A Study of Research Requirements", a report prepared for the Ministry of Agriculture and Forestry, New Zealand.
27. Tsuruta, H.; Akiyama, H. (2000) "NO and NO₂ Emissions with Application of Different Types of Nitrogen Fertilizer", in Non-CO₂ Greenhouse Gases: Scientific Understanding, Control and Implementation, edited by J. van Ham *et al.*, Kluwer Academic Publisher, Dordrecht, the Netherlands.
28. U.S. Climate Technology Program (2005) "Technology Options for the Near and Long Term", U.S. Department of Energy, <http://www.climate-technology.gov/index.htm>, August 2005.
29. U.S. Environmental Protection Agency (2003) "International Analysis of Methane and Nitrous Oxide Abatement Opportunities: Report to Energy Modeling Forum, Working Group 21", a report prepared by ICF Consulting for the United States Environmental Protection Agency.
30. U.S. Environmental Protection Agency (2004) "International Methane and Nitrous Oxide Emissions and Mitigation Data", United States Environmental Protection Agency. Available online at www.epa.gov/methane/appendices.html (in Excel file).
31. U.S. Environmental Protection Agency (2006a) "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2004" Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-002, June 2006.

32. U.S. Environmental Protection Agency (2006b) "Global Mitigation of Non-CO₂ Greenhouse Gases", Office of Atmospheric Programs, United States Environmental Protection Agency, EPA-430-R-06-005, June 2006.
33. Worrell, E. (1994) "Potentials for Improved Use of Industrial Energy and Materials", Utrecht University, Faculteit Scheikunde, the Netherlands.
34. J. Dolfing, P.J. Kuikman, G.L. Velthof, K. Zwart. Effects of cover cropping on emissions of N₂O from Dutch soils.
35. Mosier, A.; Kroeze, C.; Nevison, C.; Oenema, O.; Seitzinger, S.; Cleemput, O. van (1998) Closing the global atmospheric N₂O budget: nitrous oxide emissions through the agricultural nitrogen cycle; OECD/IPCC/IEA Phase II Development of IPCC Guidelines for National Greenhouse Gas Inventories. *Nutrient Cycling in Agroecosystems* 52 (1998) 225-248.
36. Oenema, O.; Gebauer, G.; Rodriguez, M.; Sapek, A.; Jarvis, S.C.; Corrales, W.J.; Yamulki, S. (1998) Controlling nitrous oxide emissions from grassland livestock production systems, *Nutrient Cycling Agroecosyst.* 52 (1998), 2/3: 141-149
37. Oenema, O.; Velthof, G.L.; Yamulki, S.; Jarvis, S.C. (1997), Nitrous oxide emissions from grazed grassland. *Soil Use and Management* 13 (1997) 288-295.
38. Peter O'Hara, John Freney, and Marc Ulyatt (2003), "Report prepared for the Ministry of Agriculture and Forestry on behalf of the Governor", Ministerial Group on Climate Change, the Minister of Agriculture and the Primary Industries Council, http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/climate/abatement-of-agricultural-greenhouse-gas-emissions/abatement-of-agricultural-greenhouse-gas-emissions-19.htm#P3045_283655, May 2003.
39. Reducing Greenhouse Gas Emissions from Livestock Agriculture in Manitoba, MANITOBA CLIMATE CHANGE TASK FORCE by Dr. Karin Wittenberg Head, Department of Animal Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2 and Dinah Boadi, Research Associate, Department of Animal Science, University of Manitoba, Winnipeg, Manitoba R3T 2N2, <http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/climate/abatement-of-agricultural-greenhouse-gas-emissions/abatement-of-agricultural-greenhouse-gas-emissions-05.htm>
40. U.S. Climate Change Technology Program (2005) "Technology Options for the Near and Long Term", U.S. Department of Energy, <http://www.climatechange.gov/index.htm>, August 2005.
41. U.S. Environmental Protection Agency (1999) "Report on U.S. Methane Emissions 1990-2020: Inventories, Projections, and Opportunities for Reductions", United States Environmental Protection Agency, EPA 430-R-99-013, September 1999.