Soil-Atmosphere Exchange and Mitigation of Nitrous Oxide and Methane Emissions in New Zealand's Terrestrial Biosphere

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Soil-atmosphere exchange and mitigation of nitrous oxide and methane emissions in New Zealand's terrestrial biosphere

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Introduction New Zealand is unique in having a greenhouse-gas-emissions inventory dominated by two non-CO_2 greenhouse gases (GHGs) , CH_4 (36.2%) and N_2O (17.2%) (MfE 2007) . The dominance of these gases in the inventory results from the strong agricultural base of the New Zealand economy and the relatively low levels of heavy industry and vehicular CO_2 emissions per unit land area . Both the net uptake of CH_4 by soils and N_2O emissions from soils are strongly influenced by changes in land use and management . Quantitative information on the fluxes of these two non-CO_2 GHGs is required for a range of land uses and management effects to determine their contributions to the national emissions inventory , and to assess the potential of mitigation options . Here we describe the soil N_2O fluxes and CH_4 uptake and their mitigation strategies for a range of New Zealand land-use and management systems , collated from published and unpublished New Zealand studies .

Materials and methods In situ and farm-scale N_2O and CH_4 fluxes were measured using a large number of chambers in different New Zealand farm systems including ungrazed and dairy- and sheep-grazed pastures (Saggar et al . 2004a , 2007a) . Annual fluxes were estimated by interpolation between the measured flux values and by using a process-based NZ-DNDC model (Saggar et al . 2007b) .

Results Nitrous oxide emissions are highest in dairy-grazed pastures , intermediate in sheep-grazed pastures and lowest in forest , shrubland and ungrazed pasture soils . N deposited in the form of animal urine and dung and N applied as fertiliser , are the principal sources of N_2O production . Although nitrification inhibitors have showed some promise in reducing N_2O emissions from grazed pasture systems , their efficacy as an integral part of farm management has yet to be tested . In contrast to N_2O emissions , soil CH_4 uptake was highest for a New Zealand Beech forest soil , intermediate in some pine forest soils , and lowest in most pasture and cropland soils . Soil CH_4 uptake is also seasonally dependent . Afforestation/reforestation of pastures increased soil CH_4 uptake , largely as a result of increases in soil aeration status and changes in the population and activities of methanotrophs (Tate et al . 2007) . We are testing whether soil methanotrophs could be used to capture CH_4 emissions in herd-homes on dairy farms and in barns .

Table 1 *Annual nitrous oxide emissions and methane uptake in New Zealand land use and land management systems .*

Land use	N_2O emissions(kg N_2O-N ha^{-1})		CH_4 uptake(kg CH_4-C ha^{-1})
	Measured	Modeled	Measured
Dairy-grazed	9 .6—11 .7	11 .9—14 .3	0 .5—1 .0
Beef-grazed	n/a	6 .5—9 .3	n .d .
Sheep-grazed	3 .7—4 .5	5 .5—8 .1	0 .6—1 .0
Deer-grazed	n .d .	4 .9—7 .4	n .d .
Ungrazed	0 .9—1 .8	1 .9—3 .0	<1 .0
Cropping	2 .3—3 .2 (season)	6 .0—7 .4	~1 .5
Shrub land	n .d .	n .d .	2 .3
Pine	0 .6	n .d .	4 .2—6 .4
Native forest	n .d .	n .d .	10 .5

Conclusions Strategies and best management practices for mitigation of N_2O emission include : improvement of overall N-use efficiency ; manipulation of N in the animal to reduce N excretion ; lower N contents of pastures - supplementary feed ; winter management - stand-off pads ; strategic application of farm effluents ; use of controlled-release N-transformation inhibitors and biochar . A new approach is being tested for CH_4 mitigation using the methanotrophs in soil to capture some of the enteric and animal effluent CH_4 in confined locations (e .g . , herd-homes and barns) .

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