Agricultural Methane emissions recycle, automatically producing Emission Trading credits

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1 Introduction

Global warming from anthropogenic emissions of greenhouse gases is probably the most critical problem facing humanity over the next hundred years. In 1997, concern over climate change led the international community to develop the Kyoto protocol to manage global greenhouse gas (GHG) emissions. The Global Warming Potential (GWP) was defined to provide a framework for comparing the warming effects of different greenhouse gases in terms of the " CO_2 equivalent" [3] of a pulse of gas emitted into the atmosphere. The 100 year GWP of CH_4 is 28, which means a 1 kg pulse of CH_4 over a 100 year period, warms the same as a 28 kg of CO_2. However the Kyoto protocol focusses on emissions not end results. If the GWP is used to measure the CO_2 equivalent of CH_4, without recognising that constant emissions of CH_4 from agricultural sources recycle, ineffective GHG management decisions will be made as the focus will be diverted from the more critical CO_2 emissions.

1.1 Emissions Trading Scheme

The New Zealand Government, in line with other nations, has instituted an Emissions Trading Scheme (ETS), [4] to provide an incentive to reduce NZ's greenhouse gas emissions. While the ETS is defined in terms of emissions, its purpose is to limit the rise of GHG concentrations in the atmosphere. When working properly, the carbon credits in what is called New Zealand Emmission Units, should compensate fully for emissions and the atmospheric burden of a gas should flat line. In which case, every tonne of gas emitted by a particular process would be compensated for by purchasing a carbon credit that took one equivalent tonne of gas out of the atmosphere.

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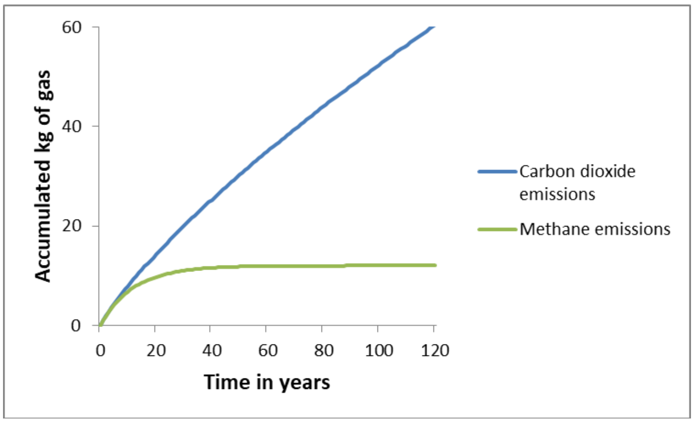

Figure 1: Comparison between the accumulation of CH_4 and CO_2 in the atmosphere for emission rates of 1 kg per year

For example if trees are burnt as fuel, carbon credits can be purchased for trees to be planted to soak up the emitted CO_2. Once the plantation has grown sufficiently, the CO_2 burden will have flat lined. However while there is pressure to include agriculture CH_4 in the ETS, the following shows that for constant historic emissions of CH_4, this is completely unnecessary and counterproductive because CH_4 recycles in sustainable manner in such a way that farming practice generates its own credits. The process is completely analagous to planting trees to offset the burning of trees or fossil fuels.

Figure 1, shows the growth of CH_4 and CO_2 in the atmosphere for continuous emissions of 1 kg a year. In the case of CO_2, 1 kg of carbon credits, need to be purchased each year, to remove sufficient carbon to reduce the CO_2 growth to a flat line. This will need to continue until CO_2 emissions fall. While this is straightforward, if trees are planted to compensate, there is very little certainty that tree growth will continue for hundreds of years. Forests may well be harvested or destroyed by natural fires.

However the situation is quite different for agriculturally produced CH_4. As the bottom curve in figure 1 shows, the agricultural CH_4 level has practically flat lined at a level of 12.4 kg, after about 30 years, and completely flat lined by 62 years for 1 kg emissions per year. As discussed in detail below, the CH_4 recycles. With fixed ruminant numbers, the CH_4 burden does not increase in contrast to CO_2. This happens because the CH_4 emmitted by a ruminant is converted to CO_2, which in turn is converted to grass to feed another ruminant. All the CH_4 from the first year is therefore removed from the atmosphere over this 62 year period. In other words for constant CH_4 emissions, the accumulated level in the atmosphere flat lines. As the process automatically soaks up the emitted gas, CH_4 burden is not increasing, and there is no need to purchase ETS credits. There is no reason why CH_4 emissions from agriculture should not join the emissions trading scheme provided it is recognised that, for constant

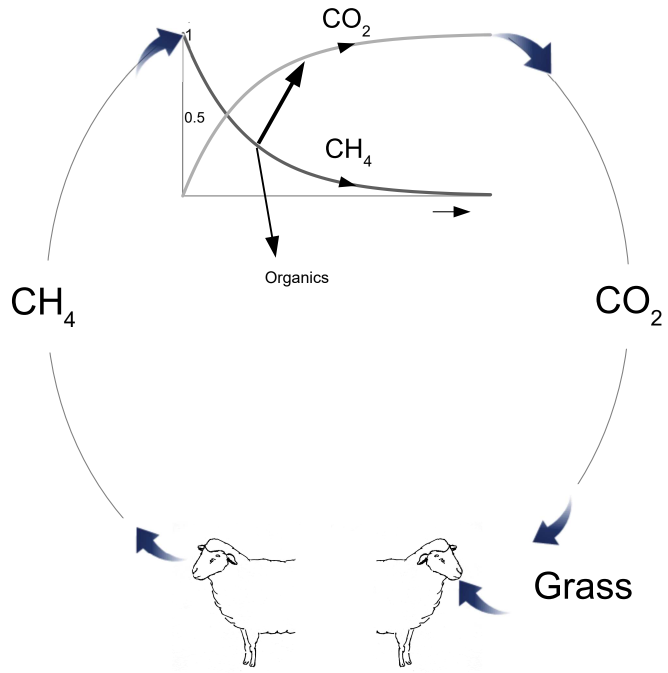

Figure 2: The CH_4 cycle showing the relationship between ruminant CH_4 production and reincorporation of CO_2 from the CH_4 into pasture and animal.

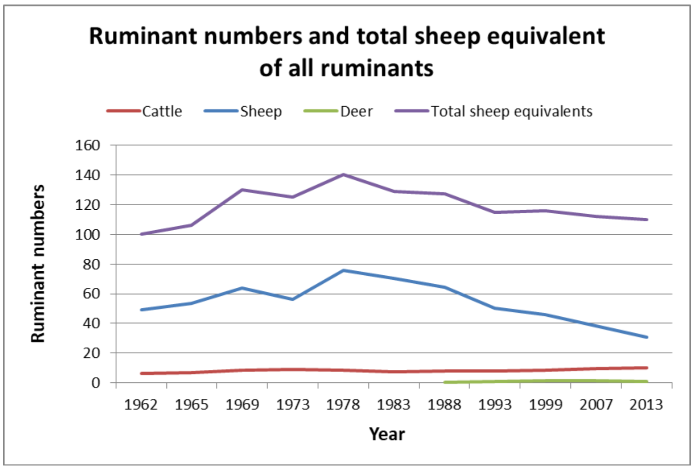

Figure 3: New Zealands ruminant populations in millions from 1962 to 2013. The top line expresses the sheep equivalent that give the same total CH_4 emissions as the accumulated emissions of the different ruminants. One cow = 7.7 sheep and 1 deer =1.7 sheep [7]. Figures for the number of animals have been extracted from New Zealands year book

emissions, which has been very nearly the case for the last sixty years, no carbon credits need to be purchased. Credits would only be needed for any increase in CH_4 emissions.

The next section expands the argument that in New Zealand CH_4 emissions have very nearly flat lined after 62 years.

2 Long term ruminant emissions of methane in New Zealand are not rising significantly

Figure 2, is a schematic representation of the recycling process for continuous emmissions of CH_4 for a fixed population of ruminants. Over the 62 year period where CH_4 emissions flat line, every mole of CH_4 emitted by a ruminant in year zero, comes from grass that has stored one mole of CO_2 from the atmosphere.

Carbon in grass $\rightarrow$ carbon in CH_4 $\rightarrow$ carbon in $CO2$ $\rightarrow$ carbon in grass. The graph inserted at the top of Figure 2 shows the decay of CH_4 as it is turned to CO_2 or organics in the soil. For fixed ruminant numbers, the CH_4 level flat lies.

Figure 3 shows the cattle, sheep and deer populations from 1962 to 2013. Over the period sheep numbers have grown and then later declined, as farming has shifted to dairying. Swainson et al. [7], indicate that the average CH_4 emission of a cow is about 7.7 times that of a sheep, while a deer is 1.7 times that of a sheep. While the authors point out that this varies between animals and their ages, these values provide a rough estimate of the sheep equivalent numbers on New Zealand farms. If one converts the total ruminant stock to sheep equivalents, as shown in the top trend line in figure 3, emissions peaked about 1978. It is seen that an increase in dairy stock has been partially compensated for by a decrease in sheep stock. The figure indicates that emissions have fallen somewhat since 1990. On the other hand, New Zealand's GHG inventory, [1] figure 2.29 page 152 indicates there has been a rise of 15% for all agricultural emissions since 1990, but this also incldues N_2O. Clearly methodology is important, but the purpose of the Figure 3 is to generate a long term time series. Figure 3 indicates that that over the longer term, CH_4 emissions have fluctuated, but overall has risen only about 10%. I.e. the emissions have been roughly constant over a fifty year period.

3 Conclusion

Without appreciating that CH_4 from agriculture recycles, New Zealand's greenhouse gas management strategy would penalise agriculture without appreciable reducing global warming. Rather than using a simple reductionist approach it is necessary to understand the methane cycle from a whole system perspective to determine New Zealand's appropriate action. For greenhouse gas management purposes, countries like India and New Zealand, with approximately stable CH_4 emissions, need to factor in that atmospheric CH_4 levels are not growing significantly. The difficulty is that the GHG protocols are driven by the high CO_2 emitting nations without any thought of the recycling taking place in agricultural CH_4.

However once it is appreciated, that, for constant emissions over a number of decades, agricultural CH_4 recycles (in contrast to CH_4 from fossil fuel sources) the CH_4 burden in the atmosphere has already flat lined. In which case ruminant agriculture practice is sustainable, automatically compensating for all emissions satisfying a rational ETS framework.

A simple analogy helps. If there is a community that has two children per couple the population stablilises. If another community has 10 children per couple the population growa. In a resource crisis, there is little to be gained by reducing the population of the two child family, the focus should first be on the 10 child family. Once that is under control the focus can shift to the two child family.

This simple argument is supported by the greenhouse gas modelling undertaken by Bowerman et al. (2013). These authors show that reducing emissions for short lived gases, such as CH_4, only reduces the peak global temperature if the reduction occurs around the time the CO_2 emissions peak and begin to fall. Any earlier reduction of CH_4 has little effect, as any transient global cooling due to reducing emissions of short life time gases such as CH_4, loses its effect quickly.

As New Zealand's CH_4 burden has nearly flat lined over the past sixty years, New Zealand is already satisfying its GHG management requirements. However, any increase in CH_4 emission rates, will add a further constant burden on global warming, and would need to be part of an ETS scheme. Nevertheless, as the Parliamentary Commissioner for the Environment discusses in depth [2], where CH_4 comes from ruminants, over the longer term, animal breeding programmes, or other approaches to reduce CH_4 emissions per animal, are likely to emerge to allow for a more flexible management regime.

New Zealand's GHG management strategy and the basis on which it operates the ETS scheme must be be effective, not just look effective. This is only possible if it is recognised that agricultural CH_4 emissions, in contrast to N_2O or CO_2 emissions, are sustainable. Just as a harvesting and planting tree cycle, satisfies ETS criteria, so too does the agricultural methane cycle.

4 Appendix: Details of the CH_4 cycle for agricultural emissions

Figure 2 shows the CH_4 cycle. In contrast to CH_4 emitted from fossil fuels, CH_4 from agricultural sources, recycles as its lifetime, τ in the atmosphere is relatively short at about 12.4 years [5]. The effect of recycling constrains the level of CH_4 in the atmosphere as shown in the accumulated growth curve in the lower line in Fig. 1. For a 1 kg per year emission rate, this curve follows $\tau(1 - e^{-t/\tau})$, flat lining at 12.4 kg after 62 years. Over this 62 year period, hydroxyl radicals oxidise the CH_4 into CO_2 or CH_4 is removed, forming organics matter in soils, [6], remaining in the soil for many years. By the end of the 62 years, for every mole of CH_4 emitted in year one, an equivalent number of moles of CO_2 are photosynthesized into plant matter to be eaten by the ruminants, and then re-emitted as CH_4. In other words, over this period with constant emissions, for every mole of CH_4 emitted one mole of CO_2 is converted into biomass to be eaten by the animal. On the other hand, CO_2 emissions are completely different, as shown in the upper dark line in Fig. 1. For the same constant emission rate as CH_4, and using the data from Table 8.SM.10 [5], the CO_2 level continues to grow for more than 600 years.

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