MM25 and MM47: Covering Slurry Stores

Category

Livestock management: slurry management

Overview

Animal excreta stored in liquid systems is an important source of NH_3 and CH_4 emissions, as during the storage N and the volatile solids excreted turn into these gaseous compounds. In these systems (unless the slurry is aerated) direct N_2O formation is less important as the anaerobic environment blocks denitrification (Sommer *et al.* 2000), however, a small portion of NH_3 emissions turns into N_2O (indirect N_2O emissions). Several factors affect the rate of NH_3 CH_4 and N_2O emissions, including manure composition and physical variables (most importantly temperature, rainfall, airflow) (Monteny *et al.* 2006, Sommer *et al.* 2004). These factors can be to some extent modified by management choices and technologies, like reducing the airflow over the manure by covering the store.

Various technologies exist to cover stored liquid livestock excreta (VanderZaag *et al.* 2015). Floating covers can be made of organic (e.g. straw, vegetable oil), inorganic (expanded clay) or synthetic materials. If manure properties allow and the slurry is not agitated, natural crust can develop on the surface, especially on cattle slurry (Chadwick *et al.* 2011). Rigid covers include wooden or concrete lids – the former suitable to be retrofitted to existing stores. Suspended impermeable plastic covers (tent-like structures) are a popular choice of slurry tank cover in Northern Europe. They are supported by a frame or stretched by blowing air under them.

Covering slurry stores can substantially reduce NH_3 emissions (Hou *et al.* 2014, VanderZaag *et al.* 2015). NH_3 loss is a physiochemical process controlled by the ability of NH_3 in the slurry to diffuse to the atmosphere, and covers restrict diffusion by creating a physical barrier. With reduced NH_3 emissions indirect N_2O emissions also reduce. The presence of a slurry cover increases the NH_3 concentration of the slurry and hence its N content and fertiliser value, but also potential subsequent NH_3 and N_2O losses when the slurry is applied to the soil, unless low NH_3-emission spreading techniques are implemented.

The effects of cover on direct GHG emissions are less explored though, and the results are variable and inconclusive, revealing varied effect of the different technologies on GHGs (Hou *et al.* 2014, Montes *et al.* 2013, Sajeev *et al.* 2018, VanderZaag *et al.* 2015, VanderZaag *et al.* 2008).

Particularly crust formation, straw addition and the use of granules tend to increase N_2O emissions substantially, often overriding the emission savings in CH_4 and indirect N_2O emission reductions (Hou *et al.* 2014, Sajeev *et al.* 2018). The effects of these covers on CH_4 emissions are variable, with high probability of increased emissions. Vegetable oils usually reduce the emission of all three gases (Montes *et al.* 2013) on the short term, but their NH_3 mitigation effect reduces as the oil surface breaks up and CH_4 emissions increase as the organic material degrades (VanderZaag *et al.* 2008).

A review by Hou *et al.* (2014) found that artificial film cover reduces the net GHG emissions (including indirect N_2O emissions) by 25%, while reducing NH_3 emissions from storage by over 90%. Their findings were based on two experiments with artificial films: one of them used a permeable synthetic cover (Biocap^{TM}) (VanderZaag *et al.* 2010), while the other an impermeable synthetic cover (PVC film) (Rodhe *et al.* 2012). The permeable cover had no significant effect on CH_4 emissions but reduced (the small) direct N_2O emissions by 68%. The plastic film reduced CH_4 emissions by 94-100%. However, there are feasibility problems with floating covers in general if applied on slurry tanks or larger lagoons (not on small earth-banked lagoons), and their durability is not yet well tested (Amon *et al.* 2014). Permeable floating covers need to be secured in a way which protects against wind but allows for vertical movement of manure in the storage. When the slurry is covered by impermeable films, the formation of CH_4 is not eliminated, and the gas builds up under the cover and in the liquid, creating an explosion risk and escaping when the cover is opened (Montes *et al.* 2013). With additional devices (gas pipes and pumping system) most of the CH_4 can be captured and converted to CO_2 either by direct flaring, reducing the GWP substantially, or by purification and use in electricity or heat generation – the former option is discussed as measure 23 (biogas capture and flaring). Furthermore, depending on the structure, rain water can accumulate on impermeable floating covers and needs to be removed via e.g. pumping.

No publications were found which compared GHG emissions of wooden, concrete lid or suspended impermeable plastic covers with non-covered slurry.

In the UK Smart Inventory three options are built in to represent the effects of covering slurry stores: rigid store cover, floating store cover, natural crust.

In the current research we estimate the GHG effects and costs of slurry cover of two technologies (both for lagoons and tanks as well):

- Permeable synthetic floating cover (MM25)
- Impermeable synthetic floating cover (MM47)

Mitigation summary

Table 1 Effects on emissions

GHG categories	Effect*	Notes
Enteric CH_4		
Manure CH_4	- or 0	
Manure **N_2O**	- or + on direct N_2O, - on indirect N_2O	
Soil N_2O: applied N	+	Unless appropriate spreading technology is used
Soil N_2O: grazing		
Energy CO_2: fieldwork		
Energy CO_2: other		
CO_2 liming and urea		
CO_2 sequestration below ground		

GHG categories	Effect*	Notes
CO_2 sequestration above ground		
Pre-farm emissions		Production of covers
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions		
	Rating	
Confidence in mitigation effect	Medium	
Cost-effectiveness**	Moderate	
Confidence in cost-effectiveness	Medium	

* ”-“ GHG reduction, “+”: GHG increase, “ ”: no significant effect
** low: =< £0/tCO_2e, moderate: £0/tCO_2e< >SCC, high: >SCC

Related measures and potential synergies

Table 2 Likely effects on the abatement potential of other measures

Measure	Impact
	-
	-

Inclusion in other marginal abatement cost curves

Table 3 Past assessment of the measure

UK 2008	UK 2010	UK 2015	Ireland 2012	France 2013	France 2019
Yes	Yes	No	No	No	?

What does the measure entail?

The measure assumes covering above and below ground slurry tanks and lagoons either attaching a synthetic permeable or an impermeable floating cover.

Anchoring the floating covers can be done either with anchor trenches or roped to stakes (English and Fleming 2006). Impermeable covers require a pumping system to remove rainwater accumulating on the cover in wet periods. Weights on top of the cover help collecting the rainwater as well as prevent lifting by gas formation. The gas can be released by vents to the atmosphere, reducing the explosion hazard (gases could also be pumped to a biofilter, but that entails a high cost and therefore not included in this measure) (VanderZaag *et al.* 2015). Different solutions exists for preventing tear caused by the vertical movement of the slurry surface, for example the cover can be fastened to a floating frame, but solutions with wall/bank anchoring also exist (English and Fleming 2006), see e.g. Figure 1.

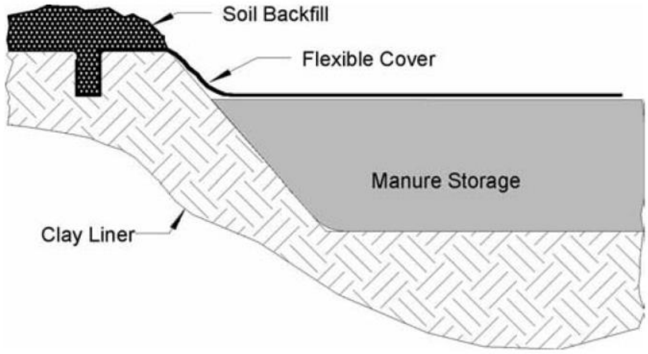

Figure 1 Anchoring a flexible cover (Nicolai et al. 2004)

Abatement rate

Table 4 Data from literature on abatement

Abatement	Value	Country	Reference
Impermeable floating cover			
CH_4 emissions	-47% (g CH_4–C (kg VS)$^{-1}$)	Sweden	(Rodhe *et al.* 2012)
Direct N_2O emissions	-100% (g N_2O–N m^{-2})	Sweden	(Rodhe *et al.* 2012)
NH_3 emissions	-80% (range: -59% - -95%)	Various	Review of four papers in (VanderZaag *et al.* 2015)
Permeable floating cover			
CH_4 emissions	+2% (g CH_4 m^{-2})	Canada	(VanderZaag *et al.* 2010)
Direct N_2O emissions	-68% (mg N_2O m^{-2})	Canada	(VanderZaag *et al.* 2010)
NH_3 emissions	-89% (g NH_3 m^{-2})	Canada	(VanderZaag *et al.* 2010)
NH_3 emissions	-60% (range: -45% - -95%)	Various	Review of six papers in (VanderZaag *et al.* 2015)

Cost

Costs information on slurry covers have been collated by VanderZaag *et al.* (2015) from North American and UK sources. They estimated the capital costs of floating impermeable covers to be in the range of €1.70 m^{-2} to €63 m^{-2} with a lifespan of 8-10 years and 2% annual maintenance costs for rainwater collection. The high cost solutions included negative pressure covers to keep the film tight on the slurry surface. The same authors estimated the permeable cover capital costs to be between €2 m^{-2} to €20 m^{-2}, depending on material. The lifespan is 5 years for the cheaper materials and 10 for the more expensive ones. Maintenance cost is estimated to be 1% annually.

As mentioned above, to reduce the risk of losing the N saved with this measure, manure spreading needs to be done with low NH_3 emission technologies. The cost of that is not included in the costs of this measure.

Applicability

The slurry covers can be installed on all slurry tanks and lagoons. As the measure causes and increase in the net GHG emissions from cattle slurry tanks and lagoons, it is only applied to pig manure storage in the calculations.

Current uptake and maximum additional future uptake

According to the Farm Practices Survey the current uptake of slurry covers is 28% for slurry tanks, and 5 and 4% for slurry lagoons without and with strainer (Defra 2018). The largest proportion of slurry tank covers can be found on pig farms (52%), while 20-40% of cattle farms have covered stores. However, the questionnaire does not distinguish between the types of cover, and crust cover is included as well. It can be assumed that most of the existing cover on cattle farms in the Defra survey is crust.

Present uptake of cover is zero in the smart inventory, except for above ground slurry tanks in the pig sector (24% uptake).

Assumptions used in the MACC

Parameter	Change in value	Notes
Impermeable floating cover		
CH_4 conversion factor[1]	-47%	(Rodhe *et al.* 2012)
Direct N_2O[1]	-100%	(Rodhe *et al.* 2012)
NH_3 volatilisation[1]	-80%	(VanderZaag *et al.* 2015)
Capital cost	£3.79 m^{-3}, lifetime 10 years	Assuming €15 m^{-2} and 3.5m depth, based on (VanderZaag *et al.* 2015)
Maintenance cost	2%	(VanderZaag *et al.* 2015)
Permeable floating cover		
CH_4 conversion factor[1]	+2%	(VanderZaag *et al.* 2010)
Direct N_2O[1]	-68%	(VanderZaag *et al.* 2010)
NH_3 volatilisation[1]	-60%	(VanderZaag *et al.* 2015)
Capital cost	£1.26 m^{-3}, lifetime 5 years	Assuming €5 m^{-2} and 3.5m depth, based on (VanderZaag *et al.* 2015)
Maintenance cost	1%	(VanderZaag *et al.* 2015)

[1] Note that these emission parameters in the MACC dataset are an average value of current practice (with 24% of the stores in the some covered stores) as they are derived from the smart inventory, therefore the mitigation might be underestimated by this method

Wider effects

Table 5 Wider effects of the measure

Aspect	Effect	Reference
Positive effects		
Off-farm GHG		
Production		
Adaptation		
Environment	Reduced odour, reduced NH_3 emissions (and related negative environmental effects, like acidification, eutrophication)	(VanderZaag *et al.* 2008)
Negative effects		
Off-farm GHG		
Production		
Adaptation		
Environment		

Identified implementation challenges and barriers

Table 6 Potential barriers of the measure

Barrier to uptake	Reference
Practicality	(English and Fleming 2006, VanderZaag *et al.* 2015)
Cost	(English and Fleming 2006, VanderZaag *et al.* 2015)
Other key risks/uncertainties	**Reference**
Limited scientific evidence on GHG effects	

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