Evaluation of gaseous pollutants arising from slurry containing recycled plasterboard

Verges Marlen, Hunter Colin, Holland Ryan, Pahl Ole
SEBE, Glasgow Caledonian University, Glasgow, G4 0BA, UK
colin.hunter@gcu.ac.uk

ABSTRACT

With the rise in prices of traditional bedding material, farmers are considering alternatives including gypsum from recycled plasterboard. Apart from meeting a range of criteria for use as a bedding material, using gypsum will reduce the amount of construction waste going to landfill. A trial to simulate gypsum use in animal housing was established using an application rate of gypsum of 20g/l; 40g/l and 80g/l to slurry over an eight week period. Levels of gases in the headspace of the barrels were monitored each week prior to slurry addition.

Ammonia levels were lower above the slurry/gypsum mix than in the slurry alone with 34% reduction in the total ammonia loading over the eight week trial. Hydrogen sulphide (H_2S) was not detected in the headspace of any barrels but after stirring, the level of H_2S exceeded the detection limit of the gas meter in most of the test barrels and at a lower level in the control barrels. This pilot indicated the potential for gypsum to be used in reducing ammonia pollution from agriculture. However, its use will increase the H_2S concentration in slurry. While further on-farm trials are required to confirm the findings of this study, the increased release of noxious gases is likely to be a major barrier to the uptake of this recycling route.

INTRODUCTION

The construction industry in the UK is one of the largest industries in the country with an output worth more than 100 billion pounds per year. Consuming more than 420 million tonnes of materials a year, it generates around 20% of the countries waste. Out of the total construction waste, it is estimated that in total more than one million tonnes of plasterboard waste is produced in the UK each year [1]. Through the Landfill Directive, the Scottish government has set a target of 70% recycling of all waste by 2025 [2]. Thus alternative usage of constructional waste, rather than ending up in landfill, needs to be considered.

Currently, recycled plasterboard is approved for use as a feedstock for the manufacture of new gypsum-based products; as a soil treatment agent in agriculture and in the manufacture of cement [3]. Plasterboard waste can be used successfully in low-medium strength concrete mixes for the foundations of minor roads and car parks. In addition, its use as alternative animal bedding has been suggested.

In the UK, 72% of dairy cattle are housed in a slurry based system; these use cubicles with either scraped passages or slatted floors. Sawdust and shavings is the most common type of bedding in these systems, with rubber mats and chopped straw also being common. UK dairy farmers use more than 8,700 tonnes of bedding material every day, which over a typical winter amounts to 1.6 million tonnes. The cost of sawdust has increased driven by the rise in wood pellets and briquettes production in the UK. In addition, the price of straw in 2012 has more than doubled since 2003. Thus with the rise in prices of traditional bedding material, farmers are considering alternatives including re-cycled paper, woodchip, ground mollusc shells and gypsum from recycling plasterboard.

Given that gypsum meets a range of criteria for use as a bedding material (absorbent; little or no adverse effect on animal welfare; free of contaminants; cheap; easy to handle and fit into traditional

systems) and the desire to reduce construction waste going to landfill, this study aims to assess the viability of the use of re-cycled gypsum in the Scottish agricultural sector.

MATERIALS AND METHODS

Model slurry tanks were created from 45l drums with pre-drilled lids to permit air. Each barrel was also fitted with mixing paddles. All slurry used in the experiment was collected on the same day from a local dairy farm's underground slurry tank and stored in sealed drums until required. The gypsum application rate, defined as standard, was derived from investigations conducted at a Scottish farm and was equivalent to 40g of plasterboard per litre slurry produced. In order to represent the range of potential scenarios of plasterboard application, two additional application rates of 20g/l and 80g/l were also used.

The use of gypsum as a drying agent in slatted animal housing was simulated by the weekly addition of a set volume of slurry and a weighed amount of plasterboard to the drums. Five drums were used for each gypsum application; three control vessels were also prepared. In all drums the final volume of slurry was 30l. To evaluate the effect of pre-mixing slurry prior to field application, each barrel was stirred for 5 seconds followed by a 30 second equalisation period prior to headspace gases being monitored.

The gas levels in the headspace in all vessels were determined using an Eagle 2 gas meter (RKI Instruments Inc., California, USA). The external probe of the Eagle 2 meter was inserted 15cm into each barrel and after one minute the concentration of each gas was recorded. Gas levels were recorded weekly prior to any addition of fresh slurry or after agitation and corrected for the volume of emitting slurry.

RESULTS

Over the period of routine monitoring of headspace gases above simulated slurry stores hydrogen sulphate, carbon dioxide or carbon monoxide was not detected in any of the test vessels from both the weekly addition and long term storage experiments.

All three gypsum application levels produced a similar effect (Figure 1), suppressing the release of ammonia by 19 to 53% compared to the control over the duration of the experiments. Overall, the use of gypsum suppressed the release of ammonia by 34%. The level of ammonia in the headspace was greatest during the early weeks in both the barrels with gypsum and control barrels. The concentration of ammonia dropped with time, which could be due partly to the fall in ambient temperatures which dropped from 12.5°C at the start of the trial to 2°C at the end.

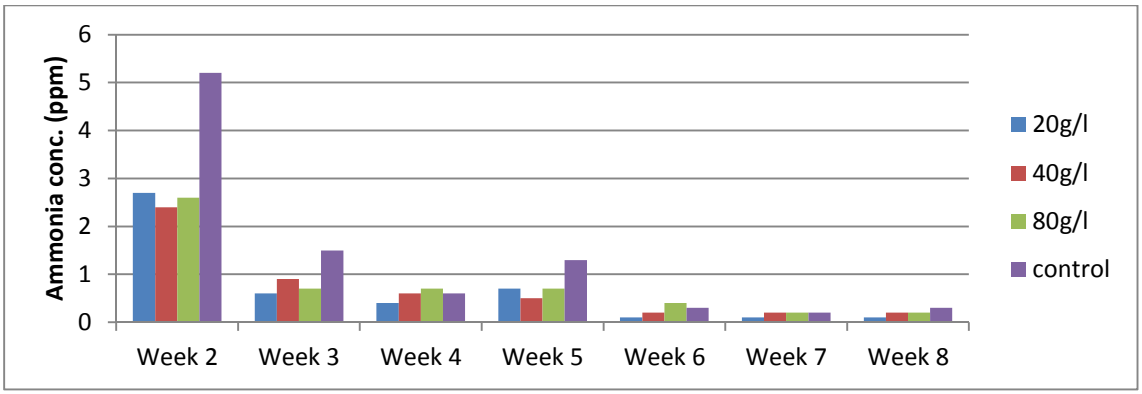

Figure 1 Weekly levels of ammonia over the three gypsum usage rates

The monitoring of hydrocarbon levels (methane) were more erratic but showed a similar trend to that of ammonia. Peak values of 670ppm and 1050ppm were recorded in the control vessels and those with

gypsum. Overall the use of gypsum suppressed the release of methane by 19% compared to control levels.

After the brief (5 sec) agitation of the slurry in all barrels carbon monoxide was not detected in any of the test vessels and levels of carbon dioxide and ammonia were less than or equal to 0.02ppm. Hydrogen sulphide (H_2S) was detected in the headspace of all vessels irrespective of the presence or absence of gypsum (Table 1). Levels of this gas were higher above slurry containing gypsum; in the vast majority of the gypsum containing vessels (84%) the level exceeded the gas analyser maximum value (100ppm) so that an accurate indication of the actual level was not possible. Levels in the control vessels were all less than 40ppm. The effect of gypsum on potential H_2S production cannot be accurately determined but it is at least a factor of 3.5. Average levels of methane, after stirring, were lower in the gypsum containing vessels than in the control vessels. Why the levels in the low and standard gypsum application vessels were so low is unclear. In these vessels there was a fivefold reduction on methane emission.

Table 1. Effect of agitation of slurry on selected headspace gases (ppm)

Gypsum	20g/l	40g/l	80g/l	control
Hydrogen sulphide	3.0	3.8	3.8	0.7
Methane	43.3	43.2	194.7	231.4

Under laboratory conditions H_2S production was recorded at between 3.6 – 7.6 ppm/g dry weight for the slurry/gypsum and not detected for the slurry alone, whereas ammonia levels were between 1.7 and 2.3 times less in the gypsum containing samples compared to the gypsum-free controls.

DISCUSSIONS

The aim of this study was to evaluate the potential of the use of recycled plasterboard, when used as slurry drying agent in dairy housing, to reduce ammonia emissions. Under the test conditions used, recycled gypsum reduced the level of ammonia in the headspace by between 22% and 34%. In the only other study known to the authors, Iowa State University [4] reported that the use of gypsum reduced ammonia losses by 14% from dairy manure storage and by 8% when surface-applied to dairy manure. In other studies examining means of reducing ammonia emissions, the addition of paper to pig slurry reduced ammonia volatilization by 29-47% [5]. The addition of 2.5% alum to dairy slurry reduced ammonia release by nearly 60% [6]. Iowa State University [4] also reported that the application of triple superphosphate, superphosphate and calcium chloride reduced ammonia losses by 33, 24 and 13%, respectively. Milic et al. [7] found the addition of 2% zeolite reduced ammonia emissions by 33% and the concentration of ammonium in pig slurry by 25%.

The use of additives to slurry has to be evaluated both in terms of their efficacy at reducing ammonia and the cost to the farmer (and environment). Using recycled plasterboard, has the advantage that it is a “waste” product, which otherwise may end up in landfill, and hence currently is marketed at a lower price per tonne than alternatives such as sawdust.

The production of hydrogen sulphide is frequently associated with slurry tanks and lagoons and is of increased importance when these storage units are located below animal housing. Hydrogen sulphide was not released from the slurry during the static trial but was detected after stirring the slurry. In laboratory trials, Clark et al. [8] found that hydrogen sulphide concentrations rose from $<10\ \mu L\ L^{-1}$ to levels exceeding the range of the instrument used, following agitation. Scully et al. [9] recorded levels of hydrogen sulphide of 275 ppm on an Irish farm following mixing of slurry, where the pre-mixing level was 7ppm. Very high levels of hydrogen sulphide have been detected both on farms where gypsum had been used as part of the bedding system [10] and where there was no evidence of its usage [11].

CONCLUSION AND PERSPECTIVES

This study, while only being a pilot, does indicate the potential for recycled plasterboard to be used in the Governments drive to reduce emissions for farms. Further on-farm trials are required to confirm the findings of this study and also to evaluate the effect of this product on emissions arising from animal housing.

The use of gypsum will increase the hydrogen sulphide concentration in slurry, thus consideration should be given to means control this gas or restricting the use of gypsum to situation where the entrapment of hydrogen sulphide is a lesser problem (i.e. above-ground or stand-alone slurry tanks).

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