Manures and Farm Resources

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Increasing quantities of organic materials are being applied to land. These include municipal solid waste in order to meet government targets to reduce the quantity going to landfill, and sewage sludge cake, since dumping at sea is no longer acceptable. The challenge facing land users and society as a whole is how to manage these organic resources in a sustainable manner. This article focuses on animal manures and other organic resources.

Livestock intensification, dependent on inorganic fertilisers, has reduced the use of manures as nutrient sources. Consequently, manures (and other organic resources) became a disposal problem. However, this perception of 'waste disposal' is changing towards one of nutrient and organic matter management, because of the need to focus on environmental issues and to reduce input costs. Increased European legislation, such as the Nitrates and Water Framework Directives, Protocols regarding gaseous emissions (greenhouse gases and ammonia) and public concern over food safety and bathing water quality require alternative practices for livestock systems and the management of organic materials such as animal manure.

Fig 10.1 Slurry application to the soil surface using trailing shoe equipment

A large part of our research is aimed at understanding key processes that occur during storage and after spreading of organic resources. This knowledge is then used to develop management practices that maximise utilisation and minimise impacts on the environment and human health and provide evidence for policy guidelines. Three inter-related research areas concentrate on understanding key processes affecting: (i) nutrient utilisation; (ii) gaseous emission; and (iii) transfers of diffuse pollutants to water. The practical outcomes from these focus areas feed into our knowledge transfer activities. Selected examples are described below.

Utilisation of manures and other organic resources

Nutrient use. Manures and other organic resources contain significant quantities of nutrients which should be used to encourage crop and grass growth. They are also valuable sources of organic matter which can improve soil structure and increase the water holding capacity of soils. Our research has quantified the rate at which important nutrients, such as nitrogen (N), are released from a range of manure types. Such information allows farmers to better

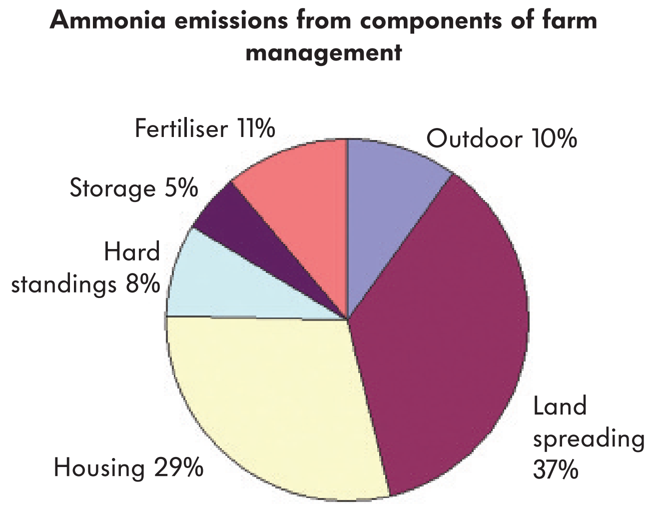

Fig 10.2 The UK ammonia emissions inventory for 2003. Total emission for 2003 was 271,000 tonnes NH_3.

predict nutrient supply from manures and reduce the need for purchasing 'bagged' fertilisers.

We have worked to increase the efficiency of utilisation of animal slurries on grassland, through optimising the time of application prior to silage cuts and using specialised slurry application equipment, such as the trailing shoe, which delivers the slurry to the soil surface below the growing sward and reduces sward contamination. Additional benefits of this slurry application technique are reduced odour and ammonia emission, a very important atmospheric pollutant.

Composting and anaerobic digestion

Knowledge of the factors controlling cycling of nutrients and energy within solid organic resources and animal slurries during storage will allow us to optimise their management, e.g., to produce nutrient-stable, weed- and pathogen-free composts and, in the case of slurries, biogas generation through anaerobic digestion.

It is essential that organic resources are only applied to land at rates to satisfy crop nutrient demands. If nutrients are supplied at too high a rate, plant uptake is not sufficient to remove them from the soil and those nutrients are at a greater risk of loss to the environment. Our other two research areas concentrate on managing organic resources and livestock to minimise losses to the environment.

Gaseous emissions

Livestock agriculture is the source of many gaseous emissions, many of which are detrimental to the environment and human health. Our research focuses on ammonia, greenhouse gases (nitrous oxide and methane) and, more recently, bio-aerosols.

Ammonia. Livestock urine and N fertilisers are responsible for >80% of the UK's annual ammonia emission. Figure 10.2 illustrates the major sources of ammonia from UK agriculture. Ammonia loss represents both a significant loss of fertiliser value to farmers and, following emission and transport in the atmosphere, it can result in significant nutrient enrichment and acidification of natural and semi-natural ecosystems. For this reason, the EU has set the UK an annual ceiling for ammonia emissions of 297,000 t by the year 2010.

Our research aims to understand the factors controlling emissions of ammonia and quantify emissions from various stages of manure and livestock management. This knowledge is used to develop and test potential mitigation practices and develop predictive models. To this end, we have developed the manure 'lifecycle facility' (Figure 10.3) which allows replicated groups of animals to be housed in slurry-cubicle or straw-bedded buildings and the manure that is generated to be collected and stored in separate stores before being spread on grass or tillage land.

At each of these stages there is the opportunity to quantify gaseous fluxes and impose management options to reduce emissions. Key findings are

- *Housing:* emissions from straw-bedded cattle housing systems are markedly lower than slurry-cubicle houses - 20% of the N excreted compared

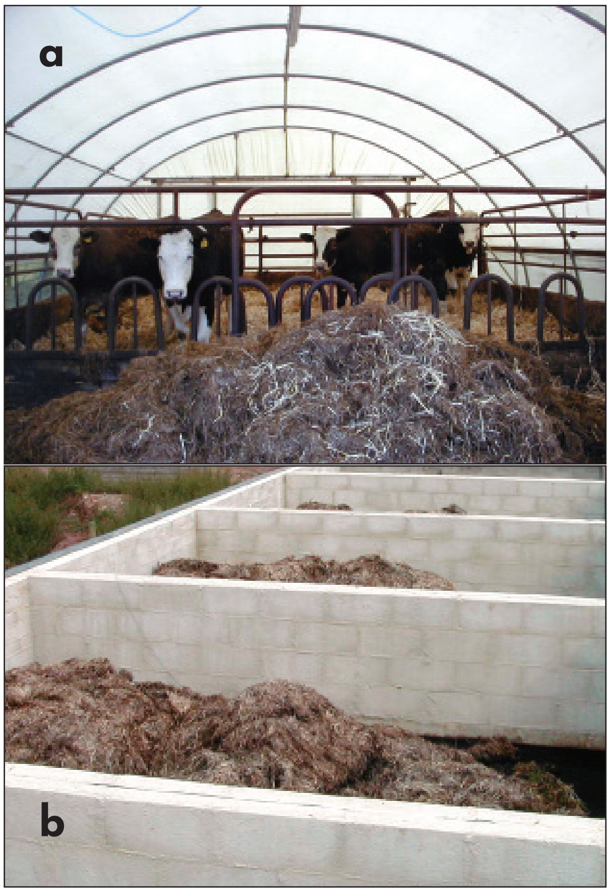

Fig 10.3 Animal housing and manure storage facilities in the manure lifecycle facility

with 30%, respectively. This is thought to be due to the immobilisation of excreted N by the straw which also reduces airflow over the emitting surface. Moreover, a doubling of straw use reduced ammonia emissions by 50%.

- *Animal diet:* a number of lines of work at IGER are indicating that there is potential to improve the N use efficiency of animal feeds – thus resulting in less N excretion.
- *Covering:* covering solid manure heaps with plastic sheets and crusting of cattle slurry or covering of slurry stores reduces ammonia emissions.
- *Land spreading:* Shallow injection of slurry is the most effective method of reducing ammonia emissions from grassland, reducing emissions by ca. 70% of those that occur when slurry is surface spread. The trailing shoe reduces emissions by ca. 55% compared with surface spreading on grassland.
- Solid manure can be incorporated by a variety of techniques into tilled land. Ploughing is most effective at reducing ammonia emissions at the plot-scale, in comparison with cultivating with tines or discs.
- *Outdoor livestock:* Livestock deposit faeces and urine in animal buildings, collection yards and on tracks, as well on the pasture. The ammonia emission, primarily from the urine, is controlled to large extent by the permeability of the surface on which it is deposited.

Greenhouse gases. Nitrous oxide and methane are major greenhouse gases. We have quantified fluxes from unmanaged areas on farms, such as ditches, gateways and areas around drinking and feeding troughs, and also from contrasting managed cattle systems. We have shown that nitrous oxide emissions are greater from straw-bedded systems than slurry-cubicle systems, the principal source being the farmyard manure (FYM) heaps.

Maintaining anaerobic conditions in the FYM heaps, e.g., by compaction (Figure 10.4) can reduce those

Fig 10.4 Compaction of solid manure heaps to maintain anaerobic conditions

Fig 10.5 Farmer discussion group meeting about woodchip corrals

emissions as can addition of high C:N materials such as chopped wheat straw. However, methane emissions may be greater from the more anaerobic heaps. This illustrates the potential for 'pollution swapping', where management practices designed to reduce one form of pollutant, e.g., nitrous oxide, result in greater losses of another pollutant, e.g., methane. It is necessary to develop 'win-win' management practices, which requires detailed understanding of processes in the soil or manure heaps.

Transfers to water

We contribute to multidisciplinary projects to develop mitigation options for a variety of diffuse pollutants including nutrients, pathogens and organic matter. Uncontained runoff from hard standings and seepage from solid manure field heaps are of concern, so too is rapid transfer following slurry spreading to drained land.

We have shown that different methods of cultivation and use of under-storey crops can be used to reduce runoff, sediment and P transfer from maize land. Under-sowing with clover and chisel ploughing were both effective at reducing runoff volumes compared to conventional tillage techniques for producing maize.

We are engaged in a multi-disciplinary project (with the Universities of Exeter and Lancaster) to evaluate the impact of management practices to control the risk of faecal indicator organism (FIO) transfers from grazing livestock, manures and other waste streams on economics and practicalities at the farm level and the 'knock-on' effects of such decisions on local communities and industries reliant on clean water supplies. We will assess the impacts of changes in management practices at the farm level (to reduce the risk of FIO transfers), on farm costs, and on costs to other stakeholder groups and the region as a whole.

Knowledge transfer activities

We generate practical information from a range of projects which has been used to contribute to technical guidelines such as the Defra Manure Management booklets. Other mechanisms of knowledge transfer include research projects which have sought direct farmer feed-back and we regularly interact with farming groups to discuss manure management related issues (Figure 10.5). Recently, we have recruited two full-time extension officers employed on the 'Grassland Challenge' project a joint knowledge transfer initiative co-ordinated by Duchy College, Cornwall and funded under the Objective 1 programme. Hence, these extension officers take key messages from relevant IGER programmes to grassland farmers in Cornwall.

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