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Recycling of livestock manure in a whole-farm perspective

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Abstract

Intensification increases the environmental impact of livestock production systems. Efforts to recycle nutrients in livestock manure for crop production will effectively reduce several pollution problems, although general solutions are difficult to devise in view of the diversity in production systems, management strategies and legislation between countries and regions. This paper argues that a whole-farm perspective taking side-effects and on-farm interactions into account is needed to determine the cost-effectiveness of strategies to mitigate pollution from livestock manure management. Animal feeding plays a key role in the control of nutrient flows on livestock farms, since the diet affects the composition of excreta. There is a great potential for manipulating manure composition by diet manipulations. Manure is a significant source of heavy metals in soil, and in Europe the permitted levels of Cu and Zn in livestock diets have been lowered to reduce their environmental impact. A variety of environmental technologies are being developed for treatment of manure, many of which have a significant potential for reducing nutrient losses. Internationally agreed and enforced regulations that link pollution control with the adoption of best available technologies could provide the demand that is needed to drive research and development. In the past, policy-makers have typically focused on individual environmental problems. It is essential, however, that the efforts to close nutrient cycles on the farm are accompanied by a corresponding reduction in total inputs, otherwise losses after field application will increase. Integrated assessment tools are needed which can evaluate all internal flows of nutrients, imports and exports, energy use, hygienic risks and contaminants, as well

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as costs, at the farm-scale and beyond. It is important to consider pollution control strategies for a farm in the framework of local and regional pollution control planning.

Keywords: Intensification; Feeding strategies; Emissions; Contaminants; Pathogen control; Manure treatment; Legislation

1. Introduction

Globally, intensification of agricultural systems increases the environmental impact of food production. Larger livestock production units result in higher local emissions of pollutants such as odour and ammonia from housing and stores. Larger production units can also lead to higher energy use for transport of livestock manure to be recycled in crop production, and the risk of disease spreading among livestock will increase. Further, high concentrations of livestock increase the risk that nutrients in the manure are used for crop production in excess of crop requirements, which may result in N and P leaching and surface run-off. Negative effects from heavy applications of manure may also include salinisation in semi-arid regions, increases in soil heavy metals concentrations and decreased soil aeration (Bernal et al., 1992, 1993). If livestock intensification continues, there is a need for development of technology and strategies to control the associated environmental problems.

Efforts to close nutrient cycles on farms by recycling of nutrients in livestock manure will effectively reduce several pollution problems, provided hygienic risks are controlled and soil heavy metal limits are not exceeded. However, general solutions are difficult to devise as systems for livestock manure management are extremely diverse. For example, in parts of Europe recycling on the farm effectively reduces the need for mineral fertilisers, whereas in other regions most livestock farms handle the manure as a dilute slurry that is stored in lagoons and frequently applied to spray fields (fields used for disposal of the slurry by irrigation), i.e., with no recycling of nutrients for crop production. Thus, priorities of farmers will be very different and call for different strategies.

Pollution control represents a necessary investment for the farmer who wants to maintain a given production level under stricter environmental regulations, or to expand the production without increased environmental impact. The lower production costs associated with intensification make environmental technologies increasingly affordable, but it is important to consider the cost-effectiveness of a given investment. This paper argues that a whole-farm perspective taking side-effects and on-farm interactions into account is needed to determine the cost-effectiveness of mitigation strategies for livestock manure management. Agricultural land (mainly on arable farms) also receives other types of organic waste, such as sewage sludge or municipal composts, but they are not considered here where the focus is on the internal flows of nutrients on livestock farms as influenced by treatment strategies and management.

2. Manure management and emissions

Emissions to air and water bodies are to a certain extent an unavoidable consequence of the recycling of livestock manures within agriculture. Emissions arise from biological, chemical and physical processes associated with the degradation of organic materials during animal digestion, treatment, storage and after land application. Of particular regional and/or global importance are nitrous oxide (N_2O), methane (CH_4) and ammonia (NH_3) emissions to the atmosphere, and nitrate (NO_3^-) leached to watercourses. Agriculture is a major source of the three gases, for which national ceiling targets (NH_3) or target emission reductions (CH_4 and N_2O) have been established. Nitrate leaching contributes to eutrophication and may pose a threat to drinking water quality. Of more local concern are emissions of odorous compounds.

Much research has been aimed at quantifying emissions from the various sources within the agricultural production system, and at understanding the key influencing processes (with the associated development of models at a range of scales and complexities) and developing mitigation measures. Research has often been focussed at the source level (e.g., NH_3 emissions from slurry storage) with the aim of establishing emission factors and assessing potential mitigation measures for that source. However, it is important that the whole-farm perspective is borne in mind, and that interactions such as secondary impacts on emissions from other sources and emissions of other pollutants are considered. For example, some mitigation measures aimed at reducing NH_3 emissions from livestock housing and manure storage will result in potentially greater losses at the manure spreading stage, reducing the overall effectiveness of such measures (Weiske et al., 2006), unless measures targeted at manure spreading are also imposed (Webb and Misselbrook, 2004). The potential for increases in N_2O emissions