6 Nutrient and pollution management - intensive livestock

Context

6.1 Agriculture is the biggest single source of ammonia in England (approximately 90% of the total annual emissions).[1] Almost all of this comes from livestock farming: 13% of emissions stem from inorganic fertilisers, of which nearly half is applied to grasslands; the remainder comes from manures and slurries, stemming from intensive units.[2] Organic manures are a source of organic and mineral nitrogen (N). Mineral N is largely present in manures as ammonium N, and can volatilise into ammonia gas. Ammonium N in the soil can be converted into nitrate N which can leach into watercourses, or be lost as gaseous nitrous oxide (a greenhouse gas) and nitrogen.

6.2 Ammonia gas, deriving from the breakdown of excreted urea, can also be released directly into the atmosphere from manure stores and livestock buildings.[3]

6.3 Intensive livestock production in the context of this chapter covers animals kept predominantly in housed environments, where all fodder and bedding requirements are delivered to the animal. Housing poultry[4] and livestock[5] in large numbers allows considerable production cost savings, but involves higher ammonia emissions per head.[6] Dairy units can also be regarded as intensive livestock units, and are considered here alongside pig and poultry units.

Current practice

6.4 Livestock manures are applied to 48% of grassland but only to 16% of arable land in the UK.[7]

6.5 Current intensive systems tend to concentrate manure and slurry outputs. The trend towards polarisation of farming enterprises in different regions, rather than 'traditional' mixed farming, often leads to logistical problems around their disposal, resulting in some areas where no manures or slurries are applied, and other areas where they may be seen as a surplus. This can often lead to water contamination through nitrogen leaching, or the mobilisation of phosphates. Table 7 provides a summary of potential nutrient output from livestock.

Table 7 Typical values for nutrient production by housed livestock

Type of livestock	Housing period (% of year)	Undiluted excreta (t or m^3)	Output during housing period (kg)		
			Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
Dairy cow	50	9.6	48	19	48
Growing/fattening cattle	66	6.2	31	12	31
Breeding sow + litter	100	4.0	19.5	20	16
100 laying hens	97	4.1	66	54.5	36

Source: MAFF (2000)[8]

6.6 Permanent housing is the dominant method of keeping and rearing pigs and poultry - 73% of chicken eggs produced in England are from housed accommodation. Most of the 3100 holdings producing broilers involve housed birds as well.[9] Approximately two thirds of pigs in England are housed for the whole of their lives.[10]

6.7 Typically these facilities are the source of large quantities of manure, as a result of the high numbers of animals involved. This can be an agricultural asset in terms of the nutrients and organic matter that it contains. It can also be a problem in that some of the nutrients can be in highly concentrated form and prone to volatilisation, and there can be an accumulation of heavy metals (particularly from pigs and poultry).[11]

6.8 It has been estimated that 40-60% of farmers do not include slurry or manure nutrients in their fertiliser calculations.[12] Grassland farmers have been reluctant to rely on the nutrient value of slurry on grasslands, although here the necessity of avoiding contamination of silage with faecal matter and avoiding a poor fermentation due to excessive nitrogen content of the herbage are important contributory factors.

Plate 6 Slurry spreading on arable land

6.9 In recent decades there has been a consistent under-estimation of the nutrient (and thus financial) value of manures and slurries, as well as the effect they have on local habitats and their effect on the wider environment. Targeted use of pig slurry could save up to £100/ha in annual fertiliser costs for an integrated arable unit.[13]

Industry trends

6.10 A large proportion of nutrients deriving from animal manures and slurries is lost to the atmosphere before it can be made available for crop uptake.[14] Despite this, some holdings within nitrate sensitive catchments struggle to cope with the quantities produced. Other holdings, where restrictions are less onerous, have continued to add to the high levels of water-borne nitrates, which are leached through their soils.[15] From 1 January 2009, the area of Nitrate Vulnerable Zones extends to approximately 70% of the country.[16]

6.11 Despite an annual reduction of 1% in dairy cow numbers nationally since 2005,[17] there has been a 6% rise in the number of dairy herds of over 200 cows since 2000 and, nationally, since 1996, average herd size has increased by approximately 20 cows.[18] Dairy cows are a major source of ammonia,[19] methane,[20] slurry and dirty water (milking parlour and yard washings).[21]

6.12 Despite the high visual impact of extensive pig and poultry units, they comprise a very small proportion of their respective industries. It has been estimated that extensive pig units only occupy approximately 7500 ha nationally. In 2007, the number of breeding pigs kept extensively had reduced by 7.5% from the 2006 level.[22] Numbers for all poultry during the same period increased by 32% to 12,255,000 birds (extensive poultry units were not recorded separately).[23]

6.13 Stored slurries are a potentially useful source of methane, though the high capital costs for installing such a system has put many farmers off investing. The initial capital cost for a digester and combined heat and power unit suitable for a 300 dairy cow unit could be in the order of £1000 per cow.[24]

6.14 For current incentives, advice and regulation for nutrient and pollution management, see Annex I to this chapter.

Key impacts

6.15 The main nutrients released from intensively reared or housed livestock are nitrogen (as ammonia, nitrous oxide and nitric oxide) and phosphates. Potash is also produced from animal housing and associated manure/litter storage and spreading, but generally does not have such a potentially damaging effect on the environment. Manures from pig and poultry units can have a high heavy metal content, which may build up over long periods of time, affecting soil function.[25]

6.16 Oxidation of ammonia in soils has an acidifying effect, with the extra nitrogen impacting ecosystems through eutrophication.[26] Aerial deposition of nitrogen from ammonia affects the resilience of native species such as heather,[27] whilst other families such as lichens and mosses can die off under high nitrogen deposition.[28]

6.17 Recent research has shown that the value of applications of manures and slurries to grassland and crop land extends beyond simple nutrient enhancement: whilst the level of soil organic carbon may be enhanced to an extent (depending on existing C levels and management), the addition of organic matter to the soil can be highly beneficial in terms of soil structure, drainflow and run-off.[29] Additionally, this can improve nutrient uptake by crops. The use of crop nutrients from manures can also offset CO_2 emissions resulting from inorganic nitrogen fertiliser manufacture and transport. An application of 8 t/ha (fresh weight) of broiler litter, with crop available nitrogen of 75 kg/ha, can yield a saving of 83 kg carbon per hectare.[30]

6.18 Storage and spreading manure can involve the emission of large quantities of ammonia, which has an acidifying effect on ecosystems. Nitrates which enter the soil but are mobilised before they can be taken up by plant growth may be released to the atmosphere as nitrous oxide, which is a potent greenhouse gas.[31] Slurry placement or injection systems have been shown to reduce ammonia emissions, and consequently nitrate loss at application and later stages.

6.19 Enteric emissions of methane, as part of the digestion process of ruminants, have been identified as potentially a major source of a potent greenhouse gas. Agriculture (predominantly dairy farming) is estimated to contribute 43% to the UK's emissions of methane.[32] Currently a number of methods are being evaluated to modify the digestion processes of cattle and sheep, such as: selective breeding, diet manipulation, and vaccination.

6.20 For further factual background to this section, see Annex II to this chapter.

Summary of impacts

Biodiversity

6.21 Oxidation of ammonia in soils has an acidifying effect, with the extra nitrogen impacting ecosystems through eutrophication. This, and the aerial deposition of nitrogen from ammonia, affects the resilience of some native plant species and can cause die-off of some mosses and lichens.

6.22 Increased deposition of nutrients on natural and semi-natural vegetation will result in a change in species composition, either due to the increased growth of some species, or because of an increase in susceptibility to disease or climatic extremes, for example frost hardiness, of other species.

6.23 Habitats such as woodlands, wetlands and semi-natural grasslands adjacent to areas of nutrient production can be affected by atmospheric deposition, surface flow or leaching.

6.24 Nutrient deposition into watercourses and groundwater can affect rivers, standing water and coastal and marine waters. Aquifers can also carry nutrients in groundwater to fens, affecting their botanical structure.

Resource protection

6.25 Intensive livestock production involves the associated production of large amounts of waste products, predominantly manure and urine. These are potentially major sources of gaseous products such as ammonia and methane, as well as nitrates and phosphates. These have a potential value as crop nutrients.

6.26 These products can also have profound negative effects on soils and water quality, as can heavy metals contained in the waste products.

6.27 Ammonia emissions can combine with oxidised nitrogen and sulphur to form particulate matter which can have a detrimental effect on human health.

Greenhouse gases

6.28 Use of manure and slurries can improve soil fertility for agriculture and offset CO_2 and N_2O emissions resulting from the manufacture and transport of inorganic fertilisers.

6.29 Storage of manures, particularly slurries, can be a major source of methane. Whilst it is possible to capture and use this gas for power generation, the equipment for its production, storage and use requires a high capital outlay.

Annex I Current incentives, advice and regulation

- *The Water Code*[33] (voluntary code of practice).
- *Nitrate Vulnerable Zone Action Programme*.[34] Compliance is also required for this under Cross Compliance Statutory Management Requirements.[35]
- *Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (as amended).*[36] *1991* regulates new or substantially modified slurry stores. Pre-1991 stores are exempt structures but the Environment Agency may require them to be improved if they believe there is a risk of causing pollution. Handling slurries is only regulated through facilities in and around the farmyard being part of the slurry storage system. The regulations do not currently apply to solid manure stores that are sited away from the farmyard.
- *Environmental Permitting Regulations*[37] legislation covers ammonia emissions. It also regulates manure spreading to land with a requirement for slurry to be spread using band spreaders or shallow injectors, rapid soil incorporation (on arable land), housing design, covering of slurry stores and management. An Environmental Permit is issued by the Environment Agency for large pig and poultry units.
- *Feeding Stuffs (England) Regulations, 2005*[38] controls the levels of Zinc and Copper used in pig diets, to minimise risk of heavy metal contamination in land-applied manures.

Annex II Impacts of livestock nutrient management on environmental sustainability

Table 8 Impacts of livestock nutrient management on environmental sustainability

Habitat quality and diversity	• Intensive livestock units are known to emit ammonia. This can result in the acidification or eutrophication of semi-natural habitats downwind.[39] • Nutrient enrichment of grasslands and other habitats has been shown to reduce botanical diversity.[40] [41] • Increases in the levels of atmospheric N have been blamed for habitat degradation in upland areas (notably on blanket bog) and some nutrient-poor lowland habitats.[42]
Species abundance and diversity	• High nutrient status of soils can allow aggressive plant species to out-compete those more tolerant of low fertility.[43] • Light levels of FYM application (12 t/ha or less) may have no detrimental effect on species abundance and composition, but this appears to depend on whether there has been a history of fertiliser use. Where there is no history of fertiliser use, applications may need to be as low as 6 t/ha to avoid change in plant communities.[44] • FYM may favour some soil diversity by increasing mycorrhiza and the ratio of fungal/bacterial biomass.[45] • Nitrogen deposition from ammonia has a direct negative effect on the survival of lichens and other heathland species such as heather and *Polytrichum* mosses.[46]
Nutrient loads in water	• Nitrates may be leached as a result of applications at inappropriate times, or of excessive quantities applied due to underestimation of N content of slurries and manures.[47] • High concentrations of N and P in water have been recorded following rainfall after manure applications.[48] • Where manures are applied for their value in terms of additional nitrates, the nitrate/phosphate ratio is such that it can lead to over-application of phosphate, which is not held in the soil, and can result in contamination of water-courses.[49]

Table continued...

Pesticide control	• There is evidence that manures from livestock treated with ivermectins can have an adverse effect on field springtail and enchytraeid populations[50]. Fears have been expressed that bat populations may be affected by reduced insect populations, but as yet there is little evidence to support this view.
Other pollutants	• Copper and zinc has been routinely fed in the pig industry as a growth promoter. This is controlled by the Feeding Stuffs (England) Regulations, 2005 . Long-term applications of pig slurry can lead to an accumulation of copper and zinc in soils and standing crops.[51] • Point-source pollution incidents in water involving organic waste are predominantly from agriculture (2005 data).[52] These are potentially destructive to wildlife as they involve high biological oxygen demand.[53]
Greenhouse gases	• Nitrous oxide (N_2O) is a potent greenhouse gas.Emissions from the livestock industry (livestock manures and forage area) are the largest source of N_2O in the UK.[54] Emissions from grassland are higher than arable land because of the high rates of fertilisers applied, higher rainfall and more compacted soils - all favourable conditions for N_2O emissions.[55] • High levels of methane emissions are possible from unmanaged slurry.[56] • High levels of methane are emitted by the digestive systems of ruminants. Where nationally 43% of methane emissions are derived from agriculture, manipulation of ruminant production, and digestion has been identified as a potential contribution to the UK's meeting it's targets under the Kyoto Protocol.[57] • Incorporation of organic matter into soils can increase carbon sequestration, although, as organic matter accumulates, the amount of carbon sequestered annually reduces.[58] • Use of organic fertilisers such as manure and slurry can offset CO_2 and N_2O emissions resulting from the manufacture and use of inorganic fertilisers.[59]
Air quality: chemical	• Ammonia emissions from livestock sources contribute to high levels of N deposition. This can lead to soil acidification and eutrophication on some semi-natural habitats.[60] • Application of slurries (particularly sprayed) can lead to over half of the nitrogen content being lost to the atmosphere as ammonia.[61] • 90% of total UK ammonia emissions reported for 2005 were from agriculture (286 kt).[62]

Table continued...

Air quality: particulates	•	Ammonia reacts with sulphur and oxidised nitrogen in the air to form ammonium particles. This provides 20-35% of the inorganic fraction of PM 1.0 and PM 2.5, having significant impact on human health.[63]
Soil stability (erosion)	•	Large-scale outdoor pig units operate on only 7500 ha nationally.[64] Whilst they have the potential to cause erosion, environmentally sustainable production can be an important added value to the output of the enterprise.
Soil function	•	Incorporation of manures improves soil structure.[65]
	•	Appropriate timing of application can be difficult, given the need to apply slurries when soils can support heavy machinery, whilst ensuring maximum nutrient uptake by the growing crops (early spring through to early summer).[66] Soil compaction can result in raised N_2O emissions due to impaired soil function.[67]

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