S4.2

Regulatory Challenges for the UK Poultry Industry in Managing Emissions.

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1. Introduction

In recent years there has been increasing pressure on the UK poultry industry to better manage their emissions to the environment. In the UK and indeed in Europe a largely regulatory approach has been taken to control the way agricultural businesses, in particular the pig and poultry sectors, manage their environmental emissions. Whilst a regulatory approach is undoubtedly going to achieve at least a degree of success in improving the environmental performance of poultry businesses, it can also present new challenges and indeed some dilemmas for the industry. Regulatory regimes are often designed for the major polluting industries and are not well suited to farming practices which are by comparison generally small scale and characterised by natural biological processes. Regulatory regimes can create a confrontational relationship with food producers and that combined with inherent inflexibility may stifle the identification of creative options that may benefit both the industry and the environment.

This paper will look at some of the current environmental issues that present challenges for poultry producers and current methods of assessing the environmental impacts of poultry farming operations.

2. Environmental aspects and impacts

Environmental impacts from poultry farming operations can be many and varied, but impacts are usually only significant on a local scale close to the source. The main environmental impacts from poultry farming operations are summarised in Table 1 below.

Table 1. Summary of environmental aspects and impacts from poultry production

Activities/Processes	Air Emissions	Releases to Water	Waste Management	Contamination of Land	Raw Materials, Natural Resources (Energy, Water etc.)	Local Issues (Noise, dust, odour etc.)
	Aspects(A)/Impacts (I)	Aspects(A)/Impacts (I)	Aspects(A)/Impacts (I)	Aspects(A)/Impacts (I)	Aspects(A)/Impacts (I)	Aspects(A)/Impacts (I)
Poultry farming operations	(A) Gaseous emissions from birds and housing (NH_3, CO_2, odours, small amounts of CH_4, N_20). Dust. (I) • contribute to radiative forcing; • CH_4 and N_20 are potent greenhouse gases; • acid deposition, ammonia is particularly implicated; • changes in species composition of flora; • direct toxic effects • reduced biodiversity; • odour nuisance.	(A) Effluent leakage from poultry housing, yards, manure stores. (I) • increased BOD/COD/SS in watercourses; • point source nitrate pollution of watercourses; • nitrate and phosphorus leaching from soils following manure spreading; • eutrophication • reduced biodiversity; • reduced amenity; • diffuse pollution of groundwater; • algal blooms.	(A) Integrity of stores and fallen stock handling systems. (I) • impacts as for air, water and soil; • possible NO_x SO_2 emissions from small incinerators used for carcass disposal.	(A) Excess nutrients in soil from land spreading of litter/manure. (I) • nutrients, particularly N & P leaching from soils into water; • possibility of pathogenic contamination e.g. salmonella, E.coli O157	(A) Energy requirements for heating, ventilation, feeding systems, manure drying systems etc. Drinking water. (I) • poor insulation or design leading to inefficient use of energy; • anthropogenic CO_2 emissions from heating systems; • lowering of water table; • increased energy use in dry manure to reduce ammonia emissions.	(A) Poultry housing, manure/litter stores, manure/litter handling, and feed delivery. (I) • odour nuisance; • emission of dust, particularly PM_{10} and $PM_{2.5}$; • visual impacts • noise.

3. Regulatory regimes - examples

Poultry producers in the UK are subject to a wide range of regulatory regimes that can be conveniently categorised as food safety, animal welfare and environmental issues. The main environmental regulatory regimes are summarised below.

3.1 Integrated Pollution Prevention and Control Directive

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain, mainly industrial, activities. In Scotland, IPPC operates under the Pollution Prevention and Control (Scotland) Regulations 2000. Similar regulations exist in England and Wales and in Northern Ireland. These Regulations implement the EC Directive 96/61 on IPPC.

IPPC applies to many industrial sectors, including the intensive farming of pigs and poultry. The thresholds for such farms to be regulated under IPPC are:

- 40,000 places for poultry; or
- 2,000 places for pigs over 30kg; or
- 750 places for sows.

Regulation is achieved through the issue of a permit by the environment agencies. The permit covers all aspects of the operation of the farm or 'installation' as defined by the installation boundary. To gain a permit, operators have to show that they have systematically developed proposals to apply the 'Best Available Techniques' (BAT) and that they meet other requirements for environmental protection, taking account of relevant local factors.

The environment agencies have developed a simplified permitting approach for the farming sector, through the development of Standard Farming Installation Rules (SFIR) and 'How to Comply' documents. These rules define BAT for the farming sector and are based on the European BAT Reference (BREF) document. The rules are wide ranging and include everything from housing to nutritional requirements of birds.

3.2 Nitrates Directive

The Nitrates Directive aims to reduce water pollution by nitrates from agricultural sources. Areas where the concentration of nitrate in water exceeds, or are likely to exceed, the levels set in the Directive are designated as Nitrate Vulnerable Zones (NVZ). For NVZs areas, legally binding rules must be put in place to reduce nitrate loss from agricultural land. The rules take the form of 'Action Programmes', e.g. in Scotland the Action Programme Regulations 2008 implement the legal and environmental obligations for NVZ areas. The occupier of any land within an NVZ is responsible for compliance with the Regulations and this will normally be the person who has the use of the land for 2 years or longer. In the case of short term lets, i.e. less than 2 years, the person letting the land is responsible for ensuring compliance with the NVZ action programme. For poultry farmers located in an NVZ area the Regulations are likely to have a significant impact on the farming activities, particularly with regard to litter and manure storage and utilisation.

3.3 Other Regulations

The two examples above are important regulatory regimes but they are by no means the only ones. This is illustrated in Figure 1 below which summarises different European regulations and policies affecting nitrogen and agriculture[1]. The impact of atmospheric emissions of nitrogen is currently causing difficulties for some UK poultry farms that are close to designated sites, particularly Natura 2000 sites.

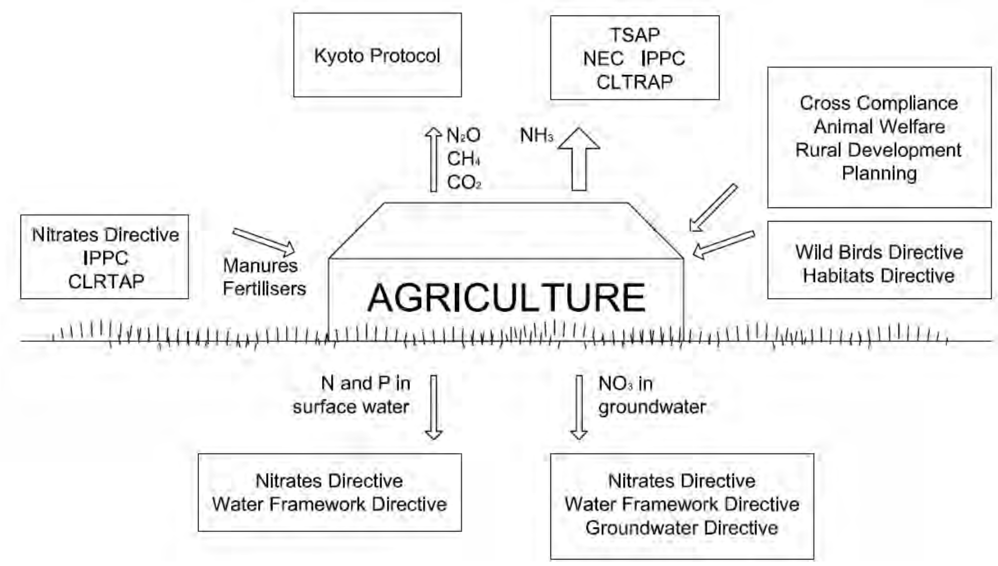

Figure 1 Summary of different European regulations and policies affecting nitrogen and agriculture.

Key: CAP, Common Agricultural Policy; C.C., Cross Compliance regulation; TSAP, Thematic Strategy on Air Pollution (2005); NEC, National Emissions Ceilings Directive; CLRTAP, UNECE Convention on Long Range Transboundary Air Pollution; IPPC, Directive on Integrated Pollution Prevention and Control; Kyoto, UNFCCC Kyoto Protocol (1977).

4. Regulatory challenges – examples of current problems

4.1 Ammonia emissions

Atmospheric nitrogen loading of designated nature conservation sites is both a local and transboundary problem. The contributions from mainly wet deposition of long-range transported aerosol bound reactive nitrogen (N_r) compounds can exceed the critical loadings of sensitive ecosystems in some European countries. But close to intensive agricultural areas, the contribution from dry deposition of locally emitted ammonia (NH_3) may equal or even exceed the nitrogen contribution from long-range transport. Due to regulatory regimes such as IPPC and the Habitats Directive this has become a significant challenge for some poultry farmers.

Ammonia is therefore recognised as a significant atmospheric pollutant and as a result agricultural sources, particularly the pig and poultry sectors, have come under greater scrutiny. A principal source of atmospheric ammonia is intensive livestock operations[2]. Although cattle are by far the most significant contributors to ammonia emissions in the UK, other work has estimated[3,4] that in the UK, poultry contributes between 7% and 9% of ammonia emissions from agriculture. More recent data[5] has raised this figure to 14%. Estimates of actual quantities from poultry vary within the range 15 to 38 kt N y^{-1} for the UK. A wide range of environmental effects can be attributed to ammonia on a local, national and global scale. These include acidification, eutrophication, formation of tropospheric ozone, contributions to greenhouse gases, and climate change through radiative forcing. Most ammonia emissions derive from agricultural practices through volatilization from livestock wastes.

Dispersion mixes ammonia (NH_3) gas in the atmosphere where it combines with acids such as H_2SO_4 and HNO_3 (from SO_2 and NO_x emissions) to form ammonium (NH_4^+) containing particles. The total of NH_3 and NH_4^+ in the atmosphere is referred to as reduced nitrogen (NH_x). Removal of NH_x from the atmosphere occurs in precipitation (wet deposition) and by direct capture of gases and aerosols by the land surface (dry deposition). Most wet deposition originates from scavenging of aerosol NH_4^+, while dry deposition derives from gaseous NH_3. Reduced nitrogen (NH_x) can have several environmental impacts:

- As NH_4^+ it acts as a vector of acidity deriving from SO_2 and NO_x emissions, since plant uptake of NH_4^+ releases acidity to the soil.
- Both NH_3 and NH_4^+ deposition can lead to soil acidification, where soil bacteria oxidize the nitrogen to nitrate.
- As a nitrogen containing pollutant, NH_x deposition leads to eutrophication. The extra nitrogen can result in changes to plant species in sensitive habitats such as moorlands, bogs and under tree canopies.

- Ammonium-containing aerosols lead to a reduction in visibility atmospheric through their light scattering properties. This also results in a direct impact on the 'greenhouse effect'. Conversely NH_4^+ aerosols promote the formation of cloud, resulting in an indirect effect of NH_4^+ on the greenhouse effect.

The pig and poultry sectors that bear the brunt of regulatory regimes such as IPPC. In the UK, difficulties have a risen for farms regulated by IPPC, whose emissions have potential to impact designated nature sites such as Natura 2000 sites and locally designated areas such as Sites of Special Scientific Interest (SSSIs). The difficulties have been compounded by a lowering of Critical Levels (CL_e) for ammonia in 2007 from an annual mean of 8 $\mu g\ m^{-3}$ to an annual mean of 1-3 $\mu g\ m^{-3}$. This has resulted in a number of poultry installations being issued with permits with very stringent conditions requiring reductions in ammonia emissions of, in a few cases, over 99%. If unable to comply the farms affected will have to close, resulting in a damaging loss of production of locally grown poultry meat and eggs.

Detailed assessment of the environmental impacts from farms at a local scale are now often routinely required as part of the IPPC permitting process and often as part of the planning process. The approaches taken to assess the environmental impacts of ammonia emissions from poultry housing vary significantly throughout Europe from not much assessment at all to highly detailed atmospheric dispersion modelling studies[6].

Modelling assessments for farms in the UK are generally undertaken as part of the IPPC permitting process or as part of the planning process for the purposes of the Environmental Impact Assessment Directive (85/337/EEC). The regulatory process for undertaking assessments for IPPC permitting are more clearly set out than assessment processes used in EIA work.

Typical stages in the UK approach for IPPC permitted farms.

- Using National GIS databases, European sites (SAC, SPA and RAMSAR) within a 10 km radius of the farm are identified. Sites of Special Scientific Interest (SSSIs) – (Areas of Special Scientific Interest (ASSIs) in N Ireland) within a 5 km radius and other wildlife sites such as ancient woodland within a 2km radius are also identified.
- Screening tools are then used to speed up the process and provide greater consistency to the permitting process. The tools used vary in different regions of the UK. Regulators in England and Wales and in Northern Ireland use a screening tool that uses generic emission factors and data provided in the IPPC application process applied to a generalised concentration/distance curve. Results are provided in the form of look-up tables. In Scotland the SCAIL[7] model is used for screening purposes.
- In cases where screening tools indicate that a farm has the potential to impact on a sensitive site then further detailed modelling is carried out. This is undertaken using advanced 'new generation' dispersion models such as the UK ADMS 4.1 and the American AERMOD. ADMS 4.1 is typical in that it uses the boundary layer height h and the Monin-Obukhov length L_{MO} to describe the atmospheric boundary layer and, using a skewed Gaussian concentration distribution, calculates dispersion under convective conditions. The model is applicable up to 60 km downwind of the source and can provide useful information at distances of up to 100 km. Distances of interest for farms are typically 100 – 5000 m.
- In order to set permit conditions, regulators have undertaken modelling as part of the permit assessment process using standard modelling assumptions and annual average emission factors. There are limitations to this approach and where more detailed modelling is required this has to be provided by the operator.
- Annual average emission factors derived from the BREF document and the UK inventory are usually used[8] but other factors may be used provided they are backed up by appropriate peer-reviewed research studies.
- A number of years (e.g. 5 years) of hourly averaged meteorological data from the nearest UK Met station are used for detailed modelling purposes.
- The source and group data used depends to a large extent on site specific features and emission characteristics of the farm. The use of appropriate methods is largely dependant on the experience of the modeller and their familiarity with complex agricultural sources. Emissions can be modelled as point, area, line, volume, or jet sources. Emissions from housing and from separate manure storage are usually modelled whereas emissions from down stream operations such as slurry/manure spreading are not. Techniques for slurry/manure spreading to reduce ammonia emissions are, however, controlled by IPPC rules.

- Currently it is usually only pig and poultry installations above the IPPC threshold sizes that are modelled although other units may be modelled as part of the EIA/planning process.
- Increasingly in the UK, particularly in England and Wales, concentrations only are being modelled for comparison with Critical Levels (CLe). This has advantages in that the operation is simpler and the uncertainties are reduced. It is the case that where very detailed assessments are required, Critical Loads (CLd) are estimated and compared with background levels. Estimates are often made based on only two deposition velocities, one for short vegetation (0.02 m s^{-1}) and one appropriate for woodlands (0.03 m s^{-1}). Information on background levels and loads and estimates of exceedence are obtained from the UK Air Pollution Information System (APIS). Wet deposition of ammonia is not modelled as it is not considered significant for short range modelling.
- A range of modelling assumptions may be used depending on the level of detail required. As far as possible these accurately reflect the situation on the farm, e.g. release heights, efflux velocities, temperature, location etc. Generally, terrain and buildings are not considered but can be included if required. The addition of building effects means that sources have to be modelled as point sources and this is not always appropriate for farms. Usually the surface roughness length selected for the dispersion site is assumed to apply throughout the domain, a typical value for agriculture being 0.3 m. If the need arises, advanced models such as ADMS 4.1 have the facility to define a distribution of surface roughness over the domain.
- It is usual for model output to be plotted on to 1:10,000 or other appropriate scale maps. Additional specific points or transects across sensitive areas are included as required.
- UK Regulators have agreed with the conservation agencies that where ammonia concentration, from all regulated sources, at a designated site exceeds the appropriate critical level an acceptable process contribution from the intensive livestock sector is 20% of the CLe where it may impact on a European site, and 50% of the CLe where it may impact on a SSSI/ASSI. Where only one livestock farm impacts on a designated site, all of that contribution is available to them. In cases where more than one permitted farm impacts on a site, in-combination effects are considered and the contribution is divided between the relevant farms. This has resulted in permit conditions specifying extremely low allowable concentrations at the site. Regulators have also asked operators to review emission factors used and to investigate options to reduce emissions and present their findings in the form of an emission reduction plan.
- Often designated sites are large and sensitive areas may be some distance from the farm. 'Ground truthing' of sites is sometimes undertaken to further establish the significance of impacts. In England and Wales the conservation agencies are currently re-assessing the site condition of all sites that have resulted in farms receiving permit conditions to abate ammonia emissions resulting from the lowering of critical levels.

Typical stages in the approach for modelling developments as part of the EIA process are less clearly set out than the above process for IPPC permitting. However it is likely that the assessment process follows a similar pattern and uses the same assessment criteria although there may be greater variation in methodologies.

In order to receive a permit to operate a poultry farm subject to IPPC must be shown not to adversely impact Natura 2000 sites designated under the EU Habitats Directive (92/43/EEC) or locally designated conservation sites such as SSSIs or ASSIs. By contrast, in most European countries there is little or no regulation on reactive nitrogen emissions to air from cattle and sheep farming, despite the fact that these farms emit more ammonia. For example in the UK cattle emit approximately 55% of ammonia emissions from UK agriculture, compared with 14% for poultry. Clearly, in the context of managing emissions, the poultry sector has to deal with a significantly greater regulatory challenge than other more polluting agricultural sectors.

Mitigating measures are essential to reduce the impacts of ammonia. Ammonia is produced in poultry houses as a result of the microbial degradation of uric acid and undigested proteins excreted by the birds. The amount that is emitted to the atmosphere is dependant on the internal concentration of ammonia in the poultry building, and the ventilation rate, either mechanical or natural. After nitrogen has been excreted by the birds, process conditions in the manure and litter and in the microclimate above the manure and litter determine the volatilisation of ammonia[9]. Different factors affect the release of ammonia at different stages of the process. These are summarised in Table 2 below.

Table 2. Processes and factors affecting the release of ammonia.

Process	Factors affecting processes
Faeces production	Birds and nutrition
Degradation	Manure conditions (moisture content, pH, temperature)
Volatilisation	Manure conditions and local climate
Ventilation	Local climate (temperature, humidity, air velocity)
Emission	Air cleaning

In principle, reduction of ammonia emissions is possible in all five stages of the process but not all methods are practicable. In practice, reduction of ammonia emissions starts with nutrition, and diets are controlled under IPPC. The rules require that birds are provided with a number of diets that minimise the excretion of nitrogen and phosphorus. The most common, and one of the most effective methods of reducing volatilisation losses of ammonia is by rapidly drying manure, or maintaining good litter quality to create conditions that are not conducive for microbial degradation. These techniques are highly effective and are now used in the majority of modern poultry houses, but care is required to avoid pollution swapping between different environmental compartments, i.e. from the atmosphere around poultry houses to soil, water and air in the fields where manure is being spread. Other techniques also have potential. The need to reduce ammonia emissions from broiler housing in the UK has prompted renewed interest in litter amendments that alter litter pH. There is also interest in so called ‘end of pipe’ solutions such as air cleaning using chemical scrubbers. In many respects this is not an ideal solution as the scrubbing solutions used can create their own environmental risks, but in cases where dramatic emission reductions are required the use of scrubbers may be necessary. One thing in common with both air drying and the use of scrubbing techniques is increased energy consumption and increased running costs.

4.2 Odour emissions

Odour emissions have had the potential to be problematical for the poultry sector for a long time depending on the proximity of poultry farms to sensitive receptors such as dwelling houses. In the UK, on smaller farms not subject to the IPPC regime, odour emissions can be dealt with as a ‘statutory nuisance’ and responsibility for investigating complaints lies with the Local Authority. If necessary the Local Authority can serve an abatement order requiring measures to be taken to prevent or reduce odour emissions. For farms subject to the IPPC regime, the regulation of odour emissions passes to the UK environment agencies and BAT must be applied to prevent or minimise odours. Measures corresponding to BAT are set out in the standard ‘rules’ for IPPC permitted farms. For larger farms subject to the IPPC regime there is an increased regulatory challenge in that there is greater public participation in the permitting process, meaning there is a greater awareness about odours, and more stringent requirements regarding the management of odours.

Quantification and prediction of odours in a rural environment can be an uncertain process due to the large number of variables, and the fact that biological processes are involved. The predominant source of odours from the poultry housing are emissions from ventilation fans, as ventilation air can contain a number of malodorous compounds which are dispersed into the atmosphere. Other sources can include manure/litter handling during cleaning out periods, and land spreading of manure/litter if these operations are not conducted in accordance with good practice.

Odour impacts are commonly assessed using atmospheric dispersion modelling techniques to compare impacts against indicative criteria. A problem for the industry is that information on odour emission factors for the wide range of production systems encountered is limited, and this adds uncertainty to the modeling process. It is also the case that ‘indicative criteria’ below which odour nuisance is unlikely to occur have been set at a low level for an agricultural process.

An 'odour unit' is a measure of the concentration of a mixture of odorous compounds in a sample of air. It is determined by means of olfactometry. A European Standard has been developed[10], the basis of which is the usual and widely accepted technique of 'dynamic dilution olfactometry'. With this method samples of odorous air are sequentially diluted with fresh or clean air using an olfactometer. After each dilution the samples of air are presented to a panel of trained people in a laboratory to see whether they can still detect the odour. The detectability threshold is the concentration to which the odour must be diluted relative to the initial concentration so that the odour is just detectable by 50% of the panel. This point is equivalent to one odour unit. The number of dilutions required to reach the detection threshold is a measure of the 'strength' of the odour. For example if a sample of odorous air has to be diluted 10 times before the detection threshold is reached, then the relative concentration of the odour is said to be 10 OU. Odour units are considered a dimensionless unit, but pseudo-dimensions of $OU_E\ m^{-3}$ are commonly used for odour dispersion modelling[11].

An important factor with odours is determining at what concentrations odours will be regarded as objectionable. Recent guidance[12] prepared by the Environment Agency for intensive livestock farms subject to IPPC legislation suggests that, based on the intensity of the odour:

- 1 odour unit is the theoretical detection limit in the laboratory
- 3 odour units is the point at which the smell may be recognisable, i.e. as poultry odour
- 5 odour units is a noticeable but faint odour
- 10 odour units is a distinct smell that may be intrusive.

When determining criteria for assessing the likelihood of nuisance, consideration should be given to the nature of the odour in relation to the environment in which it will be found. It seems reasonable to expect that higher concentrations of agricultural odours would be tolerated in a rural environment than would be the case if they were encountered in an urban environment. Similarly there is likely to be less tolerance to lower concentrations of, for example, a chemical odour in a rural environment than there would be in an industrial environment. Literature[13] has suggested that in circumstances where a rural odour may exist in a rural environment, a standard of 10 OU m^{-3} should not be exceeded for more than 2% of all hours. This can be described as the 98 percentile exposure of 10 OU m^{-3}. If a rural odour were to be encountered in an urban environment, the threshold should be reduced to 5 OU m^{-3}. However, following the implementation of IPPC, more recent guidance[(ref.12)] has suggested more rigorous indicative criteria for new poultry farms. This is 3 $OU_E\ m^{-3}$ as a 98^{th} percentile of a year of hourly means at the location of the sensitive receptors. It is important to note that this is not a standard, but an indicative criteria used for farms with more than 40,000 places for poultry. The Scottish Environment Protection Agency uses less clearly defined criteria for large poultry farms (again over 40,000 places for poultry) that are subject to IPPC. In their 'Standard Farming Installation Rules (How to Comply)' document[14], the relevant rule states "*All emissions to air from the permitted installation shall be free from offensive odour, as perceived by an authorised person, outside the site boundary*". This is a more subjective method of assessment and whilst it provides some flexibility in practice, it can also be open to varying interpretations.

Within the UK there is therefore variation in how odour nuisance is assessed, ranging from detailed modelling with predicted values being assessed against stringent indicative criteria, to more subjective assessments based on the perception of individuals in a regulatory role. Throughout Europe, the variation in methodologies and regulatory effort applied is likely to be even more variable.

Mitigating measures to reduce ammonia emissions such as rapid air drying of manure and maintaining good litter quality are also likely to be effective for odours. These measures combined with sensible practical measures like maintaining a clean and tidy site will all help to reduce odours. The design of building is also relevant and systems with high efflux velocity roof mounted fans will achieve greater dilution and dispersion of odours thus reducing impacts.

4.3 Dust emissions

Dust in poultry housing, like odours, is a problem that the industry has been dealing with for a long time. Initial concerns related to the health and welfare of workers and birds, and in the UK, health and safety legislation[15] introduced workplace exposure limits for workers exposed to poultry dust. More recently since the introduction of IPPC, emissions of dust into the atmosphere have become more of a regulatory challenge for the industry.

Dust in poultry houses consists of faecal matter, feed particles, feather and epidermal fragments[16] and is expelled to the atmosphere via the ventilation system. It has been suggested that odour concentrations are related to dust but some research[17] investigating this aspect has shown this not to be the case. Other environmental concerns have centred on the effects of dust on the surrounding flora, but it has been shown[18] that it is ammonia rather than dust that is responsible for plant damage. There is, however, growing concern about the impact of small dust particles below 10 μm in size – the so called PM_{10} dust particles, and increasingly $PM_{2.5}$ particles as well, due to the ability of these small particles to penetrate the gas exchange region of lungs hence causing damage. Particles of these small sizes are subject to statutory air quality standards[19] that are based on the current understanding of health effects and exposure to air pollutants. These standards have been specified to reduce health and environmental risks to an acceptable and very low level. The standards apply to places where people are present, i.e. dwellings around the poultry farm. The current annual mean air quality objective for PM_{10} particulates in England and Wales is 40 $\mu g\ m^{-3}$ and this value will reduce to 20 $\mu g\ m^{-3}$ by 2010. There is also a 24 hour mean objective of 50 $\mu g\ m^{-3}$ that must not be exceeded more than 35 times per year. After 2010 the number of permitted exceedances reduces to 7. In Scotland the 2010 value is slightly lower at 18 $\mu g\ m^{-3}$.

Emissions of dust can therefore be of concern if excessive. Larger particles of dust will be deposited in the immediate vicinity of the ventilator outlets with only the smallest particles being dispersed at distances of a few metres from the building. With low level ventilation fans i.e. wall or gable mounted, dispersion of smaller particles can be further reduced by covering the ventilation fans with a hood to direct air and dust downwards, but this may have the undesirable effect of poorer dilution and dispersion of ammonia and odours.

Obtaining appropriate emission factors for dust emissions in order to assess the impacts can be difficult as there is limited data. Factors are provided in UK IPPC application forms and in the EU BREF document, but they would appear to be unreliable and do not provide information on the PM_{10} fraction. Whilst there is reasonable data on internal dust concentrations in poultry houses, more data is required on the PM_{10} fraction.

Internal dust concentrations in poultry houses for laying hens are reported[20] as being in the range 1-5 $mg\ m^{-3}$. Results recorded by SAC[21] on a number of Scottish poultry farms gave mean values of 3.3 $mg\ m^{-3}$, and a major pan-European study[22] (Takai *et al*) gave mean dust concentrations of 3.6 $mg\ m^{-3}$ inside poultry buildings. However these are internal concentrations, and the majority of this dust settles on internal surfaces before it gets to the atmosphere.

The Takai study provides expected mean emissions data for layers and broilers in England, The Netherlands, Denmark and Germany. Inhalable dust emission rates for England were as shown in Table 3 below.

Table 3 Expected emission factors for poultry given in Takai *et al*.

Housing	Emission rate, $mg\ h^{-1}$ 500 kg liveweight^{-1}	Emission rate expressed as kg bird place^{-1} year^{-1}
Layers, perchery	1771	0.06
Layers, cage	872	0.03
Broilers, litter	6218	0.08*

* Note: assuming a mean broiler weight of 0.75 kg. A further reduction can be made for broilers as housing will usually be occupied for only 75% of the year (6.5 crops at 42 days per crop). This would reduce the factor for broilers to 0.06 kg per bird place per year.

Given these figures and applying a precautionary principle, it would seem reasonable to use emission factors of 0.05 kg per bird place per year for cage layers, and 0.1 kg per bird place per year for layers in perchery or aviary systems for modelling purposes when assessing IPPC permits.

The Takai paper provides details of the relative proportions of inhalable and respirable dusts, i.e. particles in the 0 - 100 μm range and particles in the 0 - 7 μm range. These data can be used to provide a crude estimate of the expected proportion of PM_{10} particles. The paper gives emission data where respirable dust comprises 26% of the inhalable dust for layers in perchery systems, 18% of the inhalable for caged layers, and 11% of the inhalable for broilers.

Given that in the worst case presented in the Takai paper sub PM_7 particles (respirable dust) comprised 26% of the total (layers in perchery systems), it can be expected that PM_{10} will comprise a correspondingly larger proportion. This has to be estimated as data is not available, but by extrapolation from the data in the Takai paper, a value of 25% could be reasonably be used for broilers and caged layers and should provide a conservative estimate. A value of 35% may be more appropriate for layers in perchery systems. Modelling assuming PM_{10} is 25% of the total dust for broilers has shown good agreement with field monitoring in Northern Ireland.

In very general terms, dust emissions are unlikely to breach air quality values unless a sensitive receptor such as a dwelling house is located very close to a poultry farm. Nevertheless, there is increasing concern regarding potential health effects from sub 10 μm dust particles. The design of the buildings also has a significant effect on emissions. Older broiler units with low ridge heights and capped roof mounted fans will create greater impacts from dust emissions than more modern taller buildings with high efflux velocity roof fans.

4.4 Treating run-off

The industry will probably recognise that treating lightly contaminated run-off from poultry sites is something that has been requiring attention. The introduction of the IPPC regime has brought the issue into sharp focus for farms subject to IPPC. In the UK the IPPC rules require that all contaminated run-off, i.e. run-off that is contaminated with even small quantities of manure (including wash water), and therefore may be deemed to be slurry, must be collected and disposed of in an appropriate manner usually by spreading to land. In the UK the rules prescribe the treatment methods that must be used to treat lightly contaminated run-off. Lightly contaminated run-off that is storm water from roofs and clean yard areas and can be treated by means of a swale, constructed wetland, soakaway, or settling pond or any combination of the above.

There are, however, qualifications in the rules regarding the circumstances in which treatment options can be used, and this can create regulatory challenges for the industry. For example, a soakaway should only be use for the cleanest of discharges where no other sustainable urban drainage (SUD) option is available. The direct discharge of ammonia to groundwater is prohibited unless authorised by the environment agencies, and IPPC permits do not normally provide that authorisation. In many cases this rules out soakaways as an appropriate treatment solution. More recently there have been increasing concerns relating to disease control and animal health authorities in the UK have expressed concern about the potential for areas of water to attract waterfowl into the vicinity of poultry farms. Waterfowl are a potential source of avian influenza viruses. This means that it is difficult to justify the use of retention ponds as a treatment option and constructed wetlands need to be designed with techniques that reduce the threat such as minimising or eliminating any open water in the wetland. Guidance is available on the design of constructed farm wetlands[23], but there is a need for greater flexibility in design criteria to allow a more practical approach to be taken.

One of the greatest challenges presented by the requirements for many farms, especially existing farms, is space. Many simply do not have the necessary space to be able to install treatment options meaning that more innovative and expensive solutions have to be considered.

5. Conclusion

There is good evidence that regulatory regimes are creating significant challenges for the poultry sector. The amount of environmental assessment work required to secure planning permission or obtain IPPC permits is high and results in significant additional costs for producers. The sheer intricacy of regulation combined with the complexity of the environmental issues can mean that assessment strategies are uncertain, yet the outcome can be a determining factor in whether a farm is allowed to operate or not.

Despite the challenges there are also benefits. For example, a benefit of IPPC is that the permitting process provides a review process that should ensure that environmental performance is maintained at a high level. A requirement for continual improvement in terms of BAT should ensure that environmental performance continues to improve as new technology becomes available. An additional positive side of a regulatory approach is that, in principle, it can ensure that certain environmental objectives are met that may not have happened otherwise due to economic constraints. It also provides a mechanism for demonstrating compliance with measurable environmental targets, albeit that in some cases this is an uncertain process.

By contrast regulation is rarely popular and can lead to mistrust between industry and agencies who operate in a 'policing' role. This can stifle potential for constructive partnerships between industry and environmental regulators, and more importantly, may affect the competitiveness of industries operating to high environmental standards when compared with industries in other parts of the world where no such regulation exists or is enforced. Consideration needs to be given to the overall benefit from regulation. At the moment the poultry sector is subject to significant regulation, yet in terms of its impacts on a national scale, at least in terms of ammonia emissions, it is not the most significant polluter. Other, perhaps less intensive, but more polluting sectors are able to operate with a lesser degree of regulation. This creates an anomalous situation in the UK.

There is an argument that a more balanced approach and greater overall degree of environmental protection might be achieved by adopting a more voluntary approach across all agricultural sectors. Government led voluntary approaches in many European countries, including the UK, has resulted in the establishment of codes of good agricultural practice (COGAPS) to reduce emissions to air, water and soil. There is some doubt about how effective voluntary codes are and some aspects may need to be made mandatory, as has been done with NVZ regulations, or requirements may need to be linked to economic incentives to achieve a sufficiently high degree of compliance.

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