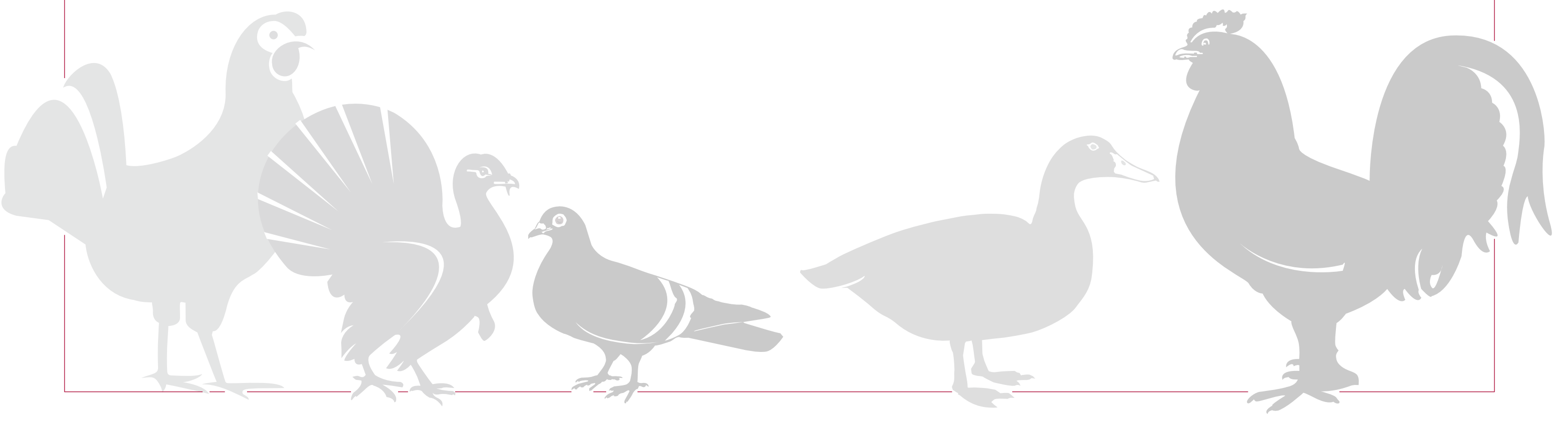
POULTRY DEVELOPMENT REVIEW

Poultry waste management in developing countries



Poultry waste management in developing countries

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INTRODUCTION

Poultry meat and eggs provide affordable, quality food products that are consumed by most ethnic populations worldwide. Advances in knowledge and technology over recent decades favour the growth and intensification of poultry production in developing countries where there are increasing human populations and economic constraints. Issues related to the environment, human health and the quality of life for people living near to and distant from poultry production operations make waste management a critical consideration for the long-term growth and sustainability of poultry production in larger bird facilities located near urban and peri-urban areas, as well as for smaller commercial systems associated with live bird markets, and for village and backyard flocks located in rural areas.

These information notes focus primarily on medium-sized to large intensive poultry production units, but many of the principles apply to smaller operations, including small family scavenging flocks. Fundamental knowledge of the environmental and health issues associated with poultry waste management will serve both small and large poultry producers now and in the future, as the intensification of poultry production continues to gain favour globally.

POTENTIAL POLLUTANTS AND ISSUES RELATED TO POULTRY PRODUCTION

The production of poultry results in: hatchery wastes, manure (bird excrement), litter (bedding materials such as sawdust, wood shavings, straw and peanut or rice hulls), and on-farm mortalities. The processing of poultry results in additional waste materials, including offal (feathers, entrails and organs of slaughtered birds), processing wastewater and biosolids. Most of these by-products can provide organic and inorganic nutrients that are of value if managed and recycled properly, regardless of flock size. However, they also give rise to potential environmental and human health concerns as the sources of elements, compounds (including veterinary pharmaceuticals), vectors for insects and vermin, and pathogenic microorganisms. With the probable exception of veterinary pharmaceuticals, these factors are also relevant to small flocks, including small family flocks that may be partially housed in containment structures.

Managing these poultry by-products as potential pollutants centres on water and air quality concerns, and in some cases on soil quality (FAO, 2008; Nahm and Nahm, 2004; Williams, Barker and Sims, 1999). Specific concerns that are well documented include degradation of nearby surface and/or groundwater, resulting from increased loading of nutrients such as nitrogen and phosphorus (and potassium in some locations). Air quality issues are less well understood and include the fate and effect of ammonia, hydrogen sulphide, volatile organic compounds (VOCs) and dust particulates emitted from poultry production facilities. Greenhouse gas emissions and health effects associated with nuisance odorants are also emerging and/or relevant issues, owing to global climate change and increasing human populations in close proximity to poultry operations, respectively.

Water and soil impacts of potential pollutants from poultry production

Most poultry manure and litter are applied to land near poultry production farms. With few exceptions, this is the preferred practice in developing countries and elsewhere. Such land management of poultry by-products brings the risk of surface and groundwater contamination from potential pollutants contained in the manure and litter. Its value depends on several factors, including the agronomic potential of the receiving crop(s) to utilize the waste nutrients, the receiving soil type and specific geological

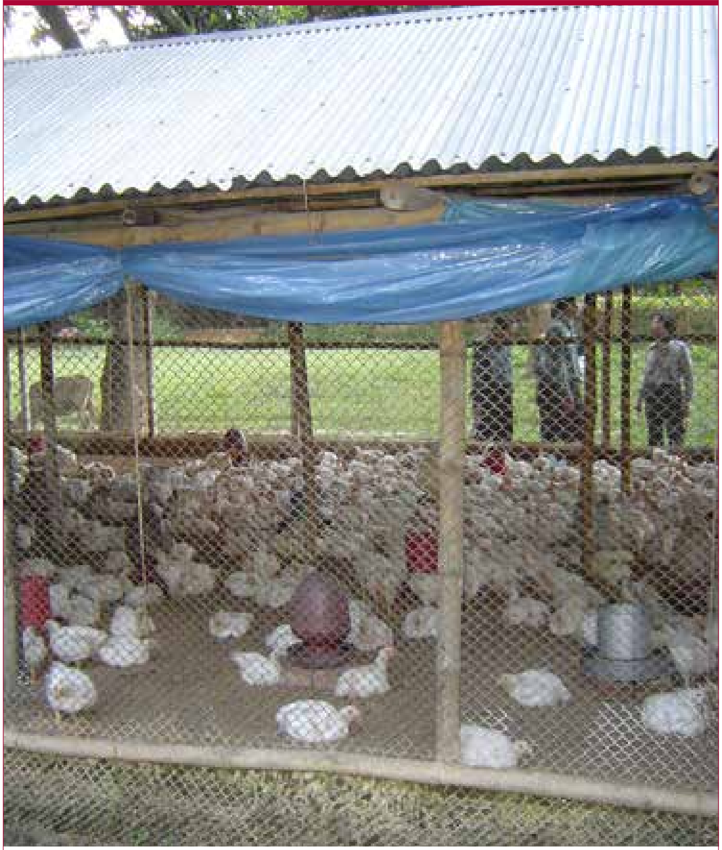
Photo Credit: John T. Brake

Housing conditions that promote good ventilation, non leaking waters and drier manure and litter results in healthier birds and manure of better nutrient value for crop fertilizer.

conditions of the land being utilized, the distance to nearby surface and groundwaters, the amount of vegetated areas (riparian buffers) adjacent to nearby surface waters, and the climate. Nutrient loading and build-up within a geological region is ecologically important and has an impact on the diversity and productivity of essential, naturally occurring living organisms within that region (Gundersen, 1992). The issue is increasingly complex owing to the trend for producing meat and eggs under intensified systems that require grain to be imported into production regions to meet feedstock requirements. This often leads to nutrient imbalances, and adverse environmental or health effects can occur when land application of the nutrients exceeds crop utilization potential, or if poor management results in nutrient loss due to soil erosion or surface runoff during rainfall. Surface or groundwater contamination by manure nutrients and pathogens is especially serious if drinking-water supplies are affected.

The primary nutrients of concern are nitrogen and phosphorus. The nitrogen compounds contained in manure and litter are very dynamic and can be removed from land by uptake of the receiving crop harvest or by conversion to gases that volatilize into the atmosphere in the form of ammonia, nitrous oxides or harmless di-nitrogen. Nitrogen is also very mobile in soil, and may be transported to groundwater and/or nearby surface waters. Unlike nitrogen, phosphorus in manure and litter is very immobile, but can leach into shallow groundwater or laterally transport to surface waters via erosion or subsurface runoff under certain climatic, soil and phosphorus concentration conditions. Nitrogen in the form of nitrates in drinking-water can cause adverse health effects; and both nitrogen and phosphorus in certain concentrations and environmental conditions can result in degradation of surface waters.

Regarding nutrient loading from poultry manure and litter, the focus is mainly on nitrogen and phosphorus, but certain metals such as copper and zinc, which may also be contained in poultry excreta, should also be considered when planning long-term sustainable nutrient balance in soils receiving poultry waste. In certain soil conditions, a build-up of these metals can be detrimental (toxic) for some crops (Zublena, 1994).

Air quality impacts of potential pollutants from poultry production

Air quality can be affected by aerial emissions of pollutants from poultry production facilities. Ammonia emitted into the atmosphere is arguably the most environmentally significant aerial pollutant associated with poultry production (FAO, 2006). The transport and fate of ammonia once it is emitted into the atmosphere are not well understood, but its presence in high concentrations can trigger environmental effects that have impacts on local ecosystems and human health. As such, consideration of the environmental effects on airsheds and watersheds of nutrient loading from poultry production is important for long-term sustainability. Ammonia from poultry operations is derived from nitrogen, which is an essential component of dietary protein, amino acids and other biomolecules necessary for life. However, dietary nitrogen not converted into meat, eggs or other tissue is excreted in the form of organic nitrogen, which is rapidly converted into ammonia under most, but not all, poultry production practices. The amount of ammonia actually emitted into the atmosphere depends on multiple variables, including climate, poultry housing design, and manure and litter storage and treatment practices, such as methods for applying them to land.

Hydrogen sulphide and other VOCs can result from the metabolic breakdown of poultry waste products, generally under low-oxygen conditions such as occur when manure is allowed to ferment (anaerobically digest) in a pit beneath the birds, in an earthen lagoon or in other open-air containment. This type of waste operation is more common with swine or dairy livestock than poultry, but may occur in some locations with layer operations. Under open-air fermentation, hydrogen sulphide and VOCs can be emitted into the atmosphere as pollutants, and can also be components of nuisance odour. Hydrogen sulphide can be dangerous to humans at certain concentrations. Donham and Thelin (2006) note that agitation of manure slurry in pits beneath animals can result in rapid elevation of ambient hydrogen sulphide to lethal concentrations, within seconds. The World Health Organization (WHO, 2000) notes an air quality guideline for hydrogen sulphide of 0.15 mg/m^3 averaged over a 24-hour period.

Particulate matter (or dust) is an aerial pollutant of more concern than hydrogen sulphide and VOCs. It occurs in typical poultry operations where appreciable numbers of birds are confined. Dust emissions can contain dried fecal matter and may include bacteria, endotoxins, moulds, mites and insect parts (Clark, Rylander and Larsson, 1983). Dust emissions from housing facilities are highly variable, depending on the climate, building design, feed consistency (dry or pellet) and control mechanisms for preventing large dust particles from leaving the area near the building – in recent years, considerable progress has been made in developing low-cost dust barriers to prevent dust dispersion (Poultry Science Association, 2009). Fine particulate matter (e.g., PM-fine) resulting from the conversion of ammonia gas in the atmosphere into ammonium salts can have greater consequences for human health, and is less likely to be mitigated by dust barrier approaches for preventing larger dust particles. This is another of the factors that make aerial ammonia emissions so important.

Climatic conditions play a very significant role in the impacts from aerial poultry pollutants, regardless of flock size. For example, excessively dry conditions, especially in litter, result in increased respiratory conditions affecting birds' productivity, while


Photo Credit: John T. Brake

Excessive dust on surfaces and equipment in poultry housing should be regularly cleaned to reduce environmentally harmful bio-aerosols.

excessively wet litter results in increased ammonia concentrations (and pathogenic microorganisms), which are also detrimental to productivity.

OPTIONS AND CONSIDERATIONS FOR POULTRY WASTE MANAGEMENT

The planning, construction and operation of poultry meat and egg operations of any size must consider issues associated with storing, managing and utilizing potential waste by-products. On a global scale, much research has been conducted on ways of recovering nutrients and value-added organic products from animal wastes, to improve agricultural efficiency and mitigate environmental impacts in their regions. Many systems and approaches can be successful if properly operated and maintained.

Land application of crop nutrients

Globally, poultry manure or litter has been applied to land to enhance crop production for centuries. When properly managed, this is an effective and beneficial option. Environmental pollution occurs when manure or litter is applied to the land in excess of the receiving crop's capacity to utilize the nutrients. Other factors that influence the environmental fate of the manure and litter applied include methods of collecting, storing, handling, treating, transporting and applying the waste by-products to the receiving land. For example, with non-liquid-flush systems, the poultry housing and manure storage area should be designed so that the manure and litter are kept as dry as possible, to minimize aerial emissions of gases and assist fly control. Manure and litter storage should be planned to prevent contact with rainfall or rain runoff. Land application should be based on the agronomic uptake of the receiving crop, accurate analysis of the nutrients contained in the manure (particularly nitrogen, phosphorus, copper and zinc) and properly calibrated application methods; it should be avoided when the land is frozen or excessively wet. Land application methods that incorporate the manure or litter directly into the soil minimize odour and gas emissions and surface runoff. These principles also apply to small family operations, whose sanitation will be improved by periodically removing manure or litter from areas where just a few birds are housed, and by storing, composting and/or land-applying the product at least 100 m from where the live birds are kept.

Composting is a natural aerobic biological process to breakdown organic matter, which provides a practical and economically feasible method for stabilizing poultry manure and litter before land application (Carr, 1994). Correctly managed composting effectively binds nutrients such as nitrogen and phosphorus in organic forms, and reduces pathogens, insect eggs and weed seed owing to the heat generated during the biological processing. Composting can also reduce nuisance odour emissions from poultry waste storage and treatment areas. A variety of composting approaches, from very simple to more complex automated systems, are available for both large and small poultry producers.

In areas where manure or litter is land-applied near streams or surface waters, an exceptionally simple and effective approach for mitigating surface runoff or the subsurface flow of potential harmful nutrients is to maintain a natural riparian buffer next to the water resources (Wenger, 1999). Riparian buffers may comprise native grasses, shrubs or trees, or a combination of these. The width and make-up of a riparian buffer are specific to its location, and the width of the buffer from the stream edge determines its effectiveness. Natural grass buffers of approximately 10 m wide have been shown to reduce nitrogen and phosphorus from field surface runoff by approximately 25 percent, while combined grass and tree buffers are much more effective. This practice is a documented inexpensive natural method of protecting water resources from the nutrients and pathogenic microorganisms contained in nearby land-applied poultry manure or litter.

Animal refeeding

Scientific research has documented that nutrients and energy from poultry waste by-products, including manure and litter, can be safely recycled as a component of livestock and poultry diets when pathogens are neutralized (McCaskey, 1995). Poultry litter has been estimated to be as much as three times more valuable as a feedstuff than as a fertilizer for crop nutrients. However, such practices depend on regional regulations and public perceptions of the concept of animals' consumption of fecal material, regardless of its documented value and safety. If practised, caution is essential. For example, copper toxicity can result when litter is fed to sheep. Incorrectly processed poultry waste can contain potentially pathogenic microorganisms, including *Salmonella*. Depending on environmental conditions and the global region of production, antibiotics, arsenicals and mycotoxins can also be present in poultry manures and litters.

The refeeding of poultry processing by-products is a common and acceptable practice in most, but not all, cultures. Advances in the treatment and processing of feathers and offal to produce value-added feed ingredients are making this practice more attractive in some regions, especially with the recent increases for feeds derived from grains.

Bioenergy production

Poultry manure and litter contain organic matter that can be converted into bioenergy under certain processing technologies. One of the most common approaches for poultry excrement managed by water flushing (e.g., some layer operations) is anaerobic digestion, which yields biogas, a gas mixture with varying concen-

Photo Credit: John T. Brake

Manure from this facility can improve the nearby grass yield for grazing cattle when properly managed.

trations of combustible methane (FAO/CMS, 1996). The biogas can be used as an on-farm energy source for heat or as a fuel for various engines that generate electricity. An additional advantage is that, depending on processing conditions, anaerobically digested manure solids and liquids are further stabilized and more acceptable and safe for use as a fertilizer or feed supplement. Numerous technologies and approaches are available for on-farm or centralized anaerobic digestion, and all are influenced by multiple variables that affect biogas yield and efficiency – operational feasibility and effective management are critical to the success of this process, especially with some of the more complex anaerobic digester technologies. Unfavourable economic and other issues associated with operational feasibility, and low biogas yield from litter-based systems have discouraged many poultry producers worldwide from implementing this technology.

Poultry litter and dry manure can be incinerated for on-farm production of heat in small furnaces, or transported to central locations where they are combusted on a large scale for the generation of electricity. For both approaches, the amount of energy produced depends on the efficiency of the equipment utilized and the moisture content of the manure or litter burned. Operational feasibility and emission issues also affect this process, especially for on-farm small conventional furnaces.

Gasification technology is a way of producing bioenergy that is receiving renewed interest for small on-farm systems and central electric power stations in some regions. The process involves incomplete combustion in a limited-oxygen environment. As noted for both anaerobic digester technology and incineration units, economic costs and returns, operational feasibility and emission issues have an impact on the implementation of this technology. However, increasing energy costs, environmental policy related to mandated renewable energy production goals in some regions, and the evolving carbon credit market are stimulating interest in all technologies for processing poultry and other waste products that yield bioenergy and reduce greenhouse emissions.

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Poultry manure characteristics

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INTRODUCTION

Knowledge of the amounts and compositions of manure and litter produced under different poultry production practices is essential for efficient and environmentally responsible management of these by-products as fertilizer, animal feed components or fuel. This knowledge is also required for the effective planning, implementation and operation of a waste management system that is appropriate for the number and type of birds in a given environment.

MANURE QUANTITY

Manure quantity and characteristics are influenced by the species, age, diet and health of the birds and by farm management practices. Estimates of the manure excreted by 1 000 birds per day (based on average daily live weights during the birds' production cycle) are approximately 120 kg for layer chickens, 80 kg for meat chickens, 200 to 350 kg for turkeys (grower females and grower heavy males, respectively), and 150 kg for ducks (Collins *et al*., 1999; Williams, Barker and Sims, 1999). Extrapolations can be calculated to give general estimates for the number of birds in a given operation.

After excretion, the quantity of manure requiring management depends on factors such as water content, whether the manure is stored in a location where rainfall collects, or whether it is mixed with materials such as straw, wood shavings or rice hulls, as is typical in meat bird housing. Estimates of the litter produced by 1 000 meat birds produced for market range from 1.1 to 2.4 tonnes for chickens, 7.3 to 12.7 tonnes for turkeys (grower females and grower heavy males, respectively), and 3.9 tonnes for ducks (Collins *et al*., 1999; Williams, Barker and Sims, 1999). Again, extrapolations can be calculated to give general estimates for the number of birds in a given operation. However, these values can be greatly influenced by management practices, such as whether fresh litter is added to existing litter after each growing cycle of birds, or a portion of the manure "cake" is removed from the existing litter prior to adding fresh litter.

Photo Credit: John T. Brake

Good ventilation and manure collection which separates the birds from the manure should promote better bird health and performance

MANURE NUTRIENTS

The scientific literature contains reliable and comprehensive information based on average values from a wide database, on the chemical (nutrient) and physical composition of manures and litter (see the references at the end of this note). Estimates of some environmentally important nutrients in manure are given in Table 1. They can vary according to the composition of ingredients in the birds' feed, and especially if the birds scavenge for all or part of their diet. Although the estimated manure weight as excreted may not vary significantly by bird type, it is essential that specific manure nutrient characteristics and concentrations be determined by reliable sampling and testing.

Manure and litter storage conditions influence some nutrient concentrations; for example, appreciable ammonia may be lost to the atmosphere from manure or litter that is stored in areas exposed to rain or groundwater. Storage in such conditions is not

TABLE 1

Estimates of nutrient contents of chicken manure and litter (kg/tonne manure excreted)

	Nitrogen	Phosphorus (as phosphorus pentoxide)	Copper	Zinc
Layer chicken manure	13.5	10.5	0.01	0.07
Meat chicken manure	13.0	8.0	0.01	0.04
Broiler litter	35.5	34.5	0.26	0.36

Photo Credit: John T. Brake

Good manure management should also include considerations for bio-security. Preventing contact with birds of differing species and other animals should be a part of good management practices.

environmentally sound, nor is it an efficient way of conserving nitrogen to be utilized for crop growth. The phosphorus content will not change significantly under such increased moisture conditions. To ensure agronomic balance and environmental management that prevent the overapplication of nutrients, it is therefore important to coordinate sampling activities with the timing of land application for maximum crop yields, rather than relying solely on established values or those measured when the manure was in the production house or during early storage. It is also very important to estimate the availability of the crop nutrients in manure or litter (Shaffer, 2009).

MANURE MICROORGANISMS AND VETERINARY PHARMACEUTICALS

Poultry manure and litter contain populations of naturally occurring microorganisms, many of which are environmentally beneficial and play important roles in the ecological nutrient cycles associated with carbon, nitrogen, phosphorus, sulphur and other elements in poultry by-products. However, depending on management and environmental conditions, poultry manure and litter can also contain harmful pathogenic microorganisms that affect human health. Chemical residues in the form of veterinary pharmaceuticals (antibiotics, coccidiostats and larvicides) may also be contained in poultry manure and litter (Sims and Wolf, 1994), depending on diet formulation, management practices and the regulation of poultry production enterprises in a given region. Accurate sampling and laboratory analyses of the harmful microorganisms and chemical residues contained in manure and litter are critical to the implementation of effective mitigation practices.

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Aerosol contamination

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INTRODUCTION

Aerosol contamination from poultry production can generally be characterized as pollutants, including gases (such as ammonia), particulates (dust) and microbial pathogens suspended in the airspace within and transported from the birds' housing or containment areas. Dust from poultry operations can include feed dust, manure, feather dust, bacteria, mould spores, endotoxins, insects, insect parts and ammonia absorbed in dust. The transport of aerosols can be an important consideration when establishing the separation distances between poultry production facilities to reduce the risk of aerial transmission of communicable disease-transmitting microorganisms. Depending on their concentration, aerosol pollutants can be harmful to the respiratory health of birds within the containment areas, and may also be harmful to the health of workers or inhabitants living close to poultry production areas. However, at the international level, comprehensive studies regarding the human health effects of aerosols from poultry operations are lacking.

Aerial-transported ammonia can affect local and distant ecosystems, depending on the ecological sensitivity of the water source(s) into which the ammonia is deposited as dry or wet fall. Aerosol ammonia is also a precursor gas for ambient particulate matter, under certain atmospheric conditions, and there is evidence of negative human health effects from exposure to particulate matter, especially fine particulate matter.

Regardless of their location or size, existing and new poultry production operations should consider mitigating the risks associated with aerosol emissions to ensure the future sustainability of poultry production practices.

SOURCE AND EMISSION OF AEROSOLS

Even under the best management conditions, poultry production can be a source of aerosol contaminants, including gases, odour, dust and microorganisms. These gaseous compounds and living organisms are generated from natural biological processes associated with poultry manure decomposition soon after the manure is produced, during manure and litter storage and treatment, and during application of the manure or litter to fertilize cropland. Particulate matter as dust can originate from both feed and the birds. However, the generation rate of these gases, microorganisms and particulates is highly variable, depending on the weather, the species and age of the birds, housing conditions, and the manure handling system, feed type and management system(s) used.

Once aerosol pollutants are generated, they can be emitted from their sources through the production unit's ventilation system, which is characteristic of larger units, or by natural weather-sourced ventilation, in smaller or naturally ventilated larger units. The emission rates of the pollutants depend on many factors including time of year and day, temperature, humidity, wind speed and other weather conditions, ventilation rates, housing type, and manure properties and characteristics – for example, dryer manure and litter result in more particulate emission, while moist conditions are likely to result in increased emission of ammonia. It is extremely difficult to determine specific aerosol emission rates from point sources such as poultry housing units, manure or litter storage areas, and during application to cropland, and definitive information is lacking. This remains a very active area of research in many parts of the world.

EFFECTS OF AEROSOL POLLUTION

Aerosol emissions can compromise bird health and productivity (feed conversion, meat and egg yield). Aerosol emissions from poultry operations can transmit communicable diseases to neighbouring poultry flocks; scientific evidence shows that some pathogenic microorganisms can remain viable and be transported for appreciable distances (from 50 to more than 500 m) in ambient air. Evidence also shows that the health of farm workers can be affected by day-to-day exposure to aerosols. Primary effects are on respiratory function, which is not surprising considering the composition of typical aerosol pollutants associated with poultry production (ammonia, dust, microorganisms and endotoxins).

Clean housing surfaces, good ventilation and good management will reduce risks caused by bio-aerosols in poultry houses.

Photo Credit: John T. Brake

An aerosol of particular ecological and human health importance is ammonia. A growing body of evidence shows that appreciable concentrations of ammonia are released from poultry (and livestock) production operations; increases in nitrogen concentration resulting from wet and dry atmospheric deposition of ammonia are having serious impacts on some ecosystems globally (resulting in decreased forest productivity, increased nitrate concentrations in surface and groundwaters, and increased risk of eutrophication); and ammonia is a precursor gas for the formation of ambient fine particulate matter (human exposure to elevated fine particulate matter has been linked to a variety of adverse health effects, including acute respiratory conditions and increased mortality risks).

MITIGATING THE RISKS OF AEROSOL POLLUTION

The most effective strategy for reducing aerosol pollution is to reduce its source. Management strategies such as improving hygiene in poultry production buildings (by constructing them so that they do not encourage dust build-up), controlling manure and litter moisture, and formulating feeds to reduce nitrogen in the excreta all help decrease aerosol concentrations. Technologies such as biofilters and/or bioscrubbers as components of point source ventilation exhausts are not economically practical in developing and many developed countries. Farm workers can reduce health risks by practising good hygiene and wearing protective eye shields and dust masks when possible and practical, especially in dusty poultry production environments.

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Location, siting and concentration of poultry units

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INTRODUCTION

Worldwide, most segments of animal production, including poultry, are increasingly affected by regulations, policy and public perceptions. There is increased attention to and awareness of the environmental and human health impacts – real or perceived – of animal agriculture. The demand for poultry meat and eggs will likely increase in the next decades, but in most parts of the world, the proportion of the population participating in day-to-day on-farm activities is steadily decreasing – a trend that is likely to continue. Although small backyard and scavenging poultry flocks are becoming more popular in some urban areas of developed countries, global demand for production and economic efficiency are likely to result in larger concentrated production farms continuing to be more prevalent in most regions.

Small and scavenging flocks controlled by cooperatives, villagers and families are prevalent in rural areas of some developing countries, where they contribute to poverty alleviation and food security. However, as larger production farms become more common in these countries, siting issues regarding biosecurity will have an impact on small-scale village and family flocks, possibly leading to conflict if proper management practices are not exercised. The sustainability and potential expansion of any poultry production or processing operation are affected by its location, especially in the long term. This is particularly true of operations located near urban or peri-urban areas. These factors demand careful planning of the location and siting of poultry production units. Failure to take such planning considerations into account when constructing new and larger facilities may result in costly changes or management expenditures in the future.

Photo Credit: John T. Brake

This poultry facility has good topography for rain drainage away from the building, utilities, fencing for bio-security, and appears to be located away from nearby residents– all good siting practices.

PLANNING CONSIDERATIONS

Infrastructure, water, regulatory requirements and permits

A first step in planning the location of any poultry unit includes assessing the existing infrastructure support, especially for larger units; for example, does the location have adequate roadways and utilities to support the transport of inputs and outputs and ensure the unit's energy requirements? The adequacy and supply of fresh and safe water to support the unit's production and operational needs should also be determined. The available labour force should be considered: larger farms need dependable workers, who should – as far as possible – live in areas without potential disease reservoir birds (village and scavenging flocks). The regulatory requirements for the region must be accurately assessed. These may involve setback stipulations from property lines, water sources, residences, roadways, schools and churches; development and implementation of comprehensive nutrient management plans that apply to the watershed or airshed in which the unit will be located; and acquisition of necessary permits.

Near neighbour assessment

The potential for affecting neighbours or neighbourhoods with nuisance emissions (primarily odour) and/or flies cannot be ignored. The management and operational efficiency of any operation can be negatively affected if sufficient time and effort are not given to resolving conflicts resulting from nuisance complaints and potential litigation, even if all regulatory and permit requirements are met. With few exceptions, the transport of potential pollutants (by surface runoff, leaching into the groundwater, or aerial emissions of volatile compounds or dust particulates) from poultry production or processing is not limited to the boundaries of the property on which the unit is located; neither is communicable disease transmission. Consideration should be given to biosecure zones, especially in developing countries, regarding separation distances from areas containing water sources supporting water fowl, nomadic ducks or village birds, which are all potential carriers of avian influenza and other diseases. Serious consideration must also be given to communication and interaction with near neighbours. Assessment of how the unit will be received (or perceived) by its neighbours should be a component of site location planning.

Specific considerations

The following are important considerations for the successful siting of a poultry operation:

- Topography and soil type, which have an impact on rain runoff patterns: Avoid areas that will not support adequate drainage, and those that are subject to flooding.
- Prevailing wind patterns relative to emissions from poultry house ventilation fans and distance to near neighbours: The distance should be sufficient to ensure that odours and dust dissipate before they reach the neighbours. Tree buffers have been effective in mitigating dust and odour emissions from poultry facilities; it is recommended that production buildings be sited in areas that contain or would support such vegetative buffers.
- Future expansion plans: Is there sufficient land area to support future expansion without affecting near neighbours and/or becoming land-limited for the application of manure and litter for waste management?
- Land area and crop type for agronomic uptake of land-applied manure and litter: Is there sufficient land for waste management practices? (Consult the references for estimates of manure and litter concentrations and characteristics.) Avoid areas where fields already contain high concentrations of less mobile nutrients such as phosphorus, copper and zinc; avoid areas in sensitive watersheds, if at all possible. Are surface water streams close to the land area that will receive manure and litter? If so, can riparian buffers be established along the stream boundary (if not already in place)?
- Visibility of the unit to public view.
- Potential for implementing robust vegetative buffers at appropriate distances from the poultry house ventilation fans to reduce dust and odour emissions.

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The following references refer to specific geographic locations, but much of the information they contain can be applied globally.

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Slaughterhouse wastes

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INTRODUCTION

Slaughterhouse wastes from poultry processing include processing water and organic solid by-products. This is also true of very small-scale processing facilities and village and home (backyard) flock operations. The World Bank Group (2007) provides detailed and useful environmental health and safety guidelines for all steps of poultry processing, from the reception of live birds, through slaughter and evisceration, to simple waste processing. This information note focuses on the utilization of organic solids, of which an estimated 1 million tonnes are generated every year worldwide. As for poultry production wastes (manure and litter), these organic solids should be considered both potential resources and potential environmental pollutants, depending on how they are processed and managed. Similarly, the siting of slaughterhouses, like that of production facilities, should give careful consideration to biosecurity and near neighbour issues. The size of the slaughter facility also has implications for environmental and food safety practices and issues – again, the size issue is similar for poultry production facilities.

The treatment and environmental fate of processing wastewater and organic solid wastes should be based on site-specific requirements, regulations and the location of the slaughterhouse. For example, some regions have very specific requirements for the organic and inorganic wastes that are discharged into surface waters following treatment, and some have restrictions or regulations for the processed solids destined for animal feed components. When possible, the treatment of solid waste should aim to produce value-added sellable by-products, such as animal or aquaculture feed components, energy (through biogas production) and agricultural fertilizer. For very small or backyard flock operations, slaughter is likely to generate very small quantities of solid wastes, and the management of these wastes should focus more on proper disposal and recycling (burial or composting) regarding biosecurity and human health issues.

COMPOSITION, CHARACTERIZATION AND REPROCESSING OF SLAUGHTERHOUSE SOLIDS

Poultry carcass yields are typically about 70 to 75 percent of the live bird weight; the quantity of potentially sellable solid waste depends on the efficiency of the processing methods and the health of the birds prior to processing.

Blood is approximately 2 percent of the live bird weight, and a source of highly concentrated protein when filtered and dried to produce blood meal. During slaughter, blood is typically collected separately from the other viscera and, depending on cooling conditions and storage time prior to further processing, may require chemicals to prevent coagulation. Processed blood meal can be used in animal and fish feed as well as fertilizer.

Feathers comprise approximately 7 to 10 percent of the live bird weight and are another source of protein (75 to 90 percent crude protein), although the utilization value of feathers as an animal feed component depends on further processing methods (e.g., high-pressure cooking at > 100 OC or enzymatic treatment) to improve digestibility. Processed feathers can also be used for bedding, clothing and other niche market items for humans.

The head, feet (recovered for human consumption in some regions) and inedible viscera make up the remainder of slaughterhouse solids. Following further processing by methods such as conventional rendering at specified temperatures and pressures, depending on the intended fate and risk factor of the material, sellable products in the form of protein-rich meals and fat are produced. Extensive further processing of these by-products may not be required in some areas, if biosecurity precautions are taken. For example, high-quality inedible viscera wastes are in great demand for intensive fish culture in some regions, and may require only simple on-farm grinding and mixing with a binder prior to use.

Regardless of location, before reprocessing, slaughterhouse solids can be broadly characterized as low-risk material originating from healthy birds, and high-risk material that may transmit disease to humans, livestock or poultry. For example, high-risk material would originate from birds that died from causes other than slaughtering, or birds or bird parts condemned as unfit for human consumption. Birds confirmed or suspected of carrying transmittable disease, especially a disease such as highly pathogenic avian influenza (HPIA), should be characterized as high-risk material. Care and management steps should be taken to keep high-risk materials separate from low-risk materials, as mixing of the two results in the entire batch being classified as high-risk. This is important not only for health and safety precautions but also for economic reasons related to the additional processing requirements for high-risk versus low-risk materials. The treatment of high-risk material intended for animal feed or fertilizer is typically an energy-intensive rendering or alternative heat treatment process, whereas reprocessing of low-risk material may include less stringent methods to make use of the solids for animal or aquaculture feed. For materials that are not suitable for processing into the food chain, alternative methods to be considered include approved burial, aerobic composting or treatments for energy production and/or processing for use as agricultural fertilizers.

The utilization of slaughterhouse solid by-products for animal feed is becoming increasingly restricted in many parts of the world. In such areas, anaerobic digestion – the biological degradation of organic matter into methane under anaerobic conditions – is an alternative that provides an opportunity for energy recovery and, depending on the type of anaerobic digestion employed, for reducing pathogenic microorganism in the solid substrate digested. Properly managed, anaerobic digestion can also reduce nuisance odours associated with slaughterhouse wastes, and conserve the non-carbon nutrient components in the digested material, which can be recovered for fertilizer or possible feed use. Salminen and Rintala (2002) provide a comprehensive review and relevant information to determine the applicability of anaerobic digestion and material recovery from poultry slaughterhouse waste.

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