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.

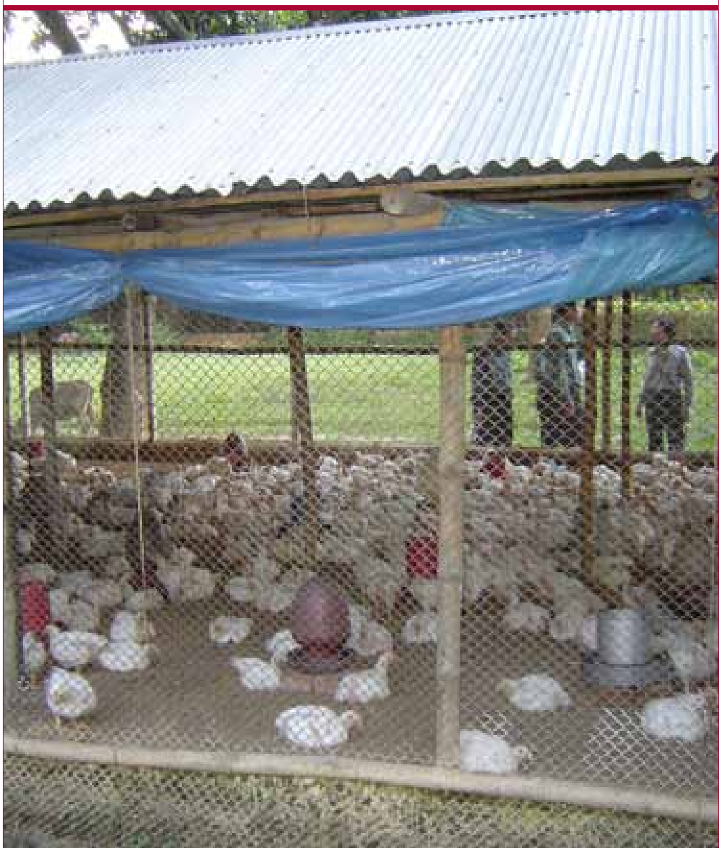
POTENTIAL POLLUTANTS AND ISSUES RELATED TO POULTRY PRODUCTION

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



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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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