Online Journal of Animal and Feed Research
Volume 1, Issue 6: 285-292 (2011) ISSN 2228-7701

POULTRY WASTE MANAGEMENT IN BOTSWANA: A REVIEW

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REVIEW ARTICLE

ABSTRACT: *A literature review was conducted to identify methods that are used to dispose of poultry waste in Botswana. It appears that the predominant methods of poultry waste disposal in Botswana are direct disposal at the landfills, application as a fertilizer in gardens or farms, burning and compositing. The use of poultry manure and/or litter to raise fertility status of the soil appears to be appropriate given that soils in Botswana are generally poor in plant nutrients, especially phosphorus. Given the high feed costs in Botswana it is suggested that the use of poultry manure and/or litter as livestock feed should be considered in areas where foot and mouth disease (FMD) is endemic such as Chobe and North West Districts, as meat from these districts does not enter the European Union market.*

Keywords: *Beef, calcium, litter, manure, phosphorus, pollution, potassium*

INTRODUCTION

Worldwide, the poultry industry is growing rapidly and contributes towards addressing key national development goals, as well as, in improving the standard of living of people through poverty alleviation and creating employment opportunities (Agblevor et al., 2010). Roeper et al. (2005) contended that the problem coming along with the poultry production is the manure that needs to be taken care of, as a non-appropriate treatment or disposal can become risky for environment and humans. For instance, manure can support the spread of diseases and may pollute soil and groundwater resources if not properly handled.

Waste is defined as anything that is no longer useful and needs to be disposed of. Furthermore, waste may be defined by the type and place in which it is produced, such as agricultural, household, industrial and mining (Ministry of Local Government, Lands and Housing, 1998).

The poultry industry produces large amounts of waste that include solid waste and wastewater. The solid waste consists of bedding material, excreta (manure), feed, feathers, hatchery waste (empty shells, infertile eggs, dead embryos and late hatchlings), shells, sludge, abattoir waste (offals, blood, feathers and condemned carcasses) and mortality. The wastewater results from washing and disinfection of chicken houses and abattoirs. Dong and Tollner (2003) stated that poultry densities on farms continue to increase and have caused manure related problems which are water, air and land pollution.

Livestock manure can be either a valuable resource or an environmental pollutant. Generally, manure refers to faeces and urine produced by animals, and it contains organic matter and nutrients, that has fertilizer value when applied on the land and used by crops. The proper handling and management of manure can augment or replace purchased commercial fertilizers (Tao and Mancl, 2008). On the other hand, poultry litter is a mixture of poultry droppings and bedding materials, such as wood shavings and rice or peanut hulls. In Botswana, ashes, which result from using coal for brooding, are also produced in large quantities on farms, especially in medium and large-scale broiler operations as waste, and these need to be disposed of.

In general, broiler or turkey litters have higher dry matter content (60%) than layer manure (35%), although all manure types had similar concentrations of nutrients (*e.g.*, sodium, potassium, phosphorus, magnesium and sulphur) on a dry weight basis. Typically, sodium: phosphorus: potassium ratio is 6:2:2 for layer manures and 6:2:3 for broiler or turkey litters. The readily plant available nitrogen content of the poultry manures is approximately 30 – 50% of the total nitrogen (Nicholson et al., 1996).

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Journal homepage: http://www.ojafr.ir

Poultry wastes pose serious environmental pollution problems through offensive odours and promotion of fly and rodent breeding (Adeoye et al., 1994). Several poultry waste management methods can be employed to reduce the negative impact of poultry waste on the environment. Given the large volume of poultry waste that is produced on farms and that needs disposal, a review was undertaken to identify methods of disposing poultry waste in Botswana.

Poultry liiter and manure production

Tao and Mancl (2008) estimated daily manure production by a broiler and laying hen to be 0.09 kg and 0.18 kg, respectively. Factors that influence manure production include type of chicken, age and breed, stocking density, feed conversion, kind and amount of feed type and amount of litter, moisture content of litter, type of floor, and even climatic conditions during accumulation (Perkins et al. 1964). On the other hand, factors affecting composition of litter/manure are type of birds, feed nutrient density, bedding material and amount, time in use and other management factors (Ritz and Merka, 2009).

The properties of manure depend on several factors including animal species; feed ration digestibility; protein and fibre content; animal age and productivity; manure management and handling; and the environment (Tao and Mancl, 2008). According to Faridullah et al. (2009), ashing poultry manure can improve its nutrient content depending on the temperature of ashing and source of the poultry waste. Chicken litter ash contains more phosphorus and potassium than duck litter ash but the latter contains more calcium and magnesium.

POULTRY WASTE DISPOSAL METHODS

The disposal of poultry carcasses presents significant environmental, biological, and financial problems for the poultry industry (Cai et al., 1994). Worldwide, there are several ways of disposing of poultry waste including burial, rendering, incineration, compositing, feed for livestock, fertilizer or source of energy. Each disposal option has advantages and disadvantages.

Malone (2004) estimated that in the United States (US), 40% of meat-type mortalities are composted, ~20% incinerated, ~20% rendered and ~20% buried. For layers, rendering and incineration are predominant and composting is the least used disposal option. In Botswana, spent hens are sold alive or are slaughtered for meat that is regarded as a delicacy. Malone (2005) and Council for Agricultural Science and Technology (CAST) (2008) identified mass disposal methods to include burial, landfills, incineration, composting, and rendering. The most predominant waste disposal methods in Botswana appear to be burial in the landfills, burning, incineration and use as a fertiliser in gardens and arable lands. A brief description of each disposal method is given in the sections below.

Application to arable lands

Poultry manure has long been recognized as perhaps the most desirable of all animal manures (fertilizers) because of its high nitrogen content (Sloan et al., 2003). As a result, direct land application of poultry litter from broiler operations is the most widely used and cost effective disposal method. Olexa and Goldfarb (2008) argued that if waste must be transported to a disposal site, it must be placed in sealed containers to prevent spillage. Globally, an excess of 90% poultry waste is spread on land close to the poultry farms (Moore et al., 1995). For some poultry producing regions, the spreading of poultry waste has become less cost effective mainly because of restrictions on land availability. Excess nitrogen and phosphorus have been noted in soils applied with poultry manure because of lack of soil analyses to determine the mineral content of the soil. Coote and Zwerman (1975) pointed out that the risk of nutrients, organic material, and pathogens contaminating water bodies and public water supplies will greatly increase if manure is spread adjacent to streams, waterways, and lakes.

Generally, soils in Botswana are poor in phosphorus; hence application of poultry manure or litter in the farm lands appears to be the most ideal method of disposal. A recent study of Dikinya and Mufwanzala (2010) in Botswana revealed that chicken manure is a potential source of nutrients and chemical conditioner. The investigators reported increased electrical conductivity together with exchangeable bases with increased application rates of chicken manure in all soil types, indicating positive effects on soils.

Manure can be applied directly to the soil or it can be pelleted before application. Pelleting manure converts a wet heterogeneous material which is difficult to apply on the land uniformly into a uniformed matter which is easy to handle and transport to areas where there are infertile soils to reduce the excess of nutrients in soils and water in poultry producing regions (Hamilton and Sims, 1995). Also, pelleting can allow for low quality manure to be fortified with inorganic fertilisers. Previous study of Roeper et al. (2005) reported that pelleting results in approximately 75% of the total nitrogen remaining in the pellets.

Poultry waste in livestock feeding

Poultry litter has been used in diets for poultry, swine, lambs, ewes, lactating cows, wintering cattle and brood cows. Poultry litter and/or manure are used as livestock feed in most countries (Smith and Wheeler, 1979) including Israel and some states in the US. Poultry waste used for animal feeding is obtained primarily from laying hens (caged and not caged) as well as broiler operations. Poultry litter is also used to feed livestock. Cage layer

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waste can be used by ruminants as a source of supplemental protein. Chaudhry et al. (1997) stated that amino acid nitrogen of cage layer waste ranges from 37 to 40% of total nitrogen and that about 40 to 60% of total nitrogen in poultry excreta is present in the form of non-protein nitrogen (NPN). Uric acid, the major NPN source in poultry is degraded to ammonia by rumen microbes.

According to National Research Council (NRC) (1984), the maximum inclusion rate for poultry waste in ruminant feeds is 20%. Crickenberger and Goode (1996) suggested that adding broiler litter to beef cattle rations at a level of 20% or higher (as fed basis) generally meets the animal's needs for crude protein, calcium and phosphorus. The investigators reported beneficial effects of feeding corn silage to which poultry litter has been added at a level of 30%. Furthermore, Muller (1980) observed that poultry waste fed at levels above 35% usually covers almost the total protein requirement of sheep, and contributes substantially to the energy of the total ration. The investigator noted that the only problem encountered in feeding processed poultry waste to sheep is the toxicity derived from the high copper level in poultry diets. Additionally, Chaudhry et al. (1997) argued that the danger of feeding poultry waste to livestock includes health hazards like pathogens and residues of pesticides. As a result, the investigators suggested that ensiling poultry waste, i.e. slaughterhouse wastes with molasses and lactobacilli improves NPN and reduces pathogens.

Dried poultry waste contains 28% protein and 30% ash and is also an excellent source of calcium, phosphorus, potassium, iron and zinc (NRC, 1984) which are useful in supplementation of sheep in winter. Jordon et al. (2002) measured body conditions of sheep fed dried poultry waste, soybean or urea as winter supplements and concluded that feeding a supplement containing dried poultry waste resulted in performance similar to that of conventional supplements containing soya bean meal. In Nigeria, Owen et al*.* (2008) investigated the nutrient quality of heat treated poultry litter and obtained dry matter (DM), crude protein, energy, crude fibre, ether extract and ash values of 87%, 20%, 621.41 kcal/kg, 10.40%, 2.2% and 18.50%, respectively. In addition, phosphorus, calcium, sodium, potassium and magnesium values in the litter were 4.50%, 2.00%, 0.10%, 2.05 and 0.48%, respectively. The investigators concluded that poultry litter could be incorporated into animal feeds.

In Botswana, the use of poultry waste as cattle feed is prohibited according to Statutory Instrument No. 126 (2004). This is because beef that is processed in the local export abattoirs is exported mainly to the EU, which prohibits the use of poultry waste as a feed ingredient for fear of transmission of Bovine Spongiform Encephalopathy (BSE). This is consistent with Olexa and Goldfarb (2008) from the University of Florida in the US who reported that animal feed that reuses poultry waste as an ingredient may not be fed to ruminant animals due to disease concerns. In addition, Statutory Instrument No. 126 (2004) prohibits application of fertilizers containing ruminant protein on pastures accessed by livestock (cattle, camels, equines, pigs, sheep and goats) and also to dispose of any substance including poultry waste in places where livestock has access to grazing. Although Makobo and Mosimanyana (1985) reported that Botswana does not use chicken litter for livestock feeding but occasionally as a fertilizer, poultry litter or manure has been used by some farmers as a feed resource prior to 2004, especially during the drought periods. In addition, mortality from some large-scale broiler operations is used as feed for the crocodile industry.

Burial

Besides burning and rendering, the carcasses of dead domestic animals may be disposed of by burial. The carcasses may not be disposed of by dumping on any public road or right-of-way left where they may be consumed by animals (Olexa and Goldfarb, 2008). According to Malone (2005), on-farm burial has been the predominant disposal option for many catastrophic mortality events such as avian influenza outbreaks. Anon (2005) mentioned that for mass disposal of certain production animals (poultry, swine, and calves) burial pits may be used if they are designed, constructed, maintained, and used in a manner to prevent the spread of diseases.

Burial is one of the simplest and most cost-effective methods employed to deal with many types of mass mortality losses. However, burial of dead birds in a pit can lead to ground water contamination (Cai et al., 1994) and public perception concerns if not properly managed. Payne mentioned that when proper guidelines are followed, burial is a safe option but that poor site selection, such as sandy soils or areas with high water tables, may pose a threat to groundwater.

Previous work (Payne) indicated that burial of mortality requires the construction of a pit, which must be located at least 91.44 m away from any wells, waters of the state, neighboring residences, public areas or property lines. The bottom of the burial pit must be at least 30.48 cm above any floodplain level and at least 60.96 cm above the seasonal-high water table. On the other hand, Anon (2005) indicated that mortality to be buried must be located more than 30.48 m away from any existing or proposed wells, water supply lines, or seasonable high water table of any water source, and 4.57 m horizontal away from the edge of any embankment. Additionally, burial sites must not be in areas with gullies, ravines, dry streambeds, natural or man-made drainage ways or sinkholes. Payne stated that if there is bedrock in the area, the bottom of the pit must be at least 60.96 cm above the bedrock. In addition, carcasses must be covered with a minimum of 76.2 cm of top soil after placement in the pit. Anon (2005) stated that mortality must be buried at least 0.91 m below ground level but no more than 2.44 m deep. Animals may be buried in mass burial pits or in approved landfills. The soil for a burial site must be of moderate or slow permeability and must be at least one 30.48 cm above the seasonal high groundwater elevation.

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Burning

This is one of the common methods of disposing of mortalities in Botswana, especially among small-scale farmers. In this disposal method, mortalities are fully burned at relatively high temperatures using fuels such as wood, tyres or diesel. However, this waste disposal method may lead to atmospheric pollution in the event of catastrophic mortalities resulting from outbreaks of highly infectious diseases such as Newcastle disease and avian influenza. Anon (2005) argued that burning is not a preferred method of disposal because of the resulting air pollutants.

According to Anon (2005), mass cremation of mortality should be performed in a flat area that is easily accessible to heavy vehicles for transporting the carcasses and away from public view. The site must be located away from buildings, public roads, and overhead electric and telephone lines, underground utility wires, and shallow underground pipes or gas lines.

Incineration

Incineration is recognized as one of the biologically safest methods of disposal, eliminating the threat of disease (Blake et al., 2008). Mortalities and condemned carcasses from the slaughter facilities are burned at high temperatures in a purpose-built incinerator, usually in the abattoirs. Incinerating poultry and small animals is biologically the safest disposal method. The residue from properly incinerated mortality is largely harmless and does not attract rodents or insects. Payne stated that incineration eliminates all pathogens but high operational costs and incineration's potential to contribute to air pollution (if not properly maintained and operated) decreases its usefulness for widespread use as a mortality carcass disposal option.

Malone (2005) argued that the incineration process is slow, loading decomposed carcass poses a problem and it will require disposal of 0.3 tonnes of ash per tonne of carcass. Without the proper sources of fuel and supervision of the process, smoke and odour can create nuisance complaints. Cai et al. (1994) observed that incineration is expensive and can potentially pollute the air. Therefore, this makes incineration not recommended for large-scale poultry operations that produce large amounts of mortalities but mainly for poultry slaughter facilities.

Compositing

Composting is a natural, biological process by which organic material is broken down and decomposed (Malone, 2004). It is also the manipulation of the natural aerobic process of biological decomposition of organic materials to increase the decomposition rate. This process is carried out by successive microbial populations which function under increasing temperatures to break down organic materials into carbon dioxide, water, minerals, and stabilized organic matter (Evanylo et al., 2009). Composting of waste is viewed as a viable means of reducing litter needs by recycling and reusing litter. Additionally, composting results in a product that is much more environmentally acceptable than raw litter for land application. It is a biological process in which organic wastes are stabilized and converted into a product to be used as a soil conditioner and organic fertilizer (Brake, 1992). According to Anon (2002), composting provides an inexpensive alternative for disposal of animal-based wastes and other biological residuals. Properly composted material is environmentally safe and a valuable soil amendment for growing certain crops.

The basic objective in composting is to maximize microbial activity at the expense of the waste material. To achieve this, maximum metabolic heat output by thermophilic bacteria must be attained (Drake, 1992). According to Malone (2005), microorganisms will rapidly compost carcasses in the presence of oxygen (>5%), moisture (40-60%), and a proper carbon to nitrogen ratio (20:1 to 35:1). This process produces carbon dioxide, water vapour, heat and compost. Under proper conditions, thermophilic organisms will cause the compost to heat to temperatures ranging from 57 to 63 °C. Evanylo et al. (2009) stated that mesophilic bacteria thrive at temperatures of 25° to 42 °C, but they can survive at higher temperatures. Mesophilic bacteria feed on the most readily available carbohydrates and proteins. Their metabolic activity raises the temperature of the windrow sufficiently to allow the takeover by thermophilic bacteria which perform best at temperatures ranging from 50° to 60 °C. If the temperature rises much above 66 °C, the majority of the bacterial population and many other living organisms will die. Anon (2002) stated that it takes 2 to 6 months for the animal to decompose.

The benefits of compositing are manifold. Compositing has the ability to reduce poultry litter, dispose of carcasses, stabilise trace minerals and reduce odours (Turnell et al., 2007; Bonhotal et al., 2008). Also, compositing can kill pathogens and help control disease outbreaks; it can be done any time of the year and can be done with equipment available on farms; hence it is economical (Bonhotal et al., 2008). The most efficient temperature range for composting is between 40 °C and 60 °C. However, compost pile temperatures are dependent on the amount of heat produced by the microorganisms that is lost through aeration or surface cooling. In the opinion of Turnell et al. (2007), the immobilisation of nitrogen and phosphorus during compositing reduces the risk of these nutrients entering the water systems. Imbeah (1998) stated that the decomposition process kills pathogens, converts ammonia nitrogen to organic nitrogen and reduces waste volume. Furthermore, compositing reduces the pathogenic organisms due to the high heat produced during the process of compositing. Das et al. (2002) reported that hatchery waste compositing reduces E. coli and salmonella by 99.9% and 100%, respectively.

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Composting of poultry litter offers a convenient and environmentally acceptable method of its disposal (Chaudhry et al., 2007).

The disadvantages of compositing are loss of some nutrients including nitrogen, the land area required for the compositing and odour problems (Glatz et al., 2011). A potential problem with compositing is the emission of greenhouse gases such as methane and nitrous oxide, which are efficient in absorbing infra-red radiation resulting in global warming and acid rain. Animal production contributes 7% of greenhouse emissions worldwide through the decomposition and degradation of manure (Hao et al., 2004).

Rendering

Rendering is a process of using high temperature and pressure to convert whole animal and poultry carcasses or their by-products with little or no value to a safe, nutritionally and economically valuable feed ingredient. It combines blending, cooking, pressurizing, fat melting, water evaporation, and microbial inactivation (CAST 2008). Rendering process cooks the product while killing pathogenic agents and converting the product into a value-added product which can be used as pet feed ingredients or livestock feed ingredients. Although rendering is an effective method, only few poultry operations in Botswana use it probably due to high operational costs. CAST (2008) argued that rendering is only feasible if there is a local rendering plant close enough for convenient pickup.

Rendered products are used in feed production. In India, Santhi et al. (2011) reported significantly ($P<0.05$) higher body weight, as well as, better feed conversion ratios in poults fed diets with 25% poultry waste carcass meal crude protein replacement compared with diets containing only fishmeal as a protein source. The investigators concluded that levels of poultry waste carcass meal replacing the crude protein from fishmeal up to 25% appeared acceptable based upon eighth week body weight and feed efficiency.

Other Waste Disposal Methods

Waste disposal methods presented in the sections below are currently not practised in Botswana but are likely to be employed in the future.

Conversion of poultry waste to energy

Poultry litter has been shown to be a viable, renewable biomass fuel. This conversion of poultry litter to energy furnace provides a high value alternative to land application and helps to control rising energy costs (Habetz and Echols, 2006).

Anaerobic digestion and direct combustion are technologies that can be used to convert poultry waste material to energy. Methane gas produced during anaerobic digestion can be gas cleaned and used as a renewable energy in households for cooking and heating (Collins et al., 2002). A recent study of Phanthavogs et al. (2011) in Laos Peoples Democratic Republic showed that biogas generated from pig manure reduced the amount of fuel wood and charcoal usage by 69.30% and 47.32%, respectively. Biogas production appears to be an attractive technology for Botswana given high energy costs, as well as, frequent power outages. Other benefits to using biogas include less odours and lower fly populations, as well as, reductions in greenhouse gas emissions (Phanthavongs et al., 2011).

Heat and electricity can be generated from manure combustion as renewable sources of energy. Habetz and Echols (2006) noted that because of the controlled combustion process, the resultant ash is converted to a concentrated fertilizer or fertilizer amendment, high in phosphorous, potassium, calcium, magnesium and other valuable micronutrients. However, concerns have been raised due to the gas emission into the air. As a consequence, it is necessary that technologies such as gas cleaning are employed to reduce the impact of these emissions.

Poultry litters from broiler chicken and turkey houses, as well as, bedding material can also be converted into biocrude oil in a fast pyrolysis fluidized bed reactor which is a source of renewable energy. The biocrude oil yield depends on the source, age and bedding material content of the litter. The hardwood shavings give a biocrude oil yield of 63%. The viscosity of the oils is a function of both the source of litter and the pyrolysis temperature (Agblevor et al., 2010).

Use of poultry waste for treatment of heavy metal contaminated water

Utilization of poultry litter as a precursor material to manufacture activated carbon for treating heavy metal-contaminated water is a value-added strategy for recycling the organic waste (Guo et al., 2010). Poultry litter-based activated carbon possesses a significantly higher adsorption affinity and capacity for heavy metals than commercial activated carbons derived from bituminous coal and coconut shell and does not pose secondary water contamination risks.

CONCLUSION

Direct disposal of poultry waste (mortality and abattoir condemnations) at the landfills, application on farm lands as a fertilizer, burning and compositing are the most commonly practised methods of poultry waste disposal in Botswana. These methods are challenged by issues of environmental pollution and restricted land to use. As Botswana is prone to droughts, it is probably high time that poultry manure and/or litter is considered as livestock

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feed in areas where FMD is endemic such as Chobe and North West Districts because beef from FMD zones is not exported to the European Union or sold outside the boarders of these districts.

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To cite this paper: Moreki, L.C. and Chiripasi, S.C. 2011. Poultry waste management in Bostwana: A review. *Online J. Anim. Feed Res.*, 1(6): 285-292.
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