BROILER LITTER DISPOSAL - A SUMMARY OF ADVANCES

J. TURNELL¹, R.D. FAULKNER¹ and S. MURRAY¹

Summary

The global poultry industry is undergoing many changes, one being the disposal of its broiler litter (BL) due to reduction in land available for cost effective disposal. To date, Australian BL disposal has been achieved by selling the litter as a fertiliser to agricultural sectors. Land availability has decreased due to encroaching urban development, legislative change, decreasing social acceptance, environmental quality issues, and increasing pathogen concerns. Alternative disposal options have developed significantly overseas and have shown potential to solve many of the issues facing BL disposal in Australia. Commercialisation of composting, vermiculture, anaerobic digestion and direct combustion for large scale BL disposal is still in its infancy for Australian conditions but has already been achieved overseas.

I. INTRODUCTION

Broiler production worldwide like other intensive animal systems generates a large amount of biomass including broiler litter (BL). Annually Australia produces approximately 1.6 million tons of BL. Application of BL directly onto land provides a convenient mechanism for disposal (Sharpe et al., 2004) and acts as both a fertiliser and soil addiment (Ribaudo et al., 2003). In excess of 90% of BL is spread on land usually located close to the grower (Vervoort and Keeler, 1999) negatively affecting biosecurity. However, for some poultry producing regions this practice is becoming less cost effective, due to restrictions on land available and costs associated with moving BL to appropriate land (Jackson et al., 2003; Ribaudo et al., 2003). In Australia these restriction will potentially increase due to encroaching urban development, legislative change, decreasing social acceptance, environmental quality issues (Nash and Halliwell, 1999), and increasing pathogen concerns.

Alternative BL disposal options include composting, vermiculture, anaerobic digestion and direct combustion. Research into the feasibility of these options to provide an alternative disposal mechanism for BL, has received increased interest from potential commercial operators. Currently growers in Australia sell BL, which is predominantly disposed of to land and covers the cost of buying new bedding. However, recently some growers in Queensland have had to pay a small fee for BL disposal (McTavish, K. 2004, personnel communication).

II. COMPOSTING

Composting can be defined as the aerobic microbial breakdown of organic matter and can immobilise nitrogen and phosphorus in organic wastes, reducing the risk of soluble P and N entering aquatic systems (Vervoort et al., 1998; Cooperband et al., 2002; Peigne and Girardin, 2004). Composting has been shown to significantly reduce pathogen concentrations in organic wastes due to the heat produced in the decomposition process (Das et al., 2002; Kelleher et al., 2002). Hatchery waste composting systems have reduce E. coli by 99.9%, whilst amending hatchery waste with small percentages of BL enabled the composting process to remove all Salmonella (Das et al., 2002).

¹ University of New England, Armidale NSW 2350
Trace elements are used by the poultry industry to improve broiler feed conversion ratios, including Cu, Zn and As. Composting BL under the right conditions can degrade arsenic in the 3-nitro-4-hydroxyphenylarsonic and 4-aminobenzenearsenic acid forms to more stable arsenate ions (AsO$_4^{3-}$), potentially limiting contamination of ground and surface waters with arsenicals (Garbarino et al., 2003; Jackson et al., 2003).

Methane (CH$_4$) and nitrous oxide (N$_2$O) are considered significant greenhouse gases due to their efficiency in absorbing infrared radiation, with CH$_4$ and N$_2$O absorbing 20 to 200 times more infrared radiation respectively than CO$_2$ (Sommer and Moller, 2000). Composted and surface applied animal manures have been shown to contribute to greenhouse gas emissions, and potentially contribute to global warming and compounds that contribute to acid rain (Hao et al., 2004; Peigne and Girardin, 2004; Sharpe et al., 2004). Nitrogen losses through NH$_3$ volatilisation during composting, reduces the agronomic value (Vervoort and Keeler, 1999; Kelleher et al., 2002; Tiquia and Tam, 2002). Commercialisation success of large scale composting in Australia will be determined by the agronomic value of the composted product.

III. VERMICULTURE

Vermiculture can be defined as the non-thermophilic biodegradation and stabilisation of organic materials, by interactions between earthworms and micro-organisms (Arancon et al., 2003). Vermiculture in Australia is receiving increasing attention for its ability to breakdown and value-add to organic wastes and produce worm protein (Edwards and Steele, 1997; Bajsa et al., 2003). Casts, vermicasts and vermi-composts are digested organic remains, mucus, and nitrogenous excretory substances, from the worm’s intestinal tract (Tripathi and Bhardwaj, 2003). Using a grinding gizzard, worms produce casts that have a much finer texture than either raw or composted wastes, increasing the commercial value due to its soil like texture and lack of unpleasant odour. The casts in comparison to their organic source have been shown to exhibit: more plant available N, P and K; greater organic carbon; lower C/N ratio; and increases in beneficial microbes, enzymes and hormones (Ndegwa and Thompson, 2000; Atiya et al., 2002; Arancon et al., 2003; Bajsa et al., 2003; Tripathi and Bhardwaj, 2003).

Vermiculture systems can be established at minimal costs anywhere in Australia (Smith et al., 1999) and can reduce the volume of organic waste by up to 45% (Ndegwa and Thompson, 2000). A vermiculture system using sewage sludge resulted in 4-fold reductions in pathogens that effect humans, and is considered a safer treatment than direct land application of sludge (Eastman et al., 2001; Bajsa et al., 2003). Trials in the USA have shown that the integration of thermophilic composting before vermiculture achieved almost complete pathogen removal (99.9%), without increasing costs in the vermiculture process (Ndegwa and Thompson, 2000). This level of reduction may not be representative of large commercial operations and no current experiments have determined likely reductions. The integration of vermiculture and aquaculture in India has shown that both casts and worm protein can be used as nutrient source for fish and provide benefits to water quality, reducing filtration and water replacement costs (Ghosh, 2004). Issues that will effect the feasibility of large scale vermiculture operations are variations in cast composition (Edwards and Steele, 1997), commercial agronomic value of casts, and the development of industries that use worm protein.
IV. ANAEROBIC DIGESTION

Anaerobic digestion degrades and stabilises organic materials such as BL, producing potentially saleable methane and digestate (Collins et al., 2000). Methane can be captured and used as a renewable energy source, while the digestate can be utilised as a soil improving agent, with good fertilizer attributes (Salminen and Rintala, 2002). BL has been shown to produce more methane than swine or cattle manure and the digestate has higher available nitrogen levels (Kelleher et al., 2002). Steam pressure exerted on BL before digestion has shown improvements in methane capture by reducing the shield effect of lignin by exposing cellulose for increased bacterial consumption (Liu et al., 2002).

While anaerobic digestion has many benefits, there are several limitations to its adoption. Commercialisation of anaerobic digestion requires the BL to be supplied free, or a tipping fee is introduced, or if the digestate can be marketed as an organic fertilizer (Collins et al., 2000). Extraction of gas does not significantly reduce volume of litter, hence the digestate must represent some economic value otherwise disposal will become an issue (PPRP, 2004). BL contains high concentrations of uric acid (Bujoczek et al., 2000) which during initial anaerobic decomposition stages, forms methanogenesis inhibiting ammonia ions. Excess ammonia ions significantly influence the success of using anaerobic digestion for BL disposal (Kelleher et al., 2002; Salminen and Rintala, 2002).

V. DIRECT COMBUSTION

Direct combustion is recognised as an efficient option for generating renewable energy from organic wastes including BL (Abelha et al., 2003). Currently successful large commercial electricity utilities are operating in the UK and are powered solely on BL (Anonymous, 2000). Combustion achieves seven fold reductions in BL volume and results in an odour free and sterile poultry litter ash, with easier marketability than BL (Codling et al., 2002). With advances in gas cleanup and combustion systems being designed and operated specifically for BL combustion, emissions from these systems have been shown to be well below the limits set by air quality standards (Henihan et al., 2002; Henihan et al., 2003).

Issues concerning the use of BL as a fuel include; availability, reliability, cost, transportation and aggregation (Abelha et al., 2003). Development issues include; electricity value, connection costs, future government policies on emissions and the expansion of existing renewable energy sectors (Kelleher et al., 2002). Public concerns have been raised over the emissions from the combustion of fuels like BL, these polluting emissions are considered a major non-economic determinant in the commercialisation DC (Porteous, 2002).

VI. RECOMMENDATIONS AND FUTURE RESEARCH

For these options to be successfully adopted by the poultry industry in Australia, they need to be economically viable, environmentally sustainable and socially acceptable. Currently the most economically viable option is vermiculture as it can be conducted on-site with no capital costs if a contractor is used. A trial with a broiler grower and contract vermiculture specialist is being developed for a Masters project for the Australian Poultry CRC. The trial will utilise all BL and dead birds over a 6 month period and all vermiculture products will be sold by the contractor on behalf of the grower.
REFERENCES


