Mitigation of large-scale organic waste damage incorporating a demonstration of a closed loop conversion of poultry waste to energy at the point of source

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Summary

A fluidised bed combustion unit was selected for the thermal treatment of poultry litter, with the aim of promoting the use of poultry litter as a renewable energy and thereby displacing the air pollution and emissions of greenhouse gases associated with non-renewable energy sources, which would otherwise be used to heat the poultry production unit.

The poultry litter was analysed to establish its fuel properties. It was characterised by high moisture (40%), ash (16%) and volatile content (37%) and relatively low fixed carbon content (8%). The high moisture and ash content were found to negatively impact on the heating value of the fuel, which was determined to be approximately 10 GJ/tonne. The elemental characterisation of poultry litter identified the potential for the generation of pollutants such as NOx, HCl and dioxin/furan formation, due to significant levels of nitrogen and chlorine.

To examine the feasibility of thermally treating poultry litter, it was necessary to establish the combustion behaviour of the fuel in an operational fluidised bed combustion unit. This investigation was conducted by the University of Limerick using bench scale and pilot scale experimental facilities at INETI (National Institute of Engineering and Industrial Technology), an energy research organisation based in Portugal. The combustion tests proved that the thermal treatment of poultry litter was a viable option, however, adequate fuel preparation to reduce the moisture content of the poultry litter to less than 25% was deemed necessary to allow for autogenous combustion. Optimum combustion conditions were obtained with adequate fluidising velocity and air staging with some degree of turbulence, which resulted in reduced CO and unburned hydrocarbons in the flue gas.

Air quality modelling analysis was conducted to evaluate the environmental impact of the combustion of poultry litter as the primary fuel at the designated farm in Raheenagh, Co. Limerick. The modelling was based on the emissions from the combustion trials undertaken using a pilot scale FBC unit at INETI, Portugal. In this study, the Cambridge Environmental Research Consultants (CERC) Atmospheric Dispersion Modelling System (ADMS) version 3 was used. For the combustion of poultry litter alone, the predicted annual averages for Nox (3.15 µg/m3), CO (208 µg/m3) and SO2 (8.54 µg/m3) did not exceed legislative and guideline thresholds.

The maximum predicted ground level concentrations for the set of emissions data suggested that the environmental impact of the proposed unit would be far less than the limits and guidelines set by air quality standards.

Once the feasibility of the project was established, the second phase of the program was to commission and test the fluidised bed with ancillary equipment and instrumentation and to optimise its use, primarily as a direct contributor to heating the production shed and as an aid in drying of stored litter. The principal difficulty encountered during the combustion trials was the agglomeration of bed material, due to the inherent high ash content and level of low melting compounds in the poultry litter. The use of silica sand also played a significant role in the formation of agglomerates, which impede fluidisation and therefore optimum combustion. In order to minimise or prevent the ash related problems, it was necessary for certain mitigating steps to be taken, such as, fuel preparation to reduce particle size, lowering the bed temperature below the initial sintering temperature (<800oC), and regular refreshment of the bed material before a critical ash-accumulation or agglomeration level was reached. The disposal of the ash generated from the combustion process was also examined through a series of leachate experiments. These results revealed that excessive temperatures and poor design of the combustion chamber resulted in contamination of the ash with chromium. Once the source of the problem was established, the ash was characterised as an inert material and was deemed not to pose a threat to the environment and therefore could be disposed of safely.

Due to the experimental nature of the program a number of problems were encountered with the initial operation of the combustion unit on-site, consequently several process alterations and modifications were necessary. Nonetheless, the fluidised bed combustor installed at the site is fully operational and the heat generated from the process is used to heat the poultry production shed.

The focus group raised potential difficulties with biosecurity and with ash disposal. It was suggested that transportation in airtight containers may provide a solution. However, this issue is currently under review by the department of agriculture, but it is believed that storage in a separate shed at least 50 m from the poultry house is the likely practicable solution.

Ideally, the nutrients would be returned to the soil from which the grain to feed the poultry is taken. Lands already saturated with nutrients from poultry litter are not likely to require the high phosphorous and potassium content of the ash in the medium term. However, the ash is similar to that from the Fibrowatt installations in the UK, where it is pelletised and sold at similar rates to comparable NPK fertilisers. Approximately 750,000 tonnes have been sold in the UK under the brand 'Fibrophos' to date (not generally available in Ireland). As an example, 0:22:12 was £90/tonne delivered in bulk as of 27 April 2007 (personal communication). The trace nutrients

appear to be a unique selling point for 'Fibrophos'. Other grades of Fibrophos include 0:15:15 and 0:11:22 and are achieved by mixing the fly ash with the bottom ash in different ratios to provide the desired ratio. The installation in Scotland employs a fluidised bed, which provides a slightly different mineral mix (Annex C). Pelletising is not essential, but does improve the transport and saleability of the product. It does add a cost and requires a significant initial investment.

An economic assessment was conducted to determine the economic feasibility of the installation and operation of the fluidised bed combustor. The aim was to provide as accurate a Cost-Benefit Analysis as information allowed for the alternative waste disposal system. From the assessment it was found that the economic success of the utilisation of a FBC for the disposal of poultry litter is significantly reliant on the marketability of the ash.

Nonetheless, the project was deemed to be an appropriate alternative to current waste disposal practices employed in West Limerick.

Recommendations

- The combustion unit should be fully equipped with online monitoring equipment to allow for continuous monitoring of the combustion process.

- Licensing should include a measurement of potential to produce chlorinated products in flue gas.

- Pelletisation of the litter should be evaluated, as it could enhance the combustion properties of the poultry litter. As poultry litter by nature is not a homogenous material it is difficult to achieve consistent feed rates with the current system (screw feed auger). Pelleting the litter could increase the energy density of the fuel, reduce the bio-security risk as the pellets are dehydrated reducing pathogenic bacteria. The durability/resilience during storage and combustion would have to be assessed.

- The potential value/use of the ash residue generated from the combustion process should be explored in more detail to establish potential uses, which include; in agriculture as a fertiliser and/or liming agent; as road aggregate; as cement blocks; and in the remediation of abandoned mines and brownfields.

- The use of alternative bed media in the combustion of biomass fuels should be examined to establish the full impact on agglomerate formation.

- An investigation should be carried out to establish the full impact of biomass combustion on the selection of construction material for the combustion unit.

- An EIA (Environmental Impact Assessment) should be conducted to establish to impact of the combustion facility on the local environment.

- The prospect of a centralised combustion facility should be examined, as it would allow for greater control of combustion parameters, the use of abatement technology and the possibility of generating green electricity.