

Poultry litter as an energy source

Crop growers have, for a long time, been aware that poultry litter is an energy source, but now there is interest for this poultry farming by-product from other energy consumers: people. A team of US researchers has a look into the issue of producing energy and bio-oil from this source.

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Chicken litter sampling.

When growing a 2 kg broiler you are left with approximately 1 kg of litter. So, if you know how much chicken your family consumes in a year, you can calculate your contribution to a pile of litter. A team of researchers from the Department of Biological and Agricultural Engineering of the University of Georgia in Athens, USA, try to make energy using this contribution of by-product. They are working on an ongoing USEPA funded project: "Energy and bio-oil production from poultry litter using fractionation and pyrolysis".

Chicken litter

Poultry litter or broiler litter is a waste resulting from a periodical cleanout to promote bird health and limit build-up of wet manure. Generally, a poultry house is cleaned to ground level after 4-8 flocks having growth cycles of 47-49 days. Poultry litter is a combination of manure, bedding materials, feathers and spilt feed. The new management practice of a partial cleanout is known as "de-caking". The "broiler cake" is litter that has become caked because of spilt water or high humidity. Cake is removed after the harvest of each flock using a "de-caking machine" that removes the cake and leaves the un-caked litter in the house.

Environmental impacts

The US poultry industry produces more than 50 billion tonnes of waste every year. Georgia ranks first in the US in the production of poultry and poultry products, supplying approximately 12% of US production. The abundance of poultry litter in the region led to consider different utilisation methods of poultry litter, which is primarily applied to land because it is an excellent source of organic fertilizer. One alternative use that is gaining momentum is to use poultry litter as an economical

source of energy. This energy is used either for space heating or power generation through combustion, gasification, co-firing and pyrolysis. When used in raw form, both the primary and secondary applications have adverse environmental effects. While poultry litter is an excellent source of organic nutrients for crop production, many farms produce more nutrients than the region or farm can use. This results in regional and farm level nutrient imbalances. The nutrient imbalances can cause severe problems of eutrofication in some watersheds. According to the Georgia Watershed Agricultural Non-point Source Pollution Assessment, approximately 39% of total phosphorus produced from animal waste could potentially be exported to the state's waterways. The report also stated that some 1,419 miles (2300km) of streams and 10,700 acres (4330 ha) of lakes in Georgia are not meeting their designated uses, primarily due to rural Non-point-source pollution. The EPA and state environmental agencies have tried to address this problem through nutrient management planning efforts.

Energy production options

Stringent regulations for land application of poultry litter have recently motivated scientists to study the potential use of poultry litter as an economical source of energy. In the US, it is estimated that using poultry litter as fuel could save 283 million gallons (1,287 litres) of LPG equivalent fossil fuel energy source. According to one study conducted in 2001, if poultry litter were used for fuel, almost every poultry farm would have surplus energy after meeting its own demand. Generally, a poultry farm with production capacity of 100-110,000 head per year will produce 125 dry tonnes of litter per year. If 100 tonnes of that litter is used in a 75% efficient gasifier it would produce the equivalent of 9,300

gallons (4,000 litres) of LPG, or \$10,000 in equivalent value. The value of the resulting 25 tonnes of ash (for fertilizer) would be \$1,250. The poultry grower only uses 6,000 gallons (27,280 litres) of LPG in a year, or 82 dry tonnes of litter.

Direct combustion, gasification and co-firing with coal and pyrolysis are the known options available for extracting energy from poultry litter. Heating the biomass with unlimited oxygen is called combustion. Gasification is a process of heating the biomass in limited oxygen. In pyrolysis oxygen is absent during the heating process. Every method has its own advantages and limitations.

During direct combustion, gasification and co-firing, problems like NOx and NH3 emissions arise. Also, high ash and moisture content need supporting fuel, and high volatiles cause corrosion of boilers. Both of these methods require storage of poultry litter. Long storage causes decomposition of litter resulting in reduced heating value. In general, broiler litter is a lower quality fuel than coal due to its high mineral and ash content.

What's new in this project?

A combined solution to raw utilisation of poultry litter lies in the process that involves screening of the poultry litter. According to own research conducted in 1990, a simple screening of poultry litter can concentrate the nitrogen in the fine fraction, which increases its value as fertilizer. The best option to utilise the remaining coarse fraction would be energy production with some improved technology, like pyrolysis. Fractionation would reduce the mineral content and increase the volatile yield during this process. Pyrolysis would result in three energy products: gases, bio-oil and char.

This energy production from poultry litter was achieved through following two objectives. In the first objective, the focus was on finding the optimum

"Let us remember that in the US alone, it is estimated that using poultry litter as fuel can save 283 million gallons (1,287 litres) of LPG equivalent fossil fuel energy source." We have potential and we need to figure out how we can use it.

conditions for producing high heating value and low ash content char from poultry litter. The litter was collected from three commercial farms and screened by using a 0.85 mm screen. The coarse fraction was pyrolysed at two heating rates and two peak temperatures. The higher heating value and ash content of the char were measured. Meanwhile, we also looked at the characteristics of the bio-oil produced. In the second objective, the most efficient mixture of char and coal for combustion within emission limits will be determined. Here, the results of the first objective will be used to produce char and then mix it with standard coal in five proportions. The output from this study will not only provide the optimum pyrolysis conditions for char production, but it will also promote poultry litter to develop some creative energy products.

The preliminary results

To obtain primary results, litter samples were collected from a poultry farm in Georgia. These litter samples were refrigerated at 2 - 4°C prior to testing. The samples were screened using Screen #20 and the sample sizes were reduced by using ASTM standard methods. The heating value was measured according to ASTM standards with a Bomb Calorimeter. The proximate analysis (ash, volatiles, fixed carbon and moisture content) was done by means of a Thermogravimetric Analyzer.

One key to evaluating the screening process is determining a standard shaking period. It was determined that for an 8 inch (20.3 cm) diameter and screen #20, the standard shaking period is 2 minutes when a 500 - 700g sample is placed on the top sieve. There are some clear visible differences among raw poultry, fine fraction and coarse fraction. Fine fraction is a powder-like appearance, whereas coarse fraction is wood pieces and feathers. Course fraction has a 7% higher heating value compared to fine fraction. We also noticed that the coarse fraction has 11% less ash compared to fine fraction. In addition to

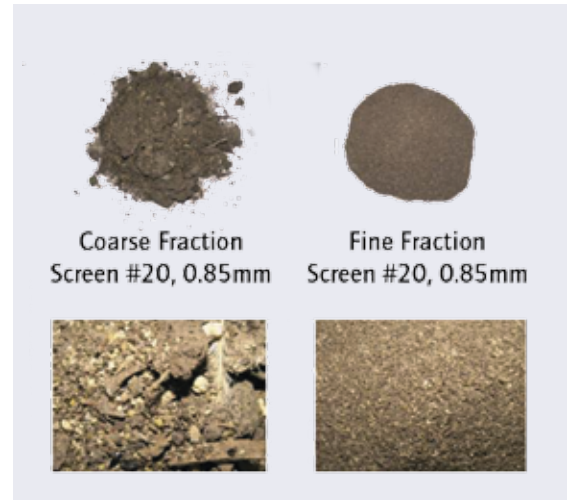
less ash, the coarse fraction has 3% higher volatiles compared to fine fraction. In future work we expect to answer the following questions:

1. Is fractionation useful?
2. Will pyrolysis be useful?
3. What is the optimum heating rate and peak temperature for producing good quality char?
4. What is the best char and coal mixture for combustion?
5. What are the emission levels resulting from combustion of char and coal mixture?

Potential impact

The state of Georgia has already taken the giant step in energy production from poultry litter. The electricity power plant, which is under construction at Franklin County, is the first in the state to use a gasification system to convert poultry litter into a useful product – electricity. When complete, the US\$20 million facility will generate enough energy annually to meet the needs of more than 15,000 homes. I see a bright future for turning waste into an economical source of energy. How can this research benefit such a facility? This power plant will store the litter for sometime, which may cause loss of BTU due to microbial decay. But, the pyrolysis process will conserve the energy in poultry litter in the form of char and bio-oil. The project also addresses several environmental concerns.

Utilisation of poultry litter is a serious concern for some agricultural operations (Solid Waste Management). If successful, the proposed study will also result in reduced impacts of nutrients and pathogens on water quality from the poultry farms (improved nutrient balance and reduction in excess land application), as well as on non-poultry farms that utilise the fertilizer pellets (slower release nutrient source that is less prone to runoff and leaching). The pelleting technology would reduce transportation costs and allow for improved nutrient distribution. Pyrolysis of the coarse fraction will result in the production of energy for



There were clear visible differences between coarse and fine fraction.

the pelleting process and yield a char that could serve as a coal replacement. The pyrolysis process will also conserve the energy in poultry litter in the form of char and bio-oil. Storing raw poultry litter for long period of time causes loss of BTUs due to microbial decay. This is replacing non-renewable energy sources with a more sustainable supply.

Experimental project

The project provides an innovative multi-media approach specifically addressing waste/energy applications to meet regional goals on waste reduction, and pollution prevention and innovation. Working with the agricultural sector, long term collaborative success would also yield progress towards healthier outdoor air, protection of water quality, restoration and protection of ecosystems, as well as compliance assistance. These secondary goals will be met by establishing commercial facilities throughout the southeast that will utilise poultry litter to produce pelleted fertilizer and char for energy production.

Development of an economical and energy efficient pelleting process for poultry litter using fractionation and pyrolysis would have a direct impact on management of poultry litter, which would indirectly reduce the phosphorous loading into the state water bodies. The development of a cheap source of energy from poultry litter would provide a cleaner source of energy, which would contribute to the state's ability to grow in an economically and environmentally sustainable manner. ■