Poultry Litter Biochar – a US Perspective

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This paper outlines the specific characteristics of poultry litter (PL) biochar based on existing research and literature, a limited number of demonstration projects in the US, and the potential market opportunities for this type of biochar. It highlights the general characteristics of PL biochar, the benefits of PL biochar production, the challenges for farmers, the uses for PL biochar (outside a soil amendment), and the alternative uses for poultry litter.

Biochar

Biochar is a solid material obtained from the carbonisation of biomass and may be added to soils with the intention to improve soil functions and to reduce greenhouse gas (GHG) emissions from the decomposition of biomass. Biochar is produced from intentionally heating a biomass feedstock via pyrolysis or gasification, typically in an oxygen limited environment, with the goal of creating a stable, carbon-rich product resistant to degradation in soils.

Biochar is actually a spectrum of materials with certain characteristics, depending on how it is produced, and the feedstock that is used. Various agricultural waste products can be converted into biochar including forestry, crop waste, and animal manures. The choice of feedstock significantly impacts the biochar product and its uses. Specific production parameters (including temperature, residence time, rate of temperature increase, pre- and post-processing, among others) also affect the resulting attributes and quality of the biochar, and can impact the nutrient availability to crops, the physical and chemical properties of the biochar, and the amount of stable carbon sequestered. Depending on the production parameters, more than 50% of the organic material's carbon may be sequestered in a stable form in the biochar. When the biochar is used as a soil amendment, a significant proportion of the recalcitrant biochar carbon can resist degradation for hundreds to even thousands of years, thus creating stable carbon pools.

Other significant benefits of biochar include improved soil fertility, crop productivity, water retention in certain types of soils, the reduced need for additional fertilizer usage, and reduced nutrient leaching. In addition, bio-fuels and process heat can be created during the production process.

Poultry Litter Biochar

Poultry farming is a high volume enterprise in a number of areas throughout the U.S. Concentrated poultry farms produce large amounts of poultry litter, which can create waste management challenges.

At this time, more litter is being produced than the industry is able to utilize effectively. Currently, the primary use of poultry litter in the US is as fertilizer for pasture, hay, small grains, and corn-producing fields (Atul and English, 2005). Additional strategies to effectively deal with this waste product currently exist, however poultry litter biochar offers a number of unique benefits.

Poultry Litter (PL) biochar is made from chicken manure and the bedding used in poultry operations—wood shavings, saw dust, straw or other organic materials—as well as feathers, feed spillage and mortalities. Some characteristics of PL biochar that differ from plant-based biochars include:

- Higher nutrient content, especially nitrogen and phosphorous (Van Zwieten, 2009). Although the amount of Nitrogen (N) conserved after pyrolysis is lower for PL versus other feedstocks, the high initial nutrient content ensures that the resultant amount is still significantly higher overall. (Gaskin et al, 2008).
- Higher cation-exchange capacity (CEC) with lower temperature pyrolysis. A recent study on CEC and PL biochar showed a significantly higher CEC in low temperature (400 degrees C) poultry litter biochar than in peanut hull and pine chip biochars at the same temperature (Gaskin et al, 2008).
- Significantly greater ability to adsorb and sequester metal ions (for cleaning mine-tailings and other toxic sites) over plant-based biochars (Lima et al 2009).
- Higher ash content which is useful particularly for low pH soils as a liming agent; a study by Das et al 2008 highlighted PL biochar with an ash content of 26% versus ash content of approx 2% from pine chip derived biochar.
- Correspondingly, the pine chip biochar from the Das et al 2008 study contained 84% carbon whereas the PL biochar contained 62%.

<u>Benefits of PL Biochar Production</u>

The production of biochar from poultry litter offers many potential benefits to farmers—especially if that production occurs onsite. Specific benefits to the producer/farmer may include:

- Reduced heating fuel requirements due to excess heat from the biochar production process (pyrolysis or gasification); heat from the unit may be used directly onsite to heat bird houses and other production/processing facilities.
- Reduced cost to dispose of poultry litter (applicable in areas of highly concentrated poultry operations where nutrient overload is causing environmental hazards such as the Chesapeake Bay; see Covell et al 2011).
- Reduced nutrient run off from alternative uses such as direct land application. PL biochar, especially when mixed with compost prior to field application, can help retain nutrients in the soil which might otherwise be lost (Steiner et al, 2010).
- Potential to use the biochar onsite for increased crop productivity, and/or mixed with poultry litter compost to reduce nitrogen loss (Steiner et al, 2010).
- Potential for added income from selling biochar to a local market or a distributer. Currently some US poultry farmers are able to trade their poultry litter to those involved in pelletization for litter disposal services but do not earn any additional income.

- Reduced liability related to pollution when farmers retain poultry litter for extended periods (e.g. they have too much of it and cannot dispose of it in a timely manner).

Challenges for Farmers in Producing Poultry Litter Biochar

- Connecting biochar product/producers to under-developed biochar markets.
- Consistent moisture content: a biochar feedstock should optimally be in range of 0% – 35% moisture; poultry litter with a higher moisture content would normally require drying prior to pyrolysis or gasification.
- Competing with alternative uses for the product which may not have the initial production costs of biochar.
- Loss of N with pyrolysis; however, studies have shown that if biochar is added to poultry litter compost, the biochar can reduce Nitrogen losses (Steiner et al, 2010).
- Capital investment required by the farmer for an onsite pyrolysis processing facility or for transportation to an offsite processing facility.
- Biochar production can distract from the core business of the farmer/producer.
- The onus to meet local/regional air emissions requirements, and any work place health and safety requirements associated with the biochar production process is on the farmer.
- With biochar as the intended end use, farmers may have to limit or omit use of food additives that can be passed into the manure and concentrated in the biochar (e.g. arsenic).
- May limit the farmer's source of bedding material as the pyrolysis process may not be designed to process all feedstocks.

Uses for PL Biochar other than as a Soil Amendment

Biochar is generally defined and understood as a product intended to be added to soils as an amendment. Some uses as highlighted below may utilize biochar for a similar purpose, while others such as bio-filtration and as an activated carbon substitute may not intend necessarily for the product to be added to soils.

Storm Water Treatment: Although some other feedstocks appear to provide stronger water retention capabilities, PL biochar binds certain toxic chemicals such as copper, cadmium and zinc (Comis, 2010). The combination of both of these benefits makes PL biochar an attractive solution for storm water treatment areas which are becoming mandatory in many areas around the country to improve water quality and ease the burden on public water treatment systems.

Reforestation efforts on reclaimed mined lands: Significant numbers of former mines were abandoned once the target minerals were extracted, leaving behind damaged landscapes, contaminated waterways and reduced biodiversity. Research on the use of biochar as a lower-cost, higher impact remediation technique has been done in both Colorado (Hansen, 2011) and West Virginia (WVU Environmental Research Center, 2011 and Todd et al, 2010), and additional research is underway domestically and internationally. Given that PL biochar is higher in certain nutrients and that it has strong filtration and binding characteristics, PL biochar may be a strong contender for remediation projects around the country.

Reduction of nitrogen loss in poultry litter compost: Poultry litter compost is often used as a natural fertilizer due to high levels of Phosphorous (P), Potassium (K), N and other micronutrients. During the composting process significant amounts of N can be lost. However research has shown (Steiner et al, 2010) that when combined with biochar the loss is reduced by up to 52% and ammonia emissions reduced up to 64% using an 80/20 poultry litter/biochar mix. This testing was done with non-PL biochar (made from pine chips) so results may vary. The ability to combine poultry litter with PL biochar offers reduced transportation advantages as the mixing can be done at a single location.

Livestock Operation Bio-filtration - odor abatement & removal of air pollutants: Large scale animal production facilities can emit significant amounts of air pollutants and strong odors. Tests done by the USDA Agricultural Research Service (ARS) and Western Kentucky University demonstrated that a combination of PL biochar and poultry litter were effective in reducing ammonia emissions by more than 90%—highlighting that biochar could be used to reduce ammonia emissions in livestock production facilities (Lovanh et al, 2010).

Tradable asset for nutrient trading programs: At least one major area of the U.S. has a growing nutrient trading program aimed at curbing excess nutrients which are impacting important bodies of water. The Chesapeake Bay nutrient trading program which currently spans parts of Virginia and Pennsylvania, Maryland and West Virginia is focused on reducing N and P. This trading program is similar to a GHG cap & trade system. Heavy generators of N and P such as wastewater treatment plants with large emissions must purchase offsets from qualified nutrient sellers such as farmers that implement certain conservation measures that reduce nutrient loads.

Activated Carbon Substitute: Similar to the market for storm water treatment and rain gardens, a growing market exists for the functions served by activated carbon (AC). It is anticipated that US regulations may be passed in the short term related to reducing mercury emissions from coal fired plants as well as limitations on releases of ammonia. Should these types of regulations pass, the market for AC could be very large. PL biochar has been found to be more effective than other feedstocks used to create activated carbon (e.g. coal, coconut shells), is generally cheaper to produce (Lima, Coble, Klasson, & Uchimiya 2010), and is a renewable alternative with large supplies in various regions throughout the US.

The USDA has patented a process for creating AC from poultry litter using slow pyrolysis followed by acid washing (Lima, Marshall 2009). The post-processing (acid wash) step increases the surface area of the biochar and neutralizes the high calcium and phosphorus found in PL biochar. The USDA has an interest in licensing the patent for commercial use.

<u>Alternative uses for Poultry Litter</u>

Existing uses for poultry litter include land application, pelletization, compost and litter-to-energy. A brief look at each of these uses including some of their limitations is provided below.

- Land application is the most common use of PL by farmers (Dunkley et al, 2011). However issues of over-application, especially in watershed areas, are beginning to be regulated.
- Composting is perhaps the most similar to PL biochar in terms of soil amendment benefits, although producing PL compost can take much longer and depending on the composting process used, could be more labor intensive. Additionally, methane emissions from composting, coupled with biochar's longer term soil benefits and stable carbon sequestration, may make biochar production a more attractive option. Producing biochar from poultry litter will reduce

the material mass—the same amount of poultry litter in biochar form will weigh much less than in compost form—therefore the transportation footprint is smaller. However, the transport of biochar may be classified as a dangerous good due to possible ignition issues, making transport potentially more expensive. On a large scale, PL biochar production requires a larger capital investment compared to composting. On the plus side, PL biochar production produces significantly less odor than composting and provides better bio-security as pyrolysis neutralizes pathogens (especially with mortalities).

- If the manure is pelletized, the litter is dried and pasteurized to create pellets and granular fertilizer. Generally farmers are provided with clean out and hauling services in exchange for their litter but typically make little income on the litter.
- The use of poultry litter for electricity generation faces significant challenges due to poor environmental/air quality track records of some companies that have been cited and fined for excess nitrogen oxide, sulfur dioxide and carbon monoxide emissions (Minnesota Pollution Control Agency, 2009). Large scale poultry litter biochar production may face regulatory challenges due to this.
- The technology for producing heat for poultry houses from woody biomass is more advanced with fewer technical issues than PL biochar gasifiers. Where woody biomass is easily available, it may be more economic to compost wood-based biochar with the PL to make a carbon and nutrient-rich compost for sale, while using the process heat to warm the poultry houses.

There are a few, but a growing number of farming operations in the US that are using poultry litter for biochar production. As more information is known about the benefits and costs of using this feedstock to produce biochar, farmers will have a better sense of whether or not PL biochar will be a good investment for them.

IBI recently engaged in a process to produce specification guidelines for characterizing biochar entitled *The Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil*. IBI began the process of establishing the *Biochar Standards* in May 2009 as a critical first step for the commercialization of sustainable biochar systems. The *Biochar Standards* provide the tools needed to universally and consistently define what biochar is, and to confirm that a product intended for sale or use as biochar possesses the necessary characteristics for safe use. Work is ongoing to develop methods to match different types of biochar to soils to study how PL biochars will react to local soils. For more information on the *Biochar Standards* please see:
http://www.biochar-international.org/characterizationstandard.

References:

Agblevor, Foster A, D. Grysko, K. Revelle (Oct. 11, 2010). Pyrolysis Technology: Environmentally friendly solution to nutrient management in the Chesapeake Bay. Presentation at Chesapeake Goal Line 2025 Presentation, Hunt Valley, MD.

Comis, Don (2010), Better Ballfields and Rain Gardens Start Below the Surface. Agricultural Research Magazine. November/December 2010 - Vol. 58, No. 10.

Phil Covell, Gena Gammie, Suzanne Hunt, Lopa Brunjes, Fai Ng, Dan Nees (2011). Advancing Biochar in the Chesapeake: A Strategy to Reduce Pollution from Poultry Litter. Forest Trends/Katoomba Incubator, Carbon War Room, Forest Trends/Chesapeake Fund. Available at: http://www.forest-trends.org/publication_details.php?publicationID=2891.

Das, K. C., Garcia-Perez M., Bibens B., and Melear N. (2008). Slow pyrolysis of poultry litter and pine woody biomass: Impact of chars and bio-oils on microbial growth. Journal of Environmental Science and Health Part A-Toxic/hazardous Substances & Environmental Engineering, Volume 43(7), p.714-724.

Dunkley, Claudia S., Cunningham, Dan L., Harris, Glendon H. (2011). The Value of Poultry Litter in South Georgia. University of Georgia.

Gaskin, J. W., Steiner C., Harris K., Das K. C., and Bibens B. (2008). Effect of low-temperature pyrolysis conditions on biochar for agricultural use. Transactions of the Asabe. Volume 51(6), p.2061-2069.

Hansen, Heather. New hope for old mines. High Country News. January 12, 2011; at: http://www.hcn.org/blogs/range/new-hope-for-old-mines.

Lima, Isabel, Akwasi A. Boateng, and K. Thomas Klasson (2009). Pyrolysis of Broiler Manure: Char and Product Gas Characterization. Ind. Eng. Chem. Res. 2009, 48, 1292–1297.

Lima, Isabel, Marshall, Wayne E. (2009). US Patent # 7,524,795. Found at: http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=7,524,795.PN.&OS=PN/7,524,795&RS=PN/7,524,795

Lima, Isabel, Coble, Christina, Klasson, K.T. & Uchimiya, Minori (2010). Effect of nitrogen flow rate on the physico-chemical and adsorptive properties of a broiler manure bio-char. Conference presentation at USBI, Ames, IA.

Lovanh, N.C., Loughrin, J.H., Sistani, K.R. (2010). Abiotic and Biotic Effect of Poultry Litter Biochar on Ammonia Removal. Conference abstract at USBI, Ames, IA.

Minnesota Pollution Control Agency (2009). Fibrominn Power Plant Cited for Alleged Air Emissions Violations. Press Release Sunday, December 20, 2009.

Sheth, Atul C. and Jennifer English (2005). Preliminary Economic Analysis of Poultry Litter Gasification Option with a Simple Transportation Model. Journal of Air and Waste Management. Volume 55. Pages 510 – 522.

Steiner, Christoph, Das K. C., Melear Nathan, and Lakly Donald (2010). Reducing Nitrogen Loss during Poultry Litter Composting Using Biochar. Journal of Environmental Quality, 02/2010, Volume 39.

Todd, John, Samir Doshi, Anthony McInnis (2010). Beyond coal: A resilient new economy for Appalachia. Solutions. Volume 1: Issue 4: Page 45-52.

Van Zwieten, Lukas (2009). Agro-economic valuation of biochar using field-derived data. Conference presentation at Asia Pacific Biochar, May 2009, Gold Coast Australia.

WVU Environmental Research Center (2011). Turning Poultry Litter into a Stewardship Asset. WVU Environmental Research Center Winter 2011 Newsletter. Issue 2; at: http://erc.davis.wvu.edu/news/current_newsletter/biochar.