Report
Biomass to Biochar for Farm Bioeconomy

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Report on Biomass to Biochar

Introduction

There were four biochar's produced from four different feedstock, namely rushes (*Juncus effuses*), bracken (*Pteridium*), hazel (*Corylus*) and gorse(*Ulex*). The rushes were produced at a temperature of 380C and residence time of 7.30 minutes, the bracken was produced at a temperature of 380 to 420C and residence time of 8 minutes, the hazel was produced at a temperature of 360 to 430 and residence time of 12 minutes. All three of these biochar's were produced using a mobile pyrolysis unit. Lastly biochar was made using the Kon tiki machine and no information is available on temperature or residence time. (Information on Kon tiki process is available on Biochar from "Kon Tiki" flame curtain and other kilns – PLOS https://journals.plos.org › plos one).

All the biochar's were very well made and of very good quality as evidenced by physical, chemical, and other properties. They have moderate to high specific surface area (BET) and were very stable as evidenced by H/C org molar ratio. (Table 1) They had very low levels of heavy metals. Organic contaminants were also very low. Organic carbon was moderate to very high. Taking the properties on board we will make a judgement call for its usage.

Table 1, Properties of Biochar's made from 4 feedstocks

Parameters	Gorse	Hazel	Bracken	Rushes
Bulk Density g/L	139	112	90	44
BET m2/g	399	266	71.2	92.6
WHC	223	277	392.4	570
Org.C %	92.3	79.2	77	65.5
Salt g/L	0.426	0.640	2.21	3.56
Heavy metals [1]	Very low	Very low	Very Low	Very low
P_2O_5 g/kg	1.4	4.9	5.1	16.5
K_2O g/kg	3.5	6.9	39.6	54.7
CaO g/kg	7.2	50.4	9.1	16
MgO g/kg	2.9	4.5	5	11.7
Na g/kg	1.4	3.2	3.7	14.7
H/C org.	0.17	0.36	0.38	0.31
Total N g/kg	0.94	1.29	2.03	1.78
Carbonate g/kg	1.4	3.8	0.7	2.0
B mg/kg	22	4.3	24	27
Mn mg/kg	72	221	995	7806

Organic Pollutants [2]	Very low	Very Low	Very low	Very low

1, 2 actual figures are available for heavy metals and organic pollutants on the Biomass to Biochar web sites, https://www.biomasstobiochar.ie

Potential Uses

1. Peat replacement (as a component of a growing media)

Based on the data, only two biochars may be suitable for use as a component of a growing media. The low Electrical Conductivity as evidenced by low salt levels and high surface area are important to their use a component of growing media and biochar made from gorse and hazel meet these requirements. Biochar made from bracken and rushes had very high levels of salt and also in case of rushes contain excessive levels of Manganese which can negatively affect plant growth. Waterlogging leads to anaerobiosis and reduction of certain mineral ions, in these circumstances high levels of iron and manganese in the reduced (available) state may build up, (Chinnery and Harding,1980)

The water holding capacity of the fraction < 2mm follows in the order Rushes>Bracken>Hazel>Gorse. But the water holding capacity could possibly be increased by grinding the materia**l.** Unfortunately data on particle size data of the biochars is not available.

2. **Use as a Biochar addition to slurry during storage and potential slurry application on the land to reduce GHG emissions**

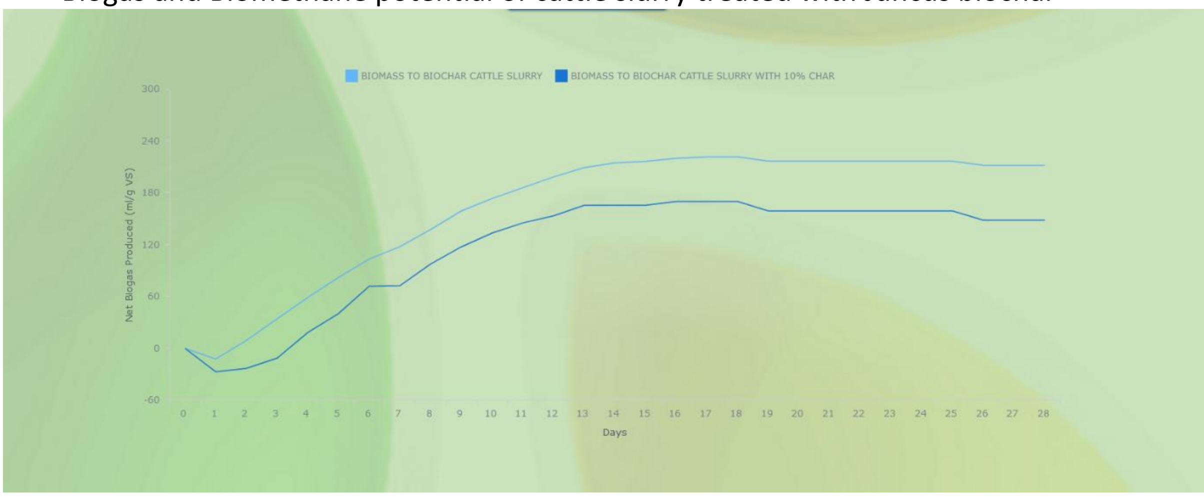
The high specific surface area should reduce methane and ammonia emissions from slurry as is generally the case. This has been proven from our studies where methane emissions is reduced by about 20%. Most of methane reduction occurs in the initial 12 to 14 days and then reaches a study rate with most of the reduction occurs 3 to 11 days. (Table 2)

There is an increase in CO2 emission as a result of biochar addition but it is not as important as methane is about 20 more damaging than CO2. This biochar was made from Rushes which according to our data did not have very high specific surface area. One can assume one would get even better reduction of methane with materials with higher specific surface area. It was not possible to study the effect of biochar addition on ammonia emissions in this study as ammonia levels were not present in the slurry used in this trial. Looking at other publications significant reduction of ammonia emissions were found (Raj Baral et al., 2022) A reduction of ammonia emission of around 21% was realised when biochar was added to cattle slurry. It would be interesting to see if the specific surface area was related to methane emissions and look at reduction of ammonia emissions from cattle slurry using these biochar's. One can only assume that some of biochars used in this study would reduce methane *and* ammonia emissions. It should, however be noted that there are unpublished reports which shows addition of biochar actually increased methane emissions in an Anaerobic Digestion situation.

Table 2, Effect of addition of Biochar(Rushes) to cattle Slurry on Biogas, Biomethane, CH4 and CO2

Treatment	Biogas Production L/KG (Dry Mass)	Biomethane Potential L/KG (Dry Mass)	CH_4 (%)	CO_2(%)
Cattle Slurry	172.2	143.5	83.4	16.6
Cattle Slurry+10%Biochar	119.2	82.8	69.5	30.5

Biogas and Biomethane potential of cattle slurry treated with Juncus biochar



3. Use as a source for energy generation (Combustion and Anaerobic Digestion)

Two biochar's based on rushes and wood from hazel were assessed either as a potential source of energy using combustion or as a feedstock for Anaerobic digestion to produce biogas. In the relation to the former the net calorific value of both materials was not high, 17.88 for Rushes and 18.95 for Hazel woodchips. These values are similar to most common wood wastes from wood industry e.g., Sawdust. Thus, this does not present a great benefit.

The use of rushes and hazel as a feedstock for the AD process based on data available does not appear to be promising either based on their Stoichiometric Methane potential based on the methane to Carbon dioxide ratio. Ideally this ratio should be 80:20. The ratio of both these materials is around 50:50. (Table 3)

Table 3. Stoichiometric Methane Potential of two biochar's (Volatile Solids Basis (L per kg VS))

Feedstock	Biogas	Methane	CO_2	% Methane
Rushes	939	488	451	52.0
Hazel woodchips	956	488	468	51.1

4. Use as Organic Fertilizer and Soil Amendment

The plant nutrient are very low levels except for K content in the biochar from rushes. Even here the K content is less than 0.5%. Mineral K fertilizer contain at least 40% K. Hence these biochar's are not suitable as organic fertilizer. It is generally accepted that application of biochar to soils can reduce nitrate leaching and nitrate run-off by locking up nitrate. As a compost additive, biochar improves composting performance, humification process, enhances microbial diversity and activity, reduces greenhouse gas emissions, and immobilizes potentially toxic metals (PTMs) and organic pollutants associated with the compost (Guo et al., 2020).

As a soil amendment the generally high specific surface area would indicate that it has high porosity thus it could improve the water holding capacity of sandy soils. The high Fixed Carbon and low C org/H ratio of biochar would indicate high stability and lead to carbon sequestration.

5. Another possibility could be the use for poultry bedding

One can speculate other usage of these biochar. One would be its use as a bedding material for poultry. It has been found that when biochar is mixed with a standard bedding material e.g., woodchips, the ammonia levels in the air are reduced. In addition, poultry can ingest some of the biochar which leads to a reduction of ammonium levels in the poultry droppings. One can also speculate that the poultry with biochar added in bedding would be healthier. The low levels of organic contaminants and heavy metal makes this biochar particularly attractive for this use.

6. Use of biochar for Animal Feed

Another possibility could be used as an ingredient of animal feed for cattle. There are reports that cattle fed with low quantities of biochar belch less methane, a GHG and the quality of the milk is improved. The fact that the four biochar's have such low organic contaminants and very low heavy metal content, the danger to the animals ingesting would be very little from these additions. For this use the processing has to be of a very high standard and tightly controlled particularly as regards hygiene.

Some Useful References;

H-P Schmidt et al., 2021.

Biochar in Agriculture: A Systemic Review of 26 Global Meta analysis

CCB Bioenergy 13:1708-1730.

H-P Schmidt et al.,

The use of Biochar in animal farming, Peer J 7373 1-54.

Huang, L., and Gu, M. (2019).

Effects of Biochar on container substrate properties and growth of plants-A Review. Horticulture *5* (*14*), 1–25
https://doi.org/10.3390/horticulturae5010014

M. Prasad and N. Tzatzikis, 2021

Critical review of chemical properties of biochar as a component of growing media.

Acta Hortic. 1317. ISHS 2021. DOI 10.17660/ActaHortic.2021.1317.14 Proc. II Int. Symp. on Growing Media, Soilless Cultivation, and Compost Utilization in Hort.

Khagendra Raj Baral *, John McIlroy, Gary Lyons, Chris Johnston,2022.

The effect of biochar and acid activated biochar on ammonia emissions during manure storage Environmental Pollution
https://doi.org/10.1016/j.envpol.2022.120815

X Guo, H Liu, J Zhang 2020

The role of biochar in organic waste composting and soil improvement: A review. - Waste Management, - Elsevier

LE Chinnery, CP Harding 1980

The Effect of Ferrous Iron on the Uptake of Manganese by *Juncus effusus* L.
- Annals of Botany, 1980 - academic.oup.com