

CHAR CHARACTERIZATION OF THERMOCHEMICAL TREATED KENTUCKY BLUEGRASS SEED SCREENINGS

S.M. Griffith and G.M. Banowetz

The on-farm production of bioenergy from straw and seed screenings and the recycling of the char from the combustion process serve as an alternative effective and efficient means of making wise-use of readily available agriculturally produced on-farm byproducts while simultaneously improving farm net profit, conserving net energy consumption, and more importantly, directly contributing to greater agricultural sustainability. Energy and char produced from on-farm gasification systems, using crop residue aftermath from a crop not specifically grown for the sole purpose of energy use, has significant merit with regard to influencing farm sustainability, curbing escalating production costs, and facilitating distributed networks.

Char produced from the gasification of post-seed harvest Kentucky bluegrass residues could be recycled to a cropping system as a soil amendment if chemical characterization determined that the gasification process had not produced or concentrated deleterious chemical or physical factors that might harm the environment, crop growth or yield. Previous reports have shown that char derived from the pyrolysis of a variety of biomass feedstocks has potential to enhance soil quality by pH adjustment, mineral amendment, and improved soil porosity.

Successful application of char as a soil amendment will almost certainly require a chemical characterization as part of the permitting process required by most localities. In general, chemical characterization for permitting processes addresses the potential for negative impacts of land application due to the presence of possible heavy metals or organic contaminants in the char. Relatively few published studies have quantified the heavy metals along with the secondary organic contaminants in gasification char produced at temperatures less than 700°C, particularly in units like those designed for small-scale implementation (Boateng et al., 2007).

The objective of this research was to characterize char produced from Kentucky bluegrass (*Poa pratensis* L.) seed mill screenings (KBss) by a small-scale gasification unit operated at temperatures between 600 to 650°C with respect to polyaromatic hydrocarbons (PAHs) and selected heavy metals as well as other physical and chemical characteristics and determine its suitability for agricultural application as a soil amendment.

Our findings, shown in Tables 1 through 5, support the hypothesis that char produced by thermochemical treatment of Kentucky bluegrass seed screenings could be applied in a cropping system without toxic environmental consequences and possibly serve multiple purposes, such as: recycling critical plant macro- and micro-nutrients back to existing cropland, enhance soil carbon sequestration, raise soil pH of acid soils (pH 10-10.5), and improve water holding capacity (fine particle size, 85% of total between 125-500 µm). Crop field trials need to be implemented to further test these hypotheses.

References

- Banowetz, G.M., El-Nashaar, H.M., Steiner, J.J., Gady, D.R. 2010. Non-densified biomass gasification method and apparatus. U.S. patent application No.12/687,639.
- Banowetz, G.M., Griffith, S.M., El-Nashaar, H.M. 2009. Mineral content of grasses grown for seed in low rainfall areas of the Pacific Northwest and analysis of ash from gasification of bluegrass (*Poa pratensis* L.) straw. *Energy Fuels* 23:502-506.
- Banowetz, G.M., Griffith, S.M., Steiner, J.J., El-Nashaar, H.M. 2009. Mineral accumulation by perennial grasses in a high-rainfall environment. *Energy Fuels* 23:984-988.
- El-Nashaar, H.M., Banowetz, G.M., Griffith, S.M., Casler, M.D., Vogel, K.P. 2009. Genotypic variability in mineral composition of switchgrass. *Bioresour. Technol.* 100:1809-1814.
- El-Nashaar, H.M., Griffith, S.M., Steiner, J.J., Banowetz, G.M. 2009. Mineral concentration in selected native temperate grasses with potential use as biofuel feedstock. *Bioresour. Technol.* 100:3526-3531.
- El-Nashaar, H.M., Banowetz, G.M., Peterson, C.J., Griffith, S.M. 2010. Genetic variability of elemental concentration in winter wheat straw. *Energy Fuels* 24:2020-2027.
- El-Nashaar, H.M., Banowetz, G.M., Peterson, C.J., Griffith, S.M. 2010. Elemental concentrations in triticale straw, a potential bioenergy feedstock. *Energy Fuels* 25:1200-1205.

Table 1. Proximate and ultimate analyses of char produced by gasification of Kentucky bluegrass (*Poa pratensis* L.) seed screenings residue.¹ Char was generated in a farm-scale gasification unit operated at temperatures ranging from 600 to 650°C.

Analysis	Parameter	As received	Moisture free	Moisture & ash free
		----- (wt%) -----		
Proximate	Moisture	4.35		
	Ash	46.29	48.40	
	Volatile matter	20.01	20.92	40.54
	Fixed-C	29.35	30.68	59.46
Ultimate	H	0.99	1.04	2.01
	C	45.71	47.79	92.61
	N	1.44	1.51	2.92
	S	0.33	0.35	0.67
	O	0.89	0.93	1.80
Heating value (kJ)		7314	7646	14817

¹ Laboratory analysis performed by Wyoming Analytical Laboratories, Inc. (Laramie, WY).

Table 2. Proximate and ultimate analyses of Kentucky bluegrass (*Poa pratensis* L.) seed cleaning residues.¹

Analysis	Parameter	As received	Moisture free	Moisture & ash free
		----- (wt%) -----		
Proximate	Moisture	7.24		
	Ash	8.92	9.62	
	Volatile matter	70.53	76.03	84.12
	Fixed-C	13.31	14.35	15.88
Ultimate	H	4.81	5.19	5.74
	C	43.11	46.47	51.42
	N	1.18	1.27	1.41
	S	0.49	0.53	0.58
	O	34.25	36.92	40.28
Heating value (kJ)		7766	8373	9263

¹ Laboratory analysis performed by Wyoming Analytical Laboratories, Inc. (Laramie, WY).

Table 3. Analysis of polynuclear aromatic hydrocarbon content of char produced by gasification of Kentucky bluegrass (*Poa pratensis* L.) seed cleanings in a farm-scale gasification unit operated at temperatures ranging from 600 to 650°C.¹ Toxicity characteristic leaching procedure (TCLP) and semi-volatile organic compounds by GC/MS.

Analyte	Concentration	MRL ²
	----- (µg kg ⁻¹ dwt) -----	
Naphthalene	nd ³	0.10
2-Methylnaphthalene	nd	0.10
Acenaphthylene	nd	0.10
Acenaphthene	nd	0.10
Fluorene	nd	0.10
Debenzofuran	nd	0.10
Phenanthrene	nd	0.10
Anthracene	nd	0.10
Fluoranthene	nd	0.10
Pyrene	nd	0.10
Benz(a)anthracene	nd	0.10
Chrysene	nd	0.10
Benzo(b)fluoranthene	nd	0.10
Benzo(k)fluoranthene	nd	0.10
Benzo(a)pyrene	nd	0.10
Indeno(1,2,3-cd)pyrene	nd	0.10
Dibenz(a,h)anthracene	nd	0.10
Benzo(g,h,i)perylene	nd	0.10

¹ The TCLP for semi-volatile organic compounds was performed using GC/MS following EPA methods 1311, 3501C, and 8270C by Columbia Analytical Services, Inc., Kelso, WA.

² Method reporting limit

³ Not detected

Table 4. Quantification of polychlorinated dibenzodioxins and polychlorinated dibenzofurans in char produced by gasification of Kentucky bluegrass (*Poa pratensis* L.) seed cleanings in a farm-scale gasification unit operated at temperatures ranging from 600 to 650°C.¹

Analyte	Concentration	MRL ²	TEF ³
	----- (µg kg ⁻¹ dwt) -----		
2,3,7,8-TCDD	nd ⁴	0.301	1.0
1,2,3,7,8-PeCDD	nd	0.378	1.0
1,2,3,4,7,8-HxCDD	nd	0.315	0.1
1,2,3,6,7,8-HxCDD	nd	0.286	0.1
1,2,3,7,8,9-HxCDD	nd	0.305	0.1
1,2,3,5,6,7,8-HpCDD	nd	0.919	0.01
OCDD	nd	2.694	0.0003
2,3,7,8-TCDF	nd	0.301	0.1
1,2,3,7,8-PeCDF	nd	0.197	0.03
23478-PeCDF	nd	0.192	0.3
1,2,3,4,7,8-HxCDF	nd	0.272	0.1
1,2,3,6,7,8-HxCDF	nd	0.254	0.1
1,2,3,7,8,9-HxCDF	nd	0.364	0.1
2,3,4,6,7,8-HxCDF	nd	0.298	0.1
1,2,3,3,4,6,7,8-HpCDF	nd	0.587	0.01
1,2,3,4,7,8,9-HpCDF	nd	0.827	0.01
OCDF	nd	3.951	0.0003
Total tera-dioxins	nd	0.301	--
Total penta-dioxins	nd	0.378	--
Total hexa-dioxins	nd	0.286	--
Total hepta-dioxins	nd	0.919	--
Total tetra-furans	nd	0.301	--
Total penta-furans	nd	0.192	--
Total hexa-furans	nd	0.254	--
Total hepta-furans	nd	0.587	--

¹ HRGC/HRMS Analyses performed according to EPA Method 8290 by Columbia Analytical Services, Kelso, WA.

² Method reporting limit (MRL)

³ World Health Organization (WHO) adopted TEF's, taken from: Van den Berg et al.: Toxic Equivalency Factor (TEFs) for PCDDs, PCDFs for Humans and Wildlife (Environ. Health Perspect. 106:775-792 (1998))

⁴ Not detected

Table 5. Metal toxicity characteristics leaching procedure (TCLP) analysis of char produced by gasification of Kentucky bluegrass (*Poa pratensis* L.) seed cleanings in a farm-scale gasification unit operated at temperatures ranging from 600 to 650°C.

Metal	TCLP extract	MRL ¹	Regulatory limit ²
----- (mg L ⁻¹) -----			
Ag	nd ³	0.02	5
As	nd	0.1	5
Ba	nd	1.0	100
Cd	nd	0.01	1
Cr	nd	0.01	5
Hg	nd	0.001	0.2
Pb	nd	0.05	5
Se	nd	0.1	1

¹ Method reporting limit

² From 40 CFR Part 261, et al., and Federal Register, March 29, 1990 and June 29, 1990

³ Not detected