Soil Contamination of Grass Biomass

Purpose: The purpose of this publication is to describe factors affecting soil contamination of biomass hay, and methods to assess it.

Does Soil Contamination Matter?

Concentrations of most elements in grasses decline with plant age, and some decrease further if the biomass is left in the field to leach. Ash content of grass is impacted by grass species, morphological component, growing conditions, harvest time, and any field leaching. Ash content is also strongly influenced by any soil contamination.

Soil contamination may have no effect on mulch hay used for mushroom compost. Soil contamination, however, will affect concentrations of many elements in hay, which can impact combustion. Emissions are a function of the efficiency of the combustion device and the composition of the combustion fuel. From a combustion standpoint, the ideal grass feedstock would be similar in composition to wood.

Fig. 1. Switchgrass overwintered in the field will result in some leaching of undesirable elements, but such management will increase the chances of soil contamination.

Factors Affecting Soil Contamination

Even when there is no visible soil found on the surface of bales when sampling, there will be some soil present in the hay. Soil contamination is typically variable within a bale and among bales. It is a function of soil type, soil moisture, surface terrain, harvesting equipment, stubble height of mowing, and the length of time between mowing and baling.

Table 1. Aluminum (Al), iron (Fe), and titanium (Ti) partially extracted from 100 representative soils in NYS, using the extraction procedure for plant materials. Soils were averaged within Soil Management Groups (SMG), data in ppm.

	SMG	Mean	Min	Max
Al	1	17,833	11,300	28,045
	2	14,413	6,731	27,860
	3	11,940	2,937	17,150
	4	10,072	5,220	15,780
	5	9,724	4,275	17,420
	6	7,036	2,777	12,150
Fe	1	22,217	12,790	36,365
	2	20,361	9,724	56,410
	3	16,889	4,043	31,960
	4	13,443	6,404	25,170
	5	14,165	4,915	28,210
	6	10,704	5,696	14,560
Ti	1	252	48	701
	2	135	31	634
	3	84	23	669
	4	143	52	357
	5	91	29	141
	6	88	50	168

Indicators of Soil Contamination

Elements in relatively high concentrations in soil are Al, Fe, and Ti. Forage grasses have no actual uptake of Ti (0 ppm) into the plant, very limited uptake of Al (<50ppm), and limited uptake of Fe (50-200ppm). Elements in soil on plant samples are partially extracted from soil during the plant digestion/extraction process (Table 1). For example, maximum Al extraction from soil was 2.8% here, but most soils will have a total Al content of 5 to 7%.

Table 1 shows relatively high extraction of Al, Fe, and Ti from soils. The large range in values within any soil management group, however, indicates that the actual amount of soil contamination on a particular grass sample could only be predicted accurately if we know the specific soil type of the contaminated soil.

Results

Mature grass hay bales were sampled across NYS in 2011, ash content would be expected to be 5 to 8%. Switchgrass also was baled from 2009-2013 in fall and spring in Freeville, NY, taking care to minimize soil contamination. Fall baling, as well as spring baling of overwintered grass, would be expected to generate an ash content range of about 2 to 5%.

Table 2. Correlations of variables associated with soil contamination for 100 mixed grass bales sampled in 2011. Ash% range of 5-33%.

Variable	Al	Fe	Ti	BTU
Ash	0.93	0.92	0.92	-0.90
Al		0.99	0.99	-0.85
Fe			0.99	-0.84
Ti				-0.83

Instances of very high soil contamination (Table 2) result in very high correlations among traits. Much lower levels of soil contamination (Table 3) still result in relatively good relationships among traits. Al, Fe, and Ti are all good indicators of soil contamination.

Table 3. Correlations of variables associated with soil contamination for 154 switchgrass large square bales (2009-12). Ash% range of 2-9%.

Variable	Al	Fe	Ti	BTU
Ash	0.76	0.79	0.61	-0.92
Al		0.98	0.94	-0.68
Fe			0.89	-0.75
Ti				-0.51

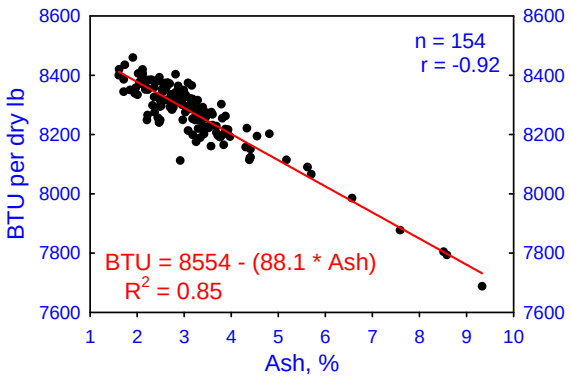

Fig. 2. Relationship between ash and BTU for switchgrass bales over 4 growing seasons.

Relationship between Ash and BTU

Since ash is devoid of calories, ash content of biomass will be negatively related to energy content. Although Ash content is highly correlated with Al, Fe, and Ti content, it is very highly correlated with energy content (BTU). The relationship is somewhat different when comparing switchgrass bales (Fig. 2) with mulch hay bales (not shown). Gross energy analysis is typically expensive; it may be feasible to reasonably estimate BTU content from the ash content of a sample.

Summary

Any soil contamination of hay will not be uniformly distributed in the bale and will not be uniform among bales. It is a function of soil type, soil moisture, surface terrain, grass species, harvesting equipment, and the length of time between mowing and baling. Aluminum, iron, and titanium content of hay will provide an indication of the level of soil contamination. Ash content is highly correlated with energy content, and could be used to predict energy content, particularly in hay from a single grass species.

Additional Resources

Cherney, J.H. and K.M. Paddock. 2013. Overwintering Switchgrass in the Field in NYS. Bioenergy Information Sheet #10. www.grassbioenergy.org.

Cherney, J.H. and K.M. Paddock. 2013. Harvest Management and Switchgrass Composition. Bioenergy Information Sheet #11. www.grassbioenergy.org.

Cherney, J.H., K.M. Paddock, M. Davis, M. Hunter, J. Lawrence, and W. Verbeten. 2013. Mulch Hay as a Combustion Feedstock in NYS. Bioenergy Information Sheet #14. www.grassbioenergy.org.

Cherney, J.H. and D.L. Robinson. 1983. A Comparison of Plant Digestion Methods for Identifying Soil Contamination of Plant Tissue by Ti Analysis. Agron. J. 75:145-147.

Acknowledgments

Research was supported by the NY Farm Viability Institute, the Northern NY Agric. Development Program, and the Cornell University Agricultural Experiment Station.

For more information

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