Ash Content of Grasses for Biofuel

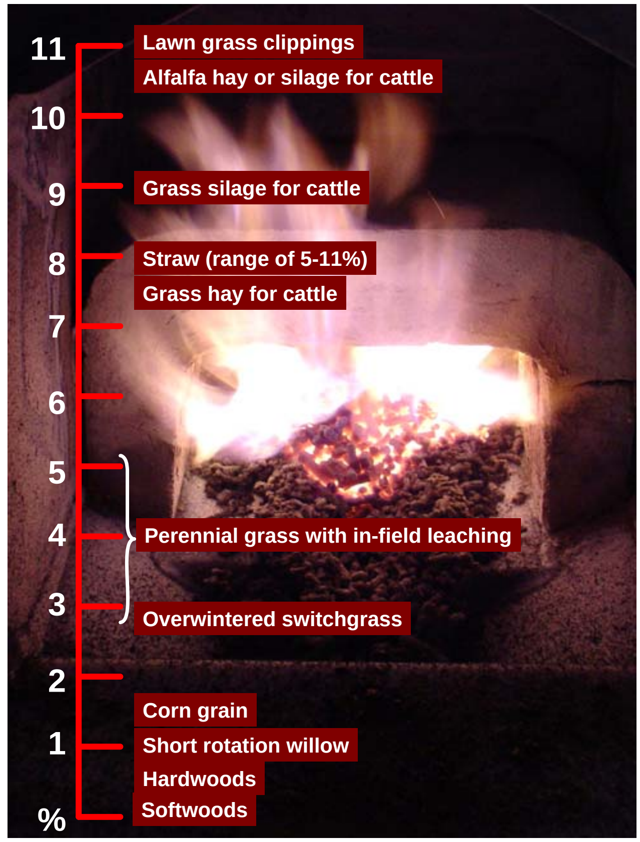
Purpose: The purpose of this publication is to describe the influence of minerals on combustion behavior and to discuss management schemes to control mineral and ash content in grasses.

Ash is more than an issue of convenience for the user. The composition and quantity of combustion residue are the primary factors determining whether or not a feedstock can be burned effectively in a particular appliance. It is possible to significantly change both the composition and quantity of ash in grasses through management. Grass breeding and selection for increased yield has been ongoing for decades, while there has been essentially no breeding in grasses for changes in ash composition to improve combustion efficiency. A long-term breeding effort would likely be necessary to change ash composition and improvements likely would be quite modest.

Ash buildup in a pellet boiler.

Total Ash Content of Grasses

The range in total ash content of grasses can be very large, from less than 2% to greater than 20%. Ash values significantly higher than 10% are most likely the result of excessive surface soil contamination. Ash content of wood tends to be quite low, although it can approach 5% if the feedstock has significant soil contamination.



Range in ash content of feedstocks.

Ash Terminology

The interaction of inorganic minerals to produce changes in ash characteristics is very complex. Terminology is also complex.

Agglomeration. Particles gather in a cluster.

Softening. Temperature at which ash begins to flow.

Melting. Ash enters a molten phase.

Slagging. Deposits in a molten or highly viscous state found in the flame section of a furnace.

Fouling. Deposits from materials that have vaporized, then condensed in cooler regions of the furnace.

Sintering. Formation of a coherent mass by heating without melting.

Clinkering. A Clinker is a solid residue formed by melting of minerals or through sintering.

Plant Components of Interest

Alkali metals, in combination with silica and sulfur, are primarily responsible for melting or sintering at relatively low temperatures. This undesirable process is facilitated by the presence of chlorine. The typical range in concentration (on a dry matter basis) of these critical components in grasses are as follows:

- Chlorine (0.01-1.0%)
- Nitrogen (0.30-1.8%)
- Alkali metals (0.2-3.0%)
- Sulfur (0.01-0.40%)
- Silica (1-4%)

Chlorine. Chlorine (Cl), as a catalyst in association with K and Na, exacerbates the problems of corrosion, slagging and fouling. Chlorine also produces emissions problems.

Nitrogen. Nitrogen (N), is an issue due to the formation of NOx compounds in emissions.

Alkali metals. Potassium (K) and sodium (Na) content have a great impact on softening and melting temperatures of ash. Potassium is much more important because the concentration may be up to 100-fold higher than sodium. Alkali metals cause increased corrosion as well as slagging and fouling in furnaces.

Sulfur. Sulfur (S) reacts with alkali metals to form alkali sulfates that stick to heat transfer surfaces. Sulfur can also form sulfates with calcium, but this is not as critical as the alkali reactions.

Silica. Silica (Si) is the largest mineral component of perennial grasses. Silica content is greatly influenced by soil type, water uptake and grass species. There can be over a 4-fold range in silica content in grass simply due to soil type. Warm-season grasses (e.g. switchgrass) have a much lower uptake of water compared to cool-season grasses (e.g. reed canarygrass), and generally contain half as much silica. Alkai metals combine with silica to form silicates that melt at lower temperatures.

Composition of Plant Parts

Ash content of plant parts differs, offering one option for a reduction in overall ash. Grass inflorescence typically has 5 times the silica content of stems. Grass leaves have over 3 times the silica content of stems. Delayed harvest can increase the proportion of stem remaining at harvest and lower ash content.

Management Options

Site selection. The primary components of ash in cool-season grasses are silica and potassium. Silica uptake can be reduced by selection of a site with lighter-textured soils (less clay). Potassium uptake in grasses is directly related to soil-available K. Sites with low soil-available K will produce low K grass.

Fertility management. Yield of perennial cool-season grasses does not respond greatly to K fertilization in the Northeast. Avoiding KCl fertilization will minimize K and Cl in grass. Grasses will need some form of N fertilization for optimum yields.

Reed canarygrass cut in August and baled in September in New York State.

Harvest management- Overwintering.
Overwintering of grass biomass in the field will significantly reduce the ash content, particularly K and Cl, with large yield reductions also possible. Silica loss from plant parts may be offset by silica gained by soil contamination.

Harvest management – In-Field leaching.
An alternative, for cool-season grasses that produce most of the year's growth by mid-summer, is August cutting with 1-4 weeks of in-field leaching prior to baling.

For more information

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