Reuse of Cellulosic Bioethanol Residues

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Introduction

The second generation biofuels emphasize the use of non-edible (cellulosic) feedstocks. However, the commercialization of second generation biofuel is complicated by technical as well as economic issues. Most studies focus on enhancing technology to improve ethanol productivity, while very few recognize the importance of the byproducts associated with cellulosic ethanol production. An estimated 20 liters of byproduct is generated for every liter of ethanol produced, so an effective solution for byproduct treatment is necessary when considering large scale production of cellulosic ethanol in the future. This study summarized the properties and reuse methods of cellulosic bioethanol residues by conducting a literature review, and proposed a possible approach of reuse as land application.

Objectives

- ❖ Investigate physical and chemical properties of the residues from cellulosic ethanol production.
- ❖ Summarize the existing and possible treatment and reuse methods for cellulosic ethanol residues.
- ❖ Propose future studies for cellulosic ethanol residues with a particular emphasis on the practice of land application of the pretreated cellulosic ethanol wastes

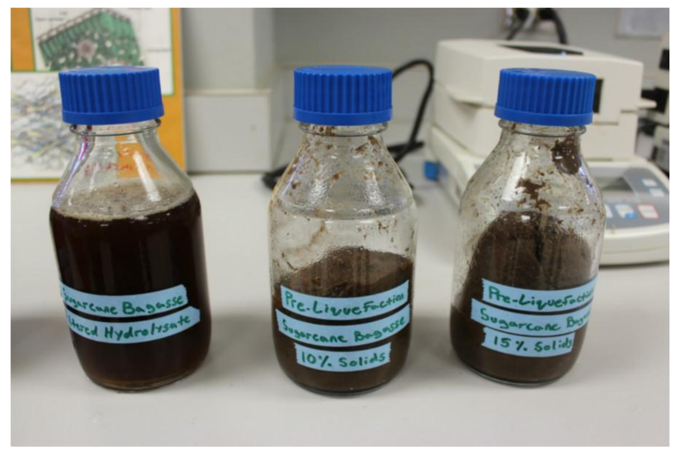

Figure 1. Bioethanol Residues from Perry Pilot Plant, FL. (from left to right): Filtrate, 10% Solids, 15% Solids

Literature Review Results

1 Summary of properties of residues

Physical and chemical characteristics of stillage are highly dependent on the raw materials and various aspects of the ethanol production processes. A comparison of cellulosic ethanol residues with first generation residues is given in Table 1. Cellulosic residues have higher C/N ratio, and lower protein content compare to the first generation residues. Data for other chemical properties is limited and variable.

Table 1. Select Chemical Properties of Solid Residues from Bioethanol Productions (values are calculated from date in literature sources) [a]

Feedstocks		TS (%)	pH	TC (g/kg)	TP (g/kg)	TN (g/kg)	NH4-N (g/kg)	K (g/kg)	Protein[b] (%)	Lignin (%)	Ref.
First Generation	Corn	96	na	na	11.2	na	na	na	40	na	[5]
	Tritical	15.9	4.1	na	na	na	na	5	31.1	na	[7]
	Rapeseed meal	na	5.0	484	na	54	0.15	na	na	na	[1]
Cellulosic	Sugarcane Bagasse	12.5	7.5	na	35.2	65.8	23.6	4.63	na	na	[2]
		18.6	na	na	na	na	na	na	8.9	22	[8]
	Corn Stover	na	na	590	na	20	na	na	12.4	59	[6]
	Wheat Straw	na	5.8	448	na	13	0.2	na	na	na	[3]

[a]na: data not available; [b]values are percentage of crude protein .

2 Reuse of ethanol residues

Beneficial reuse of cellulosic ethanol residues could provide cost savings as well as lessen negative environmental impacts such as water contaminations and greenhouse gases emission.

Several studies investigated possible reuse methods based on the physical and chemical properties of the residues.

Figure 2 illustrates some methods that have been applied successfully and the properties of cellulosic ethanol residues attributed to these reuse approaches.

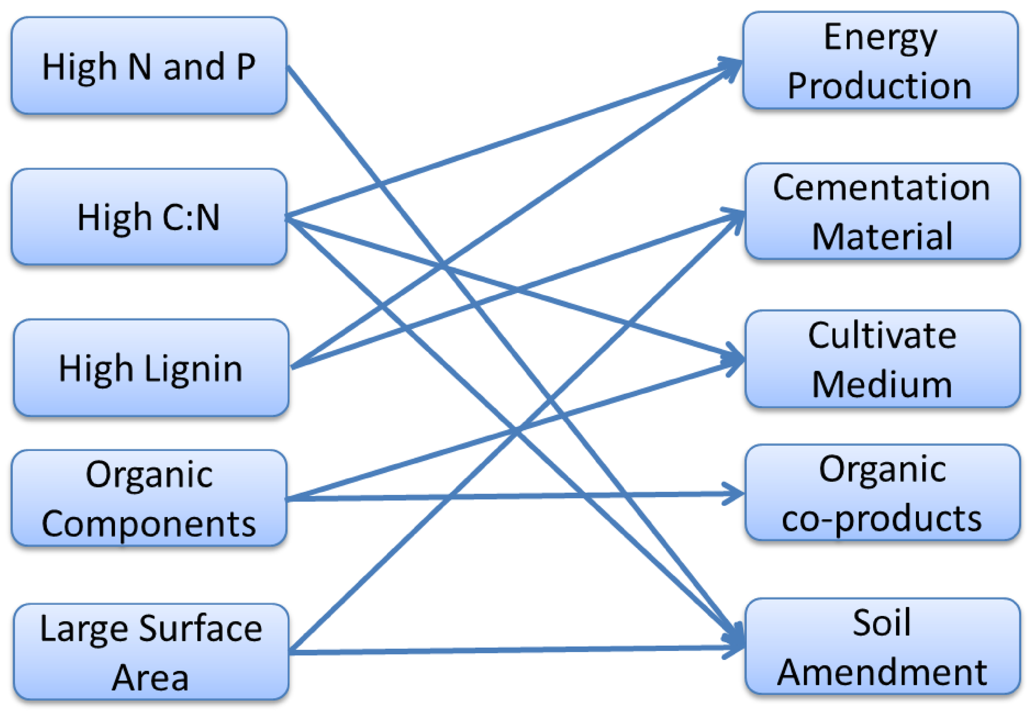

Figure 2. Properties and Reuse Methods of Cellulosic Ethanol Residues

3 Land application of ethanol residues

Possible pretreatment methods for land application are shown in Figure 3.

Positive effects of land application

- ✓ Increase soil water retention
- ✓ Improve structure of sandy soil
- ✓ Substitute for synthetic fertilizers
- ✓ Reduce metal (Cd, Zn) toxicity in soil

Negative effects of land application

- Direct application without pretreatment causes phytotoxicities
- Increase CO_2 emission, but less CO_2 emission from cellulosic residues than first generation residues

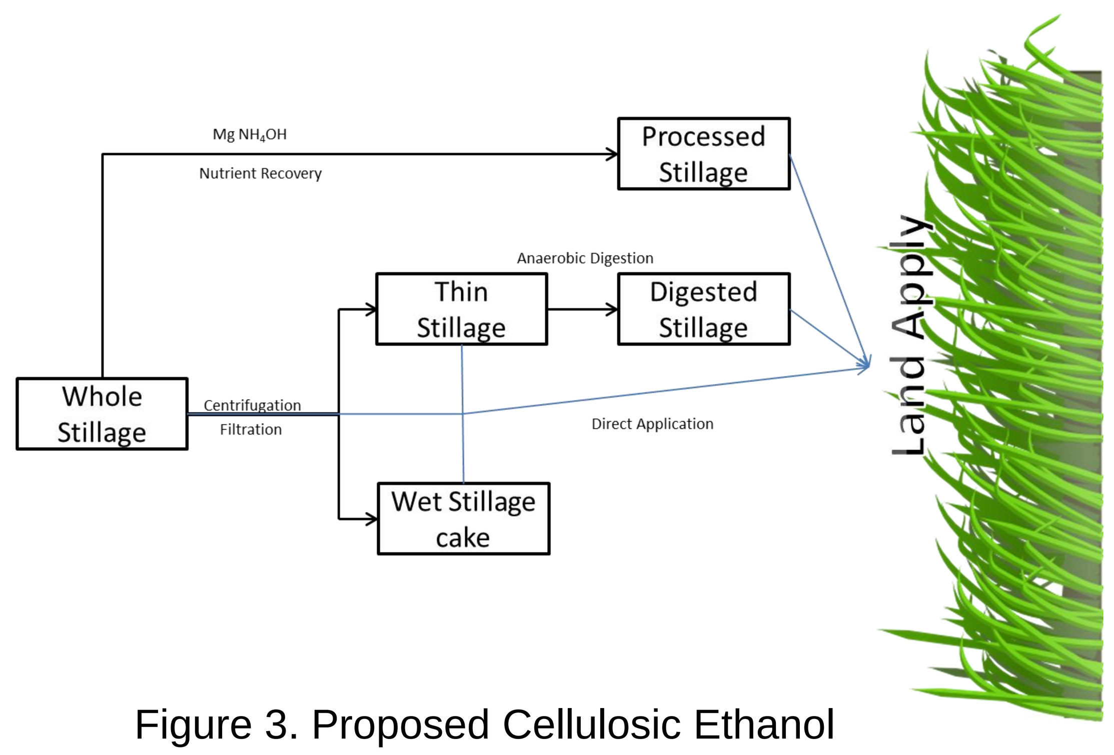

Figure 3. Proposed Cellulosic Ethanol Residues Land Application Pathways

Future Study

Previous studies have shown potentials of land application of cellulosic bioethanol residues. However, with limited data it is hard to draw a solid conclusion about its effects on the soil and the environment. To quantify these impacts, a series of studies on land application of cellulosic ethanol residues is proposed.

- **Characterization Study**
  - a. Essential elements (such as C, N, P, K, S, Ca)
  - b. Heavy metals (such as Cd, Mo, As, Fe)
  - c. Propose appropriate pretreatment methods for land application
- **Soil Incubation Study**
  - a. Study the fate of nutrients in soils after application.
  - b. Evaluate impacts on physical and chemical properties of soils.
  - c. Determine the optimum application rate.
- **Greenhouse Study**
  - a. Determine the fertility efficiency of cellulosic ethanol residues.
  - b. Evaluate the environmental impacts of land application (e.g. nutrient leaching).

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