Bio ethanol Production from the Landfill Organic Waste Fraction

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Abstract

Landfill organic waste fraction was investigated for the potential to generate bio ethanol, a liquid bio fuel that can be used in place of the conventional liquid fuels. This was achieved through acid treatment enzymatic hydrolysis. The organic fraction waste was first pre-treated with dilute sulphuric acid at 121 °C for 15 minutes. Afterwards it underwent enzymatic hydrolysis at 50 °C for a period of 5 days to allow the release of C6 sugars. The hydrolysate was then fermented at 30 °C for 5 days with yeast inoculated as the bio catalyst to produce bio ethanol. Enzymatic hydrolysis and the prior pre-treatment resulted in a high yield of 60% of the C6 sugars. The bio ethanol produced from the fermentable sugars was 40%. There is potential for utilization of the organic municipal waste fraction for bio fuels production.

Keywords: Bio ethanol, fermentation, landfill waste, organic waste fraction

1. Introduction

In Southern Africa, huge amounts of organic waste are being generated on a daily basis and these usually find themselves to the landfills facility, possibly shortening the life span of landfills if not properly managed (Manyuchi et al., 2017). In addition, the organic fraction of the municipal waste poses a challenge for green house gases emissions if left to rot, effectively resulting in climate change effects (Matsakas et al., 2014). The organic fraction of the municipal waste is a potential raw material for production of solids and liquid bio fuels such as biomass briquettes, biogas, bio hydrogen, bio diesel and bio ethanol (Saka et al., 2012; Shruti at el., 2016). Figure 1 shows the bio conversion potential of the organic fraction of landfill waste to bio fuels.

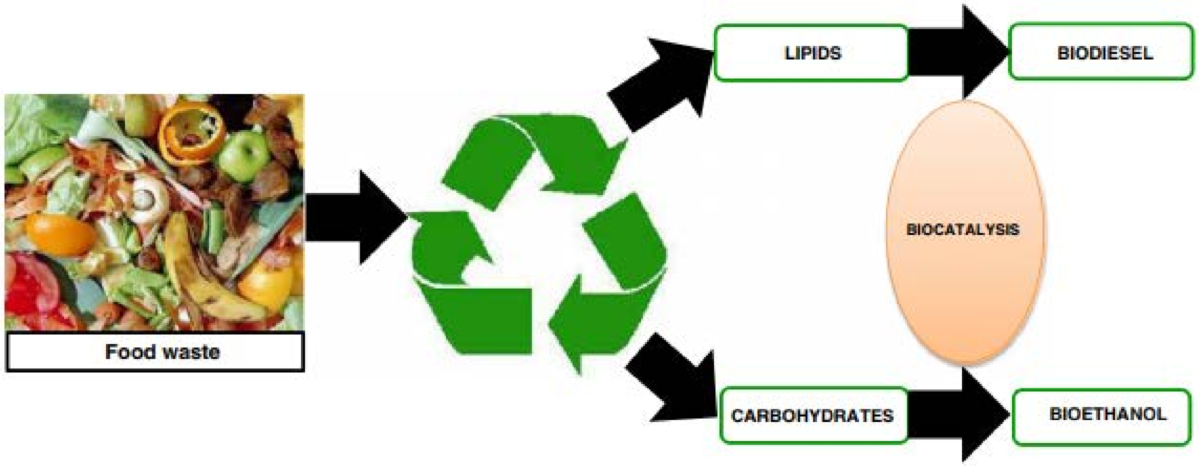

Figure 1. Conversion of municipal bio waste to bio fuels (Karmee and Liu., 2012)

The adoption and usage of the organic fraction of the food waste has potential to replace the conventional coal which is normally used as a fuel source due to the various bio fuels produced (Adeniyi et al., 2007; Nair et al., 2016). Figure 2 shows the various biochemical production pathways for bio fuels from organic waste.

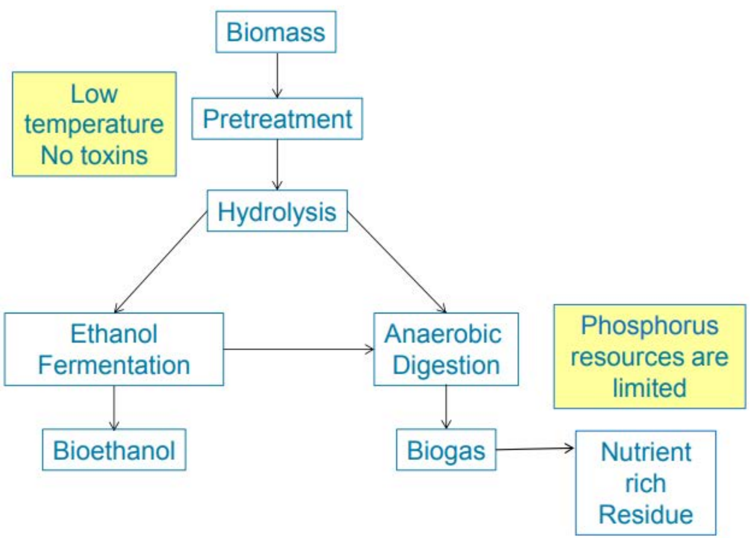

Figure 2. Biochemical pathways for bio fuels production from landfills organic fraction (Nwobi et al., 2013)

Enzymatic hydrolysis has been recommended for the hydrolysis of organic waste during bio ethanol production to sugars as this increase the amount of sugars that will be available for fermentation (Nair et al., 2016). This study focused on the potential of producing bio ethanol using enzymatic hydrolysis from the organic fraction at the landfills as a way of harnessing value from bio waste.

2. Materials and Methods

2.1 Materials

The organic fraction of municipal waste was obtained from a local landfill. Dilute sulphuric acid was used in the pre-treatment stage of the waste. 250 mL flasks were used in the pre-treatment phase. Fermentation was done in a 5L bioreactor. A model YP-2378 P1 sugar analyzer was used to quantify the amount of sugars in the hydrolyzed sample. Yeast (*Saccharomyces cerevisiae*) was used as the fermentation media bio catalyst.

2.2 Methods

A sample of 150g of the organic fraction of the municipal waste was first analyzed for its composition using standard methods (Zheng et al., 2009). The organic fraction waste then subjected to acid treatment with sulphuric acid to make the biodegradable waste more available to enzymatic hydrolysis at 121 °C for a period of 15 minutes (Shruti et al., 2016). Afterwards the pre-treated organic waste was subjected to an enzymatic hydrolysis process with cellulase (1%), protease (0.2%), amylase (1%), lipase (0.2%), pectate lyase (1%) and hemicelluloses (0.2%) which was conducted at 50 °C for 5 days. After the hydrolysis process, the hydyosate went under a cooling process then fermentation was allowed to occur at 30 °C and pH of 5 for 5 days. 20 g of *Saccharomyces cerevisiae* (yeast) was used as the fermentation bio catalyst due to its low cost and availability. After fermentation the bio ethanol was distilled so as to achieve 95% purity. The amount of C6 sugars produced was determined after every 24 hours using an automatic analyser. The fermented sugars were also taken for bio ethanol concentration analysis every 24 hours using specific gravity methods.

3. Results and Discussion

3.1 Characterization of the organic fraction of the landfill waste

Characterization of the organic fraction of the landfill waste was essential so as to see the amount of sugars and cellulose that could be hydrolyzed then fermented to bio ethanol. The organic fraction had an average of 33.6% soluble matter, glucose content of 42% before hydrolysis, cellulose content of 18.6% and ash content of 11.2% (see Table 1). These characteristics were key indicators that the organic waste fraction is an ideal raw material for bio ethanol production. The low ash content was an indicator that there is a high potential for the organic waste to be converted to the bio ethanol instead of the residue during fermentation. A summary of the bio ethanol process is given in Figure 3.

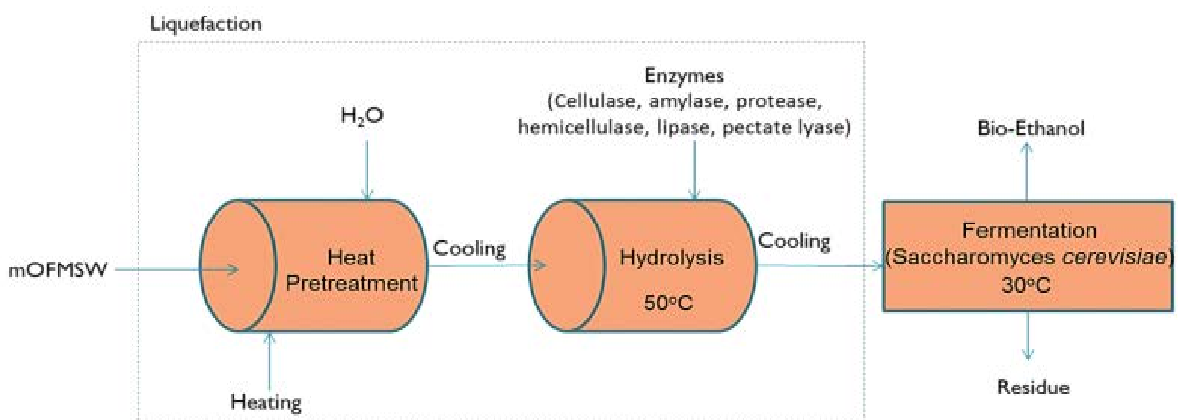

Figure 3. Bio ethanol production process from organic waste fraction

Table 1. Landfill organic waste fraction characteristics

Parameter	Value (wt %)
Soluble matter	32.8-34.1
Moisture content	1.6-1.7
Glucose	4.1-4.3
Fructose	3.5-3.7
Sucrose	4.2-4.4
Total reducing sugars	12.3-12.5
Protein	0.51-0.53
Fats	11.6-11.8
Pectin	3.2-3.3
Cellulose	18.5-18.7
Hemicellulose	7.3-7.4
Lignin	2.2-2.3
Ash content	11.1-11.3

3.2 Production of sugars

The pre-treatment of the organic waste fraction allowed optimal hydrolysis of cellulose to glucose which can easily be converted to fermentable sugars, C6. The amount C6 sugars produced increased as the treatment time increased at 85 °C and treatment time of 6 days (Figure 4). The total average yield of C6 sugars obtained was 60%. This yield correlated with C6 results already reported in literature ranging from 40-65% and can be attributed to the low ash content in the organic waste fraction as well as the high content of the soluble matter (Akpan et al., (2008). The maximum conversion of sugars was obtained after 4 days of hydrolysis.

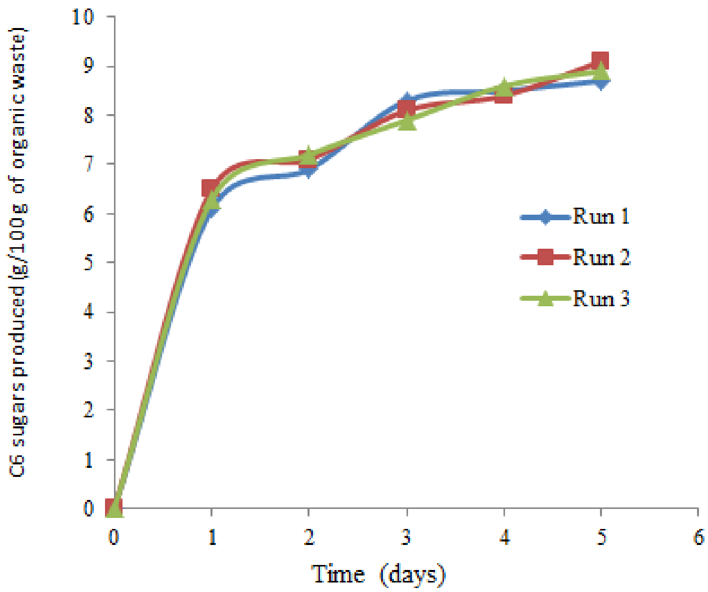

Figure 4. Fermentable sugars production from organic waste fraction hydrolysis

3.3 Bio ethanol production from organic fraction

The amount of bio ethanol produced increased with increase in the fermentation of up to 5 days. Bio ethanol and a residue were produced as products (Figure 5). The maximum conversion rate of the C6 sugars to bio ethanol was 50% and was also enhanced by the addition of yeast as the fermentation bio catalyst. The values of the bio ethanol results reported in this study are within rang to those reported in literature with percentage yield ranging from 40-60% (Akpan et al., 2008).

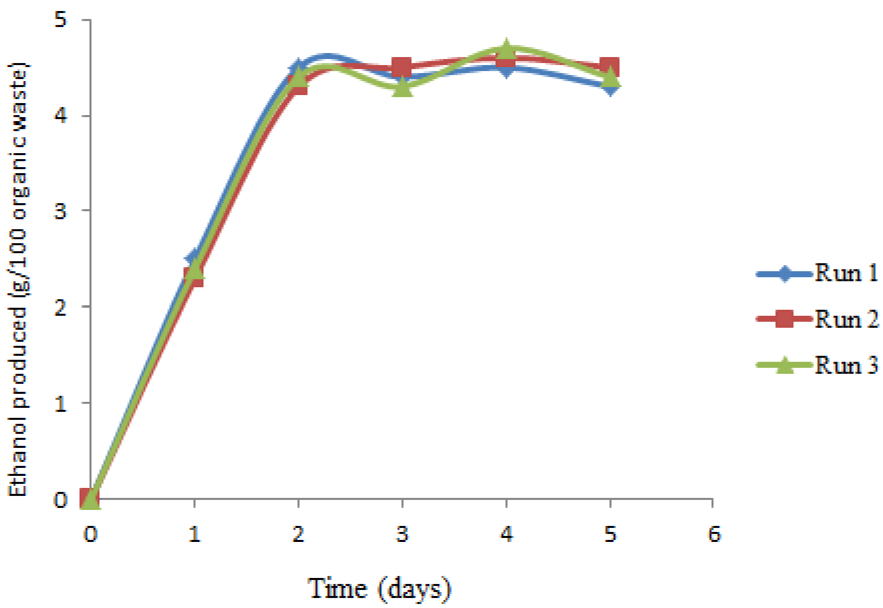

Figure 5. Bio ethanol production from organic waste fraction

4. Conclusion

The organic fraction of the municipal waste from the landfills is a potential raw material for bio ethanol production which can be used as a substitute to the conventional fuels. The organic fraction was hydrolyzed to simple C6 sugars to achieve a yield of 60%. These sugars were allowed to ferment in the presence of yeast and a 50% yield of bio ethanol was achieved. The concentration of the bio ethanol was increased to 95% through the process of distillation.

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