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# Municipal Solid Waste Used as Bioethanol Sources and its Related Environmental Impacts

## **Cover Page Footnote**

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# **MUNICIPAL SOLID WASTE USED AS BIOETHANOL SOURCES AND ITS RELATED ENVIRONMENTAL IMPACTS**

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## **ABSTRACT**

An investigation into the possibility of replacing the conventional biomass with biodegradable municipal solid waste, which provides an alternative solution for preventing the biodegradable fraction of municipal solid waste (BMSW) going into landfill required by EU Landfill Directives (1999/31/EC) was carried out. However, as every type of energy have some advantages as well as disadvantages. The use of BMSW as biomass sources for the production of bio-ethanol was investigated. The experimental results have shown that more than 90% of the cellulose from the waste can be converted to glucose which can be easily fermented to ethanol production. The potential impacts on related environmental issues, such as sustainable waste management, climate change, water issues, land use and biodiversity, are discussed. Sustainable waste management solutions are also discussed under different environmental, economic, and social scenarios.

Keywords: Biodegradable municipal solid waste (BMSW), bio-ethanol, biomass, sustainable waste management, environmental impacts

## **1. INTRODUCTION**

Traditionally, ethanol is made from biomass such as corns, sugar canes and energy crops etc. Issues such as food shortage, land-use, and the needs of biofuel for transportation have been raised. The replacement of biomass with BMSW can bring the environmental advantages particularly in waste management, carbon dioxide cut, water quality and quantity control, land use and biodiversity.

This paper discusses the potential environmental impacts of using BMSW as bio-ethanol resources from both prospects of energy development and waste management as well as sustainable waste management solutions.

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## 2. MATERIALS AND METHODS

The BMSW-to-ethanol process is shown in Figure 1 which includes sample collection, pre-treatment, hydrolysis, fermentation, product recovery and product distribution. The BMSW used in this study was selected from typical biodegradable waste, such as kitchen waste, garden waste and paper waste. The sample consists of 20% carrot peelings, 20% potato peelings, 20% grass, 20% newspaper, and 20% scrap paper. The selected waste was milled to small particles with size of 0.2mm-1.2mm, and then followed by pre-hydrolysis with sulphuric acid and steam treatment, and then enzymatic hydrolysis. Full details of the experimental procedures including sample preparation, pre-hydrolysis and enzymatic hydrolysis was given in Li et al., 2007.

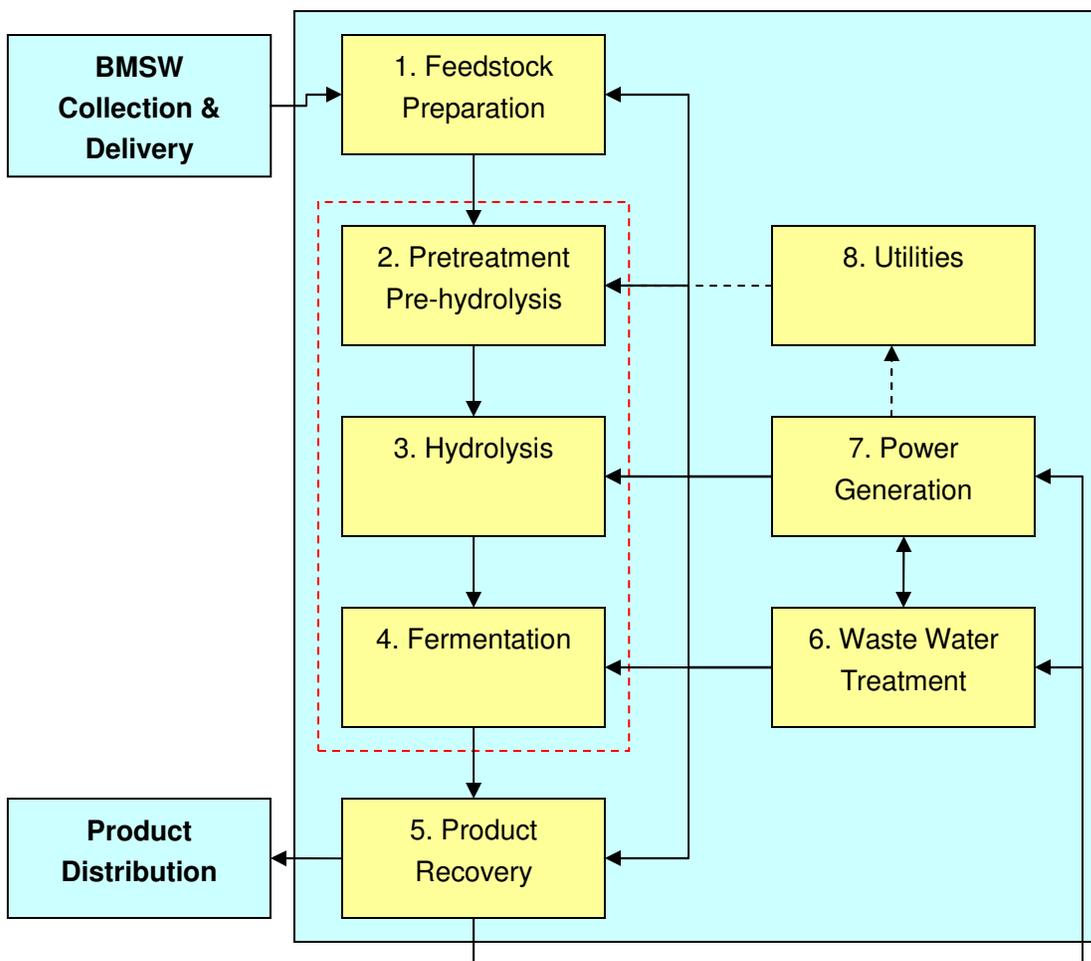


Figure 1 Simplified BMSW-to-ethanol process

The mass balances were calculated for two main steps: 1- from raw material to pre-hydrolysed biomass, and 2-to enzymatic hydrolysis residues, with consideration of the weight loss during each step.

The environmental impact assessment is based on the results from the laboratory work. The assessment covers a number of environmental issues such as waste management, carbon dioxide emission, water issue, land-use, biodiversity etc, by comparing with traditional biomass such as corn and energy crops.

The assessment of sustainable waste management is based on the sustainability of the application of this technology, by considering the environmental sustainability, economic viability and social acceptance.

### **3. RESULTS AND DISCUSSIONS**

A previous study (Li et al., 2007) showed that BMSW as a feedstock produced about 52% glucose for the production of ethanol. Recent studies on hydrolysis optimization showed that about 90% of glucose yield can be reached under the optimal conditions (lower substrate concentration, higher enzyme concentration, temperature 50°C and pH 4.8).

Results from the mass balance revealed that about 0.25g biomass remained after pre-hydrolysis and 0.1g remained after the enzymatic hydrolysis process when 0.5g BMSW was used as feedstock. This indicated that about 80% of the biodegradable waste fractions were removed by using this BMSW-to-ethanol process.

The environmental impacts were assessed from the following areas: waste management, climate change, water issues, land use, biodiversity and others.

#### **3.1 Waste management**

Using BMSW as a resource for bio-ethanol production will reduce the biodegradable fraction from MSW going to landfill which is one of the requirements of EU Landfill Directives. According to the mass balance from the laboratory plant, the amount of waste will be massively reduced by 80% and the main composition of solid residues from the hydrolysis process are acid insoluble lignin, ash content, protein absorbed and dead cells, which can be used as compost. This technology can be used as an alternative solution for sustainable waste management and material/energy recovery.

#### **3.2 Climate change**

Ethanol represents the closed carbon dioxide cycle because after burning of ethanol, the released carbon dioxide is recycled back into plant material because plants use carbon

dioxide to synthesize cellulose during the photosynthesis cycle (Wyman, 1999; Chandel et al., 2007). Ethanol production process only uses energy from renewable energy sources; no net carbon dioxide is added to the atmosphere, making ethanol an environmentally beneficial energy source. In addition, the toxicity of the exhaust emissions from ethanol is lower than that of petroleum sources (Wyman and Hinman, 1990). Apart from these, using BMSW as ethanol resources will avoid the biodegradable fraction going to traditional waste disposal plant such as landfill or incineration which often causes green gas emissions.

### **3.3 Water issues**

A large quantity of water is required to be used for growing energy crop which causes water shortage problems but there are also cases where there is plentiful water. One of the advantages is that irrigation can increase productivity surrounding plantations. For the ethanol process itself from both BMSW and energy crops, to produce 1 litre ethanol, 4-8 litres of water are required (Lang, 2007). And 13 litres of sewage effluent are produced per 1 litre of ethanol produced because of the water that has to be added to the ground corn grain for the fermentation process (Geotimes, 2005). Water remains a big issue for bio-ethanol process.

### **3.4 Land use**

Growing energy crop for bio-ethanol purpose required lots of land use. Harvesting corn stover may result in lowering soil organic carbon levels and soil nitrogen content, and may also increase soil erosion (Mann et al., 2002). If agricultural prices are increasingly linked to energy prices then impacts on food security will also be more volatility in the markets. World prices usually account for less than 25% for any variation at country level. It is currently hard to model the effect of bio-fuels (ODI, 2007). Using BMSW as biomass can free the land used for landfill and growing energy crops.

### **3.5 Biodiversity**

Input intensive energy crop production involves the movement of agrichemicals, especially nitrogen, phosphorus, and pesticides from farms to other habitats and aquifers. The use of BMSW for bio-ethanol purpose can avoid this problem.

Apart from the environmental impacts discussed above, this BMSW-to-ethanol system has its economic and social benefits. The end product: bio-ethanol is a valuable market product, which brings economic benefits from the non-valuable waste and meets the requirement of current energy market demands. However, this process requires the biodegradable waste fraction to be separated from non-biodegradable wastes from the households. The economic benefits with bio-fuel product will encourage waste separation. Waste management varies from developing nations to developed countries. Under different economic and social environment, different types of waste management methods from re-use,

recycle, and energy/material recovery to disposal etc are used.

#### 4. CONCLUSIONS

In conclusion, bioconversion of BMSW to bio-ethanol production has its environmental and economical advantages compared with traditional process with agriculture product. It can be used as an alternative sustainable waste management option. Sustainable waste management needs to involve different type of waste management methods in order to minimize the waste produced, and maximize energy/material recovery and to meet the needs of environmentally, economically and socially sustainable.

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