Waste Disposal by Pyrolysis

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Introduction

- Inspiration
  - Nature
    - No waste
    - Recycling
  - Issues with agricultural waste as feedstock for pyrolysis
    - Land use and development of fragile biomes
    - Issues with food crops
    - Carbon neutral in best case scenario
      - Net carbon releases positive if include transportation and production carbon releases

Contents

- Current waste disposal techniques and their problems
- Disposal by pyrolysis
- Look into the products of pyrolysis
- Current industrial applications of this technique
- Conclusion
- Biofuel opinion

Waste Disposal Problems

- Landfill Problems
  - Environmental
    - Harms local ecosystem
      - Leachate leaking into groundwater
      - Toxins deposited in soil
      - Noxious fumes emitted to the surrounding air
    - Largest anthropogenic source of methane
      - 20% of human releases
      - More damaging GHG than carbon dioxide

  - Economic
    - Enormous sums of money spent on containing sites and preventing environmental harm
    - Decreases surrounding land value
- Incinerator Problems
  - Emits toxins
  - Requires energy input
    - GHG emissions

Source: EPA website

Disposal of Waste by Pyrolysis

- Pyrolysis
  - Thermochemical breakdown of organic material at temperatures from 400-800°C

- Key Advantages
  - Diverse, valuable products
    - Bio char, bio oil, and syngas
  - Process insensitive to waste input
    - Development of polymers has led to majority of human products made of organic material, so almost all waste can be pyrolysized
  - Limited production of toxic chemicals
    - Common disposal techniques lead to many toxins and leachate runoff
      - Dioxins, organic chemicals such as PVC, metals
  - Process has evolved since ancient times and is well understood

Product of Pyrolysis: Bio Char

=> Carbon in the form of charcoal

- Uses
  - Historically used as charcoal heat source and soil enrichment
    - Amazon basin soil enhanced by bio char deposits left by tribal fires
  - Fertilizer
    - Disinfected
      - Other natural fertilizers such as manure are not
    - Carbon replacement
      - Remedy to nutrient poor soil associated with monoculture farms from biofuel production
  - Carbon sequestration
    - Solid carbon stored for hundreds to thousands of years

Product of Pyrolysis: Syngas

=> Gas mixture, chiefly H and CO

- Use
  - Originally developed and used successfully as a fuel for streetlamps in the 1700's

=> Return to combustion of syngas could provide energy for:

- Pyrolysis process
  - Self sustaining
- Sell as fuel back to community
  - Generate wealth and cheap, clean source of energy
- Analogous to bagasse used sugarcane ethanol production

Product of Pyrolysis: Bio Oil

=> Acidic, highly viscous black liquid made of complex organic molecules

- Current uses
  - "Co-fired" in gas power plant
  - Raw material of few chemicals

- Future developments…
  - Biofuel for engines, turbines, or boilers
    - Challenges
      - Oxygenated composition has less energy Acid leads to corrosion
      - High viscosity leads to issues
    - High expectations for bio oil as replacement for petroleum products
      - Fuel, expand raw material use, etc.

Large Scale Application

- Dutch waste disposal company
  - Successfully has been implementing pyrolysis disposal system for over 10 years
  - Self sustaining process using syngas from pyrolysis as fuel
    - Surplus energy sold to outside customers

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Application	Feedstock to pyrolysis system	Products of pyrolysis
Waste-to-Energy	•Municipal Solid Waste (MSW) •Waste plastics •Medical waste •Rubber and tyres •E-waste •Biomass /wood •Organic sludge (sewage /oil / paper sludge)	•Electrical energy •Steam •Black carbon •Oil •Non-oxidized metals
Carbonization	•Wooden chips •Organic sludge	•Solid fuel •Fertilizer
Soil remediation	Contaminated soil (dioxins, oil, mercury, organics)	Cleaned soil

Source: http://www.splainex.com/waste_recycling.htm#biomass Splainex Ecosystems Ltd

Splainex Organic Waste Pyrolysis Process

Main component:

- MSW and sewage sludge disposal
  - Production
    - Handles 500 tons per day
    - 300 MWh per day
      - Syngas combustion
- Other chemical processes
  - Plastics
    - Result in primarily bio oil and energy
  - Oil sludge treatment
    - One of limited number of processes that can clean sludge without environmental harm
  - E-waste disposal
    - Global problem because of toxic heavy metals and non biodegradable properties
    - Volatile material is thermally decomposed, while fiberglass and noble metals recycled
  - Medical waste
    - Commonly disposed of by incinerators
      - Dioxin and chlorinated furans found in residue
  - PVC
    - Chlorine recovery as hydrochloric acid
  - Soil remediation
    - Removes dioxins, mercury, PCB, and oil

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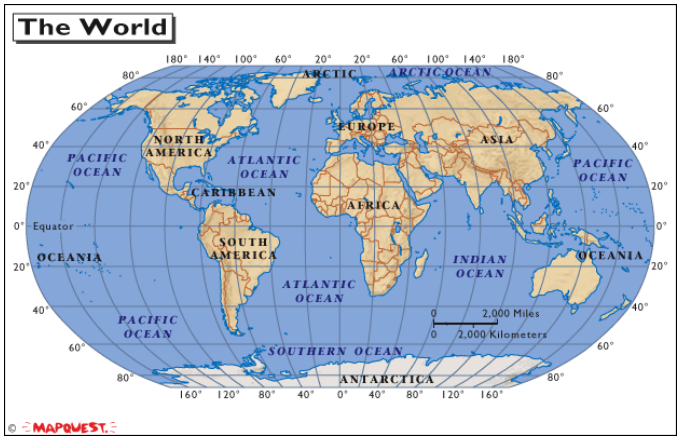
Market for Waste Pyrolysis in the US?

- Currently, very little interest in production here
- Worldwide
  - China
  - India
  - Europe
    - Private investors have funded many plants



Problems

- Engineering challenges
  - Sorting municipal waste
    - Sort organic material from glass, metal, etc.
  - Pre treatment of waste material
    - 10% water for proper pyrolysis

Conclusion

- Pyrolysis should be encouraged as the primary method for waste disposal for its countless economic and environmental benefits
  - Products of pyrolysis
    - Fertilizers, carbon sinks, engine fuels, and potential of use as a motor fuel and a petroleum substitute
  - Decrease impact of landfills and incinerators
    - Solve many environmental crises, including both air and water quality issues and limiting GHG emissions from waste sites
  - Clean oil sludge and other toxic industrial chemicals
    - Limit hazardous effects of disposal
  - Limit reliance on agricultural sources for pyrolysis that has many issues currently
    - Rising food prices, land use issues, etc.

Pyrolysis appeared preferable over incineration regarding the impacts on climate change and depletion of abiotic resources. The analysis also suggested that pyrolysis is less energy-demanding than either recycling or incineration.

-WRAP, UK, government supported non-profit pushing for sustainable disposal of waste

Biofuel Conclusion

- Support sustainable biofuels if:
  - No risk to human food consumption
    - Rising price of food
  - No risk to certain susceptible biomes
    - The Amazon
  - Economically viable without government support
    - Favoritism leads to corruption
- Support all research and development of biofuels but no large scale implementation if any of the criteria above are not met
  - Solutions to energy crisis may come from any area of alternative fuels, so we must continue research in all areas
  - Research may lead to advances in other areas of biochemistry that will benefit mankind