Impact of Landfill Gas and Global Warming

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Introduction

Emission of Greenhouse Gases

CH$_4$ in Atmosphere

Solid Waste Management

Disposal of waste

Current situations

LFG in non sanitary landfills

LFG contributions towards climate change

Current and future mitigation methods

Conclusions
Introduction

- Global climate change a significant environmental issue

- Environmental catastrophe
  - rise in sea level,
  - alteration of rainfall pattern,
  - heat wave-related fatalities
  - extinction of biodiversity
  - etc.

- Mitigating measures need to be implemented.
Melting of ice caps
Image in 1979  Image in 2005
Emission of Greenhouse Gases

- Carbon dioxide ($\text{CO}_2$),
- Methane ($\text{CH}_4$),
- Nitrous oxide ($\text{N}_2\text{O}$),
- Perfluorocarbons (PFCs),
- Sulphurhexafluoride ($\text{SF}_6$) and
- Hydrofluorocarbon (HFCs)
Solar Radiation absorbed by Earth: 235 W/m²

Directly radiated from surface: 40

Heat and energy in the atmosphere: 324

Greenhouse gas absorption: 350

The Greenhouse Effect

Earth's land and ocean surface warmed to an average of 14°C

Thermal radiation into space: 195
Distribution of anthropogenic GHG emissions by sectors in 2004

- Energy supply: 26%
- Transport: 13%
- Buildings: 8%
- Industry: 19%
- Agriculture: 14%
- Forestry/land use change: 17%
- Waste and wastewater: 3%
- Energy supply: 26%
- Transport: 13%
Annual Greenhouse Gas Emissions by Sector

- Industrial processes: 16.8%
- Power stations: 21.3%
- Transportation fuels: 14.0%
- Waste disposal and treatment: 3.4%
- Agricultural byproducts: 12.5%
- Land use and biomass burning: 10.0%
- Fossil fuel retrieval, processing, and distribution: 11.3%
- Residential, commercial, and other sources: 10.3%

Carbon Dioxide (72% of total)
- 20.6% of total
- 29.5%
- 9.1%

Methane (18% of total)
- 12.9%
- 8.4%
- 6.6%

Nitrous Oxide (9% of total)
- 29.6%
- 26.0%
- 1.1%
- 1.5%
- 2.3%
- 5.9%
Global emission of GHG according to cumulative GDP
Change in greenhouse-gas emissions*, 1990-2006, %

Selected countries†

Spain  60
Portugal  40
Australia  20
Greece  0
Ireland  +20
Canada  40
United States  60
Finland
Italy
Japan
Netherlands
France
Sweden
Britain
Germany
Poland
Russia
Ukraine
Estonia
Latvia

* Excluding land use, land-use change and forestry
† With reporting obligations under UN Framework Convention on Climate Change

Source: UNFCCC
The per capita (tons) GHG emission by selected nations in the world
Important Transitions in Emitting Countries Over the Coming Century

Business-as-usual CO₂ Emission Projections by Region

Data derived from Global Energy Technology Strategy, Addressing Climate Change: Phase 2 Findings from an International Public-Private Sponsored Research Program, Battelle Memorial Institute, 2007.
Qualitative assessment of GHG emissions by common waste treatment techniques

<table>
<thead>
<tr>
<th>GHG Generation</th>
<th>Pyrogenic</th>
<th>Biogenic</th>
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<tbody>
<tr>
<td></td>
<td>$\text{CO}_2$</td>
<td>$\text{CH}_4$</td>
</tr>
<tr>
<td>Landfilling</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Landfilling with gas utilization</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Incineration</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Mechanical biological Treatment (with combustion of the light fraction)</td>
<td>+</td>
<td>-</td>
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+ present  - absent
Global Warming Potential (GWP) values and lifetimes from 2007 IPCC AR4 p212

<table>
<thead>
<tr>
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<th>Lifetime (years)</th>
<th>GWP time horizon</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>12</td>
<td>72</td>
</tr>
<tr>
<td>N$_2$O</td>
<td>114</td>
<td>289</td>
</tr>
<tr>
<td>HFC-23</td>
<td>270</td>
<td>12,000</td>
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<tr>
<td>HFC-134a</td>
<td>14</td>
<td>3830</td>
</tr>
<tr>
<td>SF$_6$</td>
<td>3,200</td>
<td>14,300</td>
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</table>
CH$_4$ in Atmosphere

- ~18% of the global anthropogenic sourced from landfill and wastewater
- contributed 90% of the total emissions from waste segment.
- ~40-60 Mtonnes are in landfill gas
  - 11-12% of global emission
- the concentration is 200X lower than that of CO$_2$, but accounted 20% of the current warming capacity.
Trends in GHG emissions calculated based on 2006 IPCC inventory guidelines

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</thead>
<tbody>
<tr>
<td>Landfill CH₄</td>
<td>340</td>
<td>400</td>
<td>450</td>
<td>520</td>
<td>640</td>
<td>800</td>
<td>1000</td>
<td>1500</td>
<td>2900</td>
</tr>
<tr>
<td>Incineration CO₂</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Total GHG emissions</td>
<td>1120</td>
<td>1205</td>
<td>1250</td>
<td>1345</td>
<td>1460</td>
<td>1585</td>
<td>1740</td>
<td></td>
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</tbody>
</table>
Solid Waste Management

- Has been identified as one of the three main sources of environmental degradation in Asian countries.
- Apply to the developing countries including India, China, Malaysia, Indonesia, the Philippines, Thailand and Vietnam.
- Solid waste management is still developing due to various factors which impede sustainable waste management.
- > 90% of the waste generated will be disposed off into landfills.
Incineration without energy recovery 4%

Other waste treatment operations 3%

Landfill 93%

Source: Annual European Union greenhouse gas inventory 1990–2008 and inventory report 2010,
Submission to the UNFCCC Secretariat, 15. April 2010
Highly mixed waste
Leachate oozing out from the landfill contaminating surface water
The flowing river dilute the pollution impact of the leachate
Disposal of waste

- In Malaysia, < 80% of the disposal sites are sanitary landfills
- Similarly in Indonesia and Vietnam, non-engineered landfills are the main method of waste disposal.
- Lack of appropriate mechanisms such as lining system and landfill gas collection system
Activities in an operating disposal site - risks due to GHG.
LFG released from leachate pond
Current Situation

- The lack of alternative options to waste disposal
- High organic components of at least 40% of the total waste generation.
- Humid climate and high precipitation rate enhanced rapid degradation
- Economic constraints.
- Low rate of recycling among the public
  - Lack of policy on waste recycling
  - Cannot reduce the waste volume
- Composting is not very conducive
  - Lack of market
  - Non-competitive compared to inorganic fertilizer
  - Non-sustainable strategy
Percentage of Waste Generated by Some of The Asian Countries (Adapted from UNESCAP, 2000).
Generation of Organic Solid Waste in Selected Asian Countries

Organic waste in MSW in selected Asian countries (%)

- Indonesia, 70.2
- Hong Kong, 37.2
- China, 35.8
- Thailand, 48.6
- South Korea, 31
- Singapore, 44.4
- Philippines, 41.6
- Myanmar (Burma), 80
- Laos, 54.3
- Japan, 17
- Malaysia, 43.2
Valuable waste sorted out from waste stream
Heterogeneous wastes received by landfills
Recyclable material includes plastics, paper etc.
LFG in non sanitary landfills

- Lacked LFG collection and treatment system.
- LFG escape into the atmosphere from cracks of landfill cover.
- LFG emission difficult to monitor and collected.
- LFG harvesting or flaring is not viable.
- Passive release is more practical and economically feasible.
No control of LFG emission in a landfill in India
Passive release of landfill gas into the atmosphere
Gases bubbling out from leachate
Sanitary landfills have the potential to harvest LFG for energy conversion.
LFG contributions towards climate change

- Sea rising
- Alteration in earth surface pressure
- Changes in microclimate
- Etc.
Potential Impacts in Asia

- Glacier Melt in the Himalayas
- Floods
- Cyclones & tidal surges
- River bank erosion
- Salinity
- Waterlogging
- Droughts

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Climate change impact: Sea rising

- Melting of polar ice caps
- Increase the volume of water in the sea resulting with the level to rise.
- Floods low laying terrestrial areas and destroy the ecosystems within.
- Increase salinity of the fresh water system.
- Create global water crisis
Impact of increase in temperature

Since 1979, more than 20% of the Polar Ice Cap has melted away.
Florida then and Florida in future
What would be the future for Bangladesh?
Estimates of people flooded in coastal areas in the 2080s as a result of sea level rising.
Flood episodes will be more frequent
Low-laying area will no longer be inhabitable
Salinification of a rice field
New strain of rice with tolerance to high salinity will incur higher cost - unaffordable to poor farmers
Drought impacts are serious
Global water crisis
Climate change impact: Pressure alteration

- Alter the earth surface pressure.
- Change the intensity of the air movement.
- More powerful cyclone.
- Alter the frequency of the occurrence of cyclones, typhoons, and hurricanes.
- Change the rainfall patterns.
- Rain dependent crops will be severely affected.
  - Global food shortage.
Formation and location of cyclones
STAGES OF DEVELOPMENT OF AN EXTRATROPICAL CYCLONE

DEVELOPING (00 hrs)

MATURE (24 hrs)

WARM FRONT

COLD FRONT

SURFACE WIND FLOW

DISSIPATING (48 hrs)

EXTRATROPICAL CYCLONES FORM ALONG THE BOUNDARIES BETWEEN COOL AND WARM AIR MASSES
Destrucrions by cyclones
Change in rainfall pattern will cause destruction to existing ecosystem
Changes in rainfall patterns will influence water supply
Climate change impact: Changes in microclimate

- the loss of biodiversity
- unfavorable conditions for the organisms to strive
- Alter the food web → unstable ecosystem.
- Encourage insect infestation.
  - more conducive environment for breeding
  - epidemics due to insect-borne diseases increase.
Change in microclimate will severely affect the sensitive organisms
A polar bear died of exhaustion due to the change in microclimate. More energy is required for the bear to reach their hunting ground.
Warmer temperature create conducive environment for insects; Bad news to human!
Current and future mitigations methods

- Appropriate technologies applicable to local condition require the integration of various factors
  - flexible strategies
  - financial incentives
- Clean Development Mechanism (CDM)
- reduce the ecological footprint → reduce the GHG emission globally.
- Waste management sector has a potential to reduce 20% of global GHG
  - the climate change can be lessened.
Clean Development Mechanisms
Host countries of CDM municipal solid waste projects
Type of technologies supported by CDM
Simplified CDM Project Cycle

1. Agreement
2. Project Idea Note (PIN)
3. Letter of Host Gov. Non-objection
4. Baseline Methodology & Study
5. CDM Methodology Panel
6. Monitoring & Verification Plan
7. Project Design Document (PDD)
8. Validation
9. Host Government Approval
10. CDM Executive Board
11. Forward Sale Contract
12. Receiving Country Approval
13. Finance & Install Technology
14. Regular M&V
15. CER Issuance
16. Delivery to Buyer
Registered projects implemented under Kyoto’s “Clean Development Mechanism”

Number of projects by host parties

- India
- China
- Mexico
- Brazil
- South Korea
- Philippines
- Malaysia
- Chile

* Less than 5

Not many projects are financed in Africa yet.
Conclusions

- The generation of LFG has serious repercussions on climate change.
- Necessary mitigation measures need to be implemented to reduce the GHG emission.
- The sooner we initiate remedial measures, the better our chances of sustainable living.
Good news! At the current rate of global warming we should be able to just swim over there and eat him in under five years...!