# LIFE CYCLE ASSESSMENT OF MANAGEMENT OF MUNICIPAL SOLID WASTE: A CASE STUDY

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# Management of Municipal Solid Waste

- The environmentally friendly handling of municipal solid waste is one of the most pressing problems in modern society
- **Landfilling** of mixed waste is abandoned as its environmental impacts are now considered **unacceptable**
- **Source-sorting of recyclables** and **diversion of the biodegradable fraction** of MSW from landfills through appropriate treatment are now required elements in any integrated solid waste management system
- Through appropriate treatment processes, materials and energy can be recovered leading ideally to **ZERO WASTE** in a circular economy concept

# Goal of this work

- Evaluation of the environmental impacts of the management of municipal solid waste generated in a city of 1.000.000 inhabitants, producing daily approximately 1,000 tons of MSW
- Selection of the most environmentally friendly treatment technology in an integrated system of MSW management
- Four alternative scenaria were developed and compared using LCA:
  - Anaerobic digestion without energy recovery
  - Anaerobic digestion with energy recovery
  - Composting
  - Incineration

# Main assumptions in all scenaria

- Recycling part (15%) of the recyclable MSW at the source
- Disposal of MSW in bins
- Collection of MSW from the bins
- Transportation by trucks to the process-disposal location
- Mechanical separation of the MSW
- Treatment of the MSW
- Landfill disposal of the residues of the mechanical separation and the main treatment process

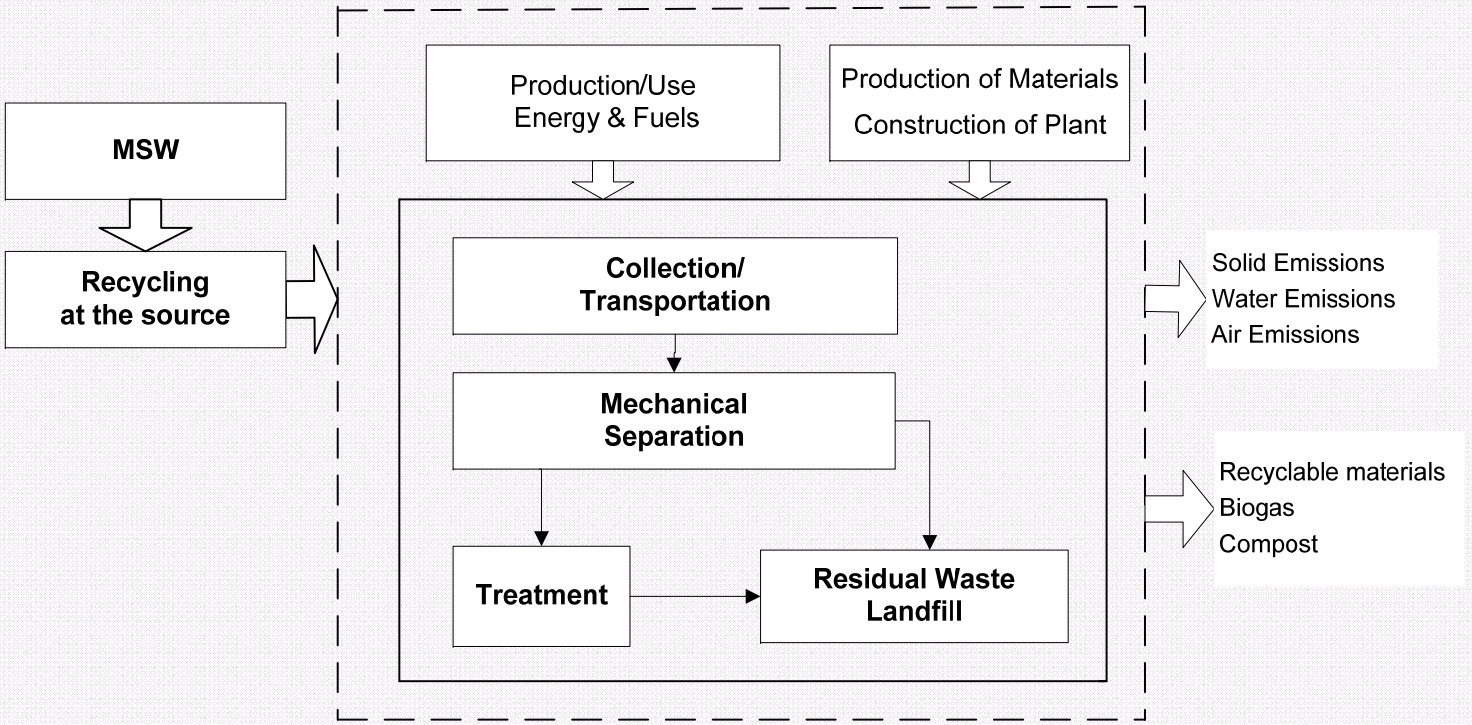
# Methodology

- A spreadsheet model was constructed
- Life Cycle Impact Assessment methodology was used:

  LCA software SimaPro 7.1 and

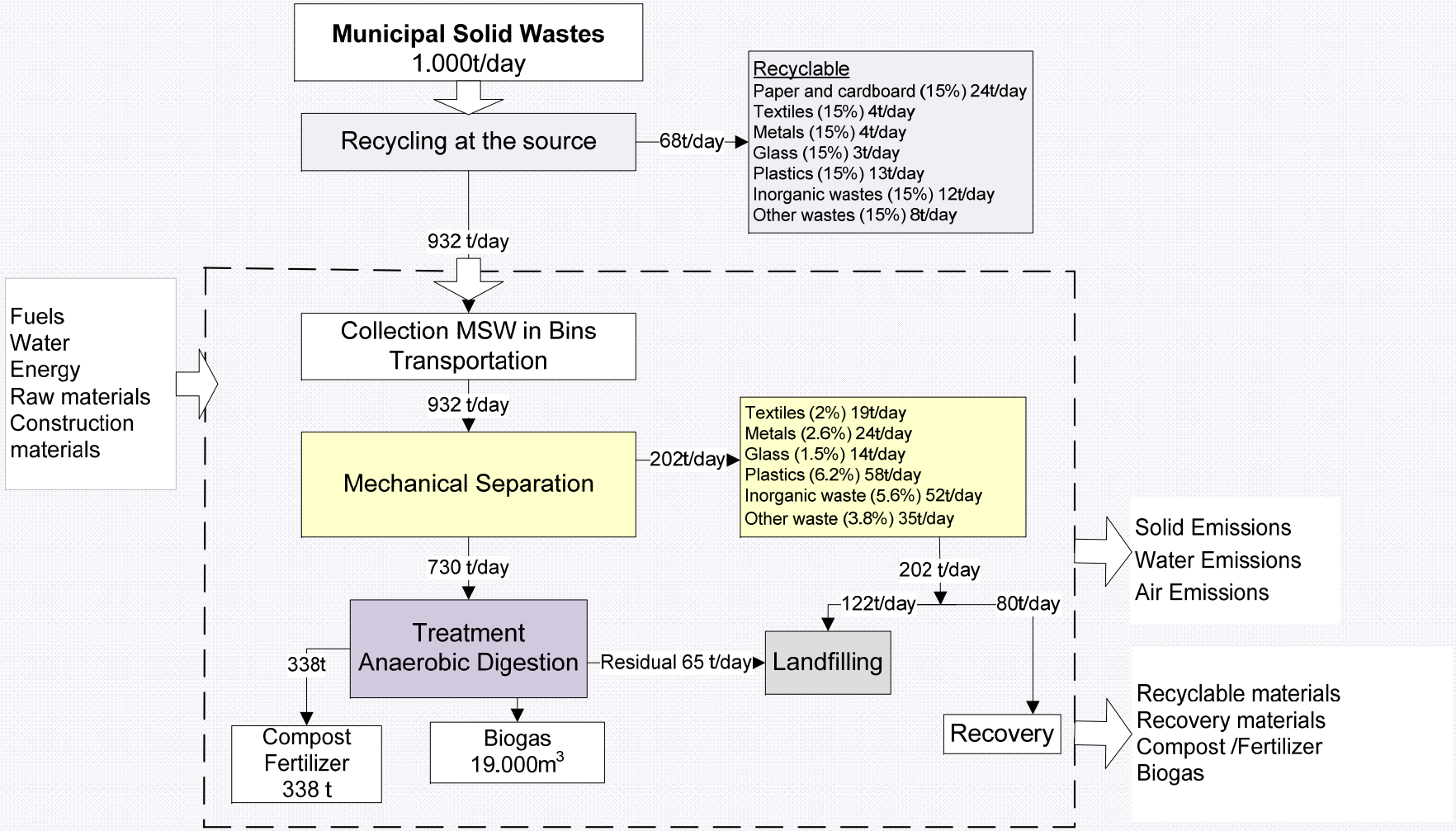
  CML 2 baseline 2000 methodology

# System Boundary

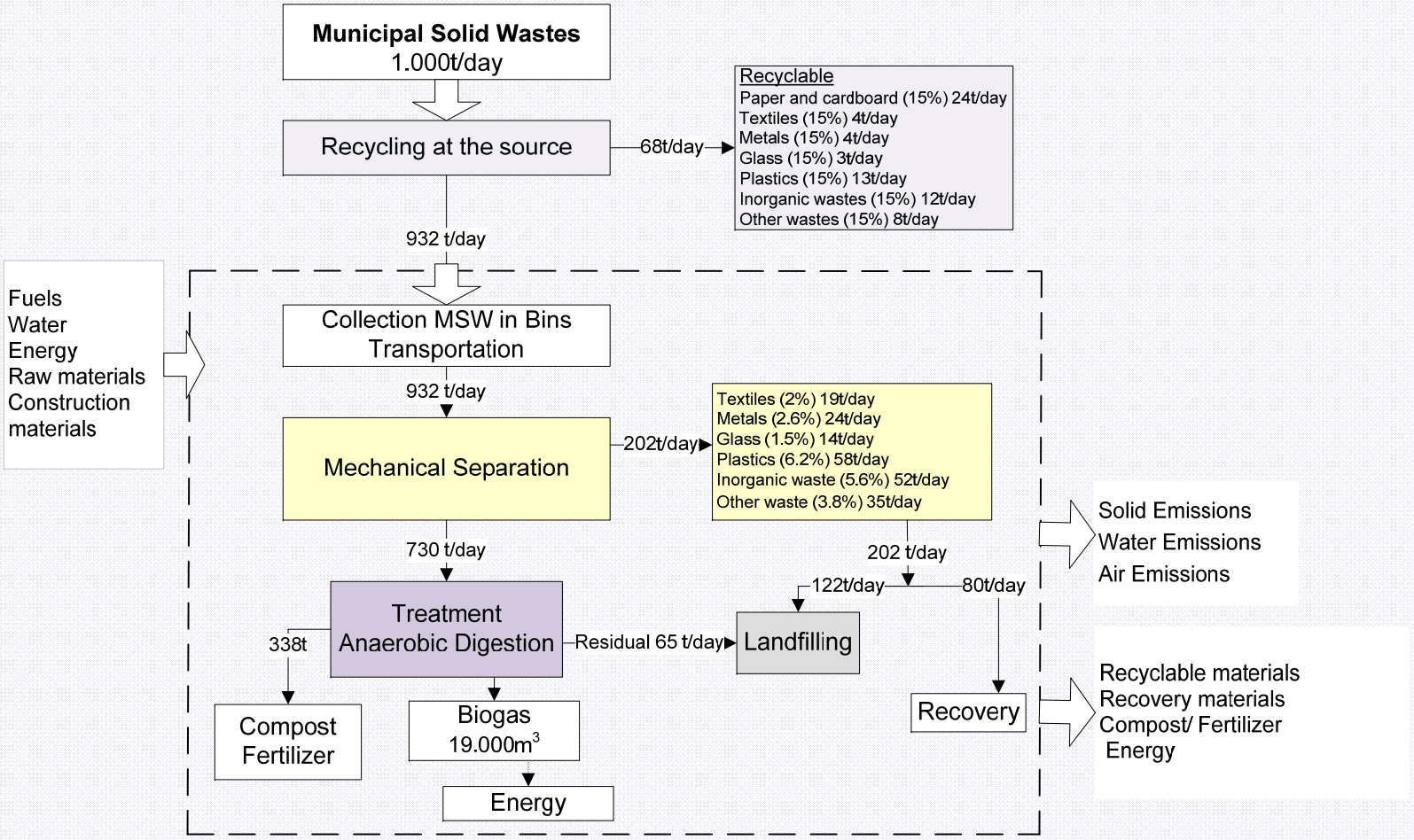



**Functional unit:** 1,000 tons per day of generated MSW

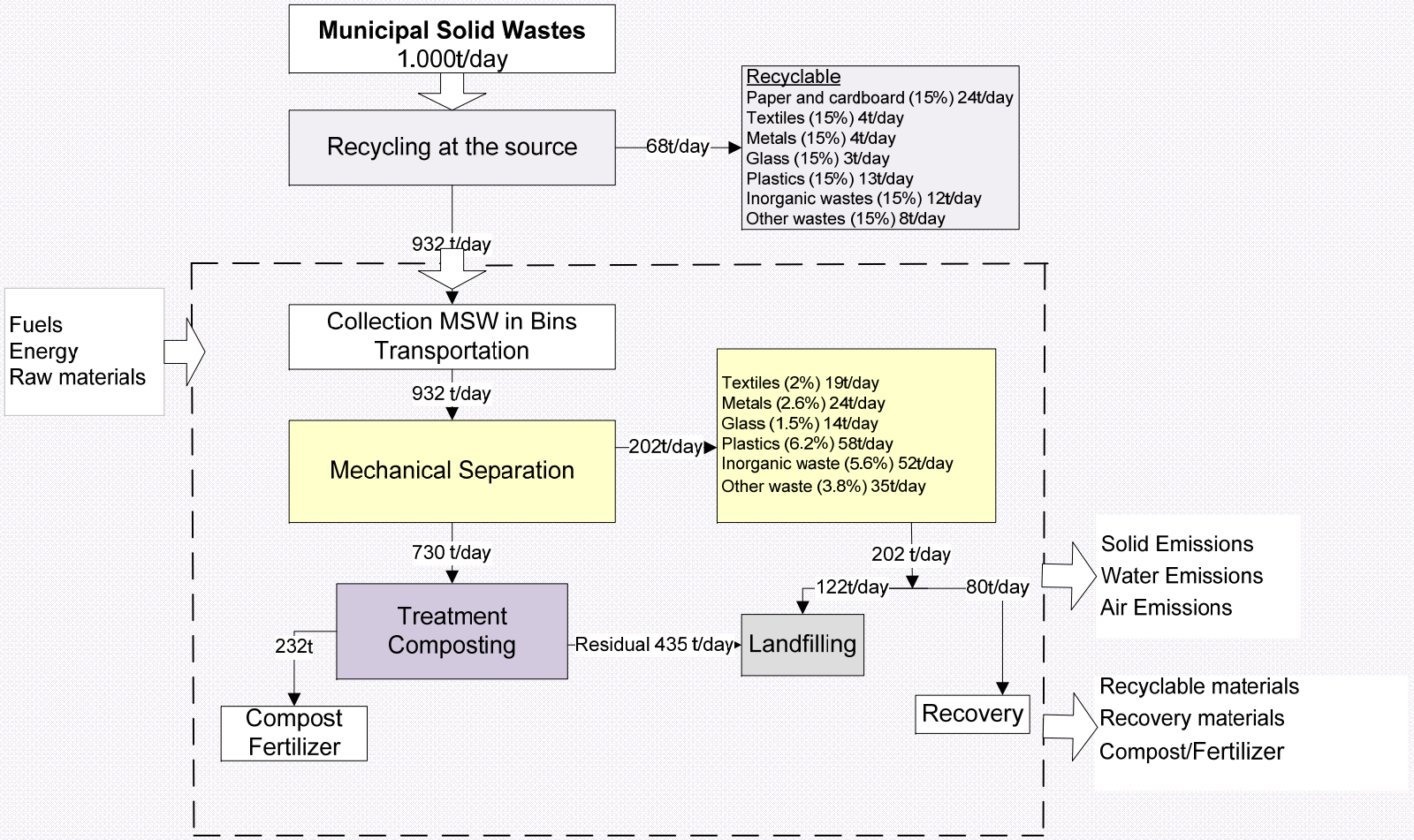
# **Scenario I:** Anaerobic digestion without energy recovery



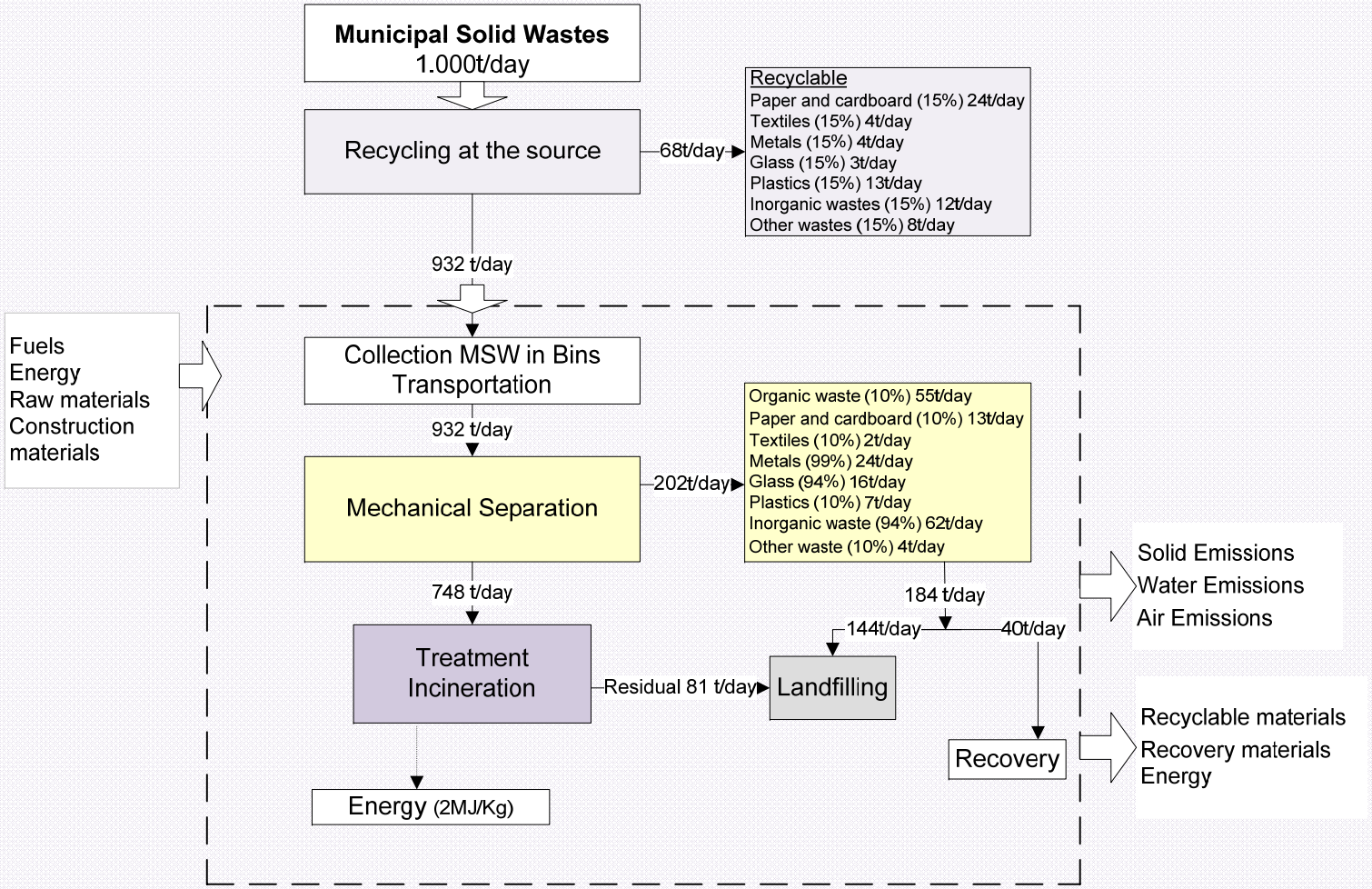
# **Scenario II:** Anaerobic digestion with energy recovery



# **Scenario III:** Composting



# **Scenario IV :** Incineration



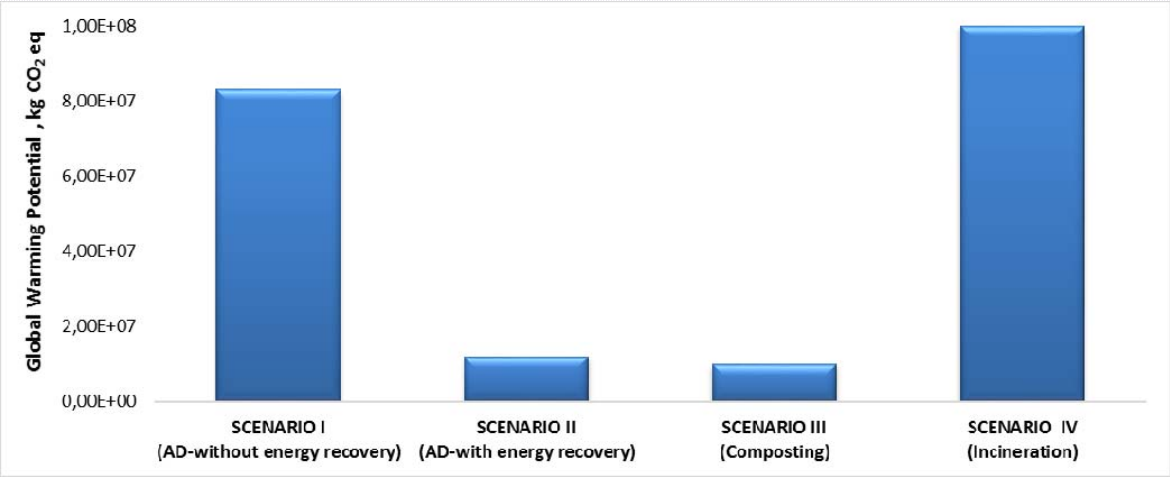
# Assumptions

- The term “generated MSW” includes residential (household) and commercial solid wastes (such as food waste, paper, cardboard, plastic, textiles, rubber, leather, wood and yard waste, glass, tin cans, aluminum, ferrous metals, other metals etc)
- The composition of the generated MSW is based on the data of MSW for the Region of Attica in Greece
- The examined alternative scenaria minimize the amount of waste for landfilling, while maximizing material and energy recovery
- The source-separated materials are collected separately from the other waste and the impacts of their treatment on the environment are not taken into consideration
- The total distance for daily collection is comprised of the distances between bins in the city and the distance between the city and the final management point

# Assumptions

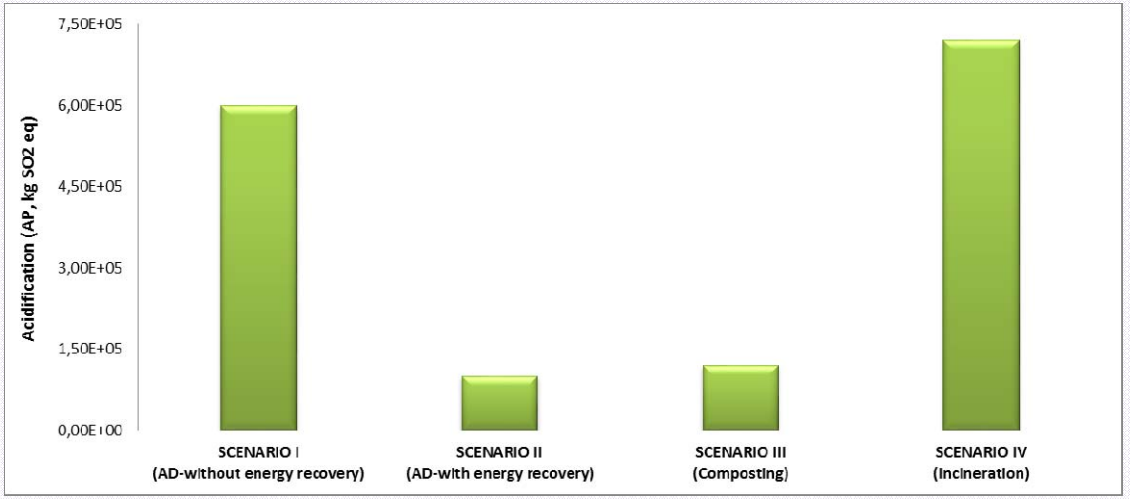
- All resources consumed during the operation phase (assumed 30 years) and activities carried out are included.
- The life cycle impact assessment includes both the operation and the construction phases
- Extraction, production and transportation of raw materials, fuels and electricity are included
- The production of equipment such as truck and separators, is not accounted for due to the lack of representative data

# Results



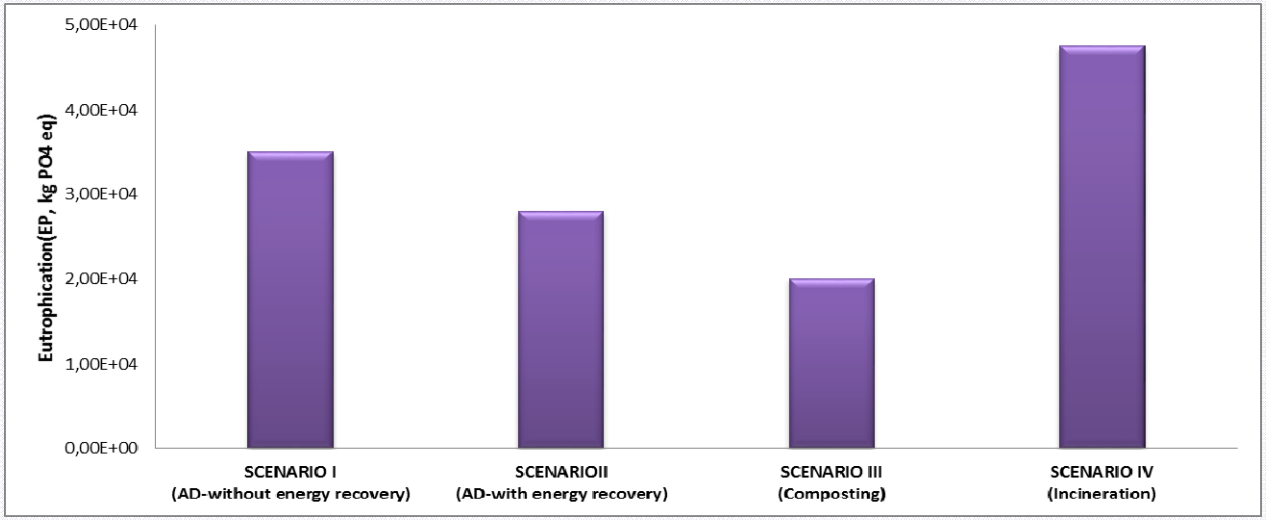

Impact category:
Global Warming Potential
(GWP, kg $CO_2$ eq)

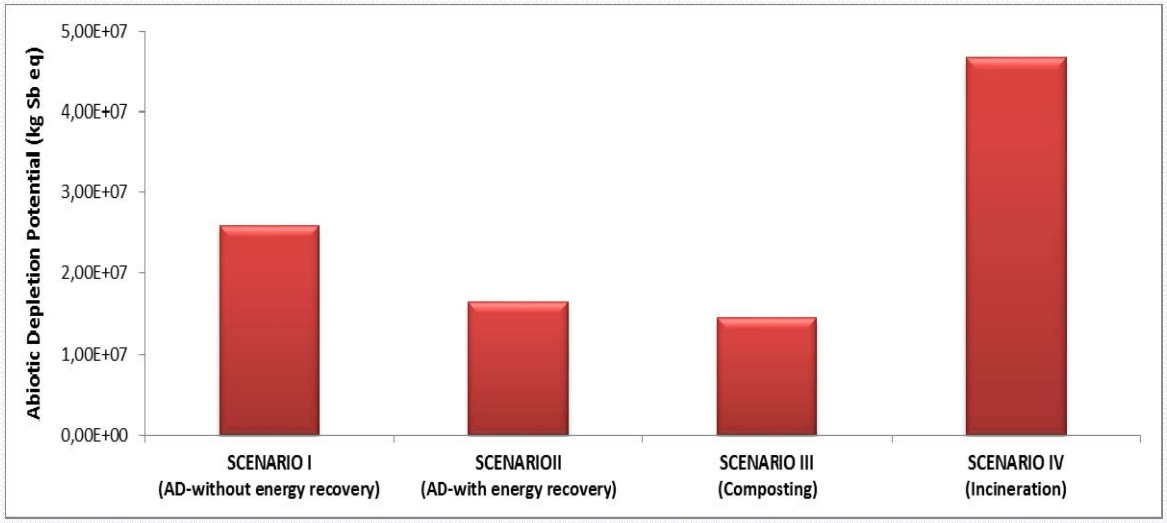
Impact category:
Acidification Potential
(AP, kg $SO_2$ eq)



# Results

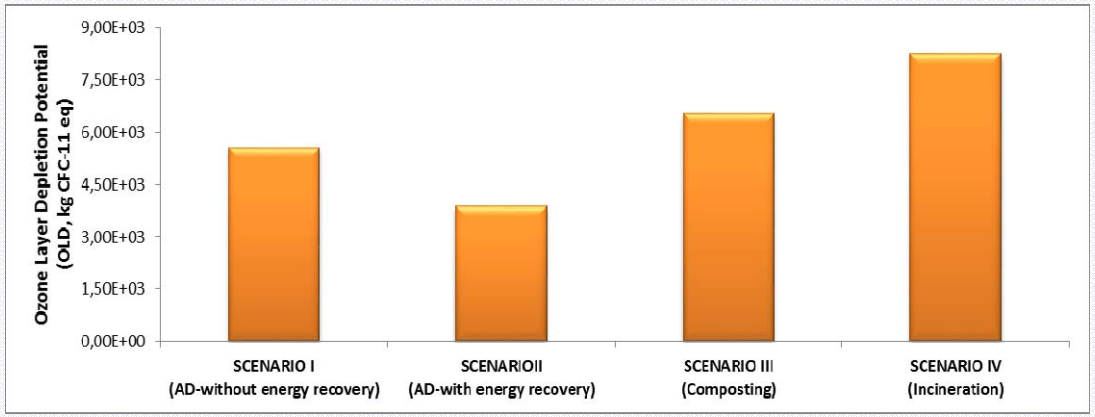
Impact category:
Eutrophication Potential
(EP, kg $PO_4$ eq)



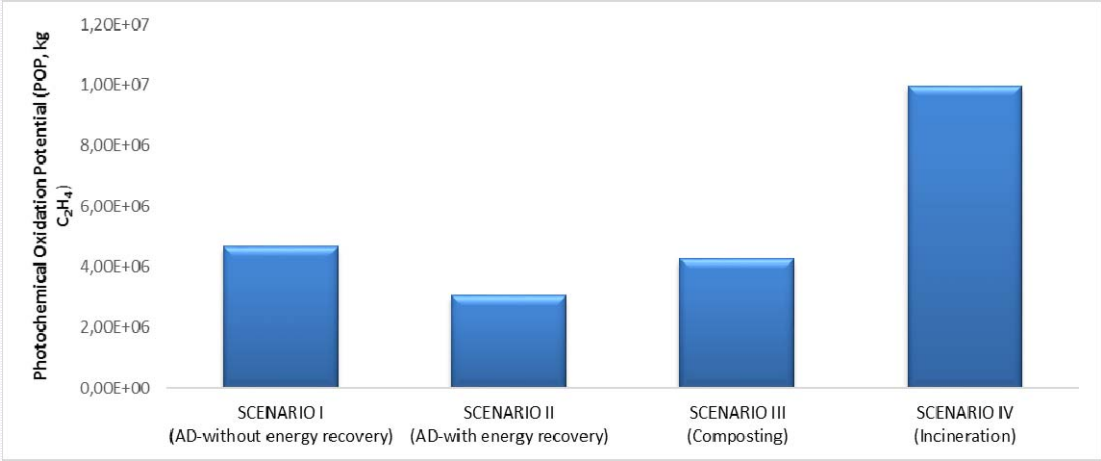

Impact category:
Abiotic Depletion Potential
(kg Sb eq)

# Results

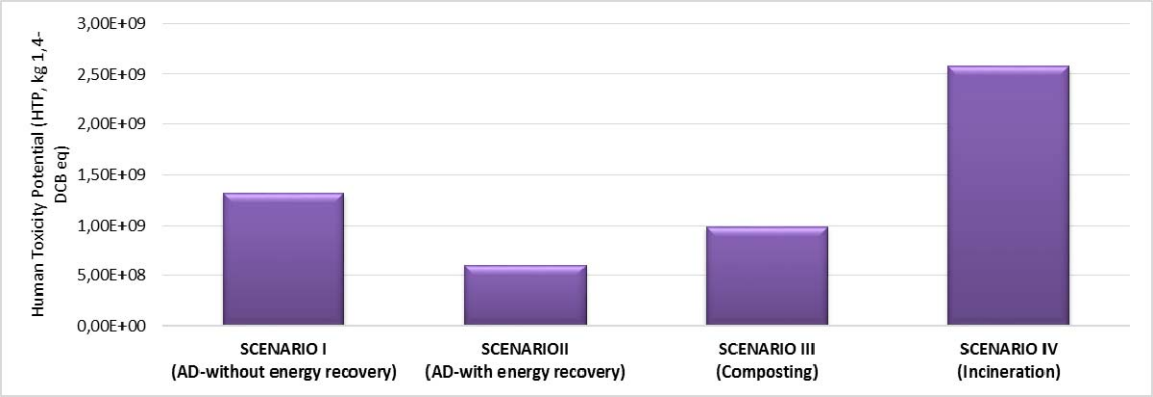



Impact category:
Ozone Layer Depletion Potential (OLD, kg CFC-11 eq)

Impact category:
Photochemical Oxidation Potential (POP, kg $C_2H_4$)

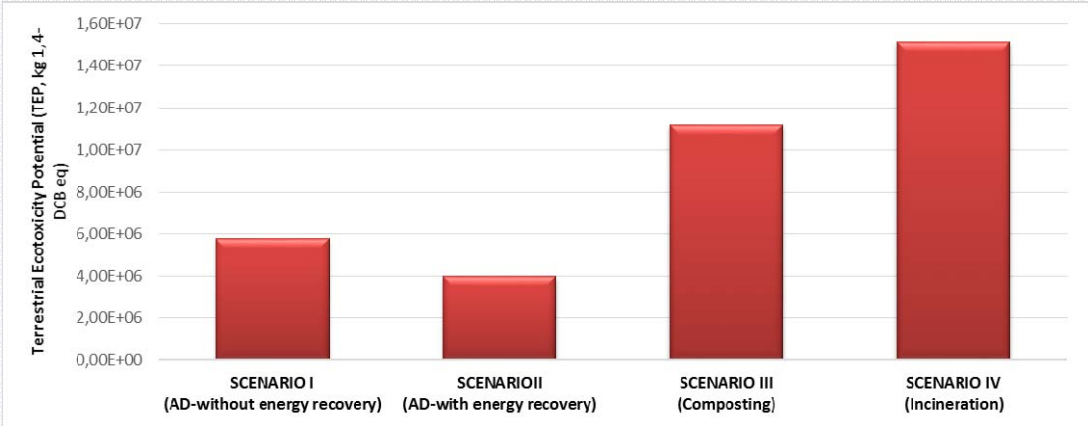


# Results

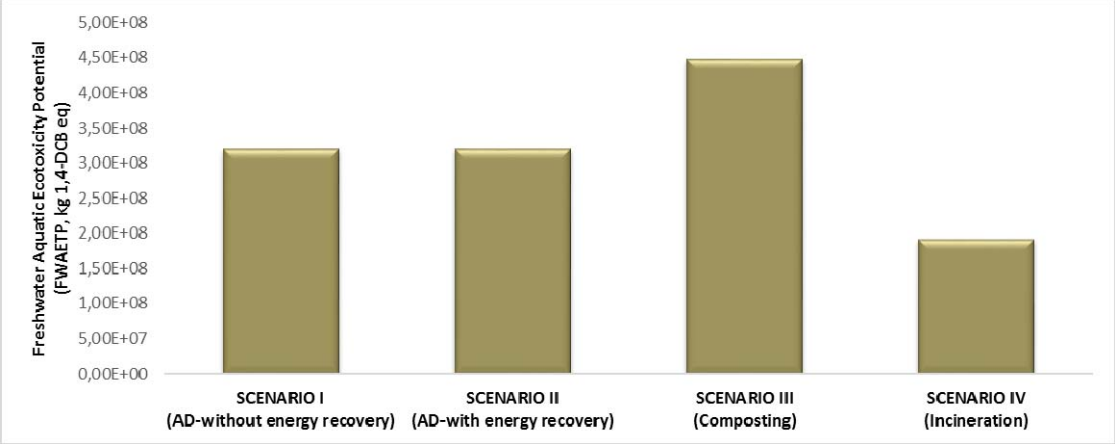



Impact category:
Human Toxicity Potential (HTP, kg 1,4-DCB eq)

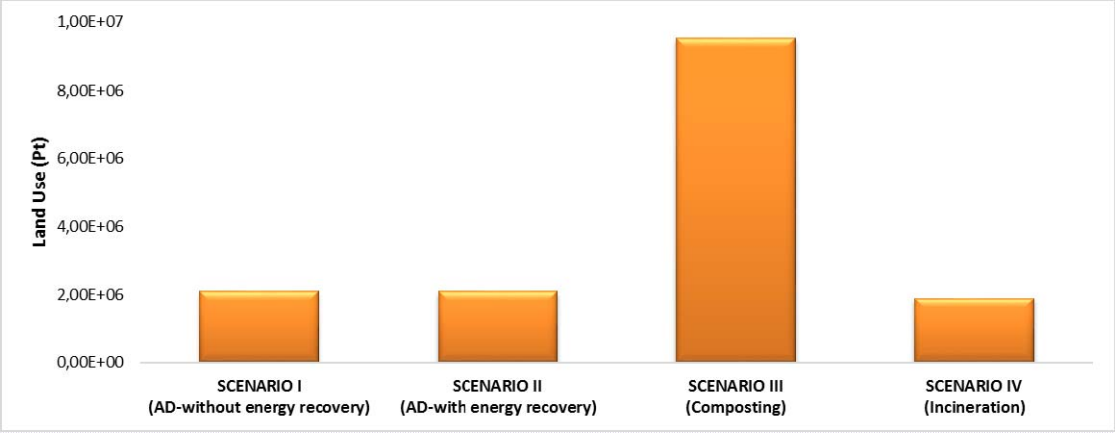
Impact category:
Terrestrial Ecotoxicity Potential (TEP, kg 1,4-DCB eq)



# Results



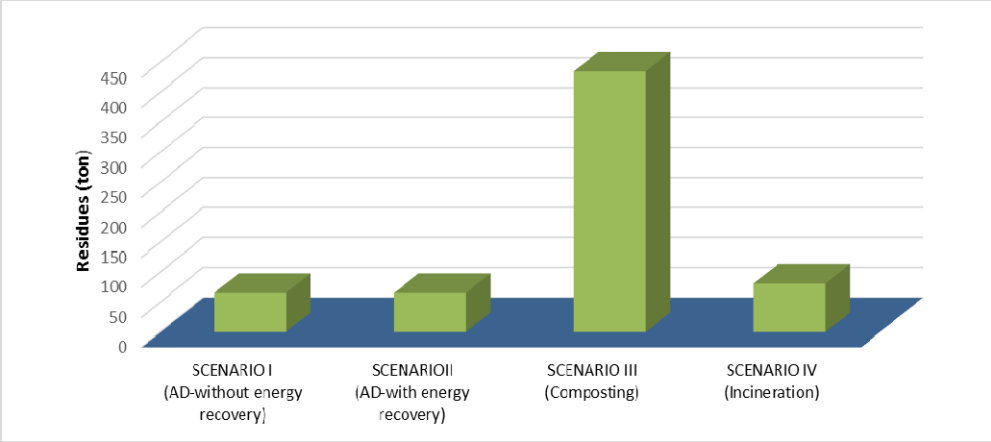

Impact category:
Freshwater Aquatic Ecotoxicity Potential (FWAETP, kg 1,4-DCB eq)




Impact category:
Land Use (Pt)

# Results

## Composting as treatment




operation phase:

- Production of high amount of residues
- low demands for energy

construction phase:

- low demands for facilities
- high demands for space

# Conclusions

- The most environmentally friendly alternatives for the management of MSW are clearly **Scenaria II**, ***anaerobic digestion with energy recovery and III, composting***, while the least preferable scenaria are **Scenaria I, anaerobic digestion without energy recovery and Scenario IV, based on incineration as treatment**
- The impact of the two best scenaria are comparable, with each scenario being preferable for specific impact categories
- In order to chose between them, other considerations such as economic viabilty and social acceptability need to be considered

***Thank you for your attention!***