PORTO 1990/2000:
EVALUATION OF ENVIRONMENTAL BURDENS FROM MSW MANAGEMENT USING LIFE CYCLE ASSESSMENT

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Overview

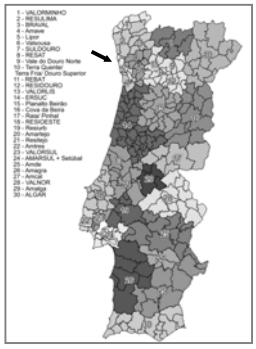
- Introduction
- Porto: from 1990 to 2000
- Results and Conclusions

Introduction

- **Municipal solid waste (MSW) management have been considered in Portugal one of the most important environmental issues**
  - the increase in the amount of waste produced
  - the need for new facilities for waste treatment and disposal
    - locations - approval by municipalities and citizens
  - the continuously increasing costs of waste collection and treatment
    - citizens complains and disagreement - the need of municipalities to support these higher costs
  - the awareness of citizens for questions related with the environment
    - environmental burdens resulting from waste treatment and collection

MSW management in Portugal

- Responsability of municipalities
- Multimunicipal associations
- **LIPOR**
  - Commited to manage the MSW of 8 municipalities in the Porto region
    - Porto - 43 km2
  - MSW collected by the municipalities and transported to LIPOR treatment sites



MSW management in Portugal

- Responsability of municipalities
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- LIPOR
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- **Changes during last decade 20th century**
  - in waste management collection and treatment/disposal systems
  - in order to
    - achieve governmental goals
    - reduce the associated environmental burdens

In this study:

- Evaluation of **environmental burdens** for air and water from the MSW management practices in the municipality of Porto for 1990 and 2000 using a model developed by White et al (White et al, 1995)
- **Operations considered**:
  - collection, sorting, biological treatment, thermal treatment and landfilling
  - savings in energy consumption and in emissions resulting from recovered materials that replace virgin materials
- For each pollutant, the **main source**, among the operations considered, was identified

The pollutants included in the study are:

Air pollutants

- Particulate
- CO
- CO2
- CH4
- NOx
- N2O
- SOx
- HCl
- HF
- H2S
- Total hydrocarbons (HC)
- Chlorinated hydrocarbons
- Dioxins/furans
- NH3
- As, Cd, Cr, Cu, Pb, Hg, Ni, Zn

Water pollutants

- BOD
- COD
- Suspended solids
- TOC
- AOX
- Chlorinated hydrocarbons
- Dioxins/furans
- Phenol
- Ammonia
- Total metals
- As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Zn
- Cl
- F
- NO3
- Sulphide

Porto:

from 1990 to 2000

Data collection

- for the description of the municipality
  - population
  - waste production and characterization
  - management practices from collection to the final disposal
- Sources of data
  - Personal contacts
    - Porto municipality environmental department
    - LIPOR
  - Statistics and technical publications

Porto - 1990

Population	**302 500**	
Hab/household	**2.7**	
MSW production (kg/person.year)	**383**	
Collection	**Kerbside collection of mixed waste**	
	6 x week	
	115 000 ton	
	Glass banks	
	1 050 ton	
Disposal	**Composting: 20%**	•Recovery of 6% Fe metals and 16% non- ferrous •Compost marketed •Residual waste to landfill
	Landfilling: 80%	•Gas collection system •Lined •Leachate collection and treatment
	Glass Recycling	

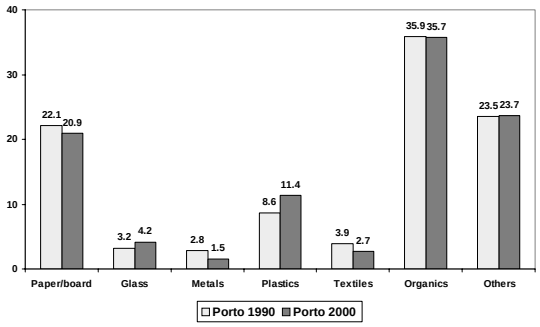
Porto - 2000

Population	**263 100**
Hab/household	**2.1**
MSW production (kg/person.year)	**551**
Collection	**Kerbside collection of mixed waste**
	6 x week
	96.4%
	Selective collection
	Door-to-door: paper/board, packages **1 x week - coloured bags**
	Collection banks: paper/board, packages, glass
	Central collection sites: paper/board, plastic, glass
Packages	**6.6%** *(2% DtD)*
Paper/board	**36.8%** *(1% DtD)*
Glass	**54.2%**
Plastics	**2.4%**

Porto - 2000

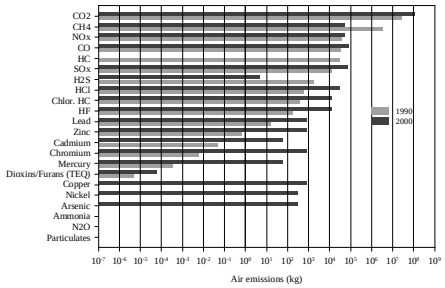
Disposal		
	Central Sorting	•Electrical energy consumption: 30.7 kWh/ton waste •Diesel consumption: 2.17 L/ton waste •Residual waste to incineration plant 15 km away
	Composting	•Recovery of ferrous scrap from bottom ash: 100% •Compost marketed •Residual waste to landfill 15 km away
	19.7%	
	Incineration	•Mass-burn with energy recovery •Efficiency of electricity production: 20% •Recovery of ferrous scrap from bottom ash: 90% •Non-hazard waste to landfill 15 km away •Fly ash to a landfill 300 km away
	79.2%	
	Landfilling	•Diesel consumption: 0.6L/ton waste •Gas collection system (40% efficiency) + burned •Lined •Leachate collection (70%) and treatment
	1.1%	

Mixed waste composition (% by weight)



Results and Conclusions

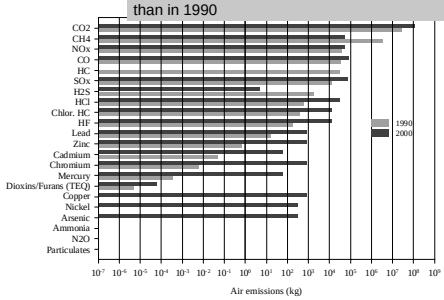
Air emissions (kg)



- 1990: Particulates, N2O, Ammonia
- 2000: Particulates, N2O, Ammonia, HC

Air emissions (kg)

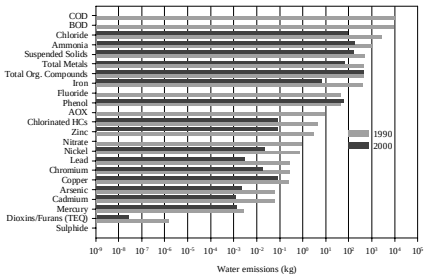
air emissions of CO2, NOx, CO, SOx, HCl, Chlorinated HC, HF, Pb, Zn, Cd, Cr, Hg, Dioxins/furans, Cu, Ni and As, were higher in 2000 than in 1990



the main pollutants to air in 1990 were CO2, CH4, NOx and CO

the main pollutants to air in 2000 were CO2, CO, SOx, CH4 and NOx

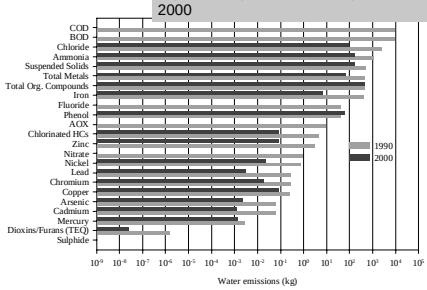
Water emissions (kg)



- 2000: Sulphide, nitrate, AOX, Fluoride, BOD, COD

Water emissions (kg)

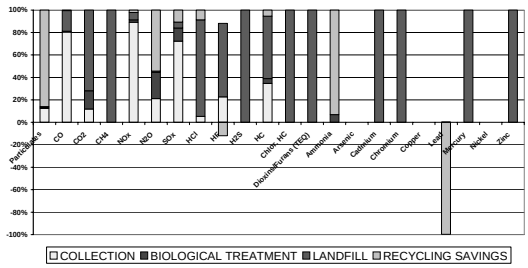
all emissions to water, except phenol and total organic compounds, were higher in 1990 than in 2000



the main pollutants to water in 1990 were COD, BOD, chloride and ammonia

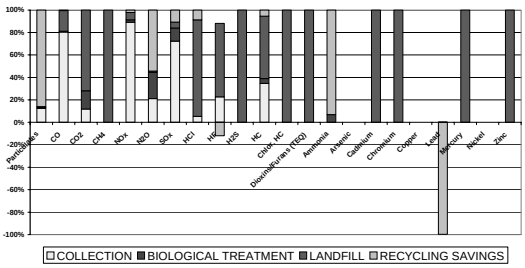
the main pollutants to water in 2000 were TOC, ammonia and suspended solids

Air emissions 1990 – contribution of MSW management operations



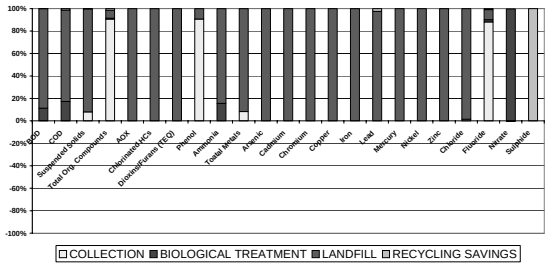
Air emissions 1990 – contribution of MSW management operations

collection was the main source for CO, NOx and SOx in air emissions in 1990



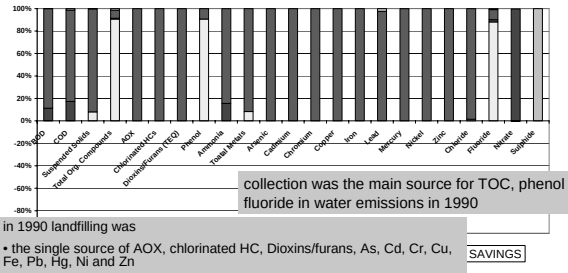
biological treatment was the main source for N2O and ammonia in air emissions in 1990

Water emissions 1990 – contribution of MSW management operations



Water emissions 1990 – contribution of MSW management operations

landfilling was the main source of air and water pollutants in 1990 followed by collection

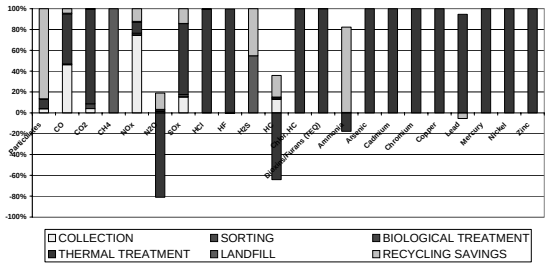


collection was the main source for TOC, phenol and fluoride in water emissions in 1990

in 1990 landfilling was

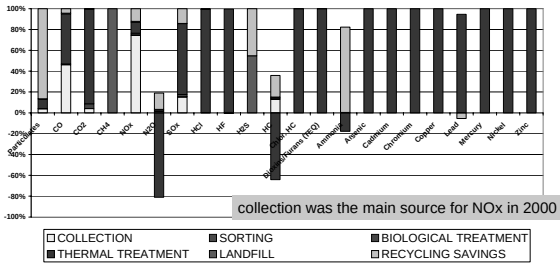
- the single source of AOX, chlorinated HC, Dioxins/furans, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn
- the main contributor for BOD, COD, and ammonia along with a small contribution from composting
- the main contributor for SS, total metals and Cl with a small contribution from collection

Air emissions 2000 – contribution of MSW management operations



Air emissions 2000 – contribution of MSW management operations

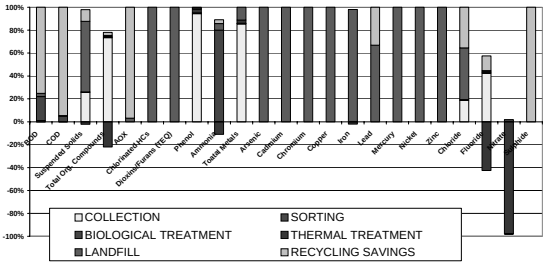
in 2000, thermal treatment was the main source of air pollutants



collection was the main source for NOx in 2000

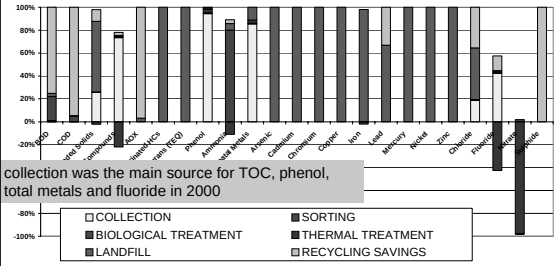
thermal treatment in 2000, due to recovery of energy, contributes to decrease BOD, COD, suspended solids, TOC, ammonia, Iron, fluoride and nitrate emissions

Water emissions 2000 – contribution of MSW management operations



Water emissions 2000 – contribution of MSW management operations

in 2000, the landfill was the main source of water pollutants



collection was the main source for TOC, phenol, total metals and fluoride in 2000

thermal treatment in 2000, due to recovery of energy, contributes to decrease N2O, HC and ammonia emissions

Conclusions

- air emissions of CO2, NOx, CO, SOx, HCl, Chlorinated HC, HF, Pb, Zn, Cd, Cr, Hg, Dioxins/furans, Cu, Ni and As, were higher in 2000 than in 1990
- all emissions to water, except phenol and total organic compounds, were higher in 1990 than in 2000
- the main pollutants to air in 1990 were CO2, CH4, NOx and CO
- the main pollutants to air in 2000 were CO2, CO, SOx, CH4 and NOx
- the main pollutants to water in 1990 were COD, BOD, chloride and ammonia
- the main pollutants to water in 2000 were TOC, ammonia and suspended solids

Conclusions

- landfilling was the main source of air and water pollutants in 1990 followed by collection
- in 1990 landfilling was
  - the single source of AOX, chlorinated HC, Dioxins/furans, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni and Zn
  - the main contributor for BOD, COD, and ammonia along with a small contribution from composting
  - the main contributor for SS, total metals and Cl with a small contribution from collection
- **in 2000, thermal treatment was the main source of air pollutants and the landfill the main source of water pollutants**

Conclusions

- collection was the main source for CO, NOx and SOx in air emissions in 1990 and for NOx in 2000
- collection was the main source for TOC, phenol and fluoride in water emissions in 1990 and for TOC, phenol, total metals and fluoride in 2000
- biological treatment was the main source for N2O and ammonia in air emissions in 1990
- **biological treatment was the only source for nitrate in water emissions in 1990 and the main source in 2000 for BOD, COD and ammonia**

Conclusions

- **recycling savings contribute to decrease the following emissions:**
  - **to air in 1990: particulates, CO, NOx, N2O, SOx, HCl, HC and Ammonia**
  - **to water in 1990: BOD, COD, suspended solids, TOC, phenol, ammonia, Pb, fluoride and sulphide**
  - **to air in 2000: particulates, CO, CO2, NOx, N2O, SOx, HCl, H2S, HC, Ammonia and Hg**
  - **to water in 2000: BOD, COD, suspended solids, TOC, AOX, phenol, ammonia, Pb, chloride, fluoride and sulphide**
- **recycling savings have a negative contribution to the following emissions:**
  - **HF and Pb to air in 1990 and in 2000**
  - **nitrate to water in 1990 and in 2000**

Conclusions

- thermal treatment in 2000, due to recovery of energy, contributes to decrease the following emissions:
  - to air: N2O, HC and ammonia
  - to water: BOD, COD, suspended solids, TOC, ammonia, Iron, fluoride and nitrate.

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Thank you for your attention