Sustainable Contaminated Land Remediation

[SUBR:IM Work Package E - Robust Sustainable Technical Solutions to Contaminated Brownfield Sites]

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Are current remediation technologies sustainable?

- Positive effects of treatment:
  - Reuse of land
  - Removal of blight; regeneration
  - Removal of risks

- Two areas to consider:
  - The effect of remediation or containment
  - The act of remediation or containment

Are current remediation technologies sustainable?

- Example: excavation and disposal
  - Creates waste, nuisance
  - Quick, simple, site completely restored (ideally)
- Immediate effects
  - During remediation
  - Most visible
- Future effects
  - Durability / failure
  - May not be considered

Are current remediation technologies sustainable?

- What do we mean by “sustainable”?
  - Future benefits outweigh cost of remediation
  - Environmental impact of the implementation process is less than the impact of leaving the land untreated
  - Environmental impact of the remediation process is minimal and measurable
  - Timescale over which the environmental consequences occur, and hence intergenerational risk, is part of the decision-making process
  - Decision-making process includes an appropriate level of engagement of all stakeholders

Sustainability and wider environmental impacts

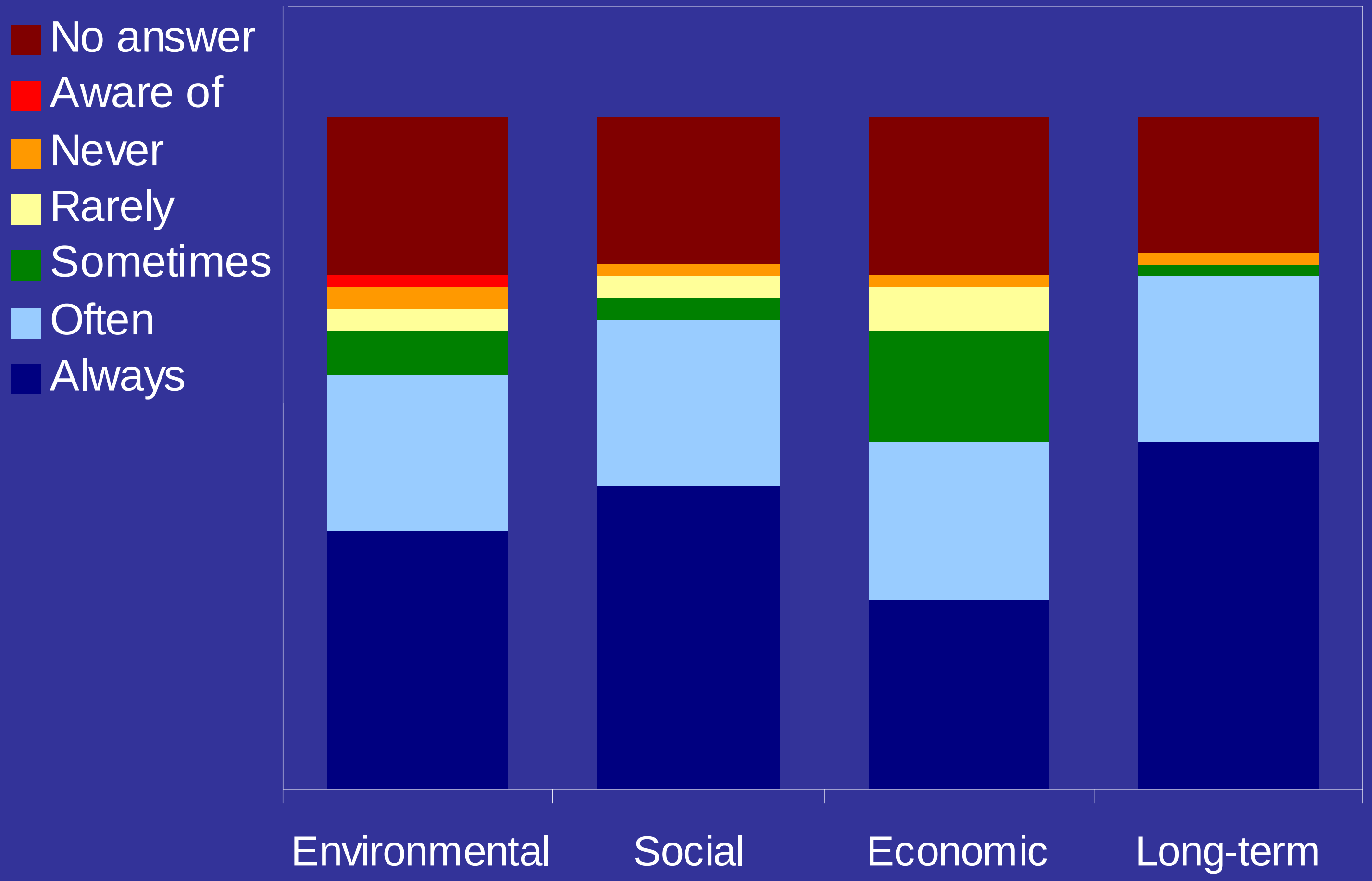
- Emphasis in various documents e.g. CLR11, EA reports, scientific papers

- Some breakthrough into industry
  - ‘sustainable’ is often quoted but how true is it?

- Process-based rather than civil engineering methods

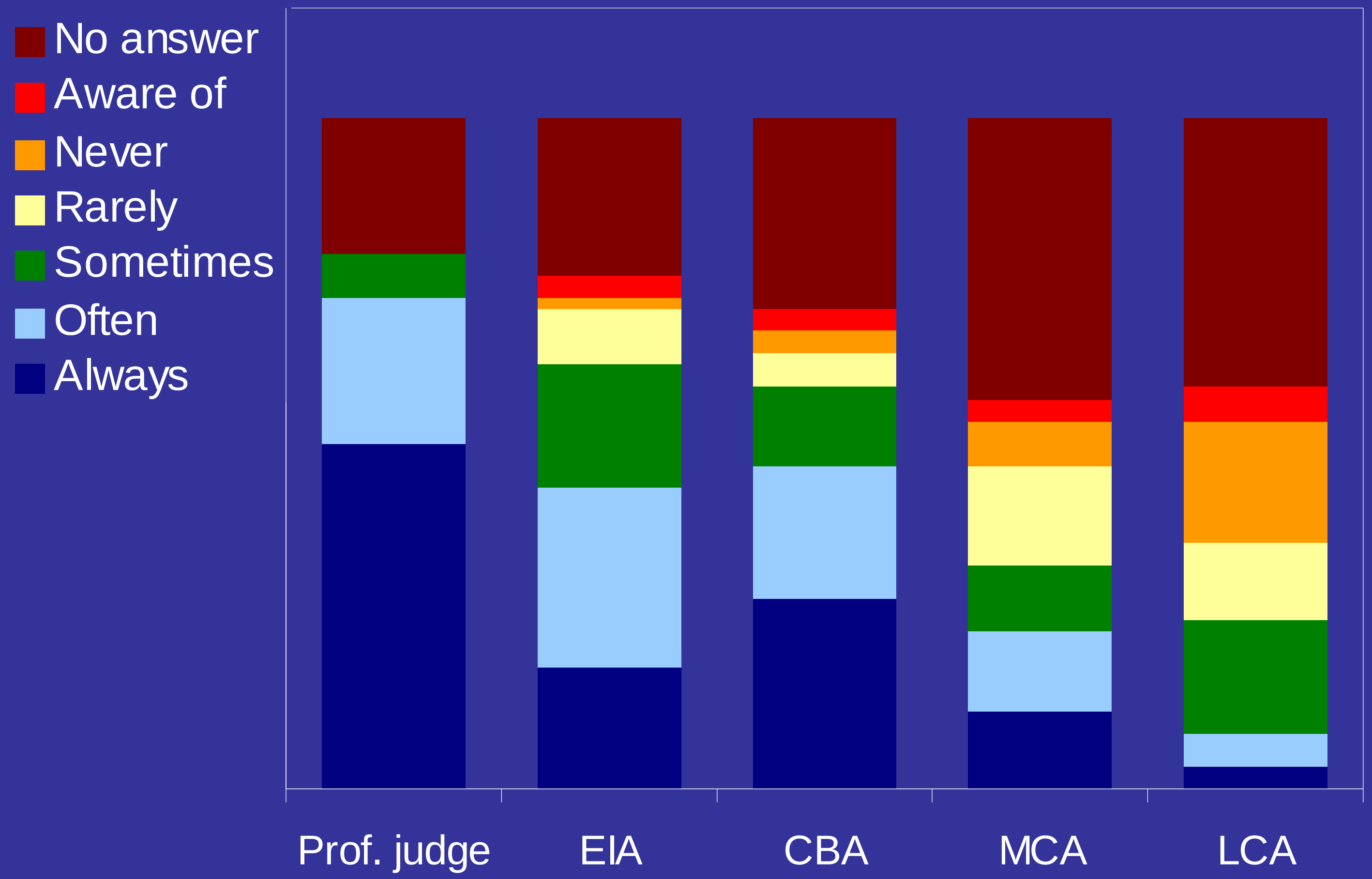
Questionnaire

"Do you consider the sustainability of any aspects of a project in the selection of a remediation technology?"



Questionnaire

"What methodologies do you or have you used in helping you to determine the best remediation technology for a particular project?"



Work package outcomes

- Assessed and compared sustainability of currently used remediation technologies
  - Methodology
  - Case studies
  - Generic understanding of technology impacts?

- Investigated potential improvements to current technologies

Sustainability Assessment Method

- Technical & environmental impacts
- Methods of comparison
  - Multi-criteria analysis
    - Semi-subjective, semi-quantitative
    - Overall impression
  - Detailed impact analysis
    - Impacts assessed and compared individually
    - Quantitative, objective

Sustainability Assessment Method

- MCA (expanded version of EA method):
  - 17 criteria
  - Scores for onsite and offsite, both during and after
  - Weights onsite and offsite
  - Sensitivity analysis

			S/S		**Landfill**	
Use of natural resources	During	Onsite	-31	31% of mass of material used in landfill.	-100	Raw materials used; landfill capping/lining
		Offsite	0		-20	
	After	Onsite	0	No material used	0	No material used
		Offsite	0		0	
	Weights		0.5 on and off site			
Overall scores			**-15.5**		**-60**	

Sustainability Assessment Method

- Detailed impact assessment includes:
  - Emissions
  - Resource use
  - Health risks
  - Transportation
  - Future site usability
- Non-aggregated data

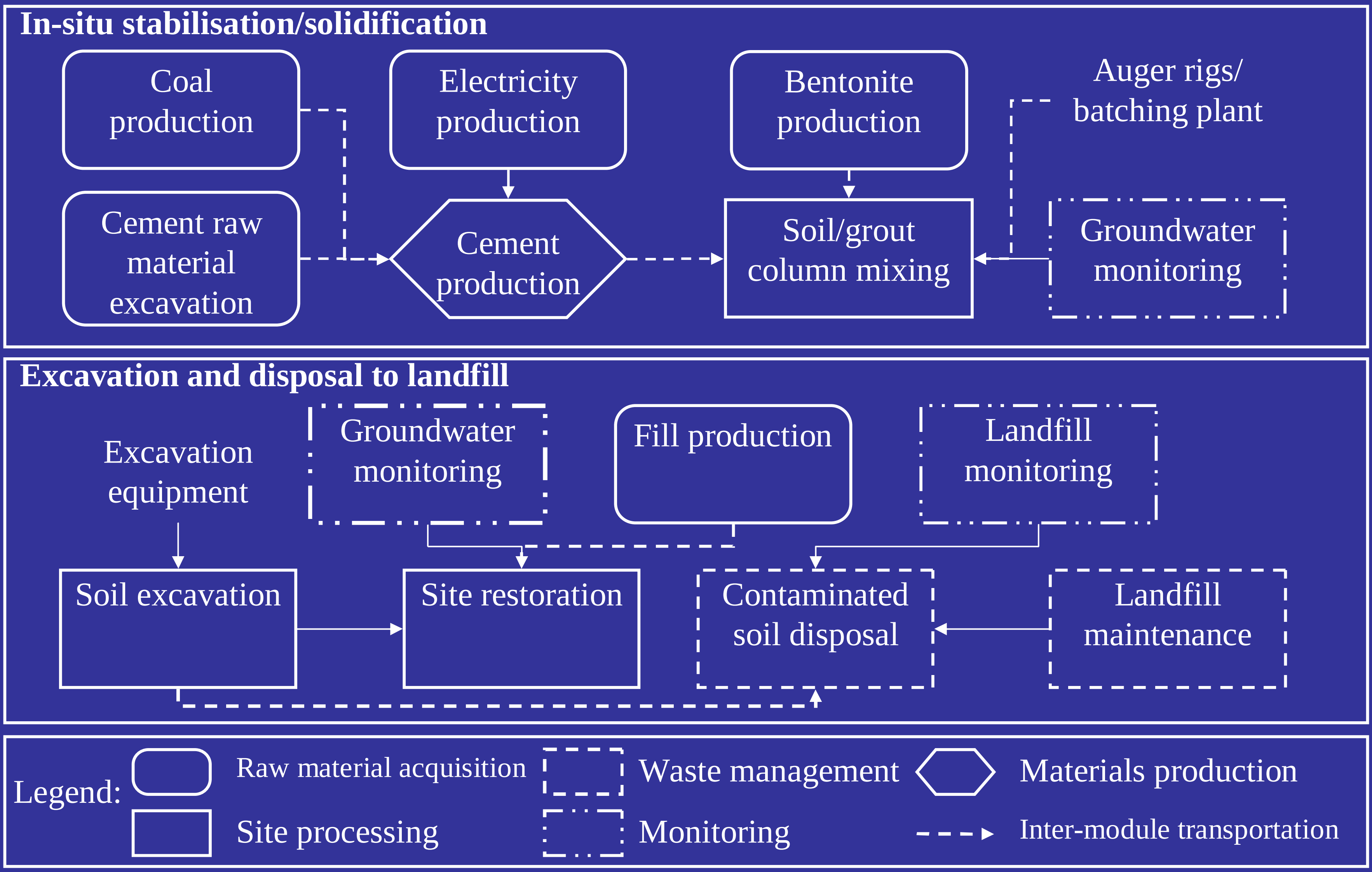
Comparison to previous work

- Comparing projects on different sites
  - Site specific
- Lack / inaccessibility of data
- Subjectivity (MCA)
  - Hence use of detailed impact analysis
  - MCA has other advantages
    - Use of qualitative information

Case study 1

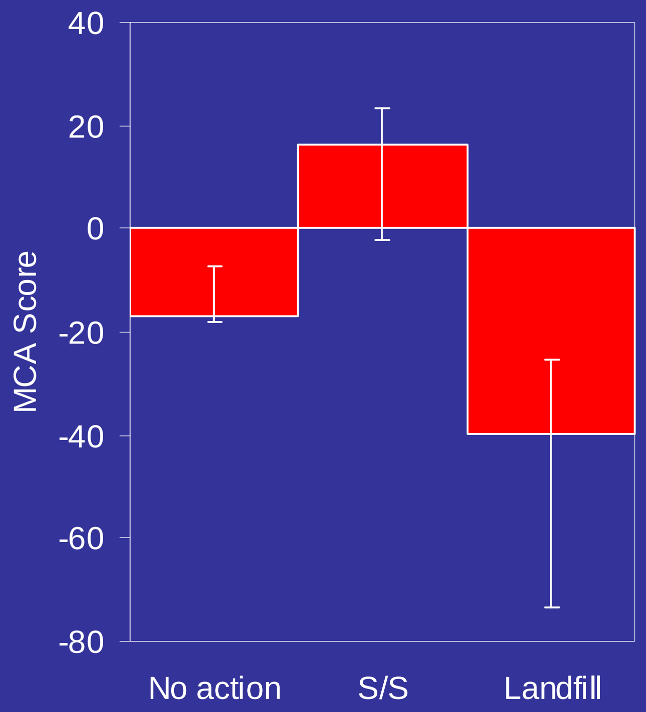
- Comparison of:
  - In-situ Stabilisation/Solidification (S/S)
  - Excavation and disposal
  - No action
- All on the same UK site
  - S/S actually performed, landfilling considered

Case study 1


In-situ stabilisation/solidification
Coal production
Electricity production
Bentonite production
Auger rigs/ batching plant
Cement raw material excavation
Cement production
Soil/grout column mixing
Groundwater monitoring
Excavation and disposal to landfill
Excavation equipment
Groundwater monitoring
Fill production
Landfill monitoring
Soil excavation
Site restoration
Contaminated soil disposal
Landfill maintenance
Legend:
Raw material acquisition
Waste management
Materials production
Site processing
Monitoring
Inter-module transportation

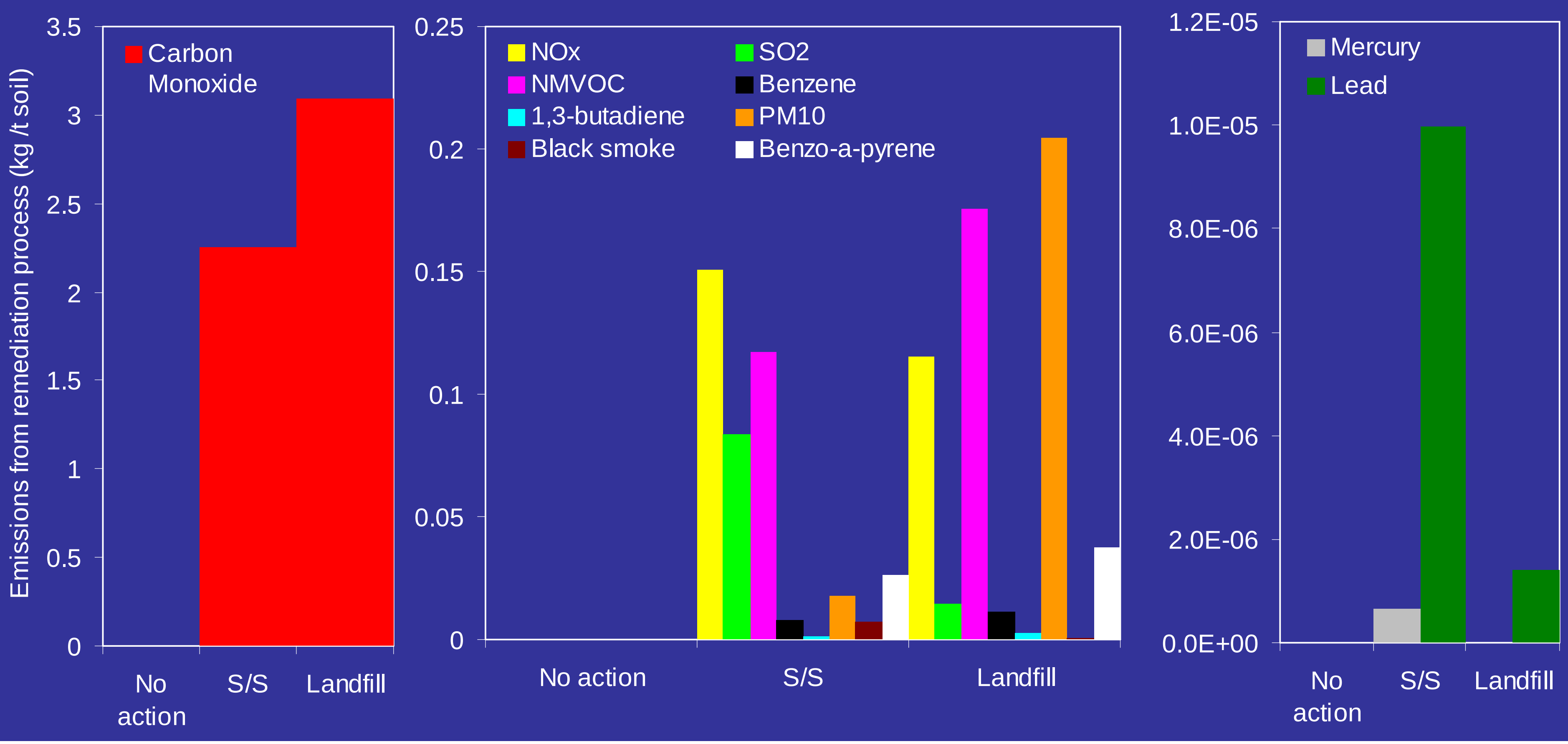
Case study 1

- MCA:
  - Low score for excavation and disposal (landfill)
  - In-situ S/S does well
  - No action better than landfilling?



Case study 1

- Detailed impact analysis
  - Example of emissions

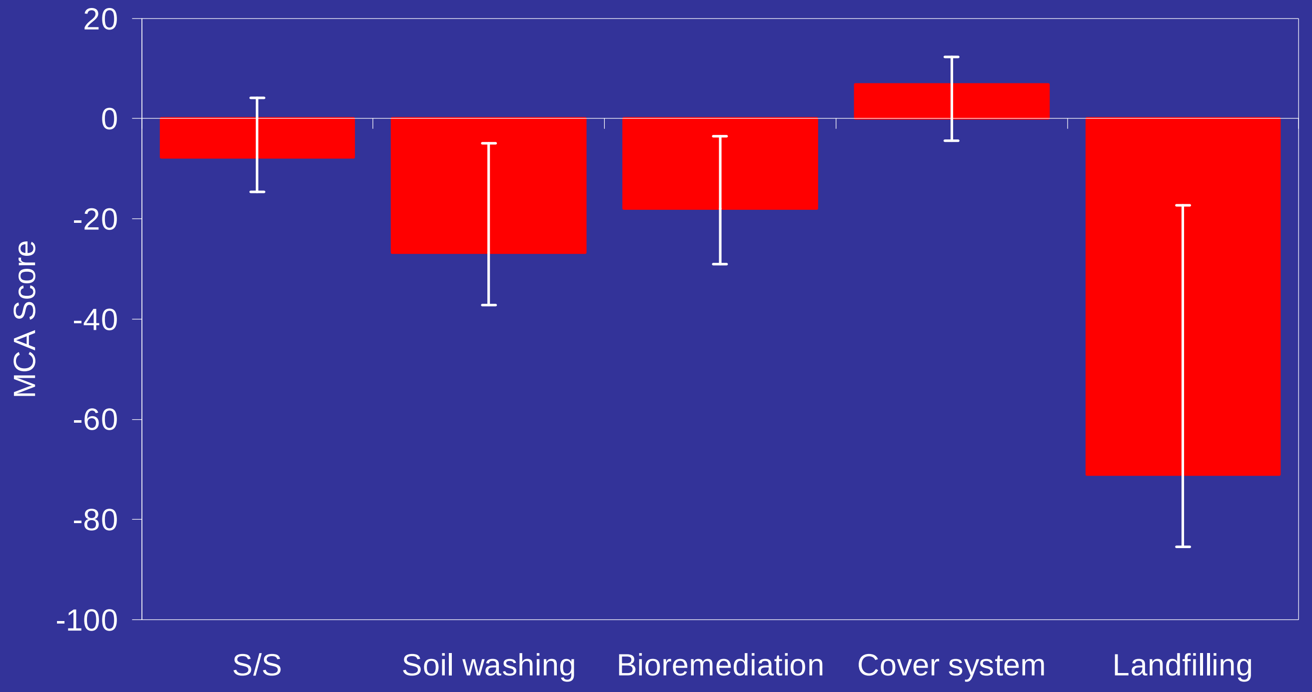


Case study 2

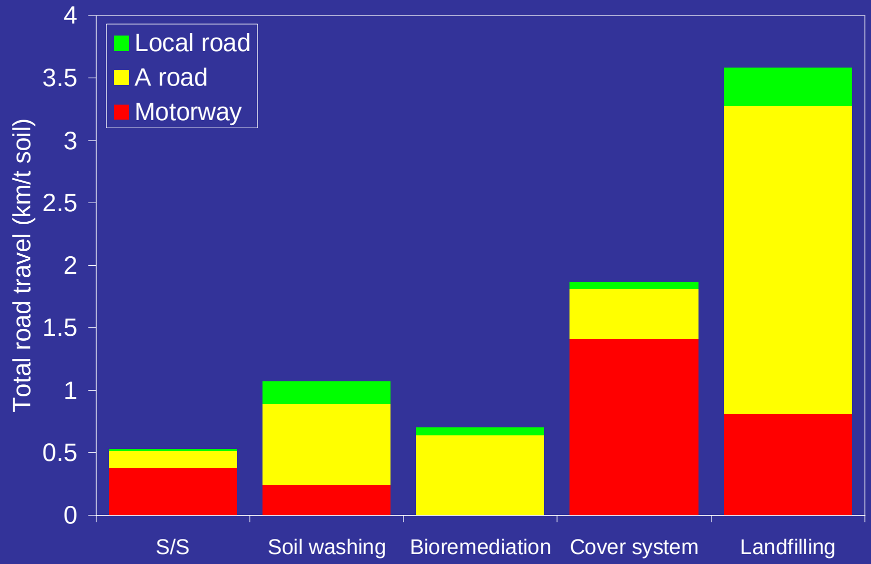
- Comparison of five projects:
  - In-situ S/S (as before)
  - Soil washing
  - Ex-situ bioremediation
  - Cover system
  - Excavation and disposal
    - different to previous study

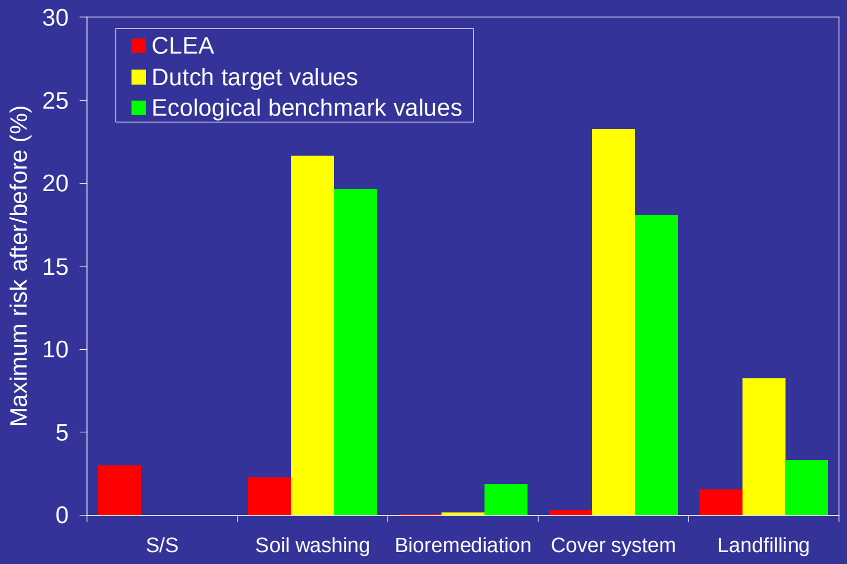
Case study 2

- MCA:
  - Cover system gives best outcome
  - Landfilling gives worst
  - Excavation and disposal leads to greatest impacts



Case study 2





(1 – best, 5 – worst)	MCA	CO_2 emissions	Resource use	Site reusability
S/S	2	5	1	2
Soil washing	4	2	4	5
Bioremediation	3	3	3	3
Capping	1	1	2	4
Dig & dump	5	4	5	1

General conclusions on assessments

- Remediation isn't necessarily sustainable
  - Long term impacts?
  - Some major impacts not considered
  - Feasible to assess sustainability?
- From case studies:
  - Landfilling performs poorly
  - The cover system had particularly low impacts
  - *In situ* systems generally perform well
- Sustainability is site specific

General conclusions on assessments

In-situ stabilisation/ solidification	Low intensity operations Low waste production Low disturbance Low transportation Low noise	High CO_2 emissions and energy use due to cement production Contaminants remain Changes to soil properties
Soil washing	Reduced transportation Reduced waste Short duration High energy use	Impacts on landfill site Fill use High intensity operation High noise
Ex-situ bioremediation	Destruction of contaminants Low transportation Low disturbance Fill use	Impacts on landfill site High intensity operation High noise
Cover system	Low waste Low emissions Rapidity Reduced transportation	Low energy use Some contaminants remain Impacts on landfill site High noise
Excavation and disposal to landfill	High transportation High waste production High material use Impacts on landfill site	High energy use Long duration High disturbance

Potential improvements

- Changes in basic practice
  - Minimisation of waste
  - Reuse of materials

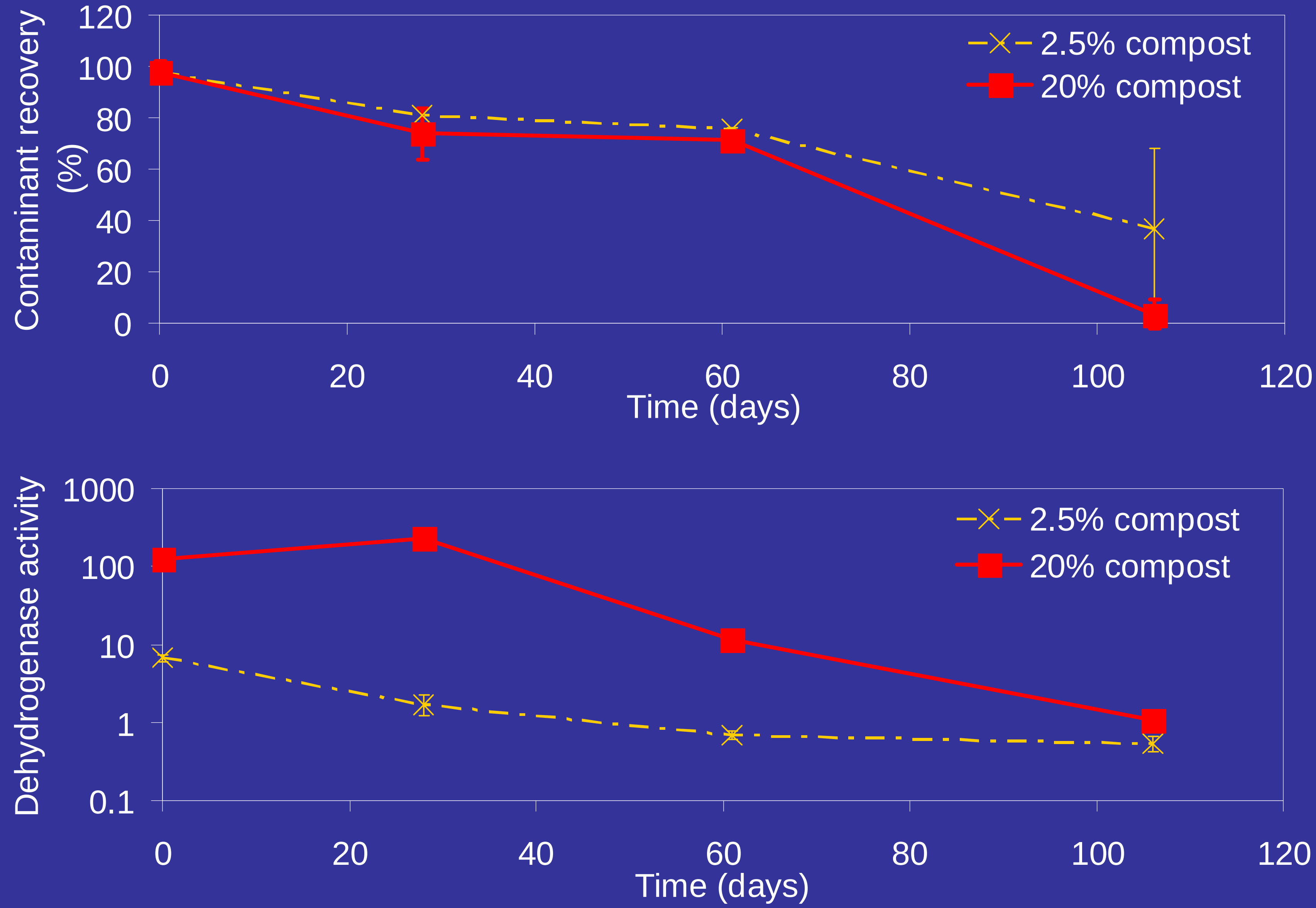
- New uses and combinations
  - 'Reactive' S/S (biodegradation, oxidation)
  - Deep soil mixing with bioremediation
  - Sustainable cements for barriers and S/S

Potential improvements

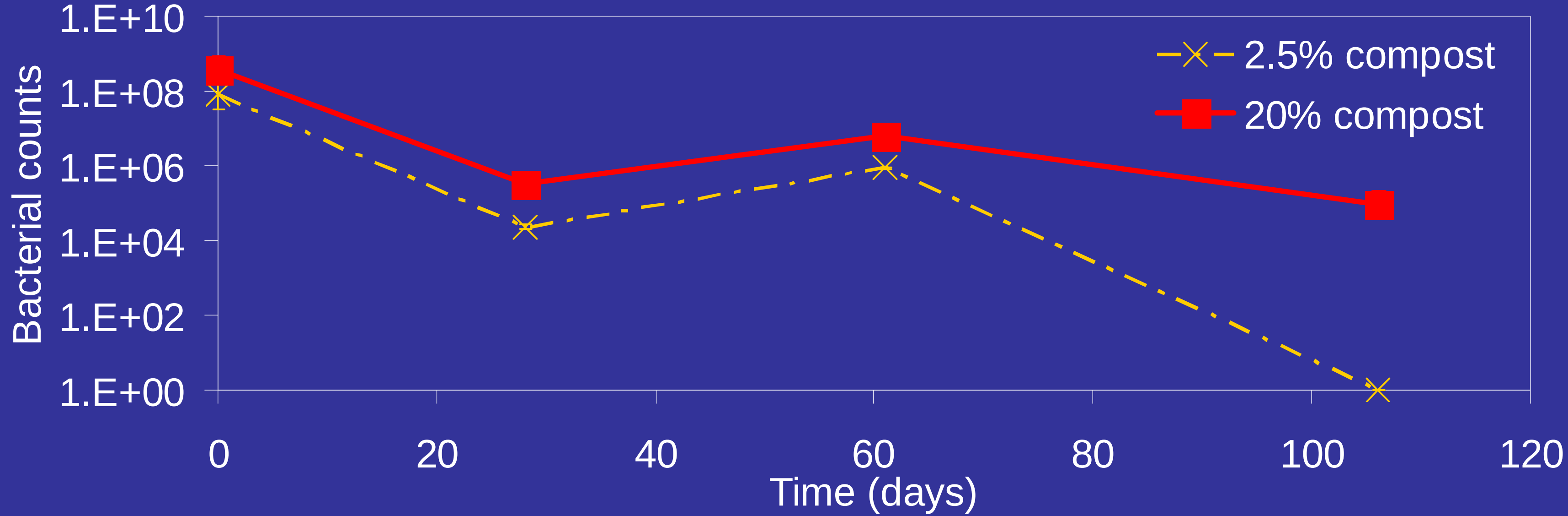
- S/S + biodegradation – could overcome:
  - Durability problems with S/S
  - Duration and homogeneity problems with in-situ bioremediation

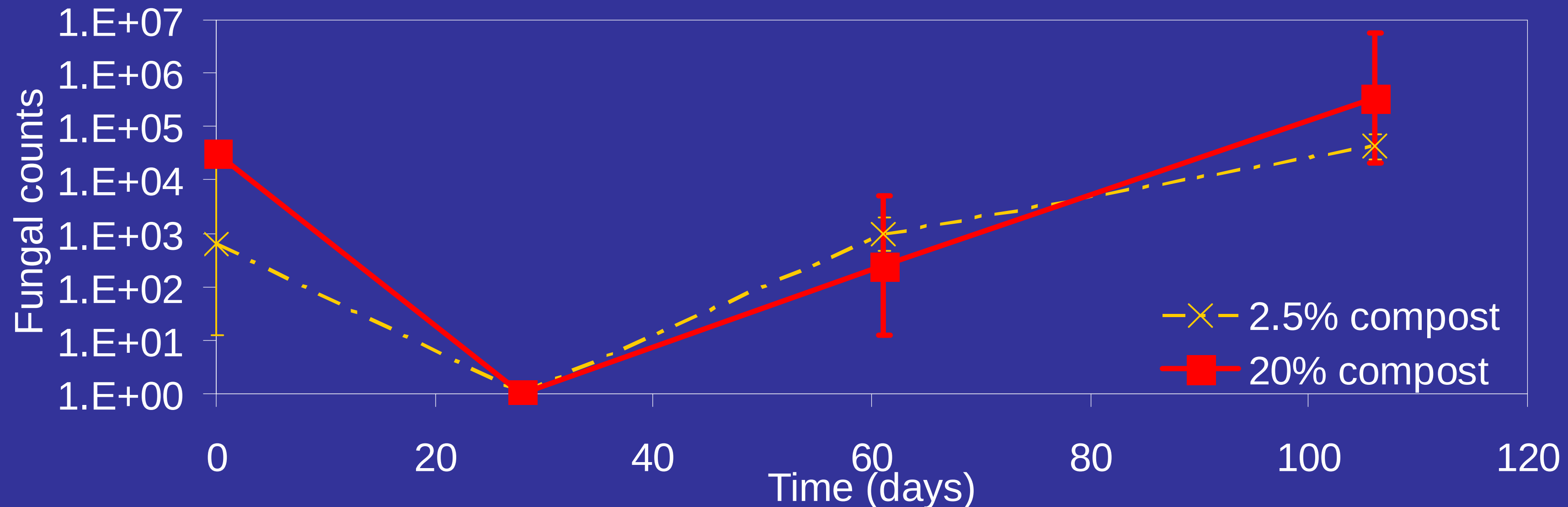
- Laboratory experiments:
  - Portland cement + silty sand
  - Addition of compost
  - Contaminant: 2-chlorobenzoic acid

Potential improvements



Potential improvements





Applicability of findings to industry

- Applicability of the methodology?
  - Complex and data-intensive
  - Used as a research tool
- Use of information from generic analyses in selecting technologies
- Improvements to existing technologies
  - Many changes without affecting practice

Acknowledgements

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