



The University of
Nottingham

Risk Assessment at Mustard Gas Contaminated Sites

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Introduction

Risk Assessment Overview

- Pollutant Linkages
- Risk Assessment Process
 - Tiered Approach
- Assessment Criteria
- Health Criteria Values
- Exposure Assessments using CLEA UK

Regulatory Context

Comparison of GAC with measured data

Uncertainties

Conclusions

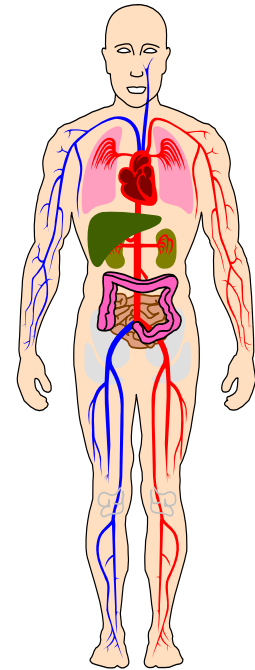
Pollutant Linkages



SOURCE



PATHWAY



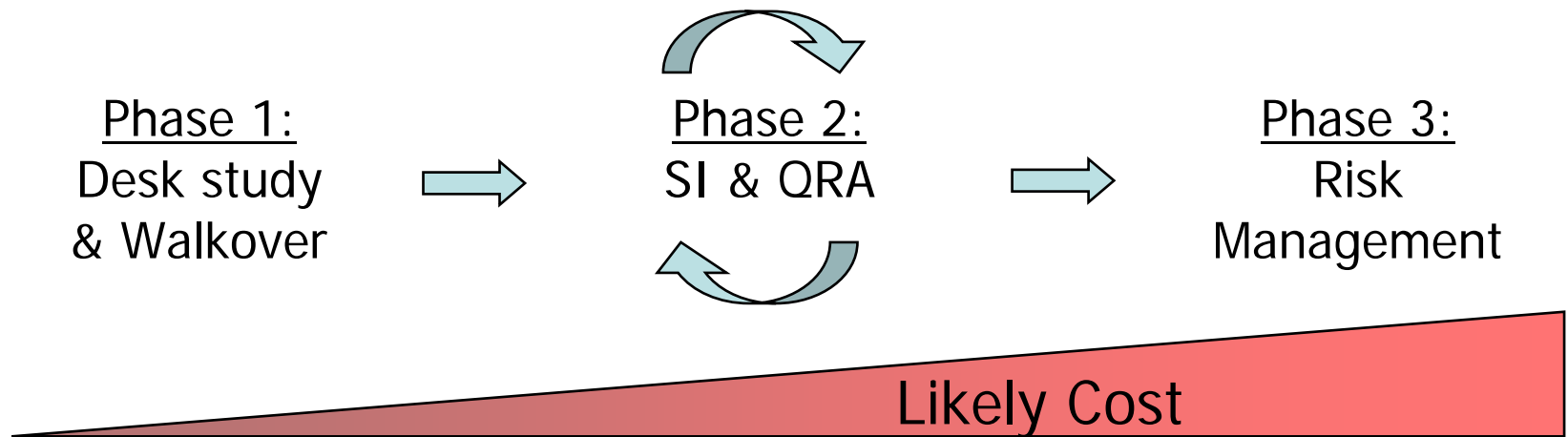
RECEPTOR

Risk Assessment Process

Four Steps:

- 1 Hazard Identification
- 2 Hazard Assessment
- 3 Risk Estimation
- 4 Risk Evaluation

Tiered Approach



Assessment Criteria

Average Daily Exposure

= 1

Health Criteria Value

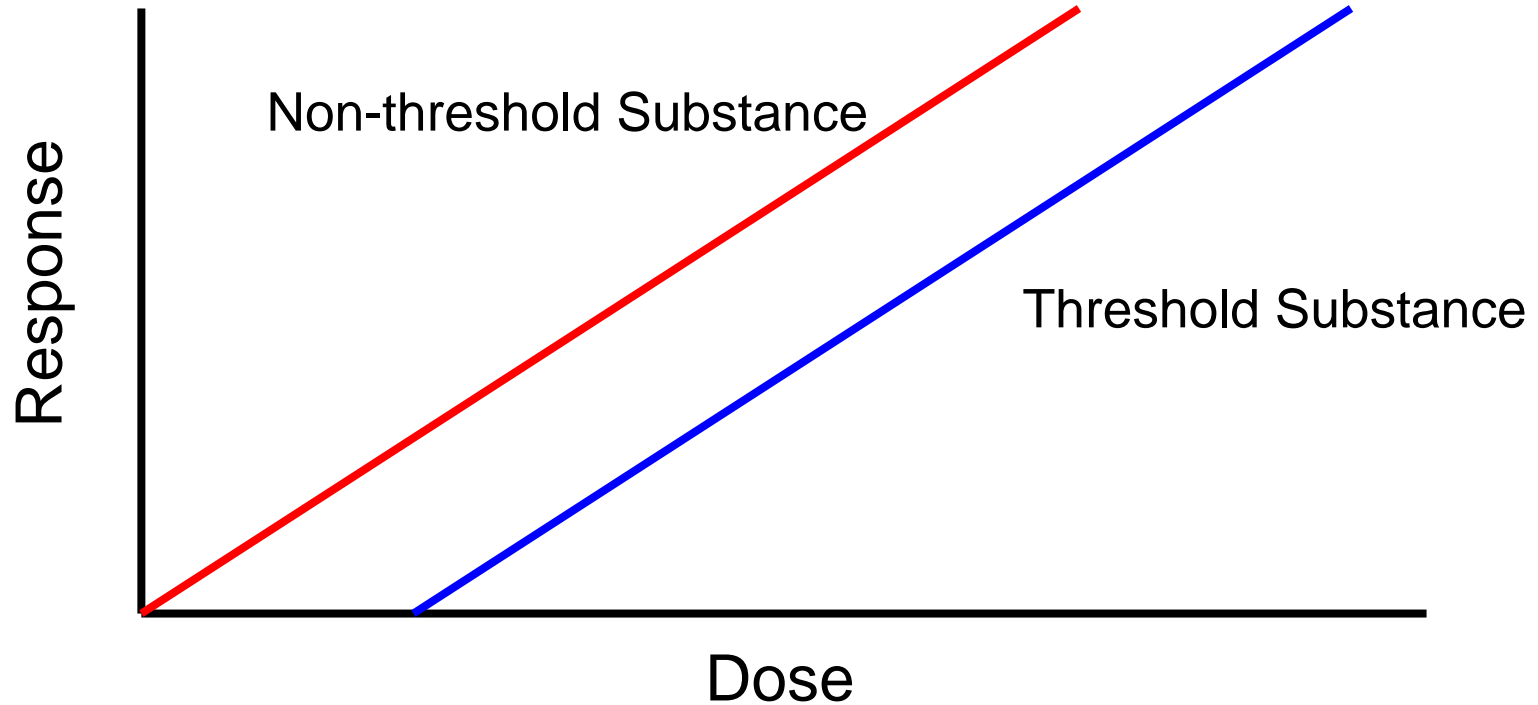
= Assessment Criteria (mg/kg)

Generic AC or

Site-Specific AC

CLR10, Environment Agency (2002)

Health Criteria Values (1)



Health Criteria Values⁽²⁾

Threshold

*Tolerable Daily Intake,
Mean Daily Intake (background) is subtracted:*

TOLERABLE DAILY SOIL INTAKE (TDSI)

Non-Threshold

INDEX DOSE (ID)

**“express a minimal risk level, with the additional requirement to keep any intake as low as reasonably practicable (ALARP)”
Environment Agency (2001) [CLR 9]**

CLEA UK

Contaminated Land Exposure Assessment

Pathway Specific

$$\text{Average Daily Exposure} = \frac{(\text{IR} \times \text{EF} \times \text{ED})}{\text{BW} \times \text{AT}}$$

IR	Exposure Rate (mg/day)
EF	Exposure Frequency (days/year)
ED	Exposure Duration (years)
BW	Body Weight (kg)
AT	Averaging Time (day)

**SUMMED
OVER
ALL
PATHWAYS**

CLEA UK

Exposure Pathways⁽¹⁾

Relevant Pathways:

- Ingestion of soil and indoor dusts
- Ingestion of Garden Vegetables
- Inhalation of Contaminant Vapours
- Inhalation of Soil and Indoor Dust
- Dermal Absorption

CLEA UK

Exposure Pathways⁽²⁾

Important Contaminant Properties

- K_{oc}
- K_{ow}
- Henry's law constant
- RMM
- Boiling Point

Important Site Properties

- SOM
- Porosity
- PSD
- Soil moisture
- Enrichment Factor

Regulatory Context

- Planning
 - Future use
 - Suitable for the intended use (i.e. *safe*)
 - Does not constitute Part IIA land...
- Part IIA (Environmental Protection Act 1990)
 - Historical contamination
 - Current use
 - Significant Possibility of Significant Harm (*SPOSH*)

Health Criteria Values

Mustard Gas

- Genotoxic Carcinogen
- **INDEX DOSE**

Thiodiglycol

1,4-Dithiane

1,4-Thioxane

- Threshold effects
- **TDI**

Health Criteria Values

	Oral µg/kg-bw/day	Inhalation µg/kg-bw/day	Dermal	Reference
Mustard Gas	1.3 x 10⁻³	3.33e⁻⁵	0.2	USCHPPM (1999)
Thiodiglycol	400	-	0.1	Reddy et al (2005)
1,4-Dithiane	10	-	0.1	IRIS (1991)
1,4-Thioxane	-	-	0.1	-

Health Criteria Values

	Oral µg/kg-bw/day	Inhalation µg/kg-bw/day	Dermal	Reference
Mustard Gas	1.3×10^{-3}	$3.33e^{-5}$	0.2	USCHPPM (1999)
Thiodiglycol	400	400	0.1	Reddy et al (2005)
1,4-Dithiane	10	10	0.1	IRIS (1991)
1,4-Thioxane	10	10	0.1	-

Generic Assessment Criteria

	Residential /mg/kg	Commercial ⁽¹⁾ /mg/kg	Commercial ⁽²⁾ /mg/kg
Mustard Gas	7×10^{-4}	2.2×10^{-2}	4.2×10^{-2}
Thiodiglycol	2800	62000	60000
1,4-Dithiane	1.36	60	1530
1,4-Thioxane	12.2	475	1500

Dominant Pathways

	Residential /mg/kg		Commercial ⁽¹⁾ /mg/kg		Commercial ⁽²⁾ /mg/kg	
	Oral	Inh	Oral	Inh	Oral	Inh
Mustard Gas	2.74 ⁻²	7.15e⁻⁴	8.72x10 ⁻¹	2.28x10⁻²	1.71	4.27x10⁻²
Thiodiglycol	5490	5770	122000	126000	121000	119000
1,4-Dithiane	2.71	2.71	120	120	3090	3020
1,4-Thioxane	12.2	24.4	24.6	955	3020	2960

GAC Exceedances

	Phase 1 (11)			Phase 2 (39)			Phase 3 (21)		
	Mustard	Dithiane	Thioxane	Mustard	Dithiane	Thioxane	Mustard	Dithiane	Thioxane
>LOD	6	6	5	14	17	17	15	20	18
Residential	11	6	4	14	11	9	21	6	5
Commercial ¹	11	4	0	3	1	0	8	5	0
Commercial ²	11	2	0	3	0	0	6	0	0

Uncertainties

Toxicity of degradation products

Assumed tumour incidence rate (1×10^{-6}) in Index Dose

Physical chemistry of Mustard Gas, and the effects of additives

Presence/absence of sulphonium species

contribution to Risk Assessment Outcomes?

Other Contaminants

Conclusions

Tiered Approach

Acute risks

Risk Assessment Drivers

Regulatory Context

Further Site Specific work



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