Application of a Human Health Risk Assessment Software to Support Revitalisation Decisions at Post-industrial Sites

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NORISC project – Network Oriented Risk-assessment by In-situ Screening of Contaminated sites

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NORISC objectives

- combine and integrate new and existing investigation methods, especially innovative in-situ and on-site techniques
- provide a standard guideline for site characterisation in the form of a decision support software system (DSS)





NORISC objectives

- demonstrate the effectiveness of this investigation approach and developed DSS by conducting field tests
- integrate site investigation with general contaminated site management that includes data management, site assessment, clean-up targeting and development of revitalisation strategy





NORISC Human Health Risk Assessment (HRA) software

one of the NORISC DSS components

a tool for site assessors to support conducting site-specific risk assessment in post-industrial sites





NORISC - HRA software

for generating information on the level and spatial distribution of human health risks at contaminated sites

for setting up preliminary Health-Based Remedial Goals (HBRGs)/Risk-Based Concentrations (RBCs)





NORISC - HRA software

- based on US EPA site-specific risk assessment procedures
- > proposed to be used when national soil and groundwater limit values are exceeded
- serves as a link between site investigation and remediation/revitalisation decision-making





HRA process as an element of the strategy for the revitalisation/remediation of contaminated sites





Site-specific human health risk assessment



Land use categories/Exposure pathways

Exposure		Land use scenario											
pathway	Residential			Indust	rial/Comm	nercial	Recreational						
,	Surface soil	Sub- surface soil	Ground -water	Surface soil	Sub- surface soil	Ground -water	Surface soil	Sub- surface soil	Ground -water				
Incidental soil and dust ingestion	~			V			~						
Dermal contact with soil	×			✓			\checkmark						
Inhalation of fugitive dusts	~			~			\checkmark						
Inhalation of volatiles outdoors		 Image: A second s			 Image: A start of the start of			~					
Ingestion of groundwater used as a tap water			~										
Dermal contact while showering or bathing			~										
Inhalation of volatiles from groundwater during household use			~						State TERENON				



Default exposure parameters

			Residential scenario		Industrial/Commercial	Recreational scenario	
Symbol	Description	Unit	Child	Adult	scenario (Adult)	Child	Adult
EF	Exposure Frequency	days/yr	350	350	225	214	214
ED	Exposure Duration	years	6	24	25	6	24
FC	Soil Fraction Contacted	unitless	1	1	1	0.08	0.08
BW	Body Weight	kg	15	70	70	15	70
IR₀	Ingestion Rate for soil	mg/day	200	100	100	200	100
IR _i	Inhalation Rate for soil	m ³ /day	10	20	20	10	20
SA	Skin Surface Area - soil contact	cm ²	2800	5700	3300	2800	5700
AF	Soil-to-skin Adherence Factor	(mg/cm ² /day)	0.2	0.07	0.2	0.2	0.07
AT (non-carcinogens)	Averaging Time AT=ED*365d/yr	days	2 190	8 760	9 125	2 190	8 760
AT (carcinogens)	Averaging Time	days	25 550	25 550	25 550	25 550	25 550
TR (non-carcinogens)	Target Hazard Quotient	unitless	1	1	1	1	1
TR(carcinogens)	Target Risk for carcinogens	unitless	1E-6	1E-6	1E-6	1E-6	1E-6



Risk characterisation

- > Non-carcinogenic effects Hazard Quotient HQ = CDI/RfD
- > Carcinogenic effects Cancer Risk = CDI x CSF
- Summing Hazard Quotients and Cancer Risks across all chemicals and pathways (Hazard Index, Total Hazard Index, Cancer Risks, Total Cancer Risk)



Risk characterisation

Calculating HQs, HIs and Cancer Risks as well as Total HI and Total Cancer Risk for relevant receptors (*child, adult*) depending on land use category:

- for each sampling point concerning soil
- as a site value for water-bearing horizon concerning groundwater (if groundwater is planned to be used by residents)





Default Target Risk levels

Target Hazard Quotient (HQ)/ Hazard Index (HI) = 1

Target Cancer Risk = 1E-06





Development of Risk-Based Concentrations (RBCs)

For contaminants with HQs and Cancer Risks exceeding Target Risk levels

- > Oral/Dermal and inhalation RBCs for carcinogenic and non-carcinogenic substances
- Selecting the lowest RBC value as a preliminary remedial goal





Development of Risk-Based Concentrations (RBCs)

Method based on site-specific exposure data

C - Chemical concentration in soil or groundwater RBC - Risk-Based Concentration (oral/dermal or inhalation)



Visualisation of HRA results (only for soil)

- > Presentation of HRA results for each soil sampling point
- > Delineation of zones
 - Risk zones with Total Cancer Risks and Total HIs below and above Target Risk levels
 - Remedial zones with contaminant concentrations exceeding the calculated RBCs



Visualisation of HRA results

Risk characterisation outputs - an example

Industrial scenario x 658818.7 y: 30345.8 Chemical Suf. Cono Subs. Cono Oral Risk Permal Ris Inh Risk Total Risk 1.1.1-Trichloro-ethane 0.00E+00 0.00E+00 0.00E+00 0.00E+00 1.91E-05 1.2.Dichloro-ethane 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 1.2.Dichloro-ethane 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 1.2.Dichloro-ethane 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 Benzene 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 Chordorm 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 Librohone 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 Yelene 0.00E+00 0.00E+00 0.00E+00 11E-0E 11E-0E 11E-0E Yelene 0.00E+00 0.00E+00 0.00E+00 11E-0E 11E-0E 11E-0E 11E-0E Previous Point Next Point Next Point Adult nonc. Child nonc.	Adult cancer	risk										
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HRA software module report Summary of HRA outputs - an example

Industrial scenario Cancer risk zone (Total CR = 6E-05)



Residential scenario Cancer risk zone (Total CR = 2E-04)





Visualisation of HRA results

Analysis of RBC values - an example





Application of HRA software

NORISC test sites

Balassagyarmat site, Hungary - former petroleum filling station

Massa site, Italy - former chemical factory, manufactured agrochemical products



Massa test site



AGRICOLTURA S.p.a.i.l. site; 15 ha industrial area of Avenza-Carrara; north-western part of Tuscany











Aerial photo; investigated area (1.2 ha) marked in yellow



Massa test site







Massa test site

Chemicals of Potential Concern

- Arsenic
- Chromium
- Cobalt
- Copper
- Mercury

- Manganese
- Nickel
- Lead
- Zinc
- Aldrin
- DDT





10 non-cancer risk zones (total HIs > 1)

1 cancer risk zone (total CR > 1E-06)





Non-cancer risk zones





Cancer risk zone





Massa test site – HRA results Remedial zone - Aldrin





Massa test site – HRA results Remedial zone - Cobalt





Massa test site – HRA results Remedial zone - DDT





Remedial zone - Manganese







Massa test site – HRA results Remedial zone – Arsenic (dominant substance)





Application of the HRA results

For designing and conducting remediation/revitalisation of post-industrial sites

For setting up remedial/revitalisation options

For facilitating other risk management decisions at the post-industrial sites (e.g., in city planning – considering different land use options)

