

INTERNATIONAL CONFERENCE CONTAMINATED SITES 2013

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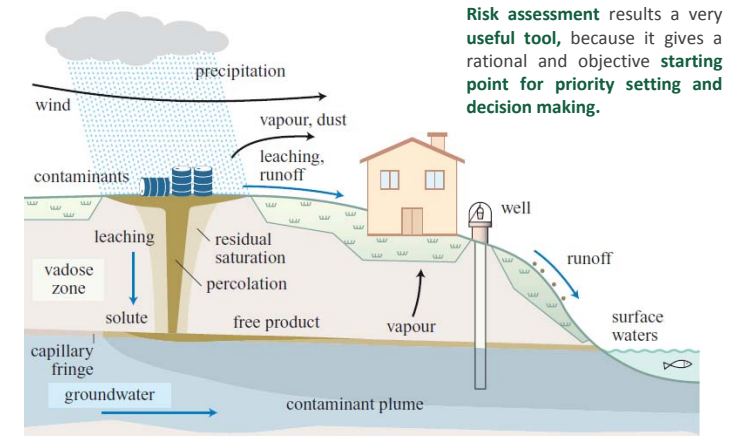
A new software (Risk-net) for the application of risk assessment to contaminated sites

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Contaminated Sites – Risk-Based Approach



A new software (Risk-net) for the application of risk assessment to contaminated sites

Risk-net

- ❑ In Italy the management of **contaminated sites** relies on a **risk-based** corrective action (RBCA) approach, where the actual pollution of the site is evaluated depending on the effective risk posed to the human health or environment.
- ❑ The **guidelines** for the application in Italy of risk assessment to contaminated site were developed by the **national environmental agency (ISPRA)**.
- ❑ **Risk-net** was designed to complete the calculations required for Tier 1 and Tier 2 RBCA evaluations according to the ISPRA Italian guidelines (2008).
- ❑ The Risk-net software has been developed within the **Reconnet network** by the Department of Civil Engineering of the University of Rome "Tor Vergata".
- ❑ The software is available **free of charge** from: www.reconnet.net.



A new software (Risk-net) for the application of risk assessment to contaminated sites

Software Architecture

1. Selection of the **type of analysis** (i.e. forward or backward mode)
2. Definition of the **conceptual model** of the site
3. Selection of the reference **scenario** (Residential or Industrial)
4. Selection the **receptors** (i.e. Adult, Child or combined exposure)
5. Identification of the **contaminants of concerns**
6. Definition of the **source concentrations** (for forward mode calculation)
7. Definition of the **site-specific parameters** (e.g. source geometry)
8. Definition of **exposure parameters** (e.g. exposure frequency)
9. Calculation of **fate and transport factors** (F&T)
10. Calculation of the **concentrations at the point of exposure** (Cpoe)
11. Calculation of the **exposure factors** (EM)
12. Calculation of the **Risks** (Carcinogenic, not carcinogenic, GW protection)
13. Calculation of the **site-specific clean-up levels** (CSR)

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Main Screen of Risk-net

The main screen of Risk-net is divided into several functional areas:

- Project:** Fields for Site Location, Date, IDV Area, and Compiled by.
- Simulation Summary:** File Name field.
- Load/Save simulation files:** Buttons for Load File, Save File, New, Print, and Exit.
- Type of Analysis:** Checkboxes for Clean-up Levels (Backward mode) and Risks (Forward mode).
- Calculation Options:** Buttons for Target Risks and Options.
- Input:** A vertical stack of buttons for Conceptual Model, Select Contaminants, Source Concentration, Receptors, Exposure Parameters, and Site Parameters.
- Output:** A vertical stack of buttons for View Outputs, Input Summary, Constituents Parameters, Transport and Exposure, Concentrations at POE, Risks, and Clean-up levels.

Labels at the bottom indicate the flow: Calculation options (pointing to the bottom of the main screen), Input (pointing to the Input section), and Output (pointing to the Output section).

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Input: Conceptual Model

Definition of Exposure and Migration Pathways

The Conceptual Model window displays a table for defining exposure and migration pathways:

Source	Exposure	Dir. Site	Target	Off-site
Surface Soil	Soil Ingestion and Dermal Contact	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Outdoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Indoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Outdoor Dust Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Indoor Dust Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
Subsurface Soil	Outdoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Indoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
Groundwater	Outdoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>
	Indoor Vapor Inhalation	<input checked="" type="checkbox"/>	On-site	<input type="checkbox"/>

Labels on the right side of the slide indicate the types of pathways:

- Migration Pathways:**
 - Surface Soil:**
 - Dermal contact
 - Soil ingestion
 - Outdoor air inhalation
 - Indoor air inhalation
 - Outdoor particulate inhalation
 - Indoor particulate inhalation
 - Leaching to groundwater
 - Subsurface Soil:**
 - Outdoor air inhalation
 - Indoor air inhalation
 - Leaching to groundwater
 - Groundwater:**
 - Outdoor vapor inhalation
 - Indoor vapor inhalation
 - Affected groundwater

Moreover the user can specify if the exposure occurs on-site (receptor located at the source zone) or off-site (receptor at any point away from the source zone).

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Input: On-site and Off-site Receptors

You can select different receptor for on-site and off-site exposure

The Select Receptors dialog box allows users to choose between On-site and Off-site receptors:

- On-site:** Residential (Child, Adult, Adjusted), Industrial (Adult Worker).
- Off-site:** Adult Worker.

Residential or Recreational use

- **Child:** Children (default age 6), with a low body weight.
- **Adult:** Adult with a full grown body weight.
- **Adjusted (Child + Adult):** For the residential exposure scenario, the "Adjusted" option calculates an average exposure values among the child and adult. Age adjustment is applied for carcinogenic contaminants only, where carcinogenic exposures are assumed to be chronic over the lifetime of the receptor.

Commercial or Industrial use

- Adult: Adult working at a full-time job.

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Input: Constituents of Concern

The Select Contaminants dialog box allows users to choose constituents of concern for different media:

- Surface Soil:** Search contaminant, Database, Insert, Remove, Remove All, Move up, Move down.
- Subsurface Soil:** Search contaminant, Database, Insert, Remove, Remove All, Move up, Move down.
- Groundwater:** Search contaminant, Database, Insert, Remove, Remove All, Move up, Move down.

You can select different constituents of concern for each medium

You can quickly enter all of the contaminants loaded in the database

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Input: Representative Source Concentration (Forward mode)

You can define different source concentrations for each medium

Soil concentrations

Soil-gas concentrations

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Input: Exposure Parameters

You can define different source concentrations for each medium

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Site-specific parameters (Unsaturated zone)

You can load the default values suggested by ISPRA (2008)

Modified default value

Calculated value

Parameter not required

Indirect estimation as a function of the soil type selected

Indirect calculation of l_{eff}

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Site-specific parameters (Saturated zone and outdoor air)

Parameters required for the saturated zone

Parameter	Description	Unit	Default ISPRA	Default ASTM	Value	Check
W	Width of source area parallel to groundwater flow direction	m	45	45	45.0	OK
W^*	Width of source area orthogonal to groundwater flow	m	45	45	45.0	OK
d_s	Groundwater thickness	m	---	---	2.0	OK
K_{sat}	Hydraulic conductivity in groundwater	m/s	CLAY LOAM	---	7.00E-05	OK
i	Hydraulic gradient	---	---	---	0.01	OK
v_{gr}	Darcy velocity	m/s	7.00E-07	---	7.00E-07	OK
v_e	Effective groundwater velocity	m/s	2.28E-08	2.28E-08	2.28E-08	OK
n_e	Effective porosity in the saturated zone	---	0.353	0.353	0.353	OK
f_{oc}	Organic Carbon Fraction - saturated zone	---	0.001	0.001	0.001	OK
POC	Distance to groundwater receptor (DAF)	m	100	100	100.0	OK
α_L	Longitudinal Dispersivity	m	10	---	1.00E+01	OK
α_T	Transversal Dispersivity	m	3.5	---	3.53E+00	OK
α_V	Vertical Dispersivity	m	0.5	---	5.00E-01	OK
δ_{gw}	Groundwater mixing zone thickness	m	2	---	2.00E+00	OK
LDF	Leachate Dilution Factor	---	---	---	4.70E+00	OK

Indirect estimation as a function of the soil type selected

Automatic calculation of GW dispersivity and groundwater mixing zone

Parameters required for the outdoor air

Parameter	Description	Unit	Default ISPRA	Default ASTM	Value	Check
δ_{air}	Ambient air mixing zone height	m	2	2	2.0	OK
W^*	Width of source area parallel to wind direction	m	45	45	45.0	OK
W_s^*	Width of source area orthogonal to wind direction	m	45	45	45.0	OK
U_{air}	Wind speed	m/s	2.25	Calc	2.25	OK
P_e	Particulate emission rate	g/(cm ² s)	6.90E-14	6.9E-14	6.90E-14	OK
t_{avg}	Averaging time for vapor flow	years	30	30	30.0	OK
POE ADF	Distance to receptor	m	100	100	100.0	OK
σ_y	Transverse air dispersion coefficient	m	---	---	1.00E+01	OK
σ_z	Vertical air dispersion coefficient	m	CUSTOM	---	1.00E+01	OK

Automatic calculation of air dispersivity

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Site-specific parameters (Indoor air)

Parameters required for the indoor air

Indoor Air		Default (SI/US)	Default (SI/US)	Value	Unit
On-Site Building					
Z _{max}	Depth to base of enclosed space foundation	m	0.15	0.15	m
L _{max}	Thickness foundations	m	0.15	0.15	m
η	Area fraction of cracks in foundations/walls	-	0.01	0.01	-
V ₀	Enclosed space volumetric infiltration area ratio	m	2	2	m
R _{max}	Volumetric water content in the foundations	-	0.12	0.12	-
R _{max}	Volumetric air content in the foundations	-	0.26	0.26	-
ER	Enclosed-space air exchange rate	1/a	1,40E-04	1,40E-04	1/a
t _{indoor}	Averaging time for indoor vapor flux	years	30	30	years
Δp	Differential indoor/outdoor air pressure	g/(cm s ²)	0	0	no check
K _v	Soil vapor permeability	m ²	1,00E-12	1,00E-12	m ²
A _b	Area of building foundation	m ²	7,00E+01	7,00E+01	m ²
K _{max}	Enclosed space foundation perimeter	m	3,40E+01	3,40E+01	m
μ _{air}	Vapor viscosity	g/(cm s)	1,81E-04	1,81E-04	g/(cm s)
Off-Site Building					
Z _{max}	Depth to base of enclosed space foundation	m	0.15	0.15	m
L _{max}	Thickness foundations	m	0.15	0.15	m
η	Area fraction of cracks in foundations/walls	-	0.01	0.01	-
V ₀	Enclosed space volumetric infiltration area ratio	m	2	2	m
R _{max}	Volumetric water content in the foundations	-	0.12	0.12	-
R _{max}	Volumetric air content in the foundations	-	0.26	0.26	-
ER	Enclosed-space air exchange rate	1/a	1,40E-04	1,40E-04	1/a
t _{indoor}	Averaging time for indoor vapor flux	years	30	30	years
Δp	Differential indoor/outdoor air pressure	g/(cm s ²)	0	0	no check
K _v	Soil vapor permeability	m ²	1,00E-12	1,00E-12	m ²
A _b	Area of building foundation	m ²	7,00E+01	7,00E+01	m ²
K _{max}	Enclosed space foundation perimeter	m	3,40E+01	3,40E+01	m
μ _{air}	Vapor viscosity	g/(cm s)	1,81E-04	1,81E-04	g/(cm s)

You can define different parameters for on-site and off-site building

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View results

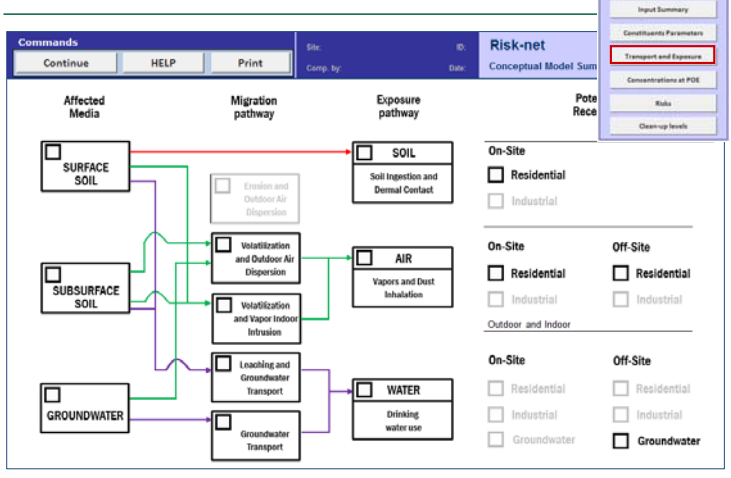
Definition process completed

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Input Summary

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CSM Summary



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Intermediate Outputs

Fate and Transport Factors

Contaminants	Soil off-site	Soil on-site	Soil off-site	Soil on-site	LRs (mg/kg d.w.)	VRs (mg/kg d.w.)	VR (mg/kg d.w.)	HR	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)	HR (mg/kg d.w.)
Arsenic	3.90E-01	3.74E-04	1.79E-04	8.87E-03	3.90E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	4.00E-07	1.00E-04			
Benzene	6.90E-03	2.76E-04	1.54E-05	4.79E-03	4.80E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	3.18E-07	1.00E-04			
Toluene	8.97E-03	2.47E-04	1.36E-05	3.79E-03	2.43E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	3.07E-07	1.00E-04			
Xylenes	5.75E-03	1.92E-04	1.05E-05	1.52E-03	1.55E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	3.02E-07	1.00E-04			
Tetrachloroethylene	6.27E-03	2.09E-04	1.27E-05	1.16E-03	3.79E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	3.79E-07	1.00E-04			
Dichloroethylene, cis-1,2	8.82E-03	2.92E-04	1.62E-05	1.16E-03	1.83E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	3.65E-07	1.00E-04			
Vinyl chloride	8.43E-03	2.90E-04	1.72E-05	8.79E-03	8.90E-02	1.90E-05	6.42E-03	NA	NA	1.62E+00	NA	4.39E-07	1.00E-04			

Concentrations at the point of exposure

Contaminants	on-site				off-site			
	CSR (mg/kg d.w.)	CSR soil gas (mg/m ³)	CSL (mg/kg d.w.)	CSL (mg/m ³)	CSR (mg/kg d.w.)	CSR soil gas (mg/m ³)	CSL (mg/kg d.w.)	CSL (mg/m ³)
Arsenic	1.00E-01	---	---	---	---	---	---	---
Benzene	1.20E-01	---	2.00E-04	7.70E-03	---	---	---	---
Toluene	4.00E-01	---	7.00E-04	2.70E-02	---	---	---	---
Xylenes	3.00E-01	---	3.00E-04	2.20E-01	---	---	---	---
Tetrachloroethylene	1.00E-01	---	2.00E-04	8.00E-01	---	---	---	---
Dichloroethylene, cis-1,2	1.00E-01	---	3.00E-04	3.00E-01	---	---	---	---
Vinyl chloride	1.00E-01	---	3.00E-04	2.00E-01	---	---	---	---

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Risk calculation

For each media of interest (surface soils, subsurface soils and groundwater) the software reports the baseline risk calculations for each complete exposure pathway (outdoor air, indoor air, soil, etc) and the associated receptors (on-site or off-site).

Contaminants	CSR (mg/kg d.w.)	CSR soil gas (mg/m ³)	Correlation Factor (Cf)	Reduced Soil CSR (mg/kg)	Reduced CSR (mg/m ³)	Carcinogenic Risk (IR)	Hazard Index (HI)	Risk for groundwater (R _g)	CSC Residential (mg/kg d.w.)	CSC Industrial (mg/kg d.w.)	CSL (mg/kg d.w.)	C.A.S. Number
Arsenic	2.50E+01	---	---	2.50E+01	---	6.43E-05	1.10E+00	NA	---	---	7440-39-2	
Benzene	1.20E+01	---	---	1.20E+01	---	4.00E-05	1.00E+00	NA	---	---	71-43-2	
Toluene	4.20E+01	---	---	4.20E+01	---	---	2.47E-01	NA	---	---	71-43-2	
Xylenes	3.00E+01	---	---	3.00E+01	---	---	1.90E+00	NA	---	---	100-98-3	
Tetrachloroethylene	1.00E+01	---	---	1.00E+01	---	1.91E-01	9.70E-01	NA	---	---	127-18-4	
Dichloroethylene, cis-1,2	5.50E+01	---	---	5.50E+01	---	1.91E-01	1.30E+02	NA	---	---	79-01-6	
Vinyl chloride	3.00E+01	---	---	3.00E+01	---	6.18E-01	1.47E+01	NA	---	---	156-69-2	

The software also calculates the cumulative risk and hazard index

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Clean-up levels

For each media of interest (surface soils, subsurface soils and groundwater) the software reports the calculated clean-up levels for the different selected contaminants

Contaminants	CSR Industrial (mg/kg d.w.)	Correlation factors (Cf)	CSR soil surface (mg/kg)	CSR soil surface (mg/m ³)	Carcinogenic Risk (IR)	Hazard Index (HI)	Risk for groundwater (R _g)	CSC Residential (mg/kg d.w.)	CSC Industrial (mg/kg d.w.)	CSL (mg/kg d.w.)	C.A.S. Number
Arsenic	3.90E-01	---	3.90E-01	3.65E-01	1.00E-06	1.00E-02	NA	---	---	7440-39-2	
Benzene	2.61E-04	---	2.61E-04	1.00E-06	2.25E-05	NA	---	---	---	71-43-2	
Toluene	1.70E-02	---	3.70E-02	1.60E-02	1.00E+00	NA	---	---	---	100-98-3	
Xylenes	2.53E+01	---	2.53E+01	2.50E+01	---	1.00E+00	NA	---	---	1330-20-7	
Tetrachloroethylene	1.51E-03	---	1.42E-03	1.00E-06	9.87E-05	NA	---	---	---	127-18-4	
Dichloroethylene, cis-1,2	2.89E-04	---	2.79E-04	1.00E-06	6.94E-04	NA	---	---	---	79-01-6	
Vinyl chloride	8.80E-05	---	8.43E-05	1.00E-06	2.79E-05	NA	---	---	---	156-69-2	

In order to compute clean-up levels based on cumulative risk effects, the software allows the user to adjust the individual constituent target levels calculated to meet the cumulative risk goals.

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Output summary (e.g. Calculated Risks)

Select Contaminant (Benzene)

Source Concentration: CSR (mg/kg d.w.) 1.00E-02, CSR soil gas (mg/m³) ---

Risk and Hazard Quotient: Risk 3.39E-03, Hazard Quotient 6.00E+01, R_g 9.94E+03

Risks: Bar chart showing risks for On-site, Soil ingestion, Dermal Contact, Outdoor Vapors, Outdoor Dusts, Cumulative Outdoor, Indoor Vapors, Indoor Dusts, Cumulative Indoor, Leaching, Off-site, Outdoor Vapors, Outdoor Dusts, Leaching.

Hazard Quotients: Bar chart showing hazard quotients for On-site, Soil ingestion, Dermal Contact, Outdoor Vapors, Outdoor Dusts, Cumulative Outdoor, Indoor Vapors, Indoor Dusts, Cumulative Indoor, Leaching, Off-site, Outdoor Vapors, Outdoor Dusts, Leaching.

Threshold values: Soil - Residential 1.00E-01 mg/kg x.s., Soil - Industrial 2.00E+00 mg/kg x.s., Groundwater 1.00E-03 mg/l.

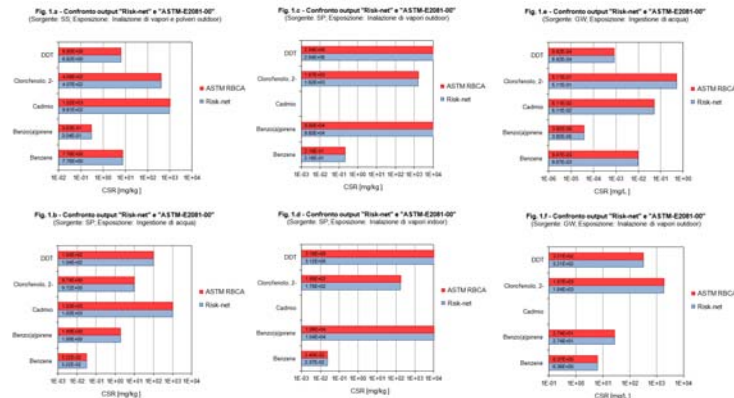
Constituent Main Properties: C.A.S. 71-43-2, Soil 1.20E+03 mg/kg x.s., Solubility 1.79E+03 mg/l, Henry's constant 2.29E-01.

F&T Summary: LFs 5.94E-02 (mg/L/mg/kg), VRs 1.80E-05 (mg/m³/mg/kg), VR soil gas 6.42E-03 (mg/m³/mg/kg), PEF 6.90E-12 (mg/m³/mg/kg), PEF soil 6.90E-12 (mg/m³/mg/kg), DCF 2.91E-01 (mg/m³/mg/m³), ACF 3.98E-03 (mg/m³/mg/m³), Dis off 2.71E-04 (mg/m³/mg/m³), Dis on 1.70E-05 (mg/m³/mg/m³), Dis soil 6.87E-03 (mg/m³/mg/m³), s indoor 4.00E-07 (mg/m³/mg/m³), s outdoor 1.00E-04 (mg/m³/mg/m³).

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Validation of Risk-net: Comparison with the screening values reported in ASTM E-2081-00

Red Charts: Values reported in ASTM-E2081-00; Blue Charts: Values obtained with Risk-net using the default ASTM parameters



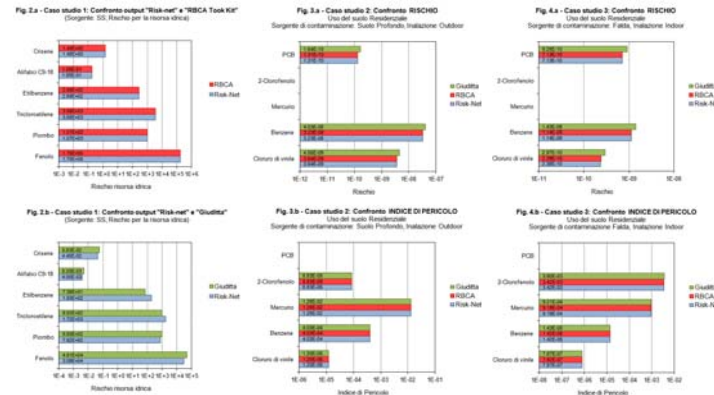
Source: Report Reconnet (2012). Validation of the Risk-net software (In Italian)

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Validation of Risk-net: Comparison with RBCA ToolKit (v. 2.5) and Giuditta Software (v. 3.2)

Red Charts: RBCA ToolKit (v. 2.5); Green Charts: Giuditta (v. 3.2); Blue Charts: Risk-net (v. 1.0)



Source: Report Reconnet (2012). Validation of the Risk-net software (In Italian)

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May 29 - 31, 2013

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