Risk Prioritization and Risk Assessment as a tool for managing Contaminated Sites

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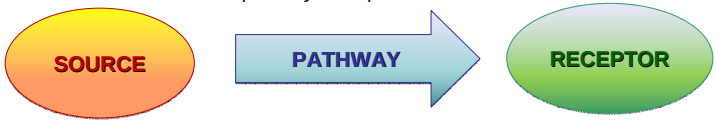
Contents

Risk assessment in the management of contaminated sites

- **EU definition of "contaminated sites" (Art. 10 p. 1 of the proposed SFD)**: *"sites where there is a confirmed presence, caused by man, of dangerous substances of such a level that Member States consider they pose a significant risk to human health or the environment"*
- **Definition of Risk Assessment (NRC, 1983)**: *"characterization of potential adverse effects of exposure of human and/or environmental receptors to hazards. It includes estimates of uncertainties in measurements, analytical techniques, and interpretative models"*
- **Key elements**: *definition and parameterization of a Conceptual Site Model (CSM) on the basis of the source-pathways-receptor scheme*



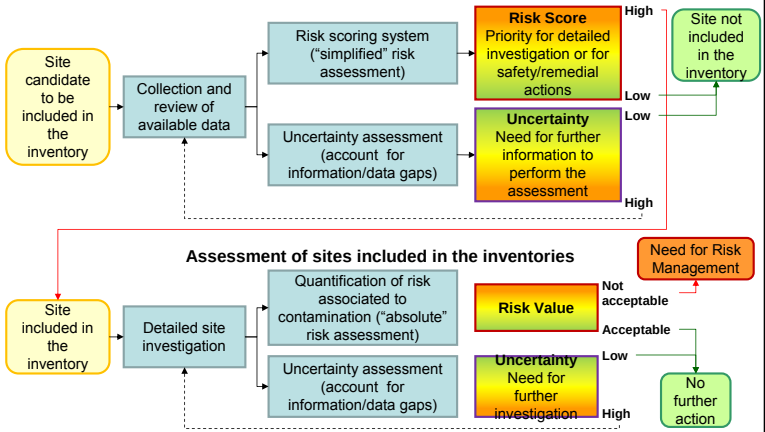
The contemporary presence of these elements determine a risk

RISK MANAGEMENT

Reducing or Modifying Source	Pathway Management	Modifying Receptor Exposure

"Simplified" and "Absolute" risk assessment

Development of national/local inventories of potentially contaminated/contaminated sites



Management of large potentially contaminated areas

- Areas characterized by a wide extension, multiple and differentiated sources, different land uses may need a large amount of information to identify real pollution problems and remediation needs.
- Both "simplified" and "absolute" risk assessment procedures, may ,at different levels, support the focusing of actions (further investigation and/or remedial actions) on "critical areas".

- The results of two project are presented:
  - **The PRA.MS project**: an EEA methodology for the identification of problem areas for soil contamination based on a "simplified" risk assessment approach
  - **The Site-specific Preliminary Risk assessment of Portoscuso municipality**: an absolute risk assessment methodology applied at a wide potentially contaminated area.

The EEA PRA.MS Project

- From 2004 to 2006 the EEA (European Environment Agency) has developed the project **"Towards an EEA Europe-wide assessment of areas under risk for soil contamination"**.
- The main aim of the EEA Project was **to develop an effective tool to identify, assess and map the areas under risk or potential problem areas for soil contamination** in Europe in order to provide inputs to EEA assessment activities and support policy development.
- The following working definition of **"problem areas for soil contamination"** has been adopted:

"Areas where soil contamination is considered to pose significant risks to human health and/or ecosystems with impacts beyond the local environment and where the assessment and reporting of pressures, state, impacts and remediation activities is of relevance at the European level. In particular, these are areas where:

- *potential soil polluting activities are currently located or have been located in the past. This activities are included in a pre-defined list;*
- *the size of the site is above certain thresholds in terms of emission and waste volumes, site area, volume of operations;*
- *the estimated risks to human health and/or ecosystems, resulting from the application of a preliminary risk assessment model, are above certain thresholds."*

Project Development

Comparison of Preliminary Risk Assessment methods used in Europe and overseas

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Identification of indicators and parameters used by each method. Development of a database. Parameters 'harmonization'

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Selection of main indicators and parameters needed for PRA.MS risk evaluation on the basis of:

- **'harmonized parameters'**
- **contaminated sites and GIS data availability at EU level**

↓

Formulation of the methodology

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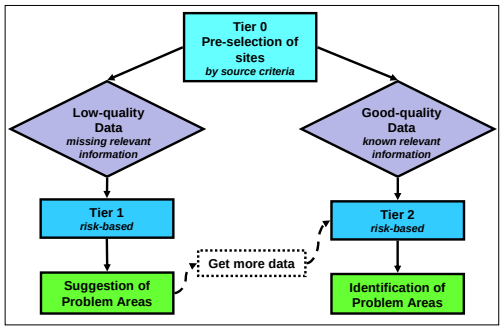
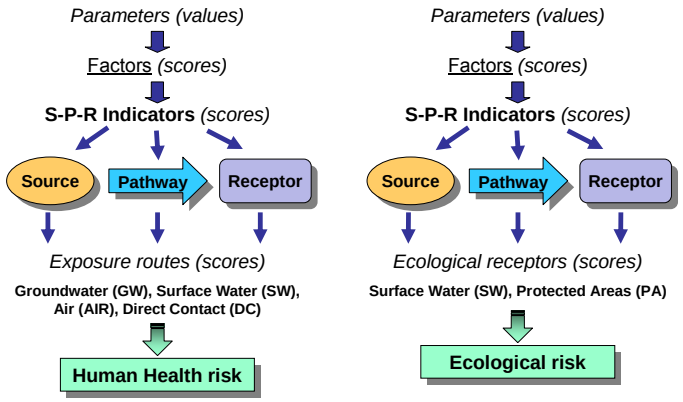
Application of the methodology to selected sites in Europe and development of maps of potential problem areas

The PRA.MS Model

- **PRA.MS (*Preliminary Risk Assessment Model for the identification of problem areas for Soil contamination in Europe*)** is the proposed risk scoring system suitable for the classification and assessment of individual sites. The system includes 2 Tiers that are applied to data of different detail. Both tiers lead to an assessment and classification of sites using risk scores.



The PRA.MS Risk Scoring System



Parameters adopted in the PRA.MS Model

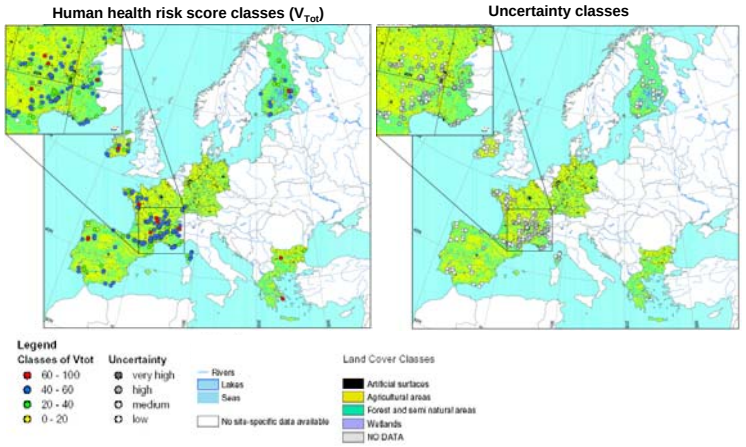
Toxicity of contaminants (Risk Phrases)	Disposal type	SOURCE
Waste mass	Engineered Containment for GW (Containment for GW)	
Waste volume	Engineered containment measures for SW (Containment for SW)	
Source area (Contaminated soil area)	Engineered containment measures for Air (Containment for Air)	
Source volume (Contaminated soil volume)	Engineered containment measures for soil (Containment for DC)	
Site area		
Known release to GW	Slope	PATHWAY
Known release in Air	Flooding return	
Known release to SW	Surface water flow rate	
Lithology of the unsaturated zone	Surface water body type	
Thickness of the lowest hydraulic conductivity layer (Thickness of the impermeable layer)	Henry's law constant	
Presence of any impermeable layer	Vapour pressure	
Aquifer depth from surface	Mean annual temperature	
Water solubility	Mean annual wind velocity	
Mean annual precipitation		
Distance of nearest well for GW from the source	Groundwater use	RECEPTOR
Minimum distance from surface body (Minimum distance from surface water body)	Surface water use	
Distance to the nearest residential area	Land use at site	
Site accessibility	Land use off site	

Results of PRA.MS applications

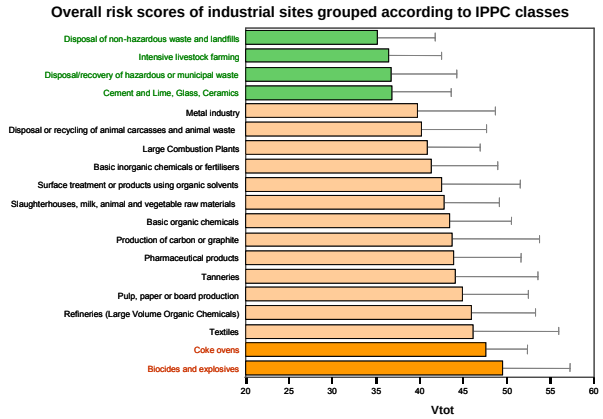
Application of the PRA.MS I model to selected industrial and mining sites:

- **Tier 0 assessment**: pre- selection of sites from relevant db (BRGM/DECHMINUE and EPER) :
  - BRGM/DECHMINUE: selection of sites with chemical characterization of stored wastes (236)
  - EPER: selection of sites on the basis of source data availability (7881)
- **Assessment over BRGM/DECHMINUE mining sites by Tier 2**:
  - Preliminary assessment of human health risks over 236 sites (9 European countries)
  - Preliminary assessment of uncertainties
  - Preliminary mapping of results
- **Tier 1 assessment over EPER sites**:
  - Preliminary assessment of human health risks and evaluation of dominant exposure routes
  - Correlation between human health risks and IPPC classes of industrial facilities

Results of PRA.MS Tier 2 application to mining sites



Results of PRA.MS Tier 1 application to industrial sites



Peer review

A **peer review process** suggested to improve the methodology by including:

- a pre-screening level in order to better focus the assessment and limit data collection requirements;
- an assessment of multiple risks and multiple sources;
- a sensitivity analysis of the required parameters;
- availability of data sources of better quality and resolution,
- finalization of ecological risks assessment,
- application of the methodology to a selection of sites using data provided by national experts and covering a wider range of sites of EU relevance.

In particular the need of a pre-screening step for the identification by each MS of candidate areas for PRA.MS application, **derived from the difficulty of setting a "common" and "generalised" criteria and procedure to be applied in the context of different national contaminated land management procedures**.

Products

Reports:

- **"Background and outcomes of the project"** (EEA Technical Report, Volume 1)
- **"Review and analysis of existing methodologies for preliminary risk assessment"** (EEA Technical Report, Volume 2)
- **"PRA.MS scoring model and algorithm"** (EEA Technical Report, Volume 3)
- **"Application of the PRA.MS model to selected industrial and mining sites"** (EEA Technical Report, Volume 4)

Software:

- ACCESS © database of existing methodologies for preliminary risk assessment
- ACCESS © based PRA.MS model

http://www.eionet.europa.eu/software/prams

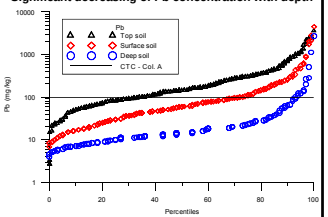
The Portoscuso Municipality "potentially contaminated" area

- The main source of contamination for Portoscuso Municipality is the Portovesme metallurgic industrial district.
- The whole municipal territory outside the industrial area (30 Km^2) has been investigated between July 2009 and March 2010.
- Investigations included:
  - **62 Surface probes** (0-1,5 m BG);
  - **139 Intermediate probes** (from ground to capillary fringe);
  - **66 Piezometeres**: 40 surface piezometers (up to15-25 m BG) and 26 deep ones (up to 40-133 m BG);
- 308 top soil (0-10 cm) samples, 371 surface (0-1 m) and deep soil samples (>1m) and 78 groundwater samples has been collected.

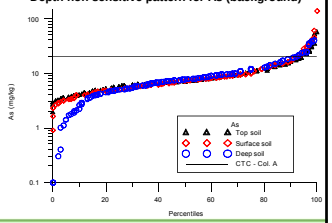
Results of site investigations

- Results of the investigation confirmed a diffuse presence in soil of heavy metals (As, Cd, Hg, Pb, Sn, Zn) above the screening values over the 30 km² wide investigated area.
- Limited presence in few samples for Cu and V has been recorded.
- For some of the diffuse elements (Zn, Pb and Cd), the contamination pattern is characterized by an impressive trend decreasing with sampling depth, indicative of a **surface soil contamination mainly due to fall-out from the industrial district**, while in deep soil the presence of contaminants may be correlated to **natural background**.
- In groundwater up gradient the industrial district screening levels were exceeded for Mn and SO_4 associated to natural background.

Significant decreasing of Pb concentration with depth



Depth non sensitive pattern for As (background)

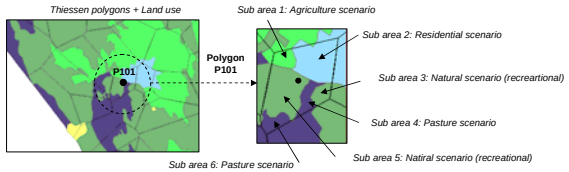


Risk assessment application

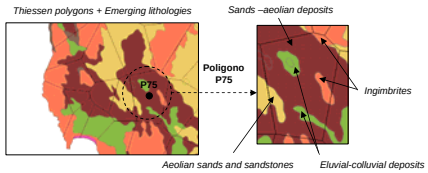
- According to the Italian legislation on contaminated sites management (Legislative Decree 152/06), a site-specific human health risk assessment has to be carried out in order to assess the need for remediation also **outside the industrial district**.
- The major problem in the application of risk assessment to a **diffusely polluted large area**, is to **account simultaneously for the spatial distribution of soil contamination and for the land use**.
- In case of a diffuse presence of contaminants in soil, **point data may be associated to a wider area identified with Thiessen polygons on the basis of the sampling strategy**. Within each Thiessen polygon it is reasonable to consider a uniform chemical concentration in each homogeneous soil layer (top soil, surface soil, deep soil). Given this conservative assumption on contamination spatial distribution, the differences in human exposure depend only on land use.
- On the basis of land use, different **sub-areas for human exposure** are defined.
- For the assessment of **risks to groundwater resources** associated to soil contamination, the **geological variability** within each Thiessen polygon should be accounted for.

Methodology for the evaluation of spatial soil contamination

Spatial soil contamination together with land use (human exposure)



Spatial soil contamination together with and geological setting (groundwater protection)



Conceptual model for human health risk assessment and for groundwater protection

Scenario according to land use	Pathways	Receptors
Residential Residential + Agricultural activities	Direct contact (for TS only) Outdoor vapor and powders inhalation (for SS and DS) Indoor vapor inhalation (for Hg in SS and DS only)	Adults and Children
Industrial Commercial Agricultural activities	Direct contact (for TS only) Outdoor vapor and powders inhalation (for SS and DS) Indoor vapor inhalation (for Hg in SS and DS only)	Workers
Naturalistic (recreational)	Direct contact (for TS only) Outdoor vapor and powders inhalation (for SS and DS)	Adults and Children (exposure frequency reduced to 1,5 hr/day)
Pasture activities	Direct contact (for TS only) Outdoor vapor and powders inhalation (for SS and DS)	Adults and Children (exposure frequency reduced to 1,5 hr/day)
Groundwater protection	Soil to groundwater leaching form surface	Compliance with GW target values

Results (1)

- The proposed approach adopted a parameterization of source geometry and exposure scenarios more conservative than the traditional risk assessment, that is generally limited to the scale of a single area defined by property boundaries. **This methodology is therefore more similar to a "generic" and "simplified" risk assessment**, even if many parameters (organic carbon content, soil/water partition coefficient, hydraulic conductivity, soil texture) have been derived from site specific measurements.
- The results of risk assessment identified **large portion of the studied area as not contaminated** (i.e. no longer posing significant risks to human health and/or the environment).
- In some **residential areas**, or **areas where the agricultural scenario has been integrated with the residential one**, the Risk Threshold Concentrations (RTCs, derived from the site-specific risk assessment, indicating non acceptable risks) of Pb, Cd, Hg and As were exceeded.
- For Pb, Cd, and As critical pathways are **direct contact** with TS and **soil to groundwater leaching** for SS and DS, while for Hg critical pathways are **indoor and outdoor air inhalation**.

Results (2)

- A **detailed investigation** in critical sub-areas (where RTCs are exceeded) identified in the first stage of risk assessment is planned in order to better investigate on:
  - **distribution of contamination** especially for areas where no soil sample is available,
  - **exposure conditions** (e.g. real residential use also in agricultural areas, presence or planning of buildings),
  - presence of volatilization and leaching transport pathways with **leaching tests**, **soil gas and flux chambers sampling**.
- A **second stage of risk assessment** will be applied on the basis of the detailed investigations.

Conclusions

- In the management of contaminated sites risk assessment has proven to be a very useful tool for identification of contamination and planning soil remediation.
- The results of application of "simplified" and "detailed" risk assessment to large contaminated areas may help in orienting actions to "critical" or "problem" areas.
- The "harmonization" of risk assessment methodologies envisaged by the Soil Thematic Strategy and the proposed Soil Framework directive is still a critical issue due to the difficulty to set a "common" procedure especially for large areas/megasites management.
- A flexible proposal of a "toolbox" of different risk assessment methodologies clearly describing the applicability, the advantages and the limitation of each tool, may be a good compromise.

Thank you for your attention!

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