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Portoscuso – An effective assessment and management of a wide contaminated area

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SESSION 7

Tackling emerging pollutants and diffuse pollution

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The Portoscuso Municipality “potentially contaminated” area

It has been included in 2003 in the National Priority List Site **“Sulcis Iglesiente Guspinese”** for the presence of the Portovesme metallurgic industrial district.

The territory outside the industrial area (about 30 km^2) is mainly used for agricultural/pasture purposes and includes two residential agglomerates (Portoscuso and Paringianu) and a naturalistic valuable area (Boi-Cerbus Lagoon).

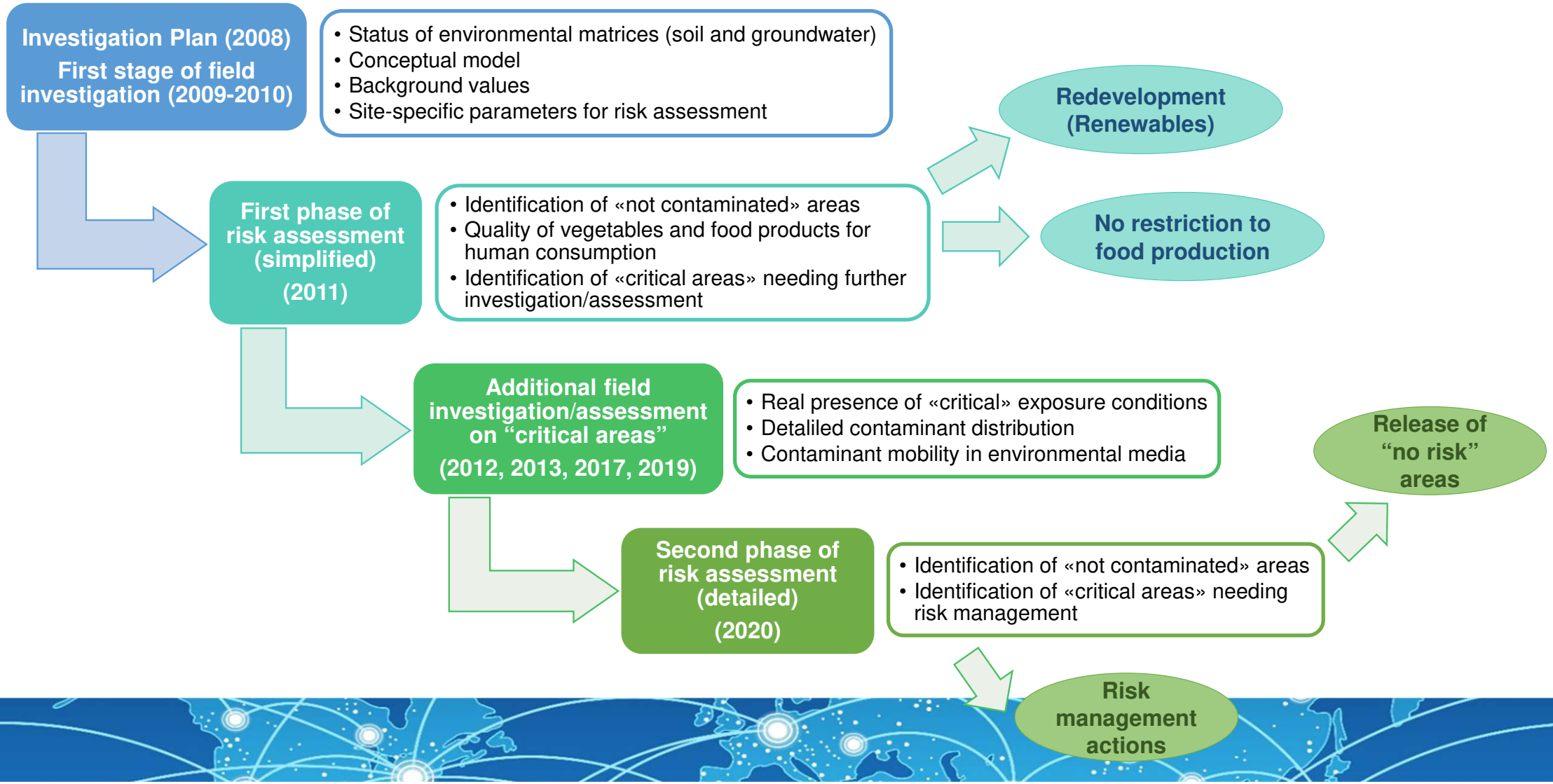
Boi-Cerbus Lagoon

The Portoscuso Municipality “potentially contaminated” area

- The conceptual model of soil contamination clearly indicates a **fall-out of heavy metals** from the emissions of the Portovesme metallurgic industrial district.
- However, the geological and hydrogeological context indicates also a **natural geochemical contribution** to the diffuse presence of inorganic substances (metals, metalloids and other inorganics) in soil and, to a minor extent, in groundwater.

Portovesme industrial district

A «stepwise» assessment process



Investigation plan – First stage of field investigation (2008-2010)

First stage of investigation involved the whole municipal territory outside the industrial district with these main objectives:

- definition of the **conceptual model** for risk assessment
- evaluation of the **natural background** for soil and groundwater

Sampling probes:

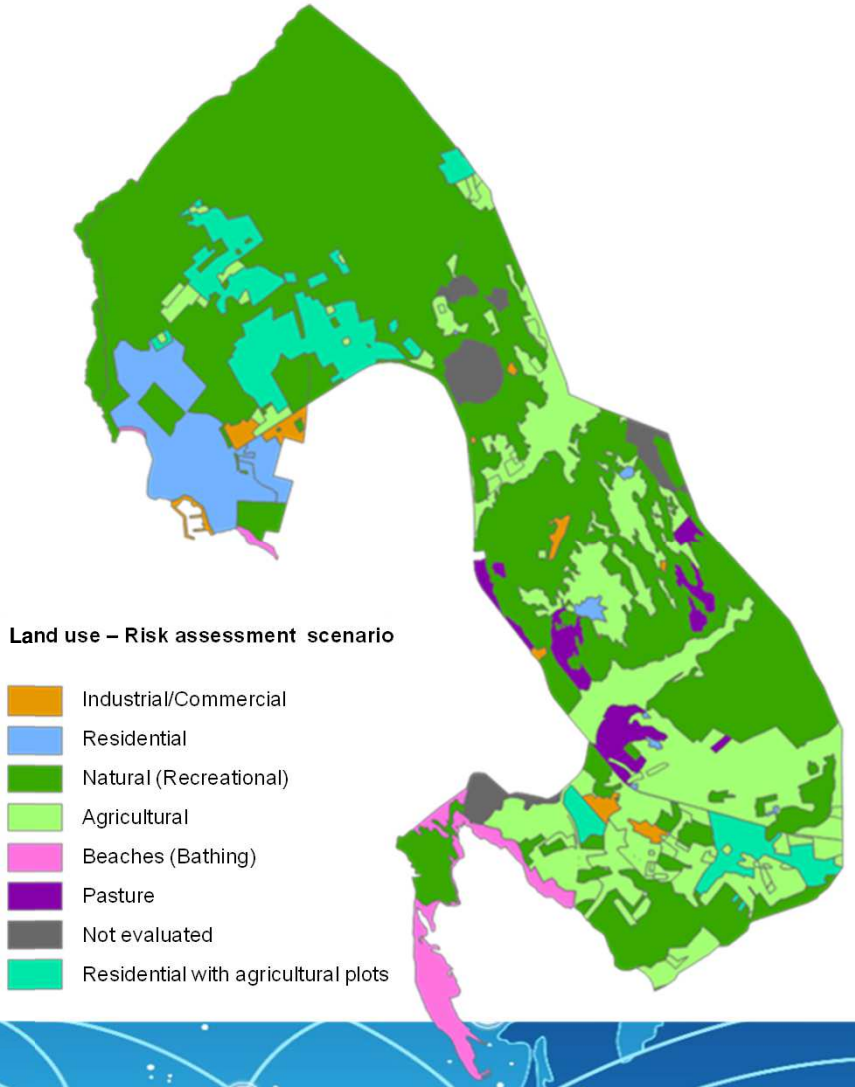
- 62 Surface probes (0-1,5 m BG).
- 139 Intermediate probes (from ground to capillary fringe).
- 66 Piezometers: 40 surface piezometers (up to15-25 m BG) and 26 deep ones (up to 40-133 m BG).

Collected samples:

- Soil: 308 topsoil (0-0,1 m BG) samples, 371 surface (0-1 m BG) and deep soil samples (>1m BG).
- Groundwater: 78 groundwater samples has been collected.

Agricultural areas:

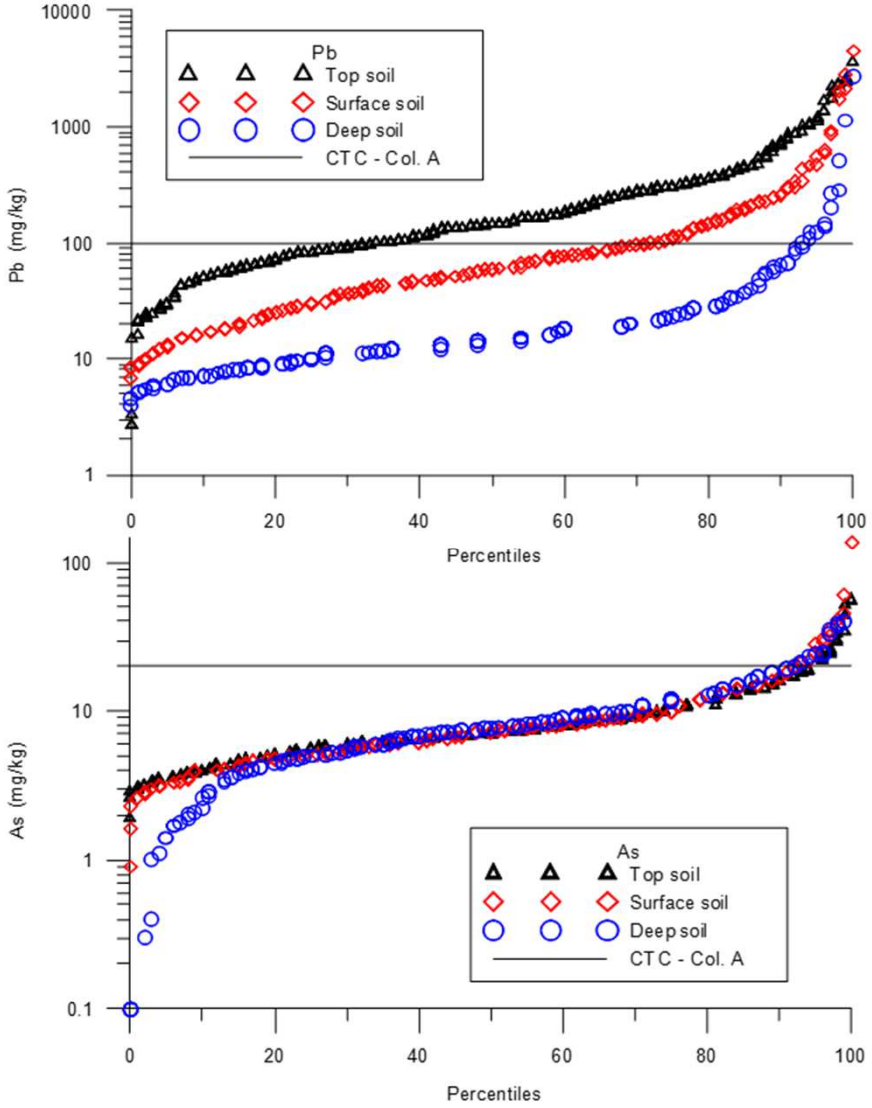
- Sampling of surface soils (composite samples; 0-0,2 m BG) and vegetables/grass produced in different “plots”.



Results of site investigations

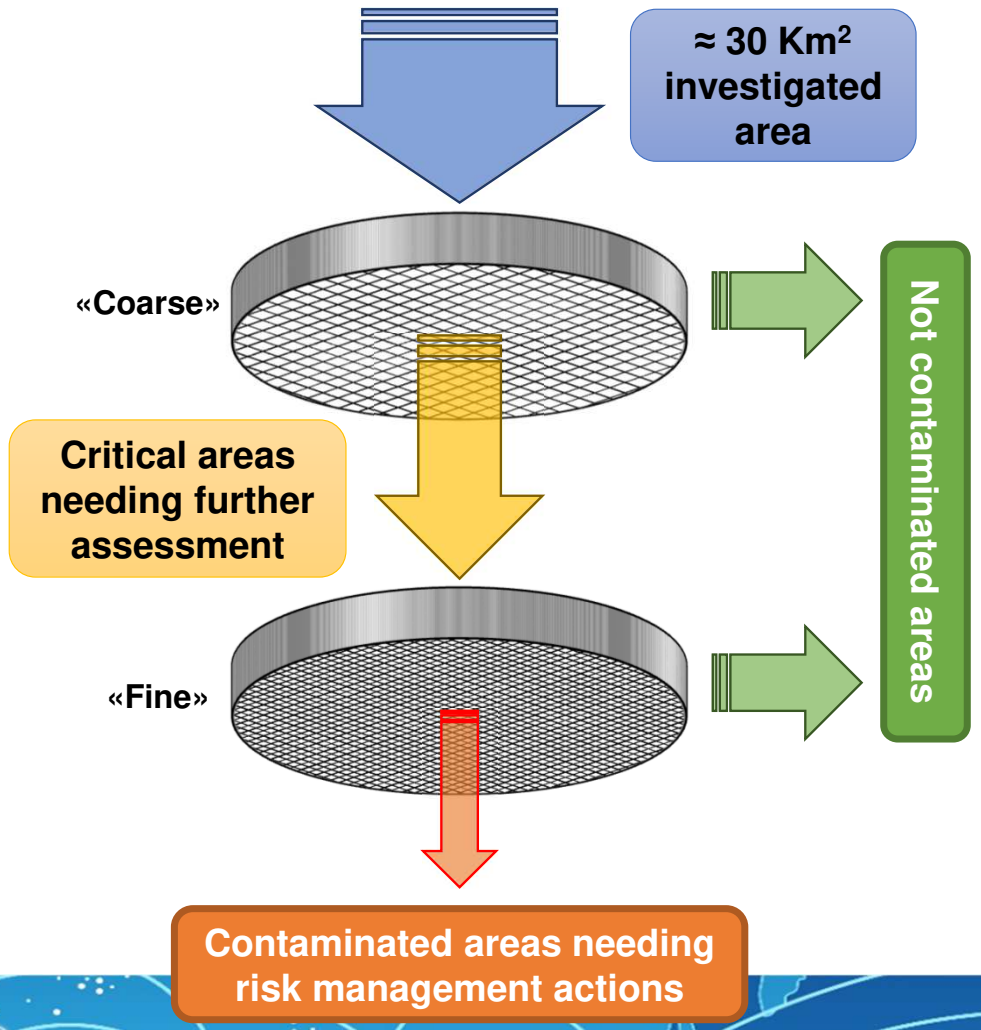
- Results of the investigation confirmed a diffuse presence in soil of heavy metals (As, Cd, Hg, Pb, Sn, Zn) above the screening values over the 30 km^2 wide investigated area.
- The evaluation of heavy metal contamination pattern in soil, and in particular the trend decreasing with sampling depth allowed to distinguish the contribute of **fall-out from the industrial district** from **natural background**.
- For inorganic chemicals in groundwater exceeding screening values upgradient the industrial district **the evaluation of background concentration confirmed that their presence is associated to natural sources**.

Evalutation of the contribute of natural background to soil and groundwater contamination allowed to better focus the following risk assessment phase



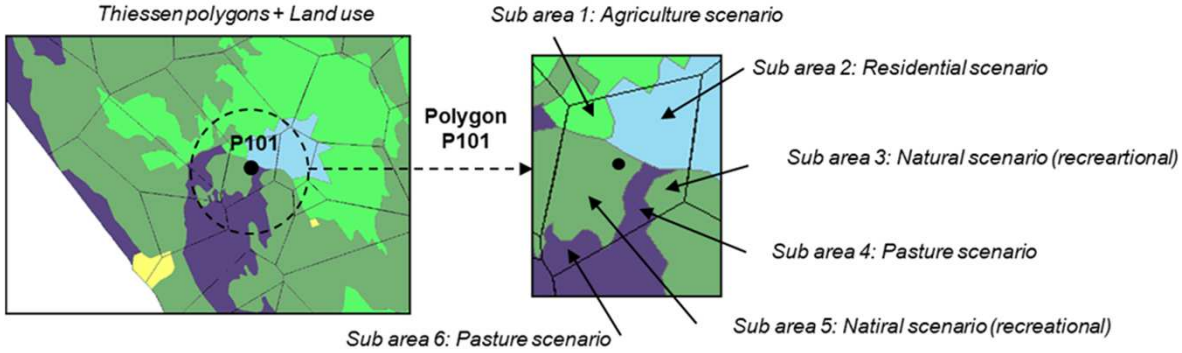
A “gradual finer sieving” approach for risk assessment

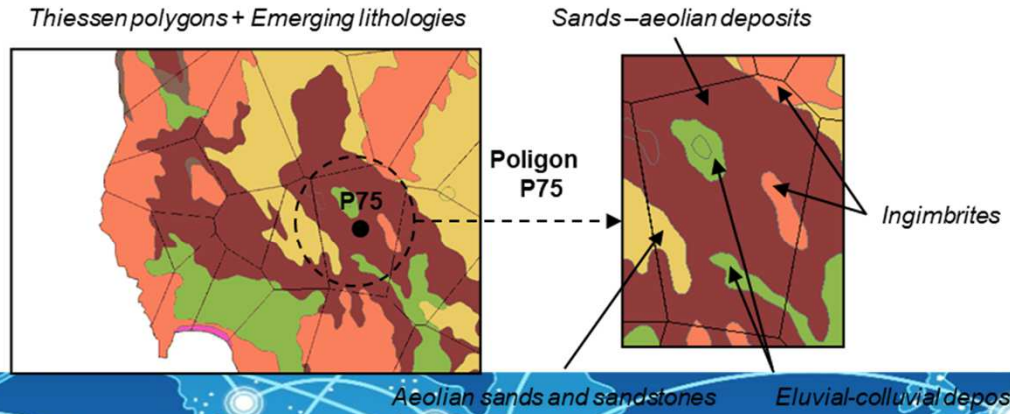
- For the risk assessment application to a large and diffusely polluted area, the main concern was to account simultaneously the spatial distribution of soil contamination, the geological setting and land use.
- A “gradual finer sieving”, two-step approach has been applied:
  1. The first **“coarse”** step consisted in a “simplified” risk assessment, combining the conservative assumptions typical of “generic assessment” (usually applied for “screening values” evaluation) with the use of many input parameters from site specific measurements. The scope of this step is to **identify “critical” areas needing further investigations and “detailed” assessment**.
  2. The second **“finer”** step included: the definition of a more detailed spatial distribution of contaminants in critical areas (additional sampling), the evaluation of the mobility of chemicals, the assessment of real exposure conditions. The aim of this step is to **identify areas needing “risk management actions”**.



First phase of site-specific risk assessment (2011)

- 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 (topsoil, surface soil, deep soil). Given this conservative assumption on contamination spatial distribution, **the differences in human exposure depend only on land use**.
- Based on land use, different **sub-areas** for human exposure have been defined.
- For agricultural and pasture use **a specific assessment on the soil to plant uptake pathway** involving vegetables produced, vineyards and grass consumed by animals (mainly sheep) has been carried out.





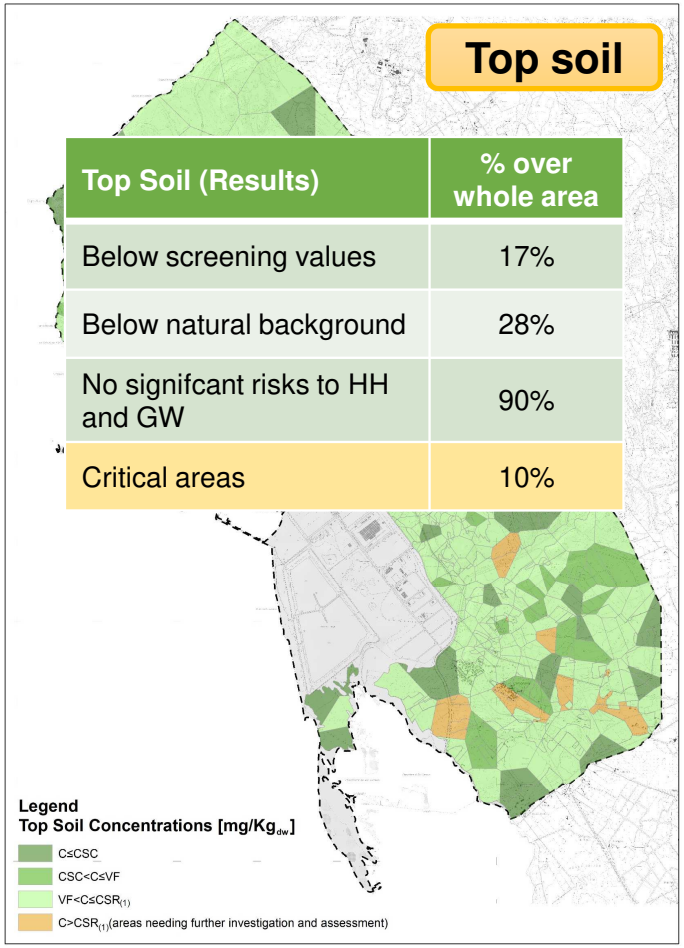
- For the assessment of risks to groundwater resources associated to soil contamination, **the geological variability** within each Thiessen polygon has been considered.

Results of “coarse” step – Critical areas

This very conservative step identified **areas with no significant risks** to human health and environment (“uncontaminated”) and no need of further investigations or actions. **No significant risk** has been estimated **for vegetable/food ingestion**.

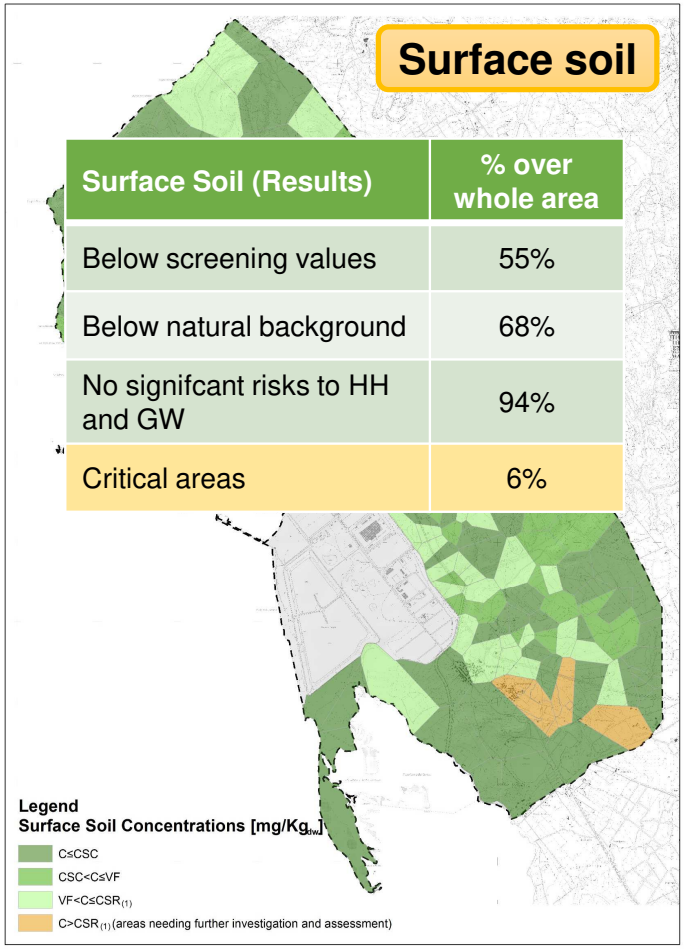
Top soil

Top Soil (Results)	% over whole area
Below screening values	17%
Below natural background	28%
No signifcant risks to HH and GW	90%
Critical areas	10%



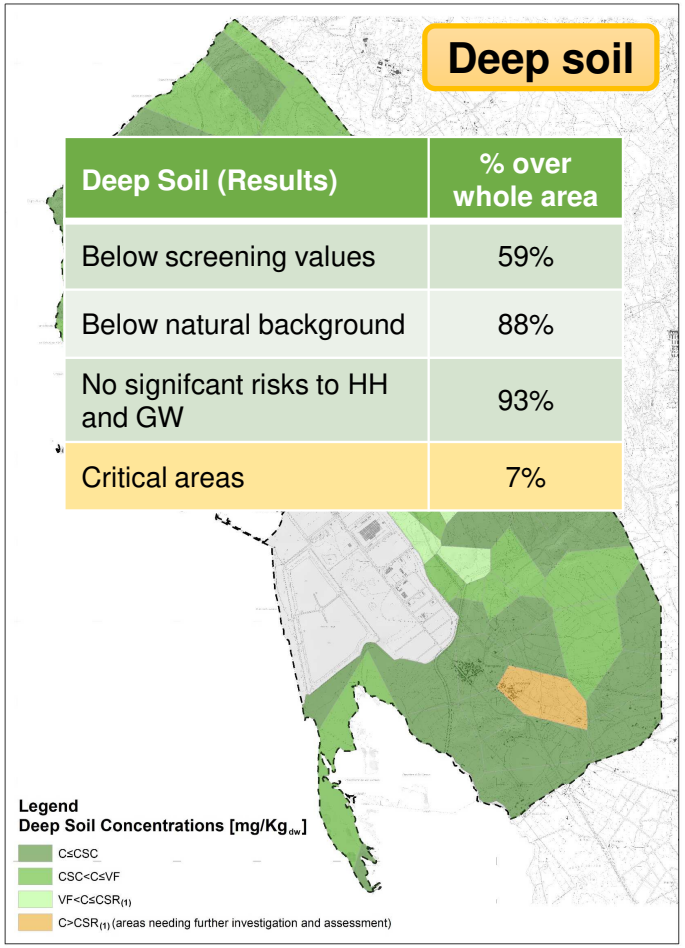
Surface soil

Surface Soil (Results)	% over whole area
Below screening values	55%
Below natural background	68%
No signifcant risks to HH and GW	94%
Critical areas	6%



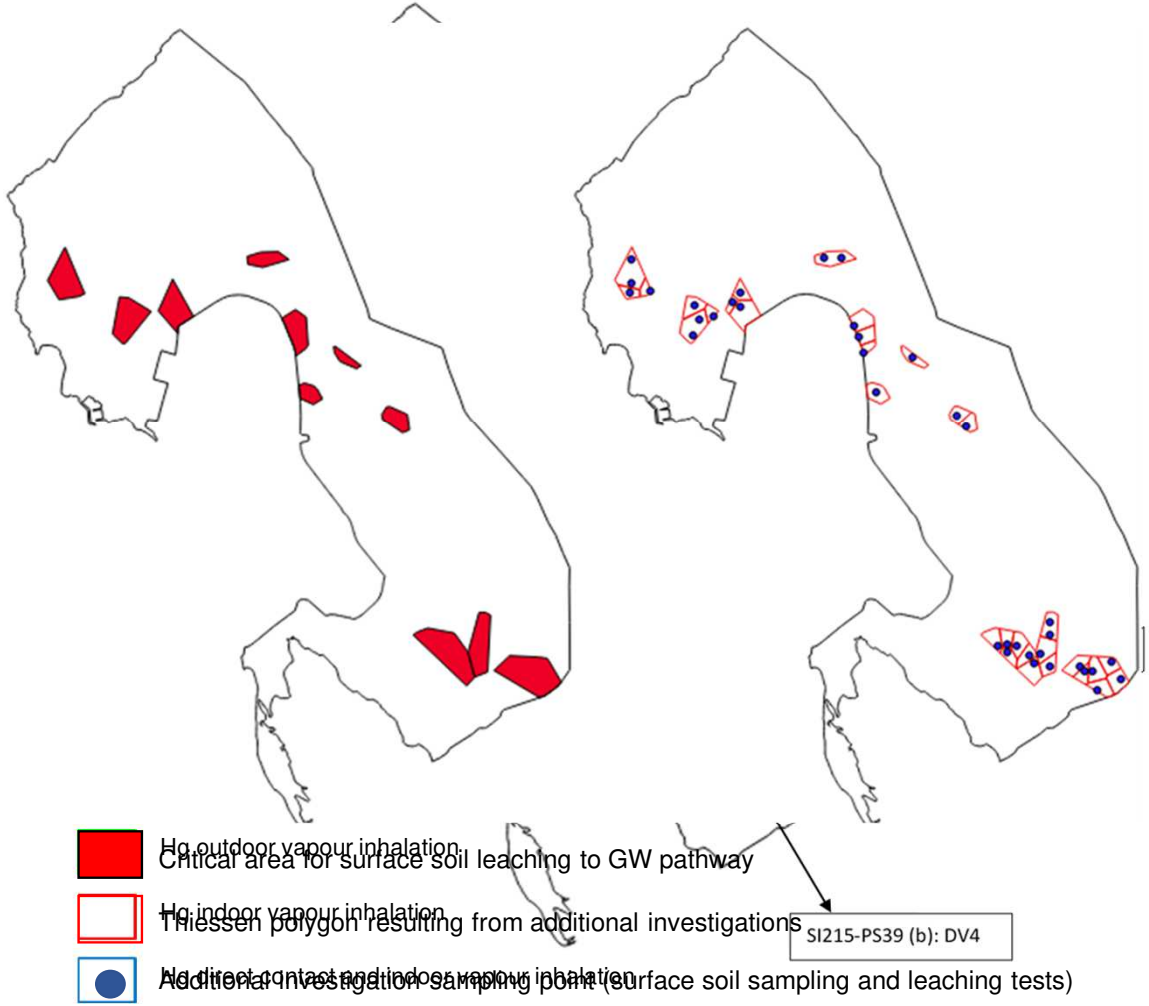
Deep soil

Deep Soil (Results)	% over whole area
Below screening values	59%
Below natural background	88%
No signifcant risks to HH and GW	93%
Critical areas	7%



Additional assessment/investigation (2012, 2013, 2017, 2019)

- A first additional assessment and a site visit (2012), **a better definition of exposure conditions** (e.g. real residential use also in agricultural areas, presence or planning of buildings, source dimension, etc.) allowed to exclude some “critical areas” from further investigations (areas no longer posing significant risk).
- Additional field investigations (2013, 2017, 2019) were focused on the critical exposure pathways (i.e. resulting in unacceptable risk) in order to refine the conceptual site model with:
  - **a more detailed distribution** of soil contamination (As, Cd, Pb) in critical areas
  - **presence of Hg volatilization** to outdoor and indoor air (soil gas survey, flux chambers and ambient air measures)
  - **mobile fractions for groundwater** of As and Pb in soil (with leaching batch tests and groundwater monitoring).

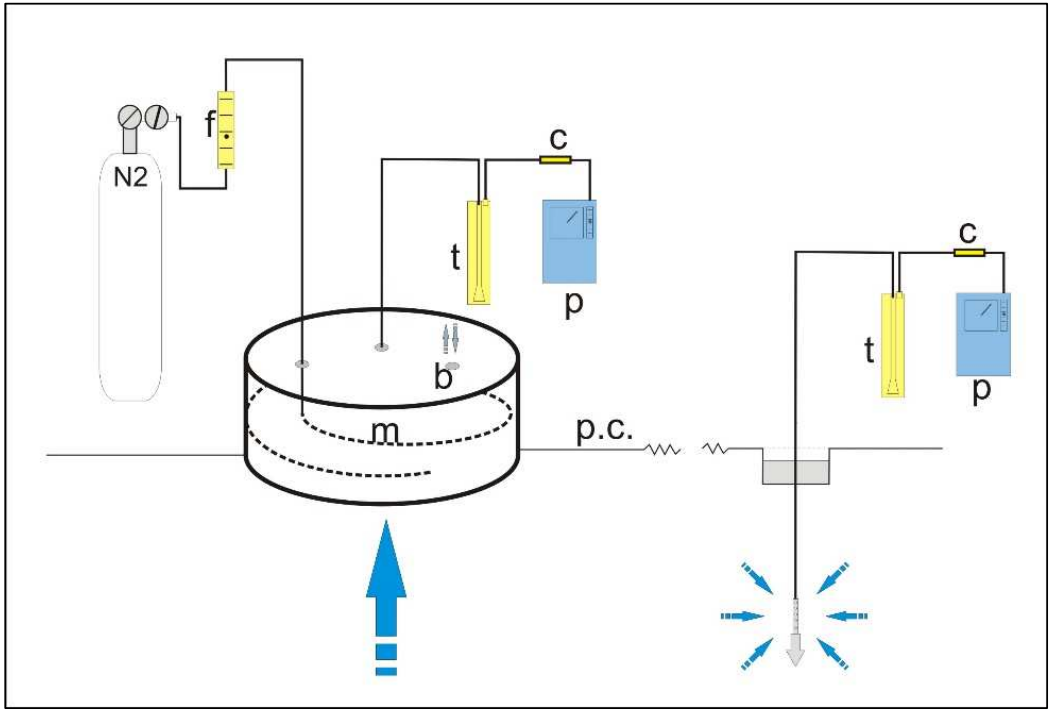


Second phase of site-specific risk assessment (ISPRA, 2020)

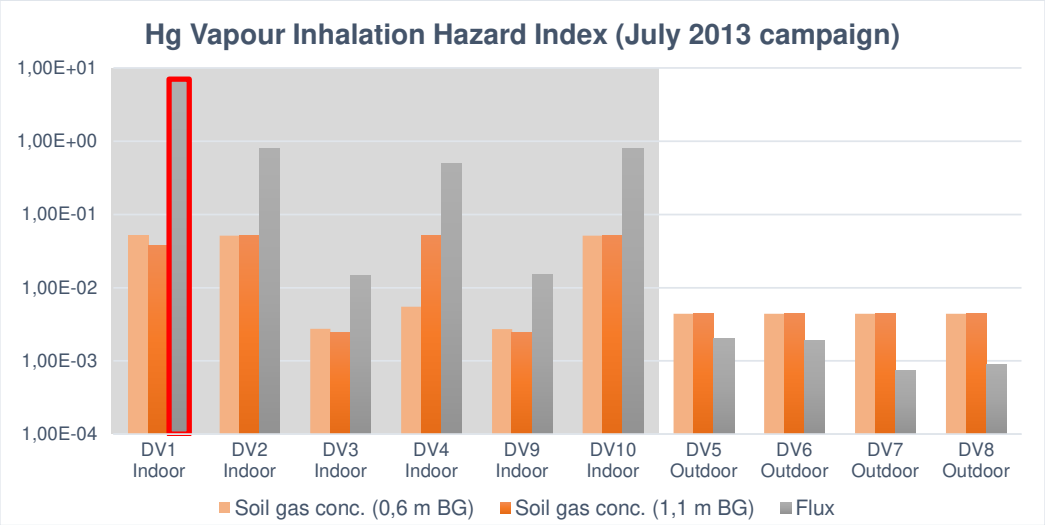
After additional investigations **the more detailed distribution** of soil contamination in TS SS and DS allowed to **exclude some areas from the second phase of risk assessment ("detailed assessment")**.

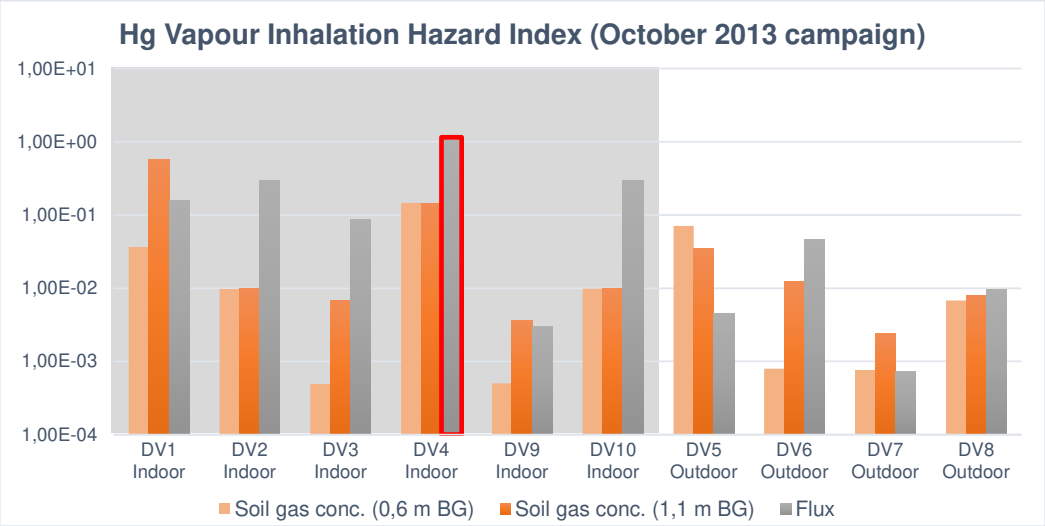
An innovative approach to the assessment of the critical pathways has been adopted with:

- Use of **direct measures of volatile fractions/emissions** (soil gas concentrations, flux measures, ambient air concentrations) for the evaluation of risks associated to vapour inhalation pathway (Hg).
- New transport model for the evaluation of **dust emissions from topsoil** caused by wind erosion.
- **New exposure assessment**: re-definition of receptor age classes, soil ingestion rates, air inhalation rates.
- Evaluation of the soil leaching to groundwater pathway using **batch leaching tests data**.
- Dispersion parameters of the fractured aquifer evaluated from the **spatial variability of the hydraulic conductivity**.



Vapour inhalation pathway (Hg)



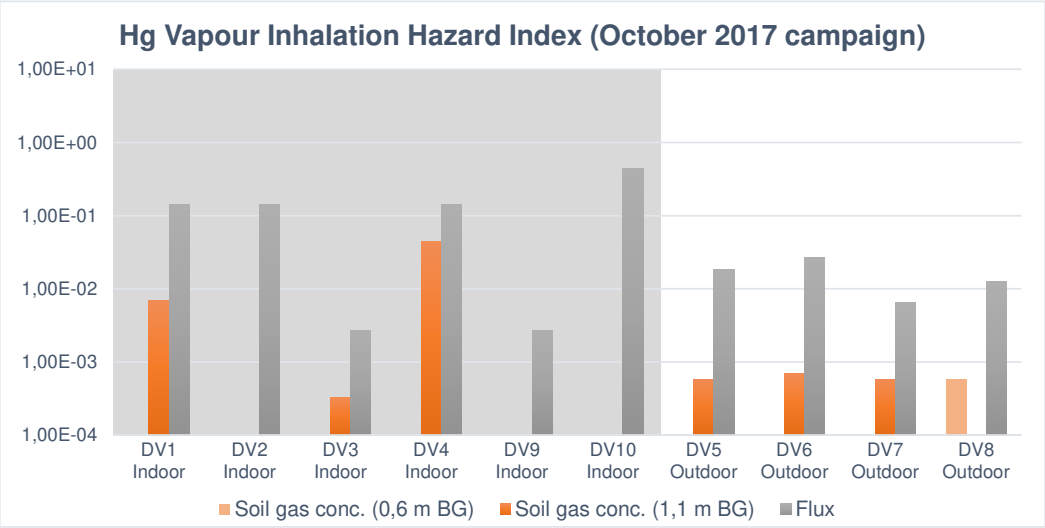


2013 Campaigns (July and October):

"Lines of evidence" – soil gas survey, flux measures:

- for indoor environment **risk associated to fluxes are generally higher** of those associated to gas concentrations in probe
- in outdoor the accumulation/release of vapours is probably **influenced by local conditions** (not homogeneous soil horizons, atmospheric variability)
- higher risks are registered for **indoor exposure** ("significant" in two cases)

Vapour inhalation pathway (Hg)



Hg vapour inhalation pathway is not «critical» and no action is needed in the related areas

2013 Campaigns (July and October):

"Lines of evidence" – soil gas survey, flux measures:

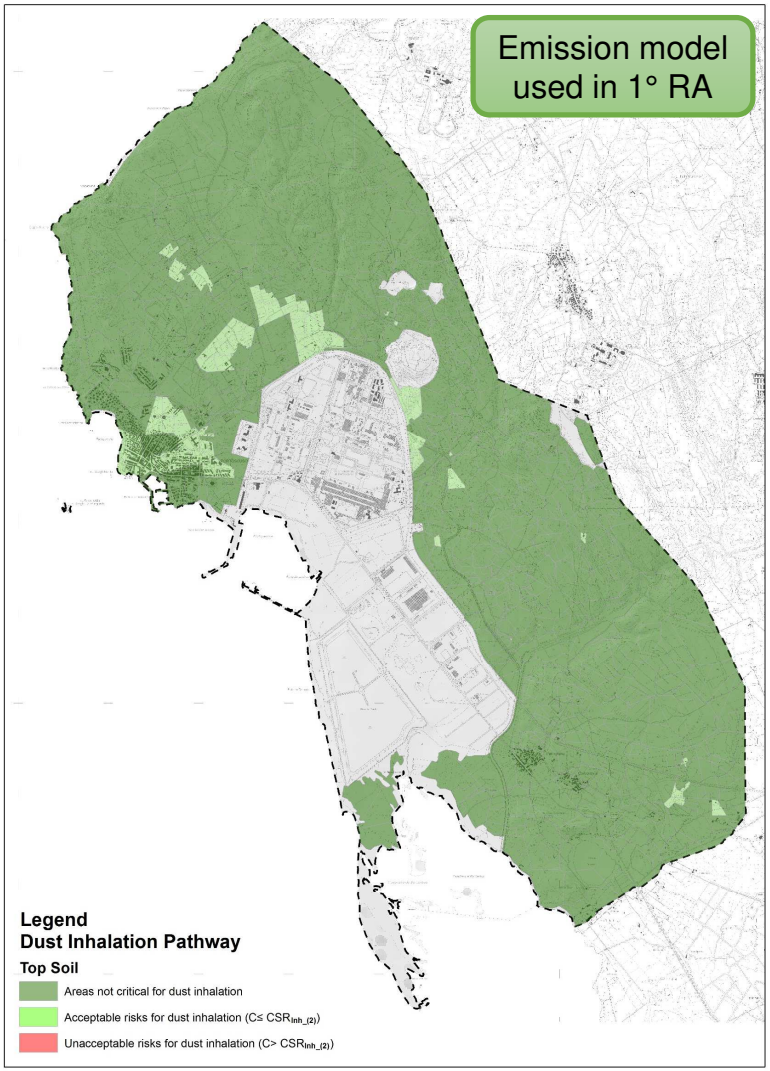
- for indoor environment **risk associated to fluxes are generally higher** of those associated to gas concentrations in probe
- in outdoor the accumulation/release of vapours is probably **influenced by local conditions** (not homogeneous soil horizons, atmospheric variability)
- higher risks are registered for **indoor exposure** ("significant" in two cases)

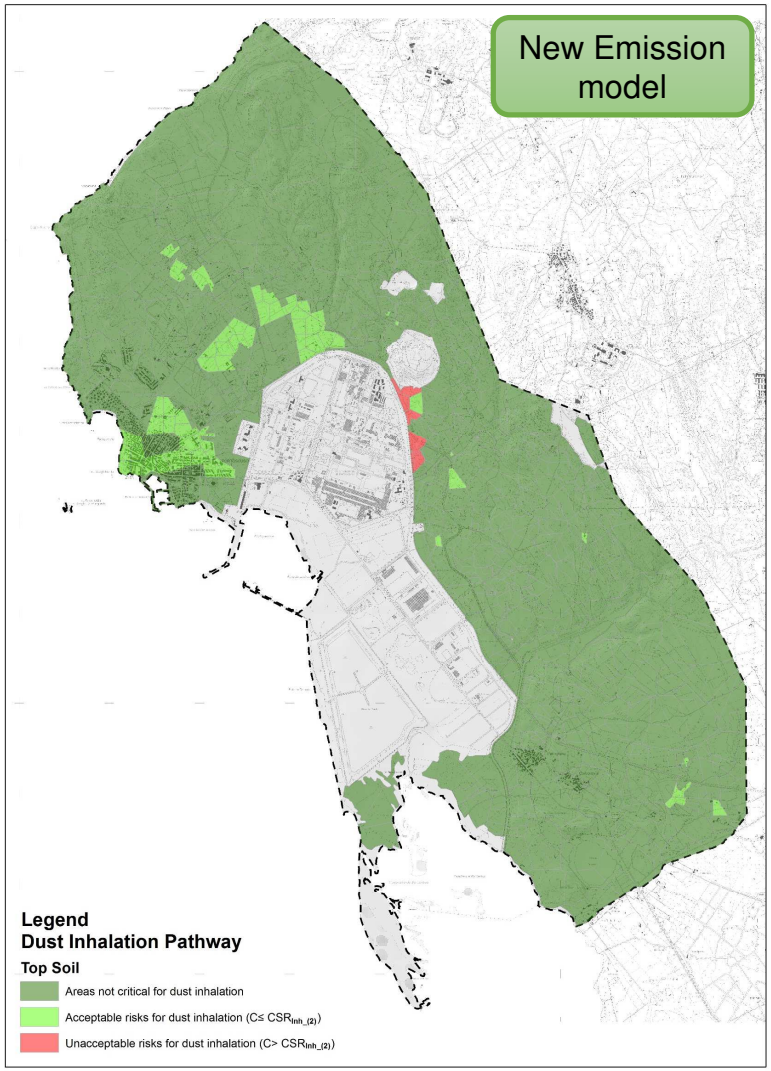
October 2017 Campaign:

"Lines of evidence" – soil gas survey, flux measures, ambient air:

- risks associated to soil gas concentrations and flux measurements **are acceptable**
- concentrations measured in ambient air (indoor and outdoor) confirm **the substantial absence of Hg vapors**.

Direct contact with soil and dust inhalation (Top soil)





Soil ingestion (Topsoil):

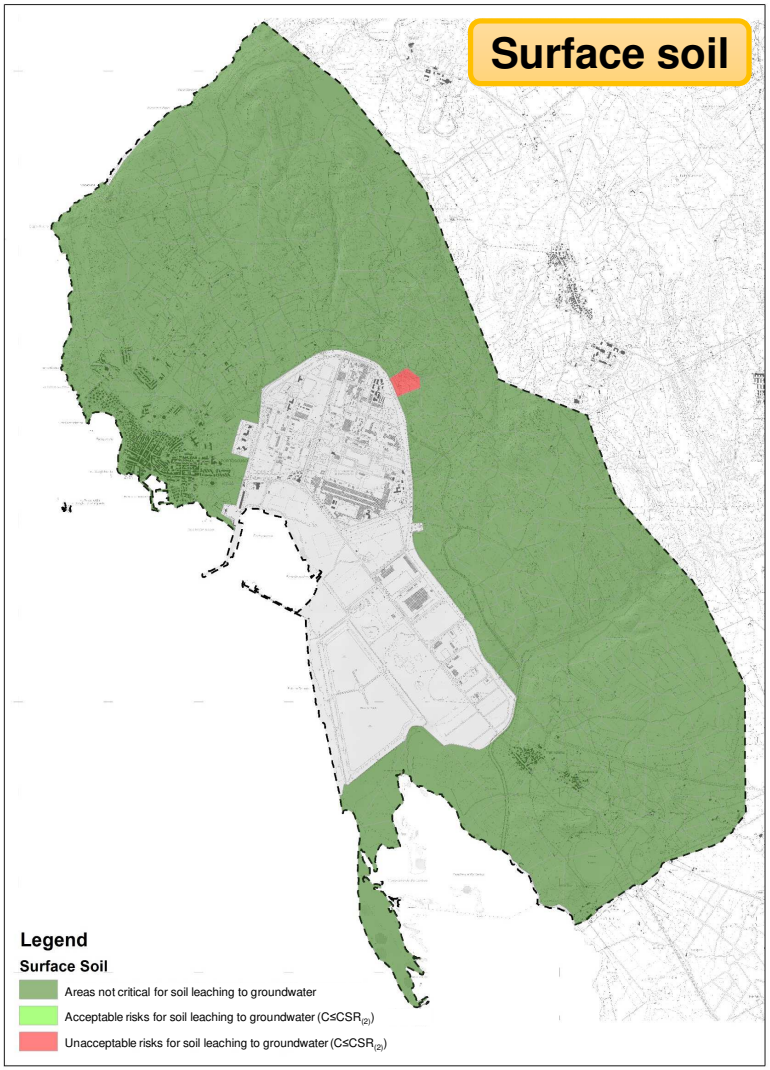
- The use of **more realistic exposure parameters** allowed to identify areas needing management.

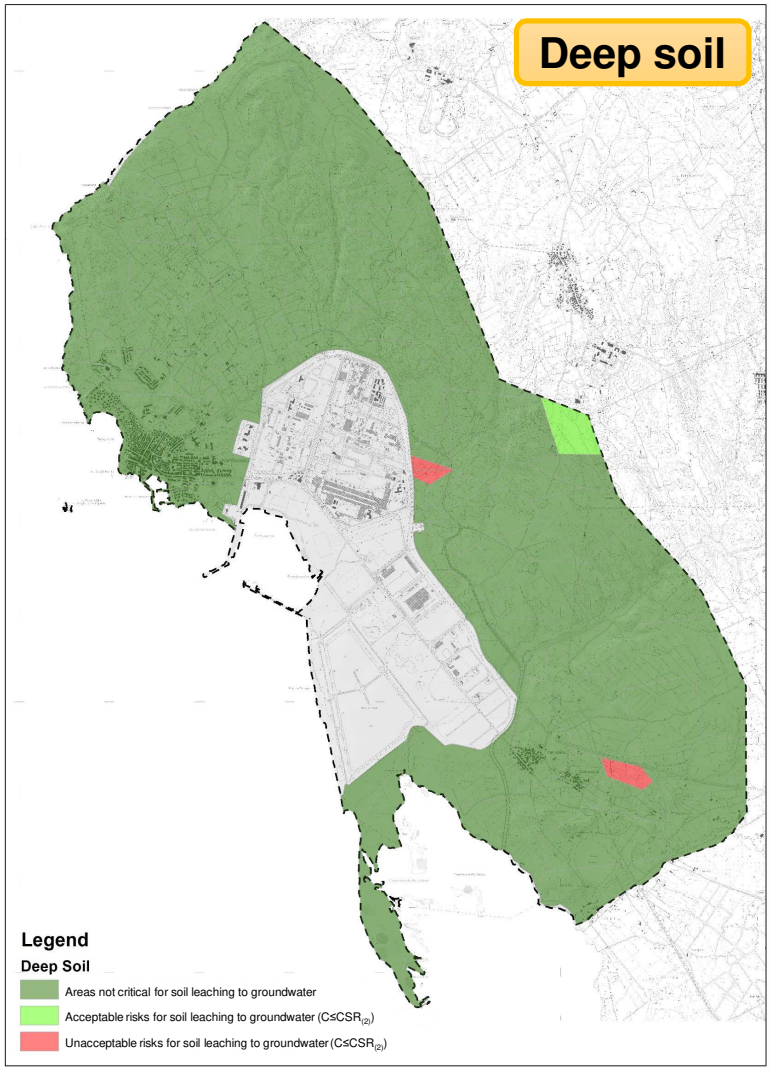
Dust inhalation (Topsoil):

- New dust emission model can consider the **relevant contribute of wind erosion**.

Direct contact and dust inhalation for top soil (As and Pb) are still «critical» pathways

Soil leaching to groundwater (Surface and Deep soil)





- Soil leaching to groundwater pathway has shown **potential impact of surface soil and deep soil As and Pb contamination** in some areas, even using mobile fractions derived from leaching tests.
- However groundwater monitoring **confirmed compliance with screening values** (tap water standards) upgradient the industrial district.

Leaching of As and Pb to GW is not «critical» and no action is needed in the related areas

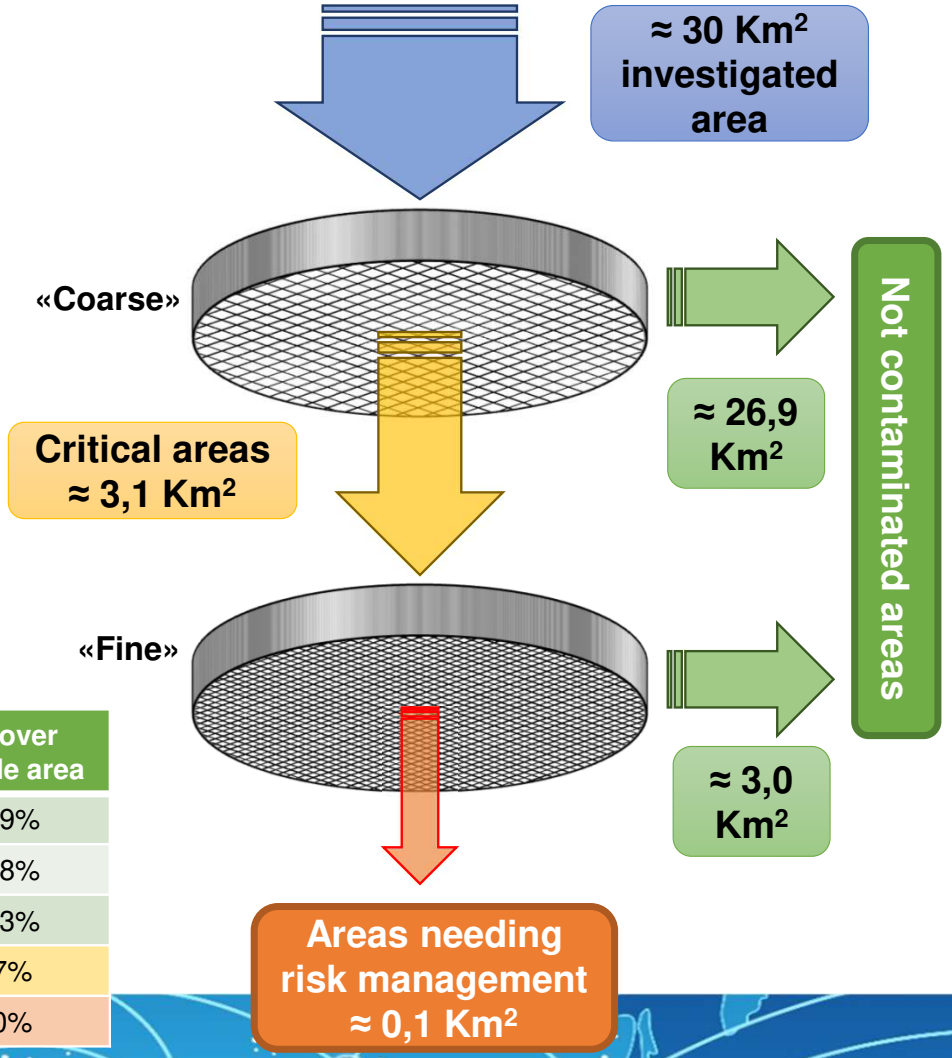
Results of “finer” step – Areas needing risk mangement

- After the “detailed” risk assessment, only topsoil layer in some areas need risk management actions.
- Direct contact and dust inhalation are the “critical” exposure pathways driving the risks to human health.
- Potential impact to groundwater resources from surface and deep soil layers was not confirmed by groundwater monitoring.

Top Soil (Results)	% over whole area
Below screening values	17%
Below natural background	28%
No signifcant risks to HH and GW	90%
Critical areas	10%
Areas needing risk management	0,24%

Surface Soil (Results)	% over whole area
Below screening values	55%
Below natural background	68%
No signifcant risks to HH and GW	94%
Critical areas	6%
Areas needing risk management	0%

Deep Soil (Results)	% over whole area
Below screening values	59%
Below natural background	88%
No signifcant risks to HH and GW	93%
Critical areas	7%
Areas needing risk management	0%



Results and conclusions

After the whole assessment process:

- almost 99% of the potentially impacted area can be declared as “not contaminated”
- no restriction to food production is applied.

Therefore the municipality of Portoscuso will be able to:

i. release the areas with no significant risk to human health and environment without any restriction

ii. identify risk management actions for limited exposure pathways in areas that were found to be critical after the second phase

iii. plan any remediation works at very local scale, in areas where management actions are not effective or not applicable.

The overall approach avoided extensive investigation and remediation in a large diffusely contaminated area, making sustainable and effective the whole management.

Thank you for your attention!

Special thanks to Dott. Paolo Montisci for the support given to spatial assessment.

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