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CENTRAL EUROPE



AMIIGA

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REMTECH EXPO
21-25 SEPTEMBER 2020



AMIIGA Interreg project: statistical and modelling approaches for diffuse contamination assessment in Milano Functional Urban Area



L.Alberti, A.Azzellino, L.Colombo (Politecnico di Milano-Dip. Ing. Civile e Ambientale)

M.Bellotti, D. Balzarolo ,E.Confalonieri (Regione Lombardia- DG Ambiente e Clima)

INTRODUCTION

The AMIIGA Project (2016-19) was funded under INTERREG CENTRAL EUROPE Program.

12 Partners participated mixing research institutions (4) and Public Authorities (8)

6 Countries : Croatia, Czech Republic, Italy, Germany, Poland and Slovenia

The AMIIGA tools will be implemented in 7 pilot actions in 7 various specific CE regions



The AMIIGA Project (2016-19) has the aim to face the problem of groundwater contamination at FUA scale: i.e. a city and the surrounding municipalities connected

The FUA scale is neither local (i.e. brownfield) nor wide (i.e. agriculture contamination) and needs special tools to investigate, remediate and manage the GW contamination

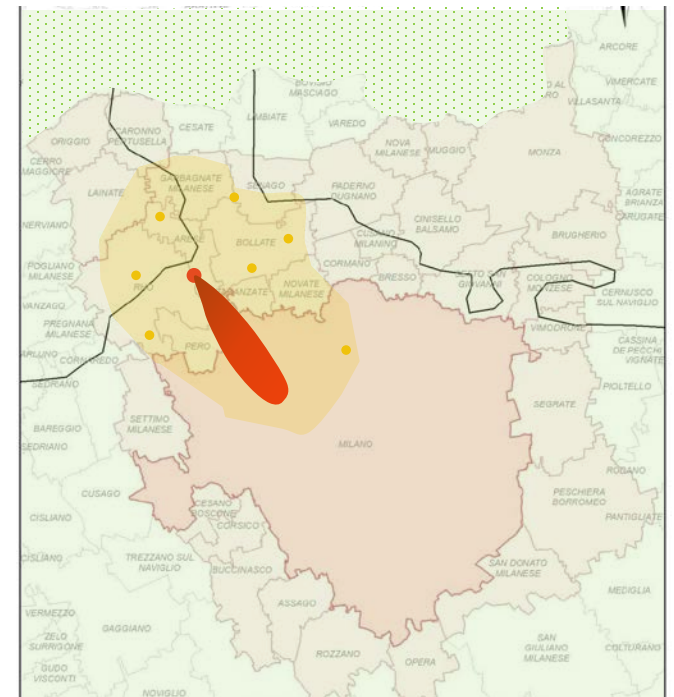
In large urban area many kind of sources can be responsible of a GW contamination and for Public Authorities is difficult to apply the “Polluter Pay Principle “:

Point Sources (PS)

(Dlgs. 152/2006) contamination hot spots corresponding to areas releasing plumes of high concentrations (e.g. brownfields)

Multiple Point Sources (MPS) (Reg. Decree 6737/2007) defined as an anthropogenic background contamination level linked to many small unidentified sources (e.g. chlorinated solvents)

Non-Point Sources (NPS) where the contaminant load comes from the development of anthropogenic activities on large areas (e.g. agriculture)



INTRODUCTION

Groundwater contamination is a problem that **goes beyond administrative boundaries** of a local public authority. There is little experience in Europe in the management of such challenges in Functional Urban Areas (FUAs).

AMIIGA project tackles in particular the problem of groundwater contamination originating from PS and MPS, which is common for CE's territory. Contamination sources located in "city core" affects the groundwater quality of "hinterlands" downstream and vice versa. It requires effective intervention at a medium (FUA) scale, neglected in existing legislation.

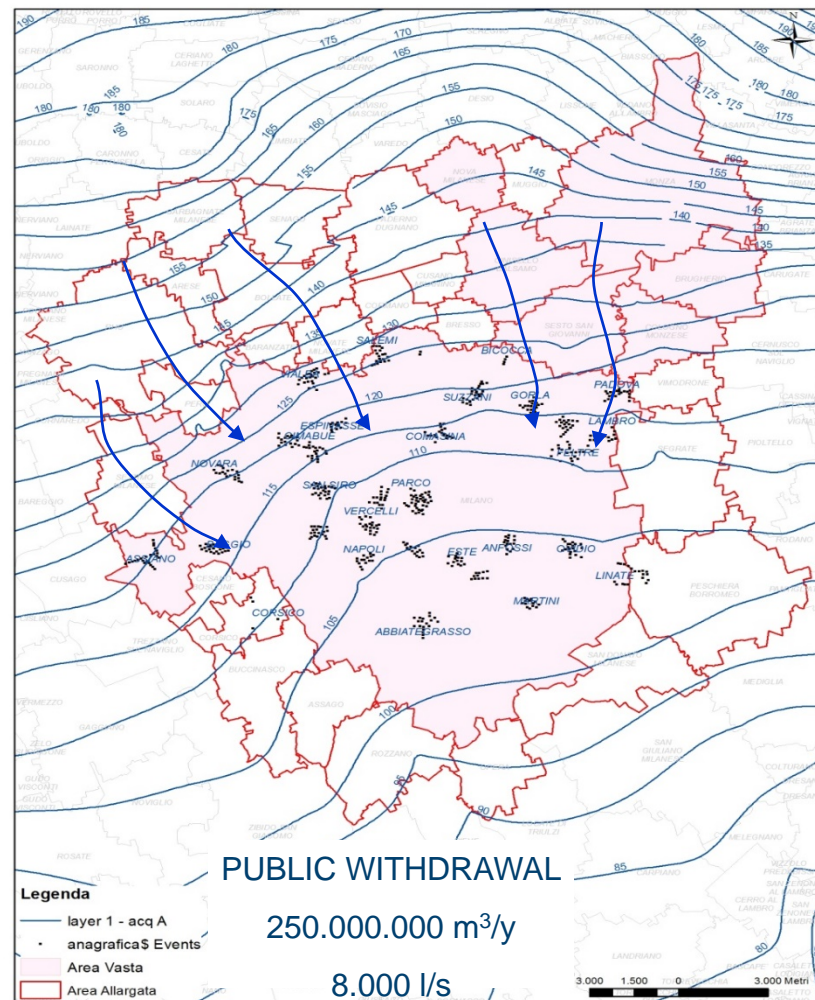
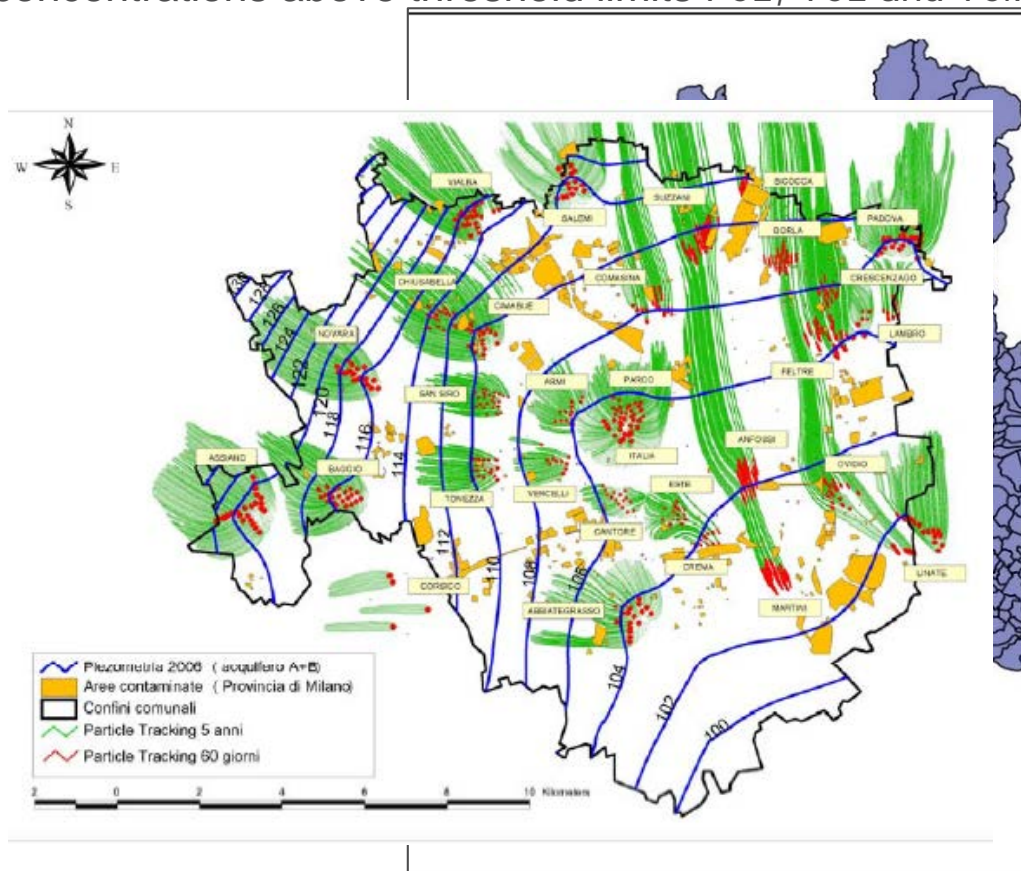
The anthropogenic **diffuse contamination** frequently is present in European FUAs and determined by many different source areas releasing small contaminant mass in groundwater. The Italian law Dlgs 152/06 (TitoloV art. 239) defines the anthropogenic diffuse pollution as the *"chemical, physical and biological alteration of environmental matrixes and contaminations determined by diffuse sources and not linked to a point source"* Dlgs 152/06 designates Regional authorities to recognize and to enact actions when such diffuse contamination is identified

In these areas in order to plan a groundwater management it's necessary:
- to asses the Diffuse Pollution Background Levels (DPBLs)



INTRODUCTION

Milano FUA represents a good case study for diffuse anthropogenic contamination as it had a long industrial history since the 50^{ies} :many Chlorinated Hydrocarbons plumes are still present and overlap a more diffuse contamination. Many public wells show Chlorinated Hydrocarbons concentrations above threshold limits PCE, TCE and TCM



METHODOLOGY

HYDROCHEMICAL DATA SET (2003-2017) AVAILABLE IN MILANO FUA (TCE,PCE, TCM)

In AMIIGA one of the aims of Work Package 1 is to develop and test a methodology to asses the DPBLs

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Cluster analysis Hot-spot location

Groundwater
Transport model
(Modflow-MT3D)

PLUME extension
in FUA

GEOSTATISTICAL analysis
(cleaned dataset)

Factor and
Multivariate
analysis

Diffuse contamination MAPS and assesment

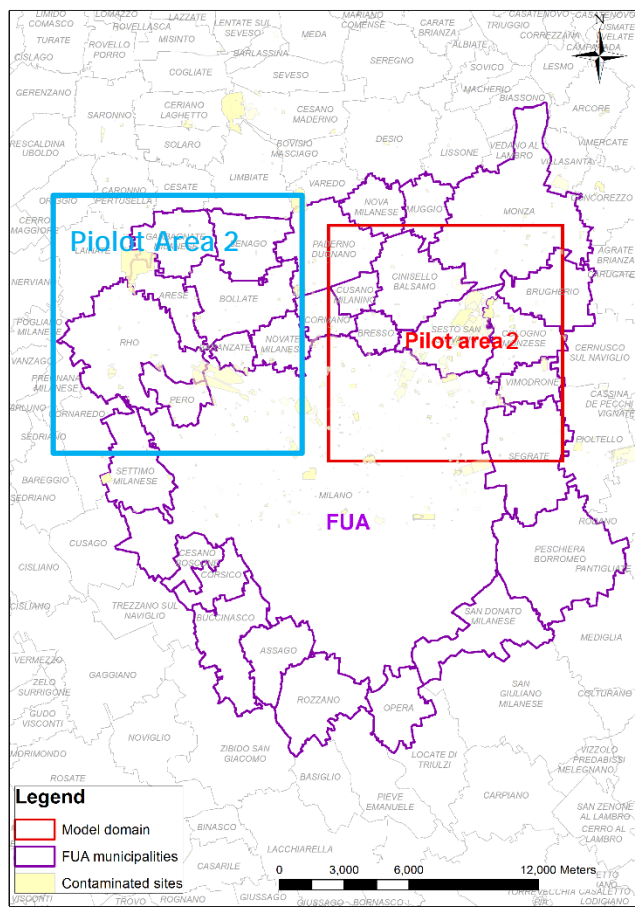
1st RESULT

Stochastic modelling for
particle backtracking

METHODOLOGY

Probabilistic MAPS of source areas position

2nd RESULT



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CLUSTER ANALYSIS

Starting from a wide dataset (45.000 chemical data) cluster analysis and a transport model have been combined to distinguish point and multiple-point sources contribution to the diffuse concentration in Milano FUA

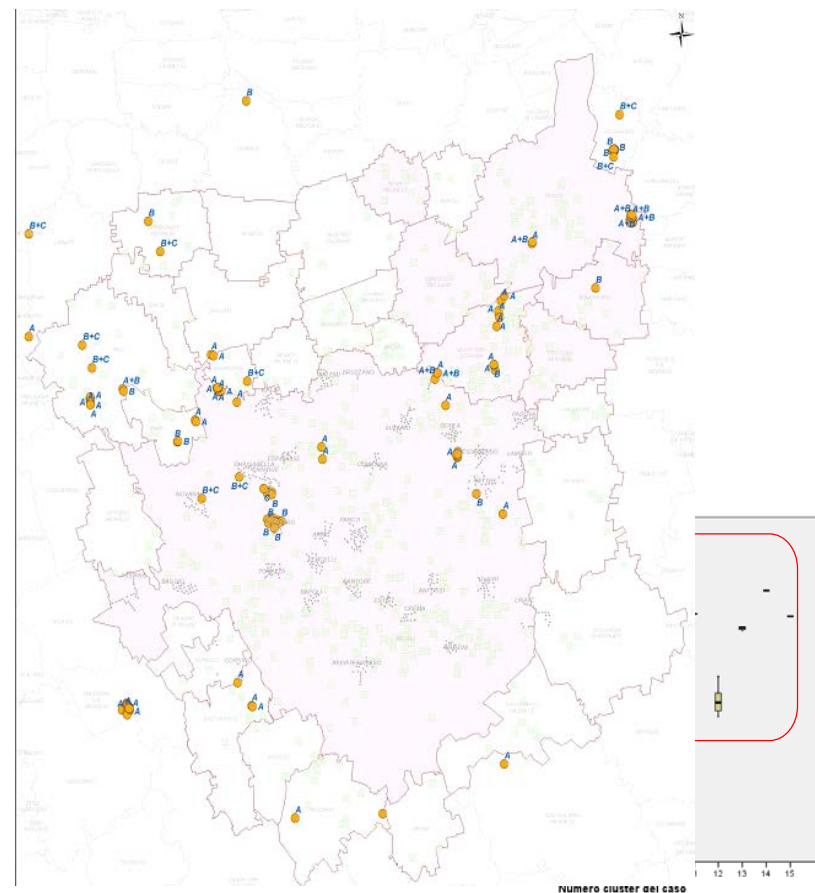
HYDROCHEMICAL DATA SET (2003-2017) AVAILABLE IN MILANO FUA (TCE,PCE,TCM)

Cluster analysis

Hot-spot location
(doc research)

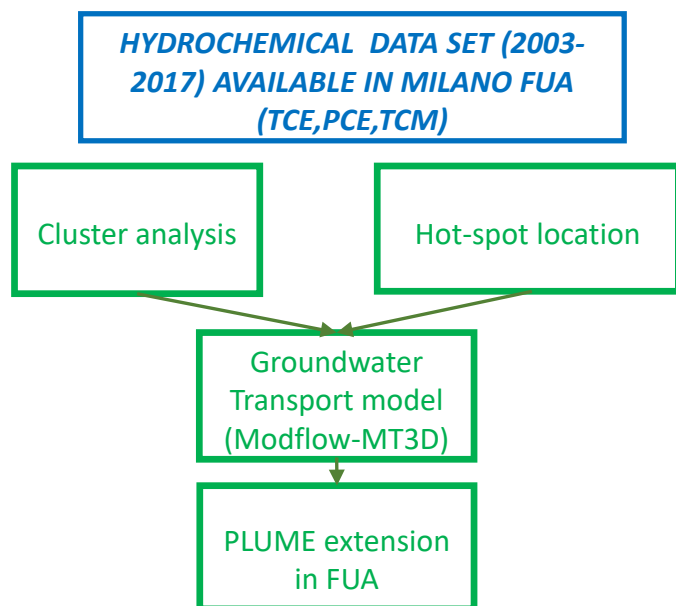
The combination of cluster and documental research is useful to:

- Analyse historical sources
- Locate punctual sources to linked to a «known» sources
- Highlight some outliers
- Point out monitored points directly involved by plumes

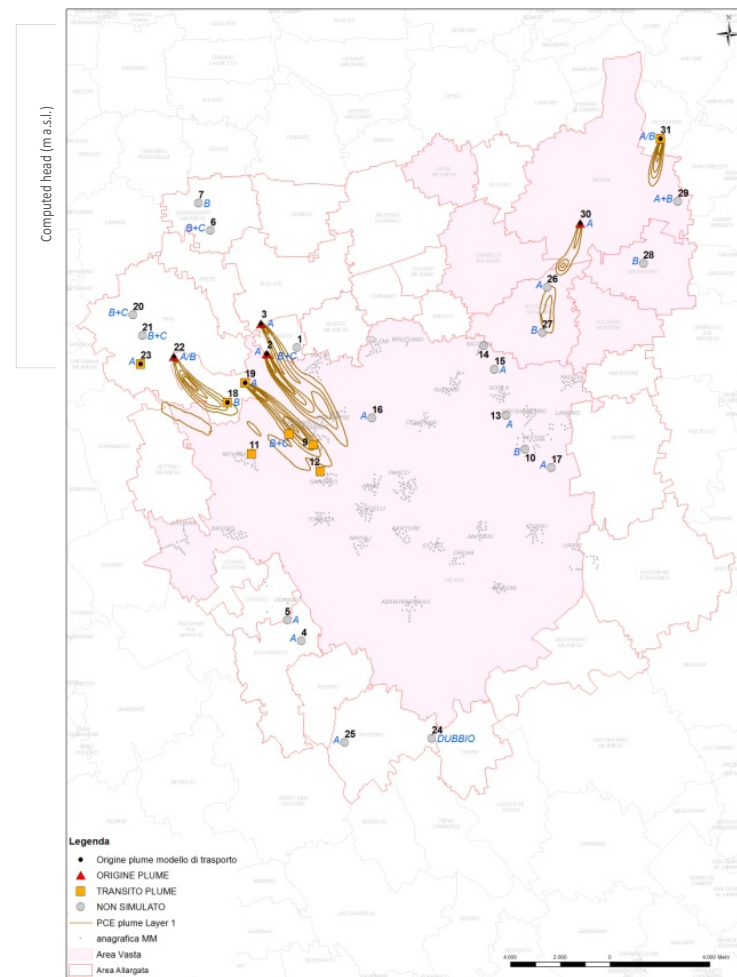


PLUMES DEFINITION

Once hot spots have been identified a groundwater transport model has been applied to assess the PCE plume extension



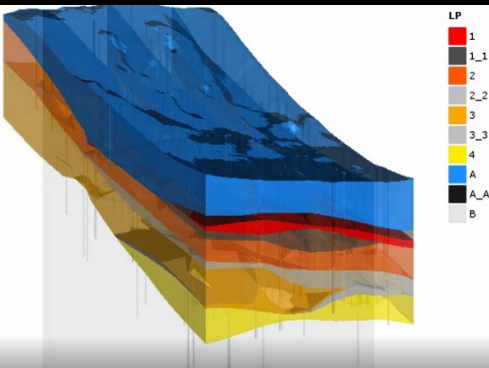
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PLUMES DEFINITION

A GW flow model was implemented and calibrated

MODFLOW 2005



Aquifer

- Aquifer A
- Aquifer B1
- Aquifer B2
- Aquifer B3
- Aquifer B4
- Aquitard



DATABASE CLEANING

Once the plumes extension is simulated the monitoring points hit by them can be canceled from the dataset. Then the cleaned database is used to prepare diffuse contamination maps

HYDROCHEMICAL DATA SET (2003-2017) AVAILABLE IN MILANO FUA (TCE,PCE,TCM)

Cluster analysis

Hot-spot location

Groundwater
Transport model
(Modflow-MT3D)

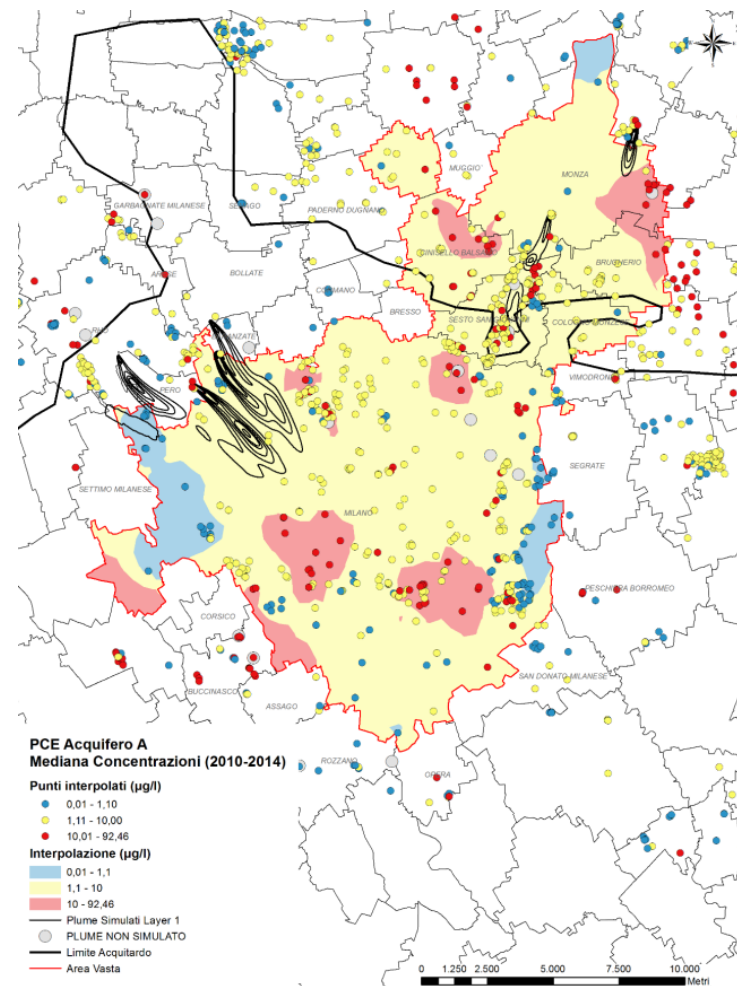
PLUME extension
in FUA

GEOSTATISTICAL analysis
(cleaned dataset)

Diffuse
contamination
MAP

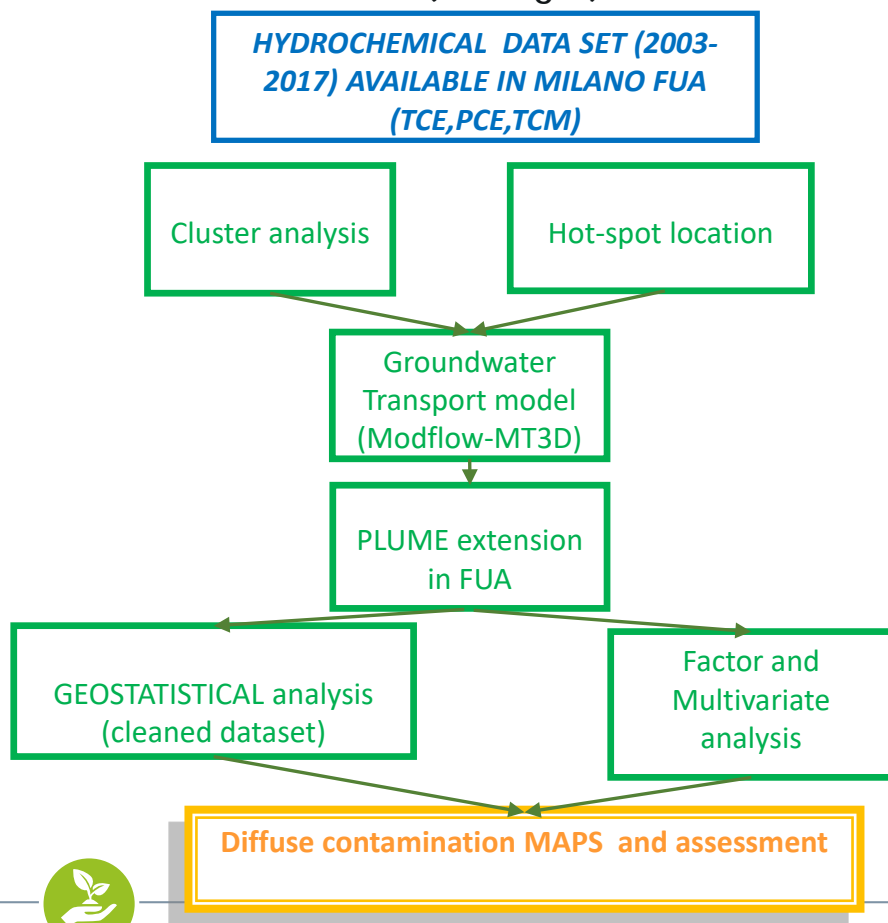
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RESULTS



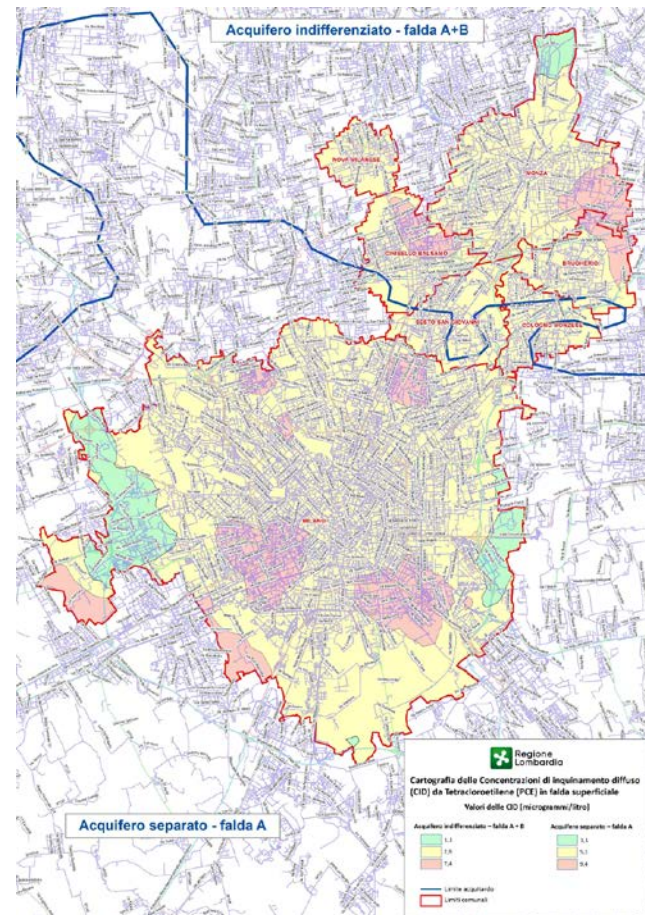
FACTOR AND MULTIVARIATE ANALYSIS

Diffuse contamination maps showed that is incorrect to define a single PCE diffuse value for the entire study area. Then Factor and Multivariate analysis have been applied to define the proper value in each of the areas (yellow and read) where concentrations are higher than the Italian threshold limit (1,1 ug/l)



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RESULTS



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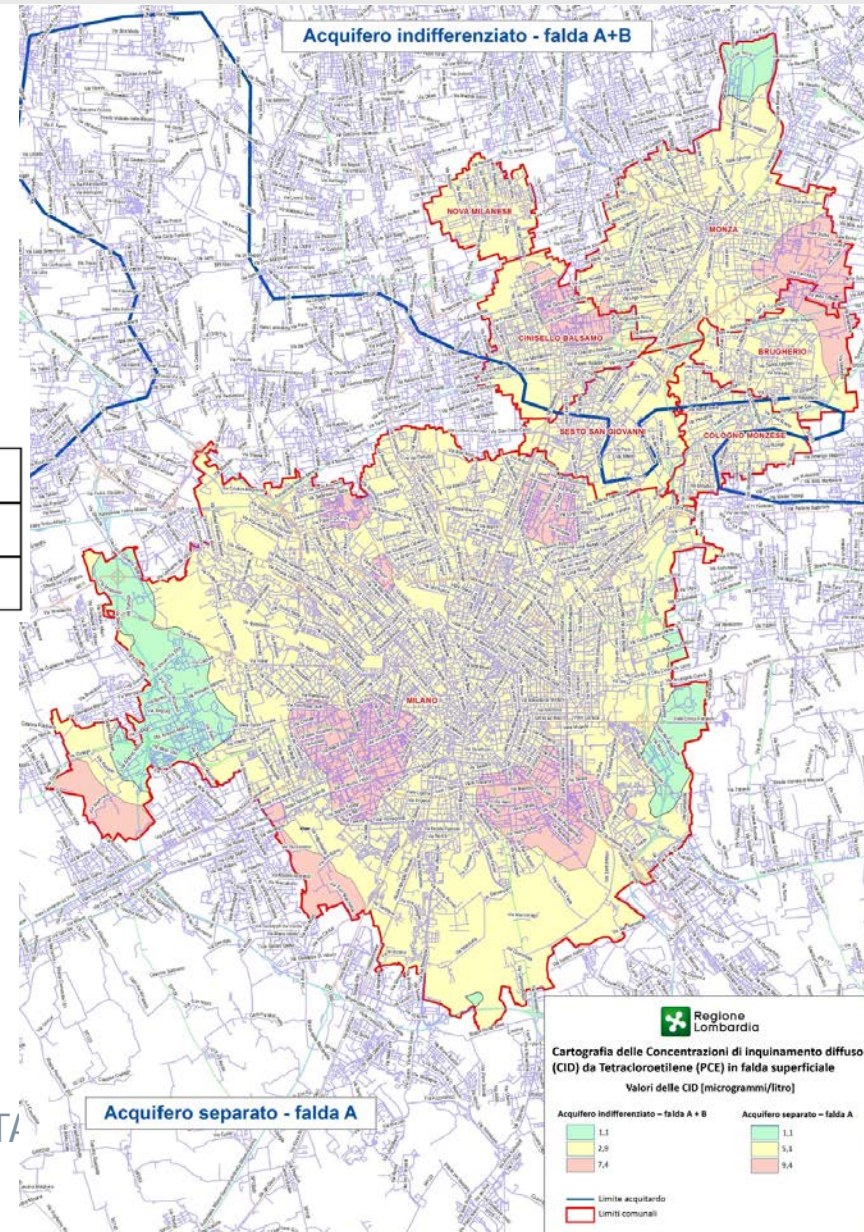
DPBLS MAPS AND RTDC DEFINITION

Finally Lombardy Region through the DGR 6773/2017 defined the Reference Threshold for Diffuse Contamination (RTDC) for the Aquifer A and the not separated one (A+B). In the Milano FUA they substitute the CSC in those area where an anthropogenic diffuse contamination has been identified

Tab. 2. RTDC values for PCE ($\mu\text{g/l}$).

Concentrazioni di Riferimento per la Bonifica del Tetracloroetilene ($\mu\text{g/l}$).

RTDC ($\mu\text{g/l}$)	Yellow Area	Red Area
Northern Municipalities (Aquifer not separated A+B)	2,9	7,4
Milan (Aquifer A)	5,1	8,5



CONCLUSIONS

The **anthropogenic diffuse contamination** in FUAs is a **challenging problem** whose management requires new tools able to support Public Authorities in planning their activities. A methodology has been developed :

- to identify the presence of a diffuse contamination
- to asses the DPBLs

Thanks to the methodology it has been possible:

- to produce maps representing the distribution of Chlorinated Hydrocarbons concentrations linked to a anthropogenic diffuse pollution
- to define different DPBLs in the different sectors of Milano FUA
- to support Public Authorities in making decisions for future management of the groundwater investigations
- to prioritize the investigation areas focusing public economic resources in those areas that are likely responsible of the diffused contamination
- to highlight areas where the FUA monitoring network should be improved for a better survey



CONCLUSIONS

Since 2014 (DGR 190/2014) Lombardy Region adopted a Regional Remediation Plan (RRP) focusing both on plumes and diffuse contamination

Now Lombardy Region defined a series of remediation measures :

- **Limits on the water use:** within the intervention measures, there is the possibility to limit the use of water for the activities concerned in order to avoid risk for the population.
- **Monitoring of groundwater quality:** ARPA will develop a groundwater monitoring plan funded by the Region. The monitoring activities will be based on the use of the existing network, with a possibility to integrate dataset with the data of Water Services, with a 6-month measurement field campaigns. The monitoring activity will allow to verify and update the mapped RTDC during the years (in a time interval 4-5 years) and evaluate the effects of the measures adopted in a medium-long term.
- **Study and definition of plumes, localization and remediation of point sources:** by using groundwater modelling tool, it will be possible to improve the plumes identification and study their evolution in space and time. An effort will be done for the identification of contaminant sources for the application of the polluter pays.



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ACKNOWLEDGMENTS

