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# The evolution of chemical quality of River Lambro in comparison with other three European “metropolitan” rivers

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# Outlines

- Project PIRVE approach: comparison of urban metabolisms between European city/river systems



- The case the **water quality** evolution of River Lambro over 50 years
  - ✓ Decadal data monitoring of hydrochemical characteristics
  - ✓ Decadal reconstruction of water quality using sediment core



- Differences and similarities of the four cities (**Paris**, **Bruxelles**, **Berlin** and **Milan**) on the water quality of their rivers (**Seine**, **Senne**, **Spree**, **Lambro**) over 150 years

# The approach of the Project PIRVE

## A central question:

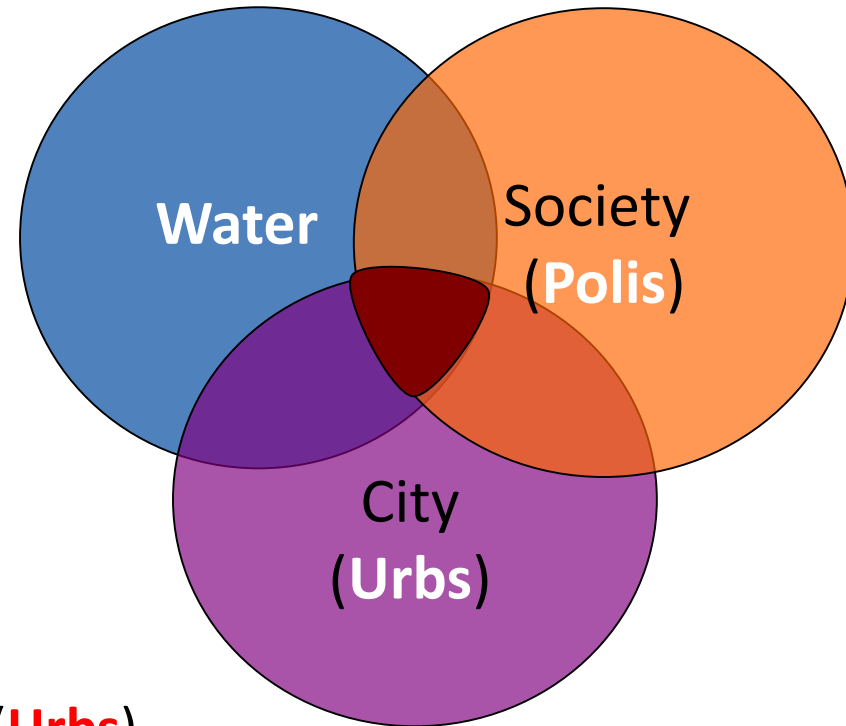
- The quality of the hydrosystem
- Its evolution over 150 years

## Three interacting objects:

- The river and the river system (**Water**)
- The city and its technical infrastructure (**Urbs**)
- Men / society (**Polis**)

## Two characteristics:

- The "point of view" of water
- The multiplicity of approaches (interdisciplinarity)



# Main characteristics of the four megacity's rivers studied

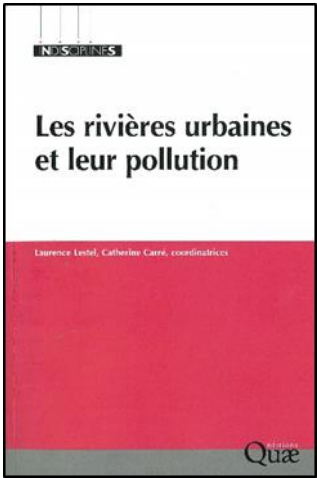
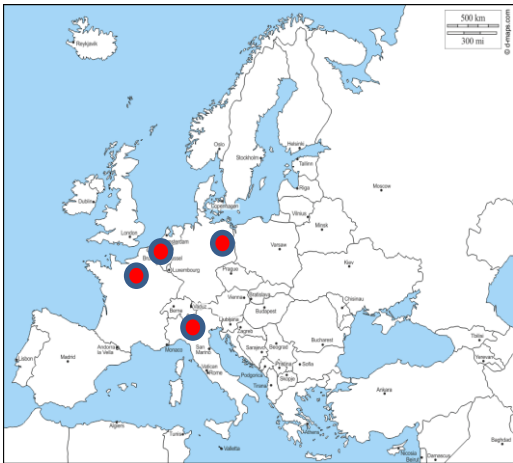
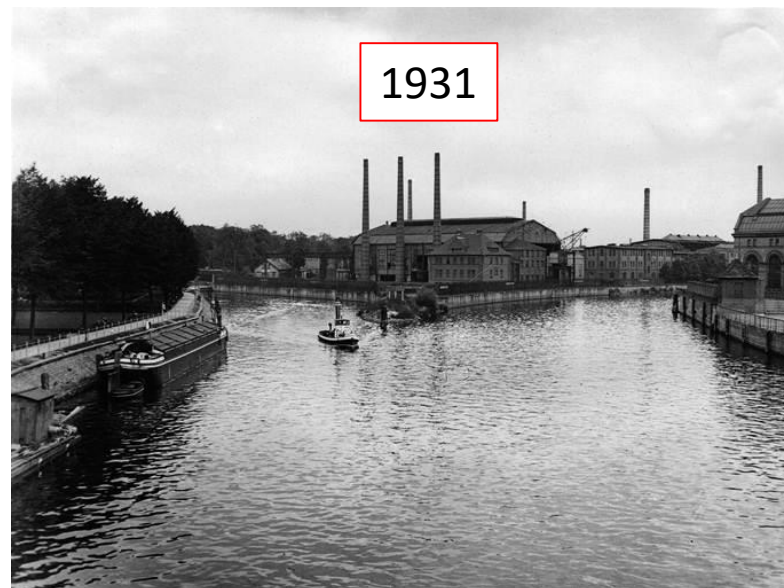
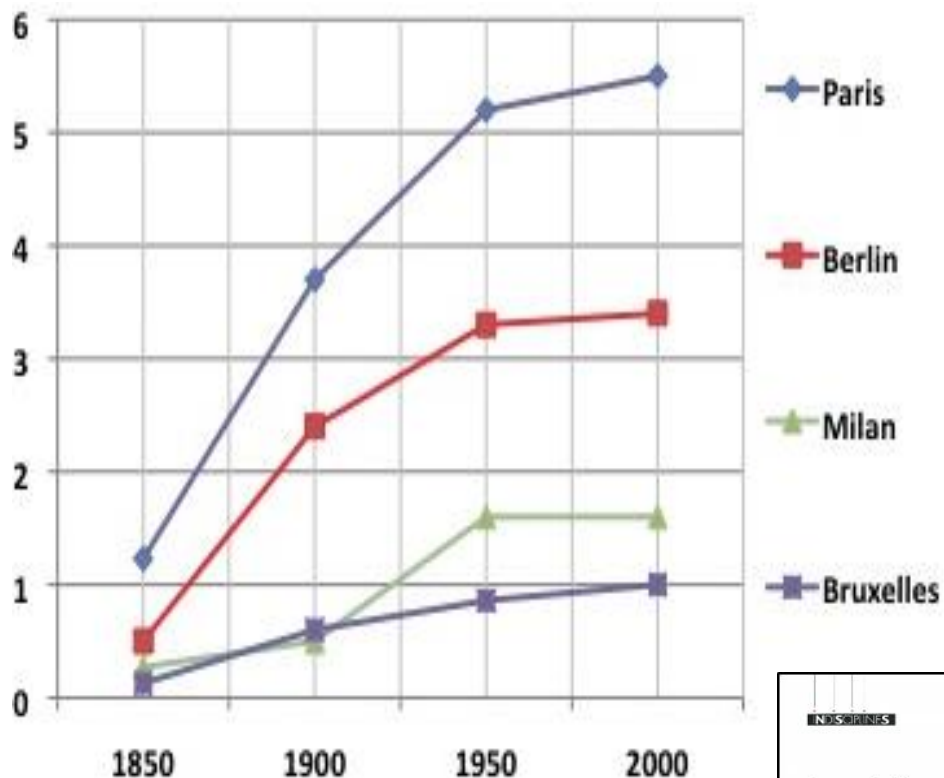


Tableau 1-1. Données quantitatives pour les quatre villes et leurs cours d'eau (1850-2010).

	Superficie du bassin versant (km <sup>2</sup> )	Débit moyen annuel en 2010 (m <sup>3</sup> /s)	Population communale vers 1850 (million d'habitants)	Population de l'agglomération en 2010 (million d'habitants)	Quantité d'eau dispo- nible en 2010 (L/jour/hab.)
Seine Paris	65 000	280 (Paris Austerlitz)	1,23	10	2 419
Spree Berlin	10 105	37 (Berlin- Ouest)	0,5	3,5	913
Lambro Milan	2 747	79 (Milan- Sud)	0,27	4,2	1 625
Senne Bruxelles	1 160	8 (Bruxelles- Nord)	0,13	1,3	532

# Population évolution ( $10^6$ inhabitants) in 150 years in the four megacities



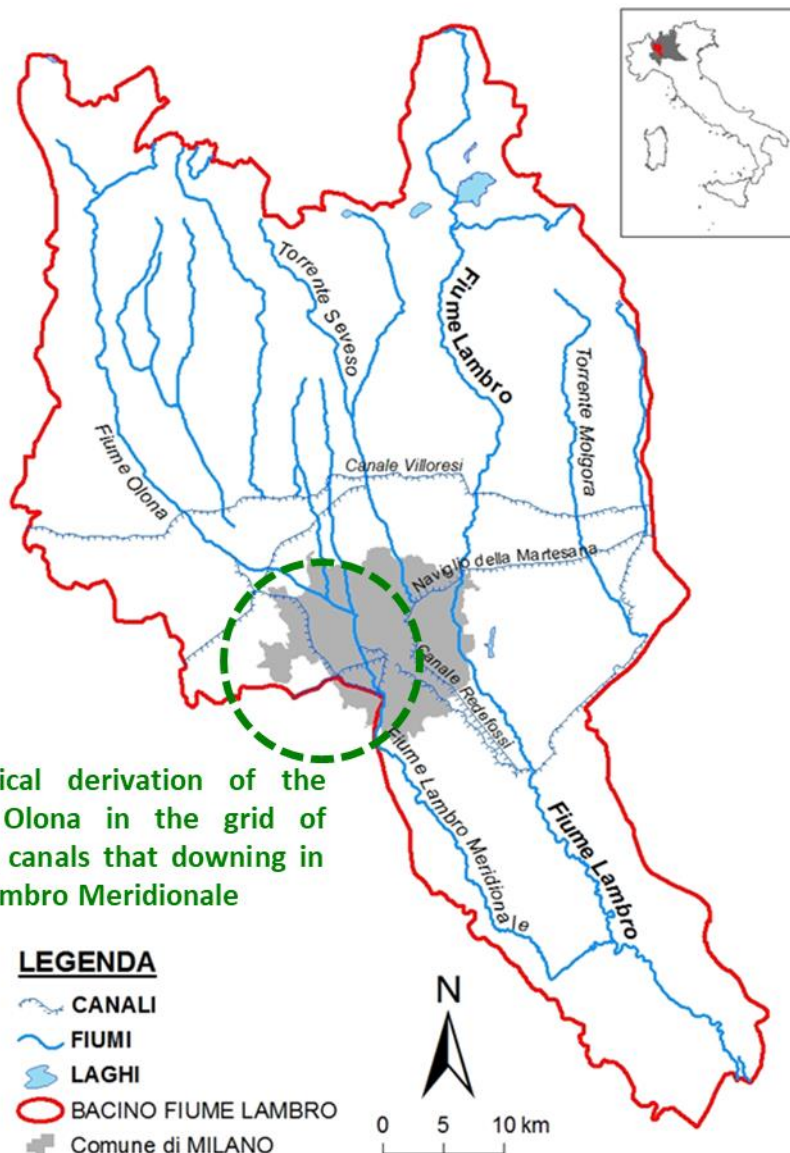
Installations industrielles au confluent de la Spree et de la Havel à Spandau. (Photo : Archives du land de Berlin)



La situation d'aujourd'hui. (Photo : Karin Winklhöfer)



# Hydrological characteristics of the River Lambro network



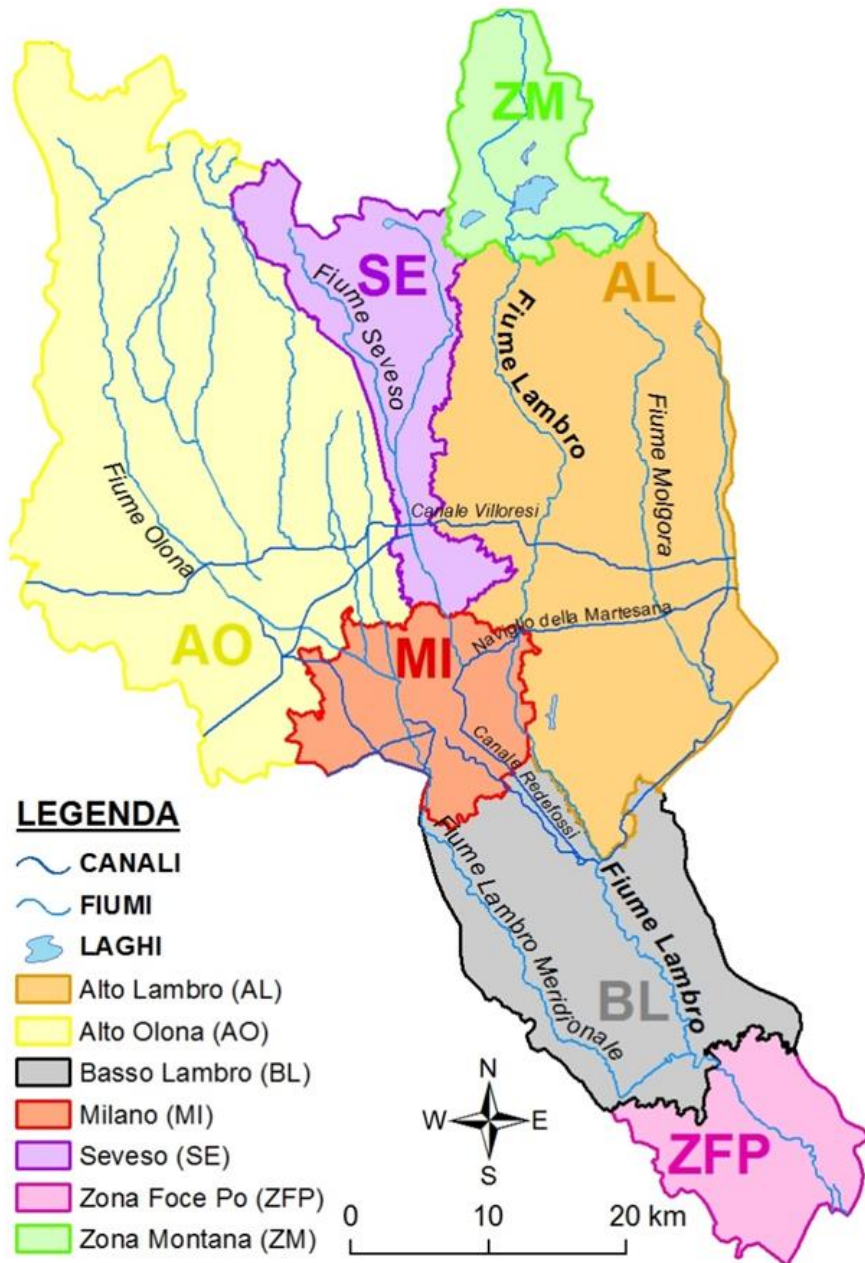
River network	Length (km)	Basin area (km <sup>2</sup> )	Flow (m <sup>3</sup> s <sup>-1</sup> )
<b>Rivers</b>			
Olona*	107	1125	30
Lambro	119	1129	79**
<b>Torrents</b>			
Seveso	36	237	7
Molgora	38***	256	2

\*Olona e Lambro Meridionale

\*\*Allodi, 1997

\*\*\*Marchetti, 1968

# Hydrological characteristics of the River Lambro network

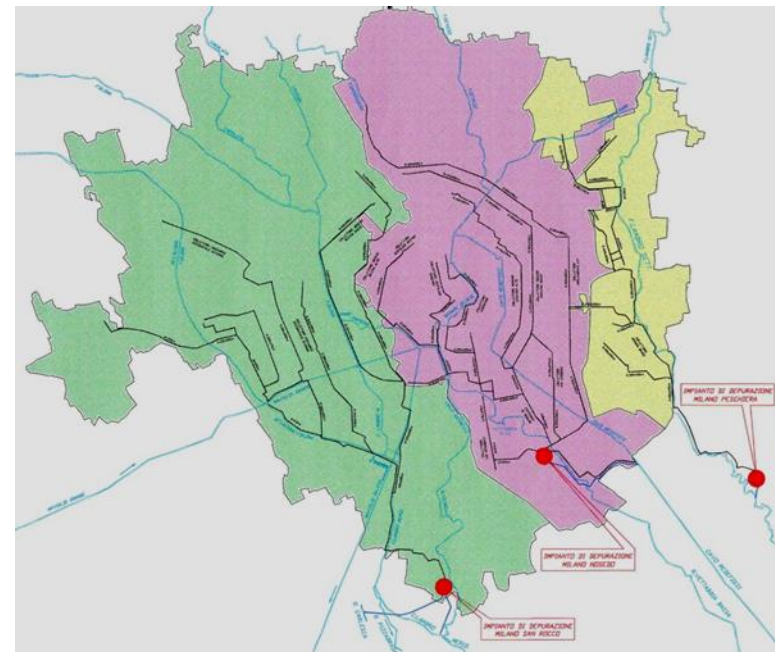


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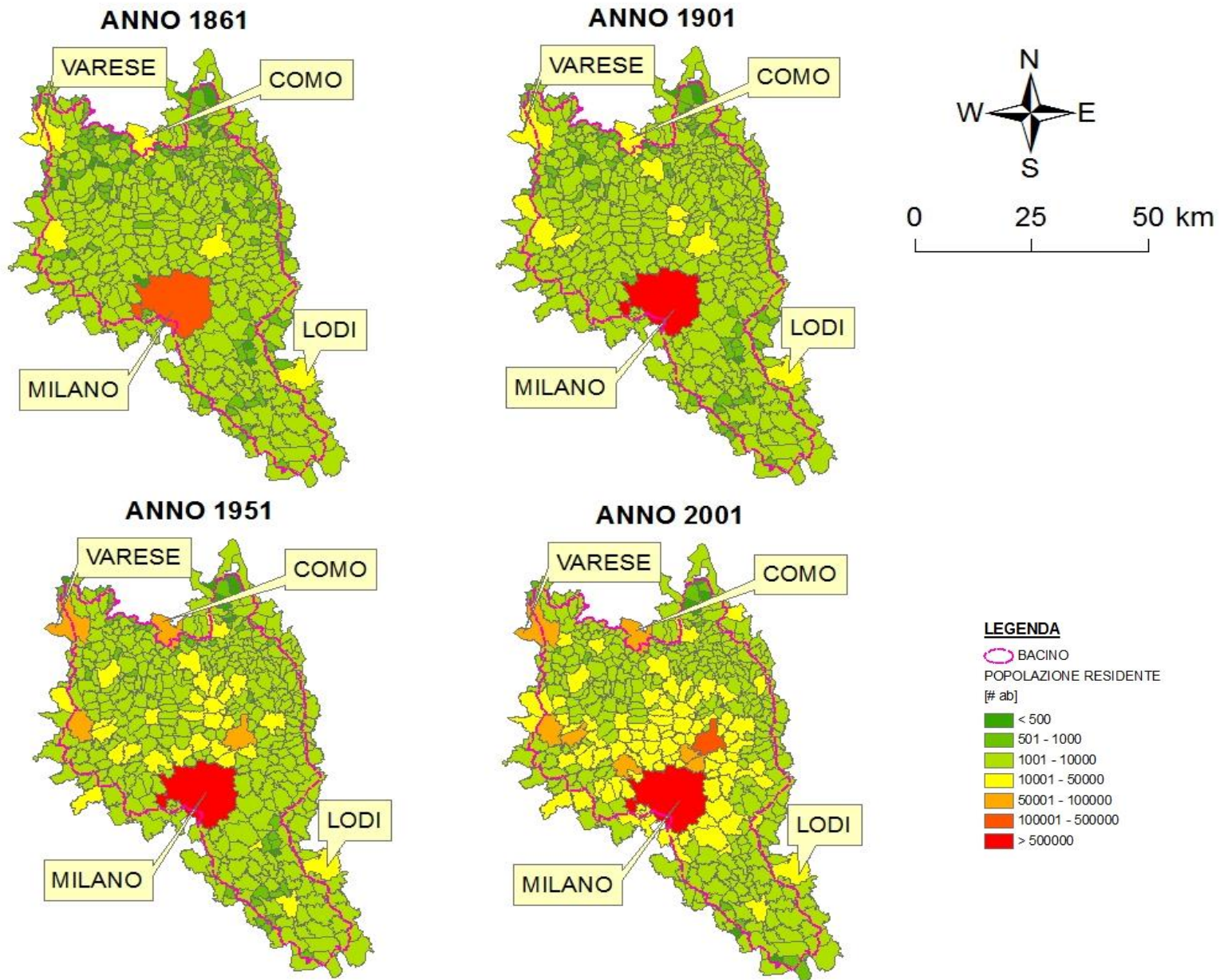
\*\*Allodi, 1997

\*\*\*Marchetti, 1968



Schematic representation of the three underlying sub-basins from the treatment plants in Milan have entered fully into operation in 2005.

# Spatial evolution of population over 140 years

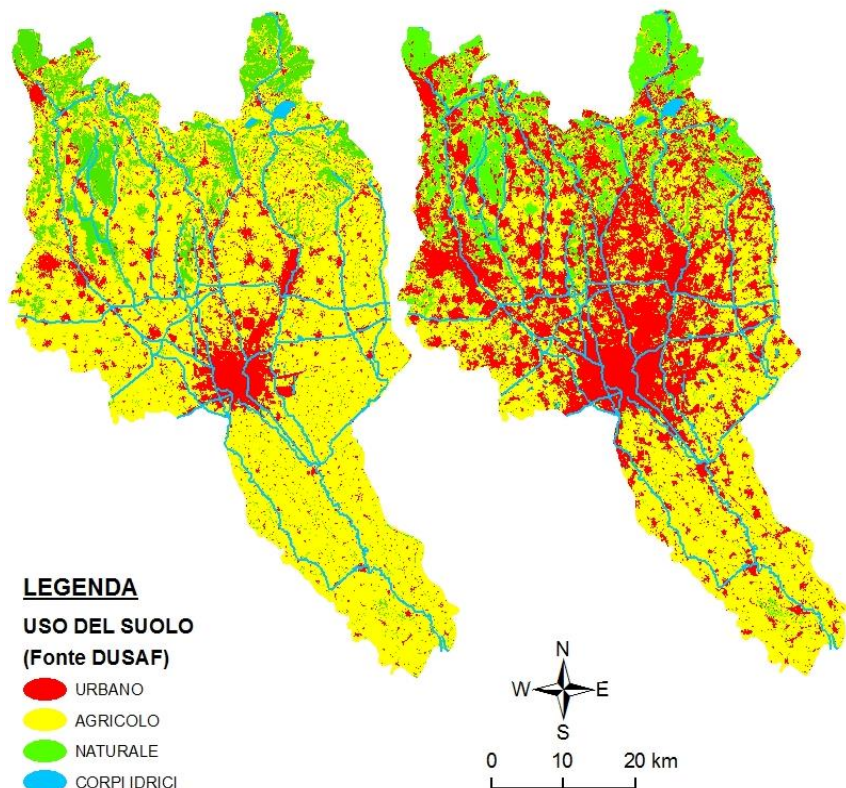




# Comparison of land Use in the period 1954 to 2001

ANNO 1954

ANNO 2001

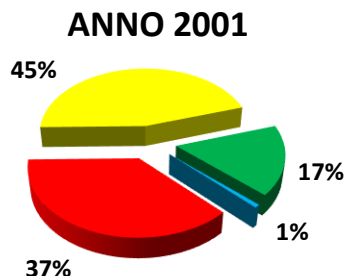
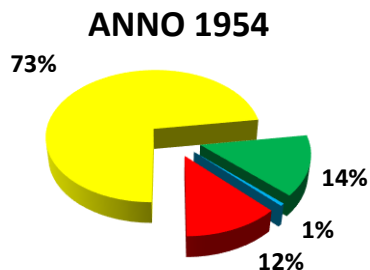


The soil was classified as **Urban, Agricultural, Natural, Water** (Based of Lombardy Region's classification for the project DUSAF).

In 1954 the basin was for  $\frac{3}{4}$  agricultural.



In 2001 Urban coverage reaches 37% (**soil consumption rate  $\cong$  0.5% a year**) of the total to the detriment of agricultural due to the economic advantage in the landuse change.

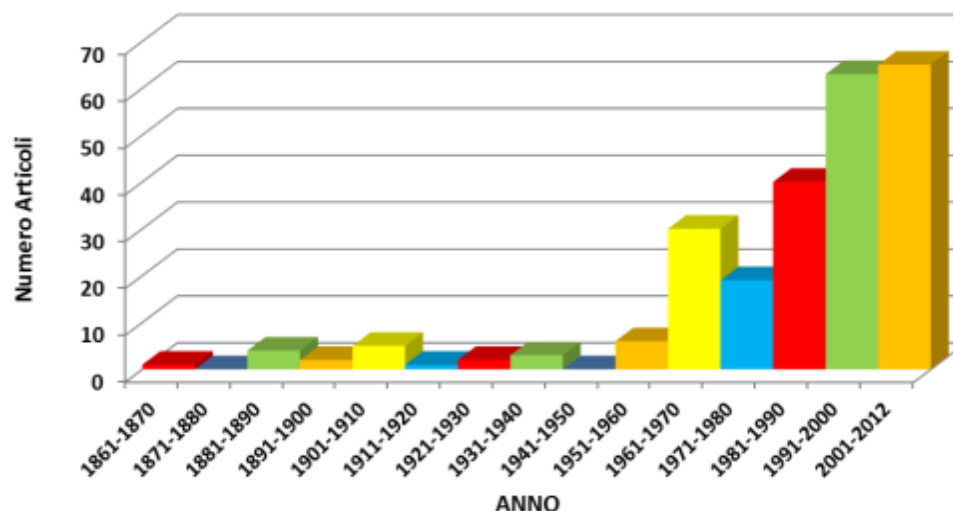


In 2007 the soil consumption is still in act at the same rhythm: **0.5 % means about 1,800 soccer fields a year are built.**

# Creation of the DATABASE «SOLAD»

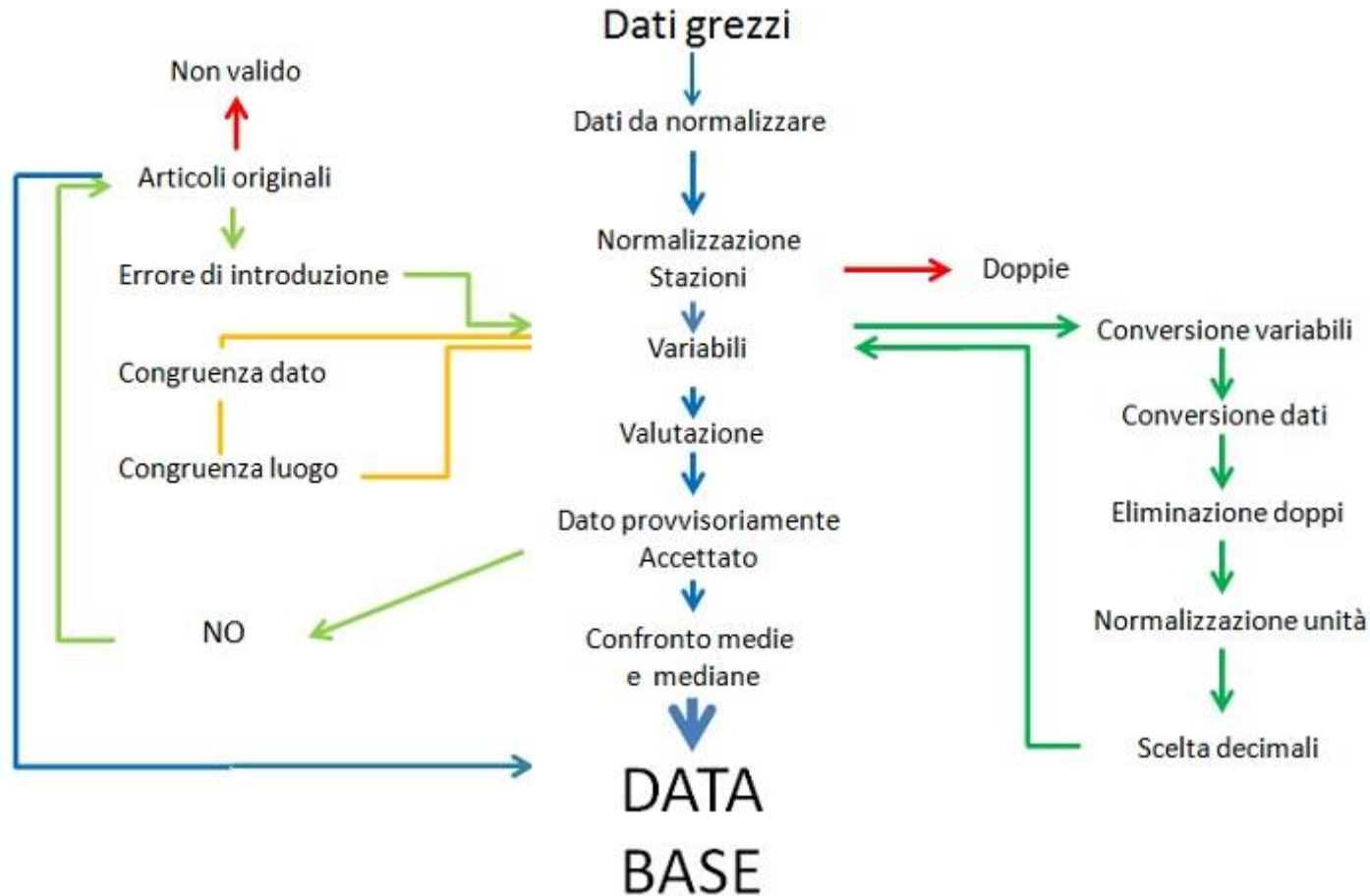
## Data entry methodology

- Place of sampling
- Compartment (water, sediment)
- Date
- Variable
- Unit of measure
- Type of result (mainly annual averages with some single data)
- Types of measured variables (chemical, chemical-physical, biological, metals, non-metals, etc.)
- Source code (alphanumeric)



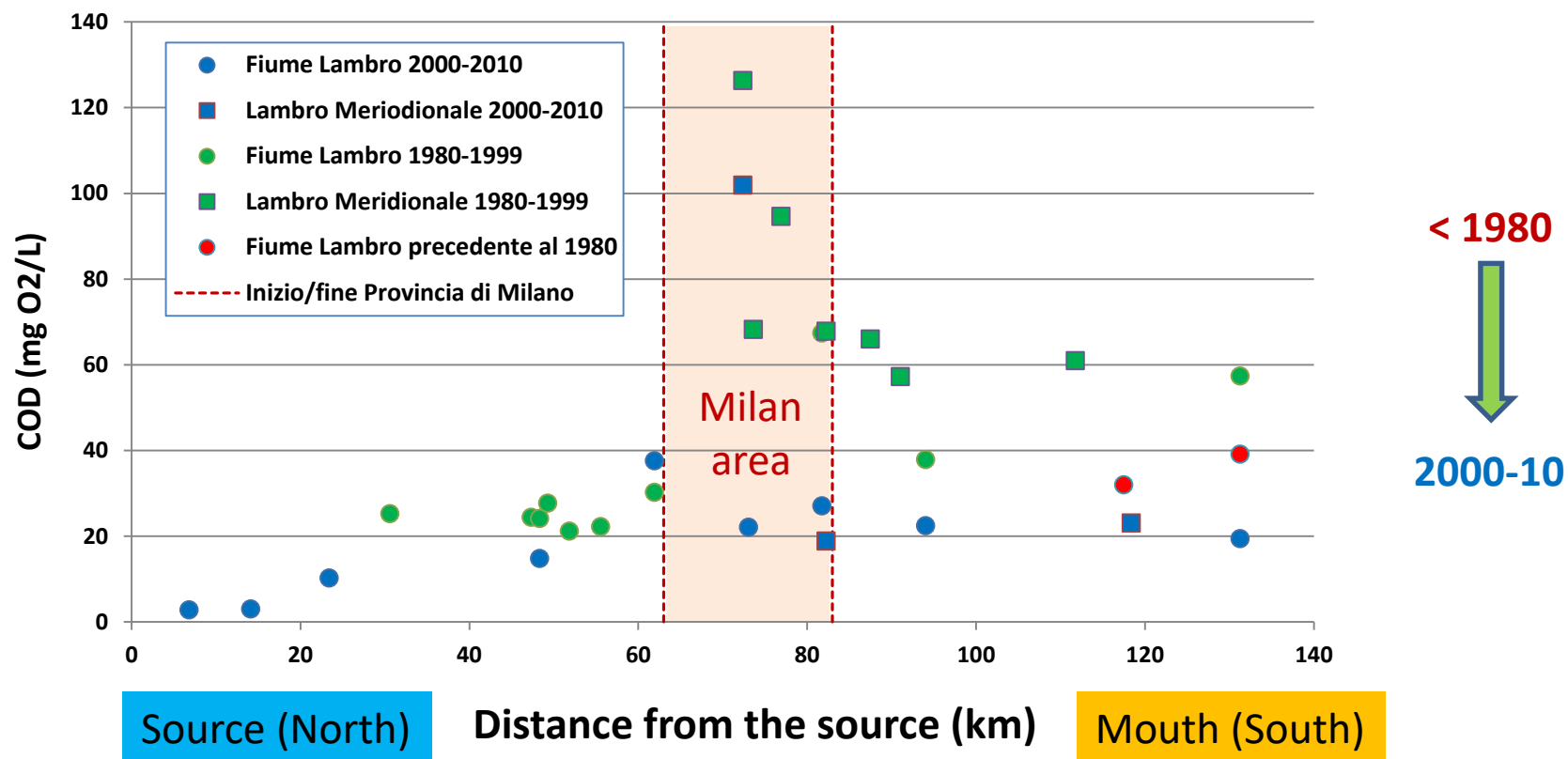
Fiume	Stazione	Comparto	Data	Variabile	Valore	Unità	Tipo di risultato	Tipo di variabile	Tipo di variabile specifico	Codice fonte
Lambro Settentrionale	Lesmo	A	1997	COD	3,00	mg O2/L	D	CHIMICA	CHIMICA	199co
Lambro Settentrionale	Melegnano	A	31814	Cd	2,30	µg/L	D	CHIMICA	METALLI	198ad
Lambro Meridionale	Rozzano (Ponte di via Curiel)	A	1999	pH	7,48		MN2	CHIMICA FISICA	CHIMICA FISICA	F. Stefani
Lambro Settentrionale	Peschiera Borromeo	A	2009	N-NH4	5,46	mg N/L	MN3	CHIMICA	NON METALLI	F. Stefani
Lambro Meridionale	S. Angelo Lodigiano	A	2001	N-NO3	2,57	mg N/L	MN3	CHIMICA	TROFIA	ARPA
Lambro Meridionale	Milano (ponte di via Pienza)	A	1982	Cu	155,00	µg/L	MN4	CHIMICA	METALLI	198f1
Lambro Settentrionale	S.Giorgio di Biassono	A	1993	BOD	7,20	mg O2/L	MN5	CHIMICA	CHIMICA	199bo

# Data normalization in the DATABASE SOLAD



# Chemical status of River Lambro (<1980 to 2010)

## (Chemical Oxygen Demand-COD)

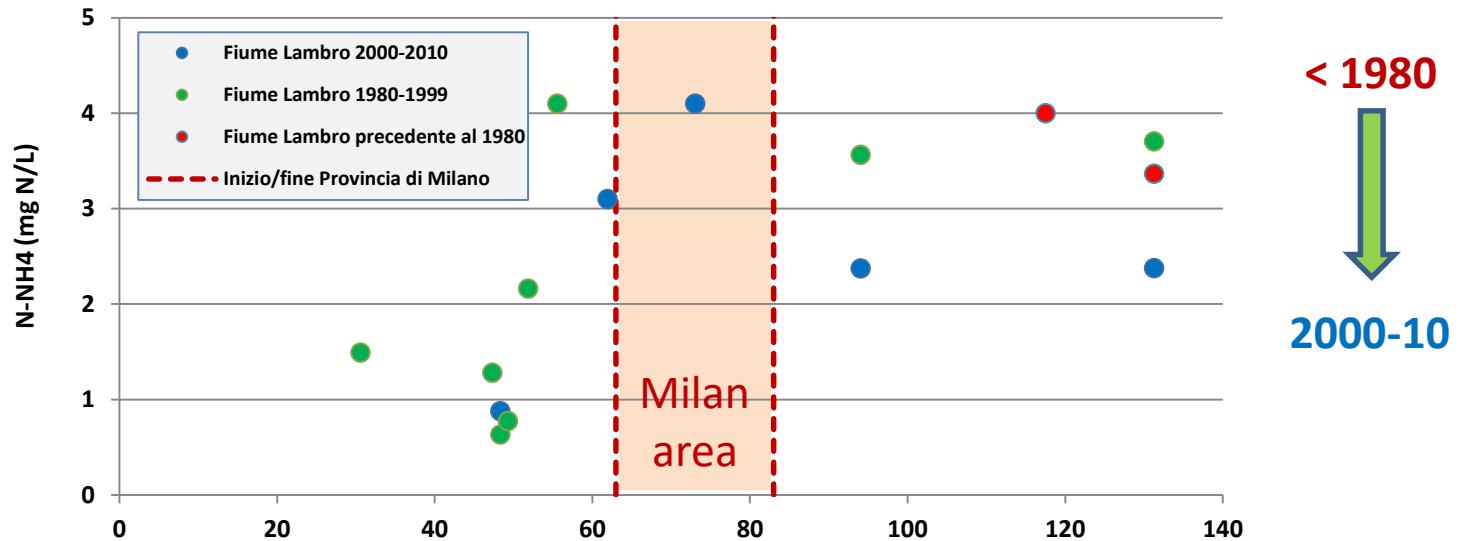




# Chemical status of River Lambro (<1980 to 2010)

## (Dissolved inorganic nitrogen-DIN)

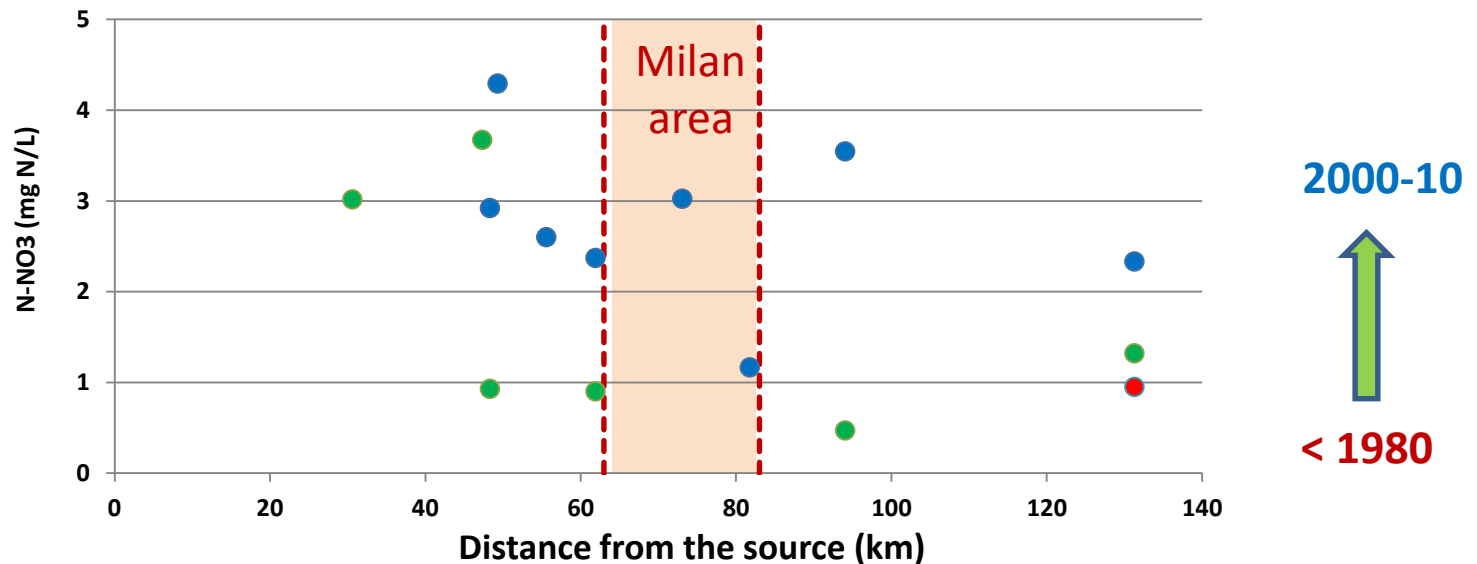
N-NH<sub>4</sub>



Source (North)

Mouth (South)

N-NO<sub>3</sub>



# Summary of chemical water quality at the confluence of River Lambro in the River Po (1959 to 2010)

Minimum of O<sub>2</sub>

mg/L



Maxymum of NH<sub>4</sub>

mg/L

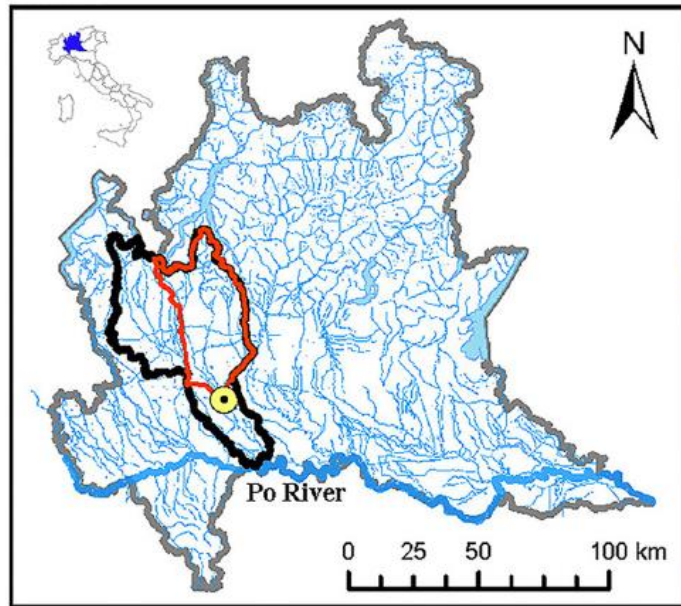


Tableau 4-3. Quantité d'oxygène, d'azote ammoniacal et de phosphore réactif dans les eaux du Lambro à la confluence avec le Pô (1959-2007).

	Unité	1959	1971-1973	1982	1987-1989	1992-1994	2002-2004	2005-2007
Référence		a	b	c	b	b	d	e
Nombre d'échantillons	N	2	26	4	12 (8)	16	18	36
Conductivité	µS/cm 20 °C		552		596	619	615	620
O <sub>2</sub>	mg/L	4,2	2,6		3,6	2,8		5,8
N-NH <sub>4</sub>	mg N/L	1,68	3,40	5,95	3,80	6,60	4,22	2,06
P-PO <sub>4</sub>	mg P/L		0,57	0,77	(0,51)	0,66	0,59	0,53

a : Bo *et al.* (1960) ; b : Renoldi et Tartari (1997) ; c : Baiardi *et al.* (1983) ; d : Viganò *et al.* (2004) ; e : Arpa Lombardia (2005-2007)

# River Lambro sediments core collected in 2012



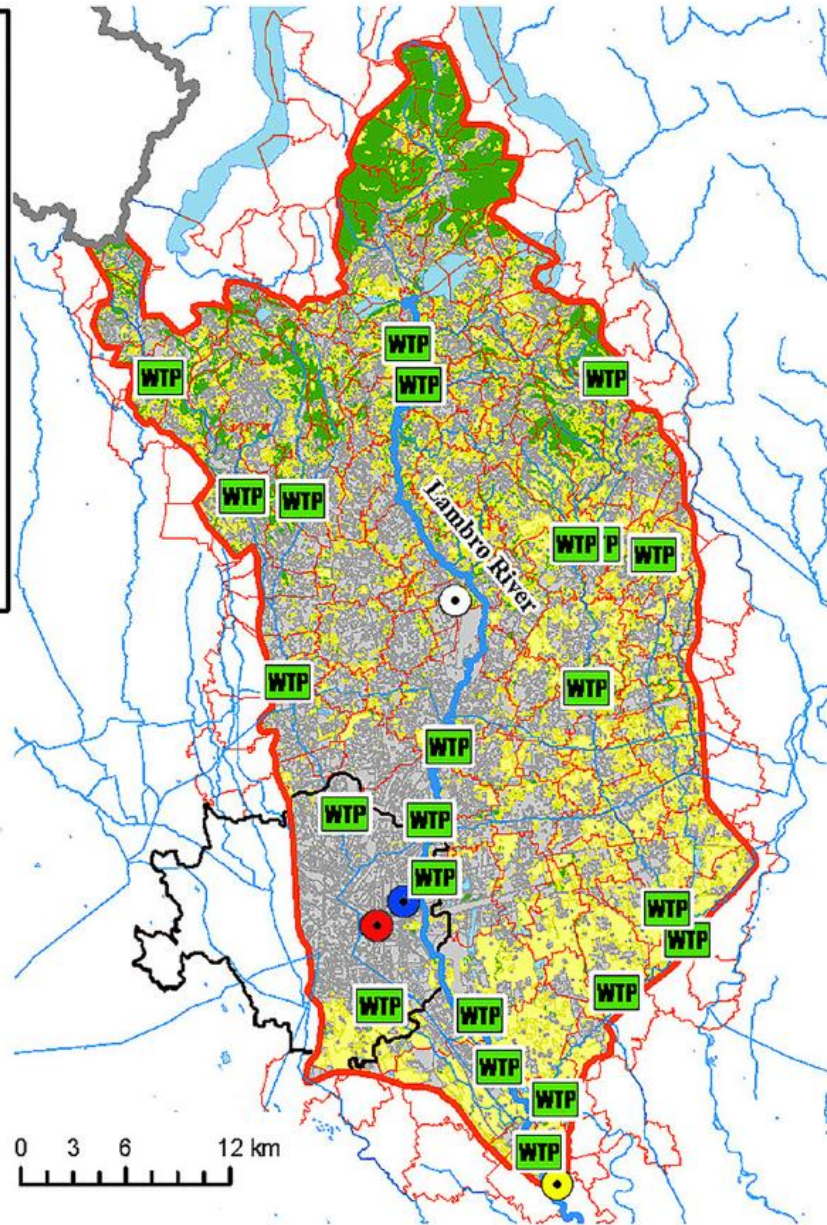
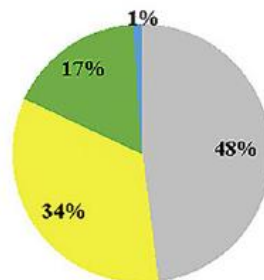
## Legend

- Lombardy borders
- Milan borders
- WWTP
- Main rivers
- San Zenone sub-basin
- Lambro basin
- Municipalities

- Sampling point
- Biassono WS
- Brera WS
- Feltre GS

## Dusaf 4

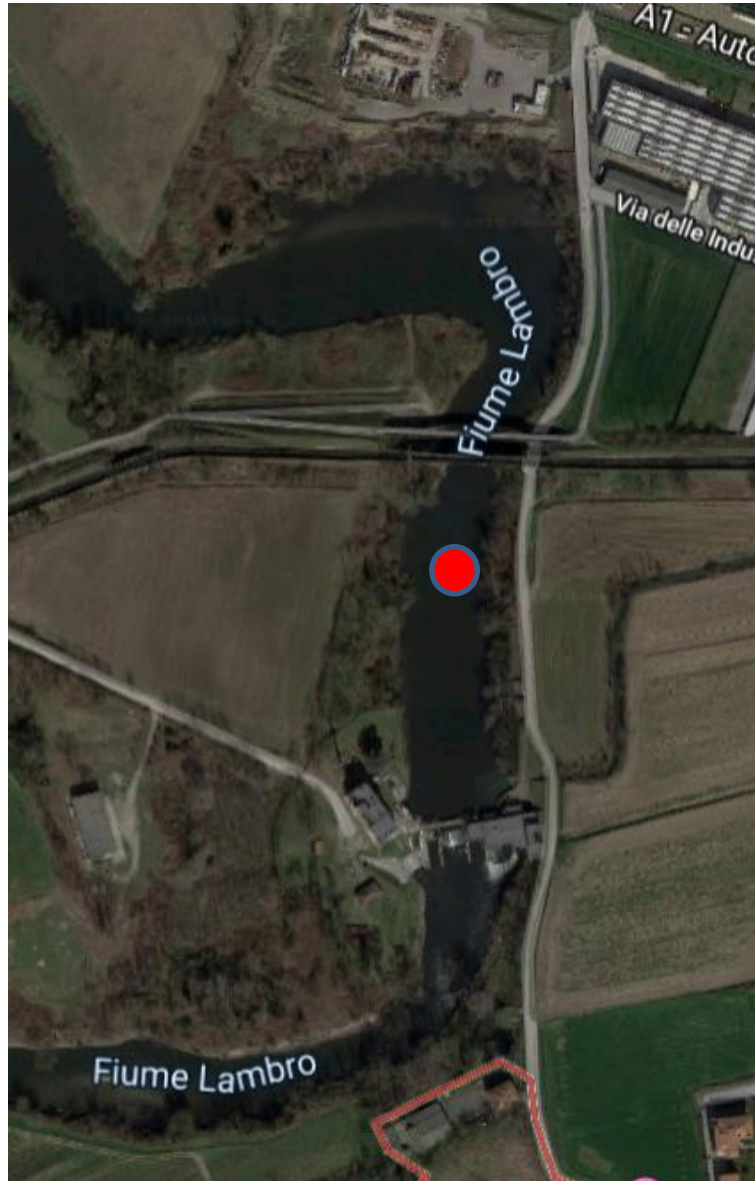
- 1 - Urban areas
- 2 - Agricultural areas
- 3 - Forests
- 5 - Water bodies



San Zenone al Lambro



## Sampling point of River Lambro sediments core





# Analysis carried out in the River Lambro sediments core

Project ARPA Lombardy /CNR-IRSA  
& Po Basin Authority  
2011-2013

**Aims:** to reconstruct the chronology of basin contamination.

- Nutrients
- Trace elements (Cd, Ni, Hg, Cr, etc.)
- DDTs, HCB and HCH
- Phthalates (DBP, DEHP etc.)
- PCB and PAH
- PBDE and HBCD ( $\alpha$ ,  $\beta$ ,  $\gamma$ )
- TBBPA, TCBPA and TBBPA-bis
- APEs and BPA
- Etc.



Credits: thanks to Dr Luigi Viganò for providing this slide

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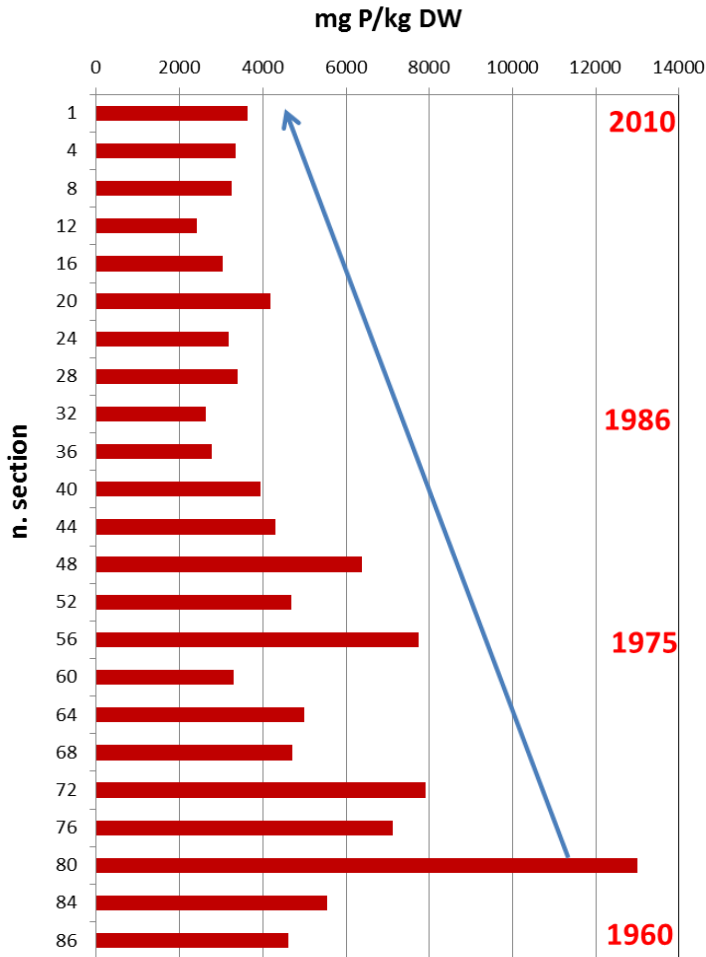


PROGETTO SEDIMENTI LAMBRO  
RAPPORTO FINALE



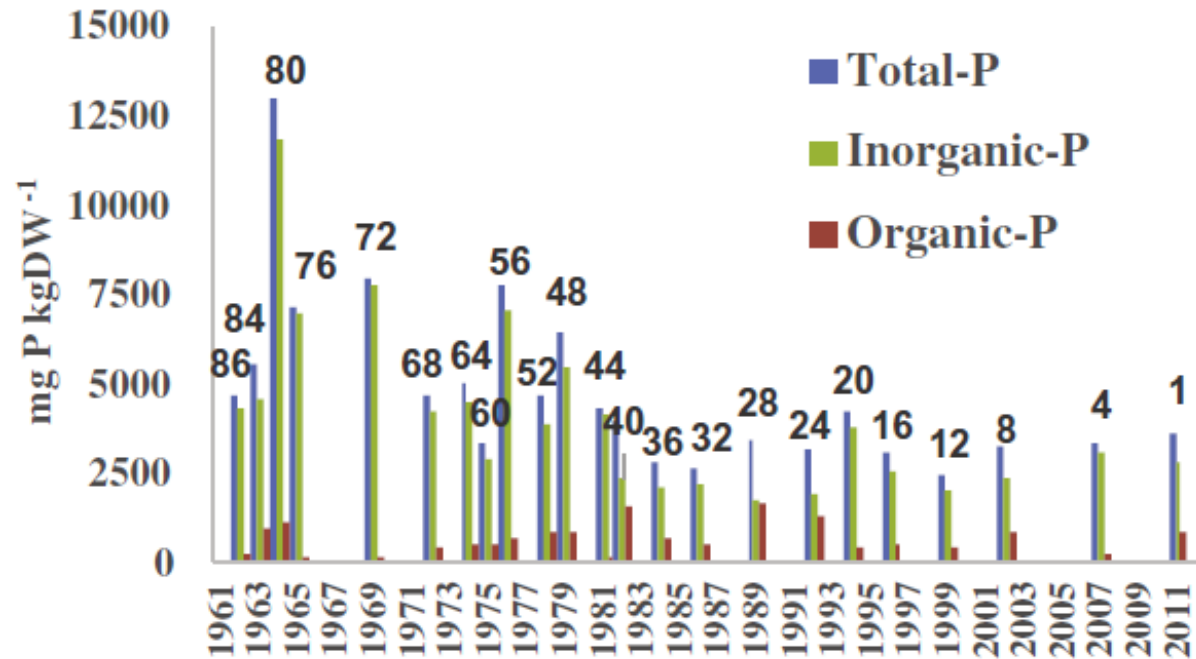
NOVEMBRE 2013

# Phosphorus in the River Lambro sediments core



TP and core dating

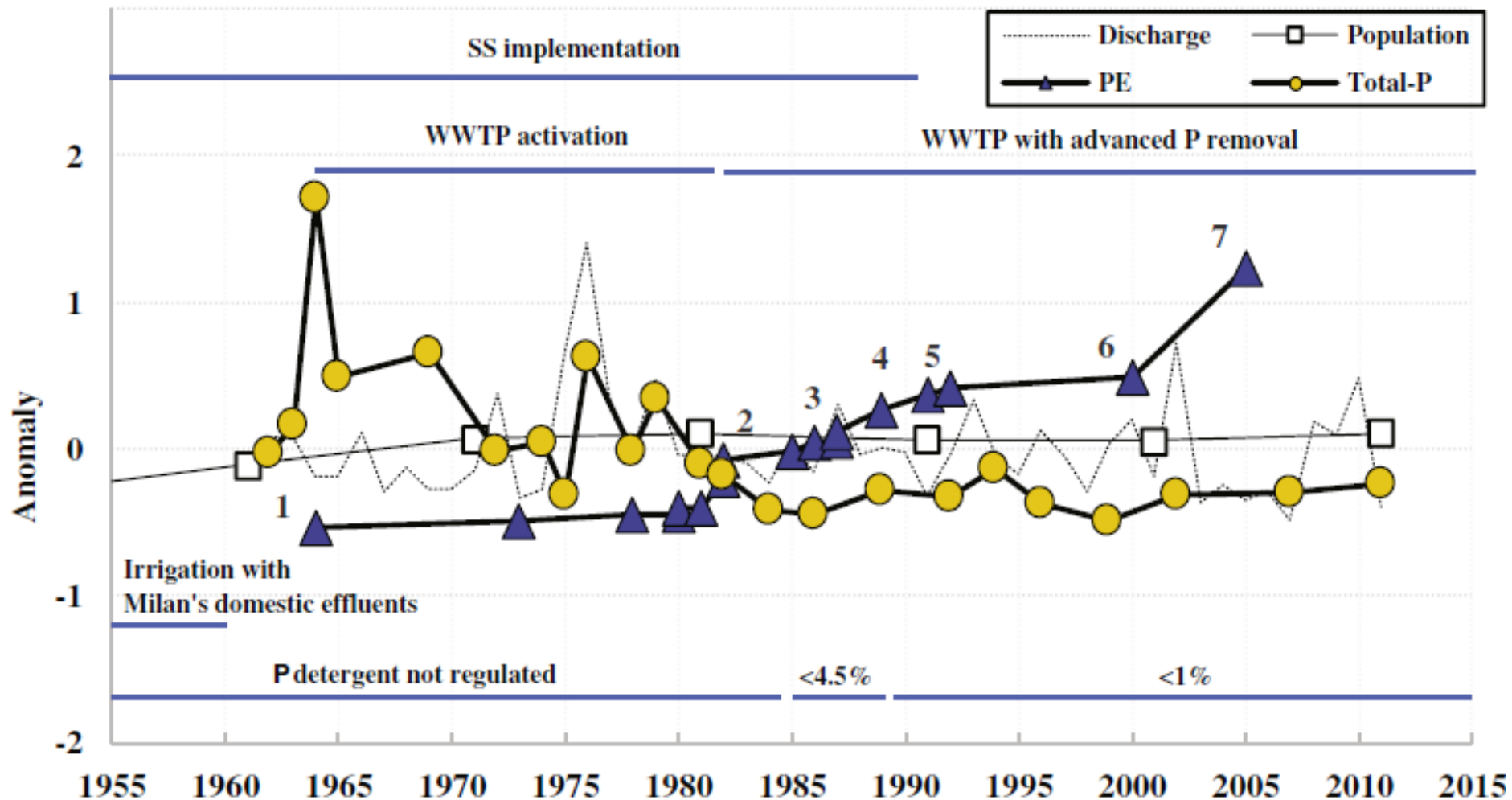
TP = Inorganic + organic phosphorus



# What happened in fifty years (1960-2010) in the Lambro River basin?

**SS** = Sewer system

**WWTP** = Waste Water Treatment Plant





# Pictorial description of the complex environmental system formed by megacity and the surrounding area: the peculiarity of the city of Milan

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Science of the Total Environment

journal homepage: [www.elsevier.com/locate/scitotenv](http://www.elsevier.com/locate/scitotenv)



## Phosphorus content in a deep river sediment core as a tracer of long-term (1962–2011) anthropogenic impacts: A lesson from the Milan metropolitan area



Diego Copetti <sup>a,\*</sup>, Gianni Tartari <sup>a</sup>, Lucia Valsecchi <sup>a</sup>, Franco Salerno <sup>a</sup>, Gaetano Viviano <sup>a</sup>,  
Domenico Mastroianni <sup>b</sup>, Hongbin Yin <sup>c</sup>, Luigi Viganò <sup>a</sup>

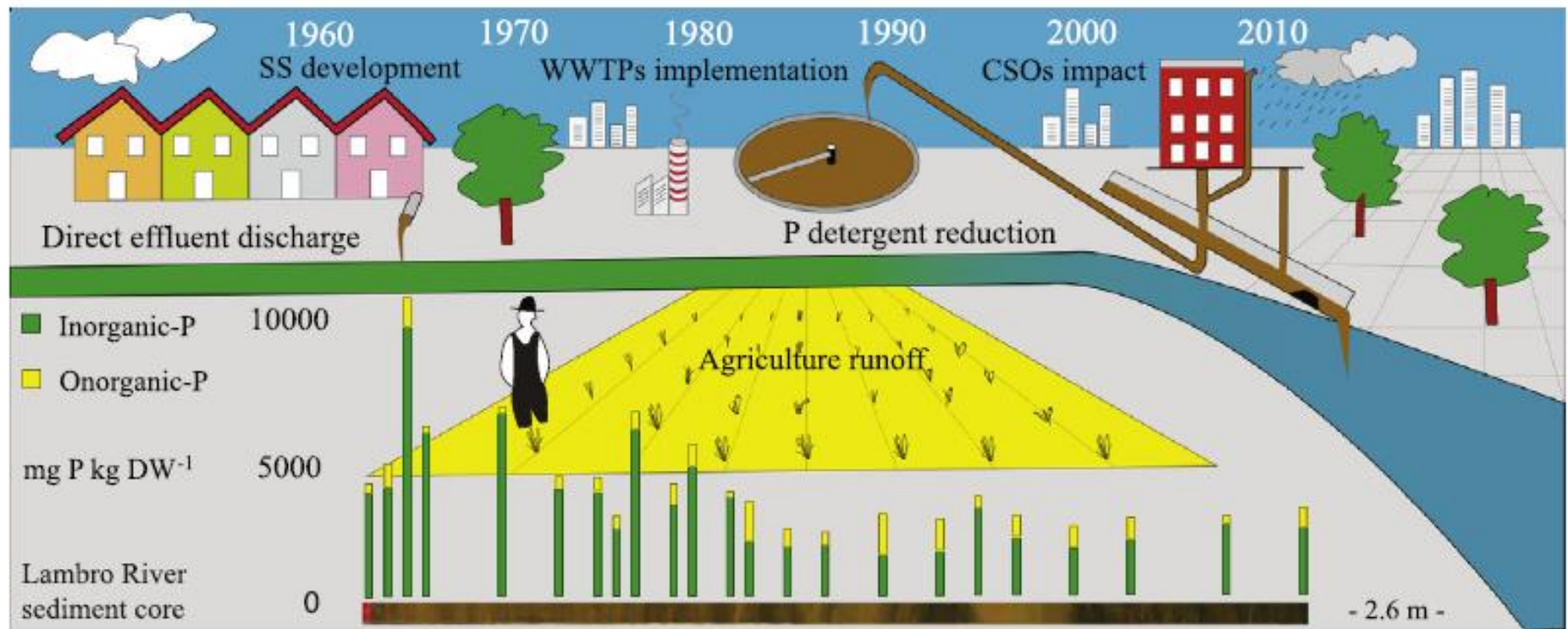
<sup>a</sup> Water Research Institute, National Research Council of Italy, IRSA-CNR, Section of Brugherio, Via del Mulino, 19, 20861 Brugherio, MB, Italy

<sup>b</sup> Water Research Institute, National Research Council of Italy, IRSA-CNR, Via Salaria km 29.300, 00015 Monterotondo, RM, Italy

<sup>c</sup> State Key Laboratory of Lake Science and Environment, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, China

# Pictorial description of the complex environmental system formed by megacity and the surrounding area: the peculiarity of the city of Milan

## GRAPHICAL ABSTRACT

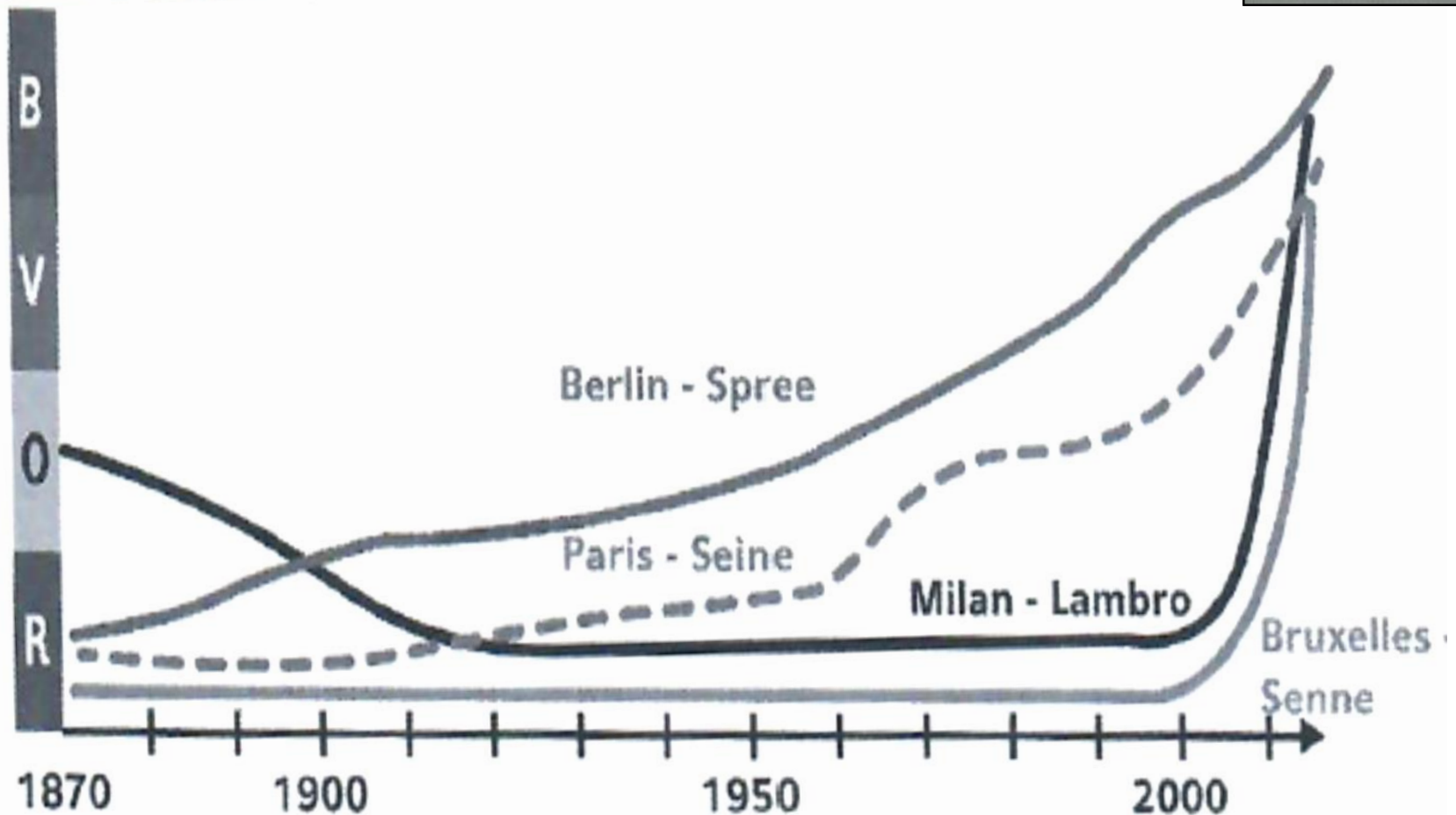


# How have evolved the four megacities over 150 years?

Synthesis of water quality based on assessments of changes in pressures and available monitoring



Échelle d'efficacité



# Pictorial description of the impacts evolution on rivers networks

## The approach

### Les rivières urbaines et leur pollution

Laurence Lefel, Catherine Carré, coordinatrices

Quæ

#### Approvisionnement en eau

-  Lac
-  Barrage réservoir
-  Captage
-  Zone de captage souterrain
-  Prise d'eau en rivière
-  Source captée - aqueduc






#### Ouvrages

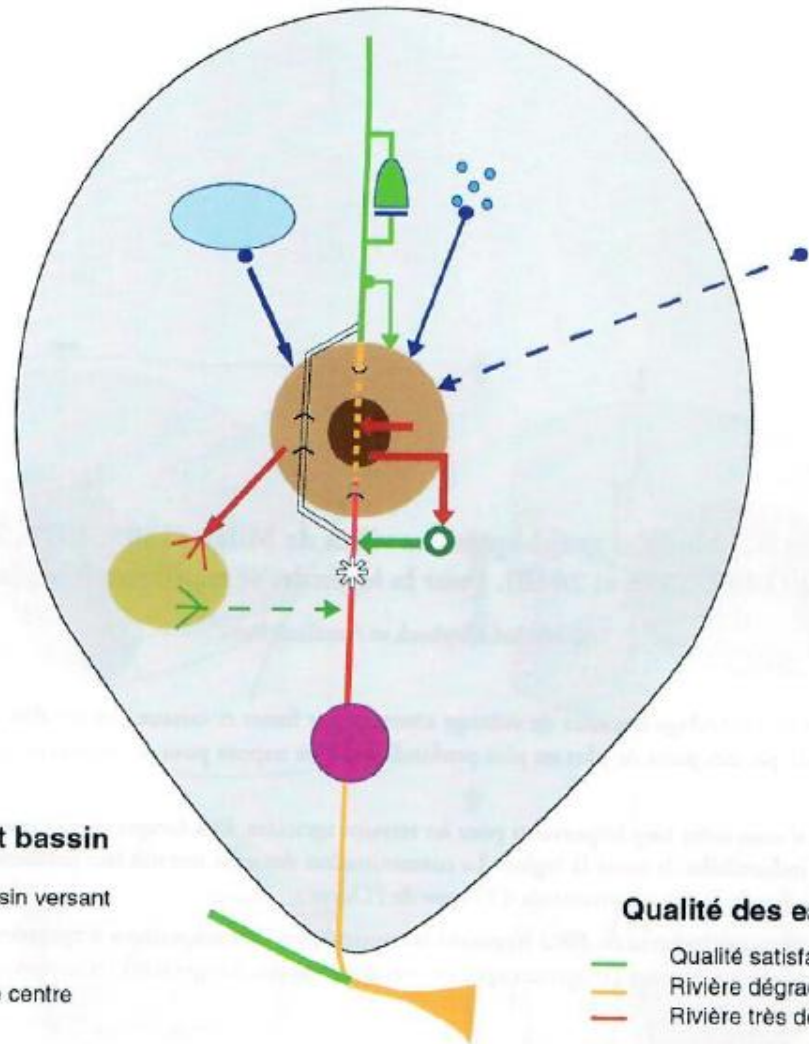
-  Canal - écluse
-  Rivière couverte
-  Collecteurs eaux usées
-  Station d'épuration
-  Zone d'épandage
-  Ré-aérateur

#### Ville et bassin

-  Bassin versant
-  Ville centre
-  Banlieue
-  Rivière
-  Milieu récepteur distal

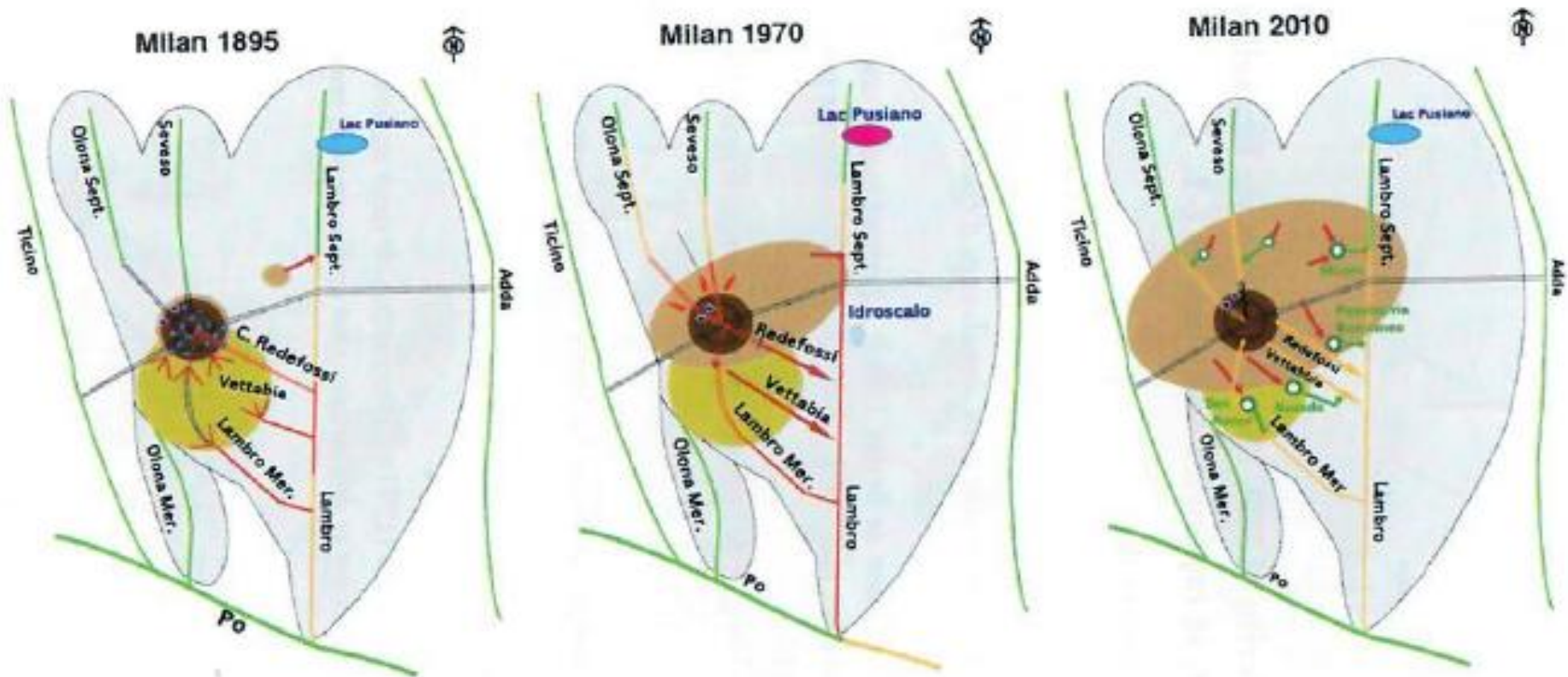
#### Qualité des eaux

-  Qualité satisfaisante
-  Rivière dégradée
-  Rivière très dégradée
-  Pollution eaux souterraines
-  Lac eutrophisé





# The case of Milan area



## Final considerations

In the last 15 decades, the enormous growth of the metropolitan aggregations developed along fluvial axes caused a high impact on water quality of rivers.

The integration of historical data by monitoring and management institutions, together with the analysis of water quality information, provided evidence for the evolution of environmental awareness since the first half of XX century.

Starting by the eighties a common tendency of water quality improvement has been evident, but with different starting point between the four cities between 1970 to 2000: before of Water Framework Directive!

The water quality improvement is probably related to the general advancement of ecological knowledge and the increase of waste waters treatment, but also to the growing and diffusion of a new cultural point of view on the environment protection.