Modelling Diffuse Pollution on Watersheds Using a Gis-linked Basin Scale Hydrologic/water Quality Model

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Background

- Diffuse pollution enters the environment by multiple pathways.
- Non point sources are generally estimated by using area- and pollutant- specific emission factors, function of land use (e.g. Autorità di Bacino del Po)
- Despite the different temporal scale, instream direct measurements, when available, have often suggested that non-point indirect estimates may lead to large overestimations or to misleading results .

Aims of the Study

- To combine a water quality model, (USEPA-QUAL2E), with a GIS-linked physical-based model (SWAT) in order to assess the source apportionment of point and non-point emissions to the global quality of the rivers.
- to simulate the factors driving diffuse pollution in large and complex watersheds.
- To validate the models by comparing their predictions over a regional scale with instream direct measurements available from ARPA monitoring stations.

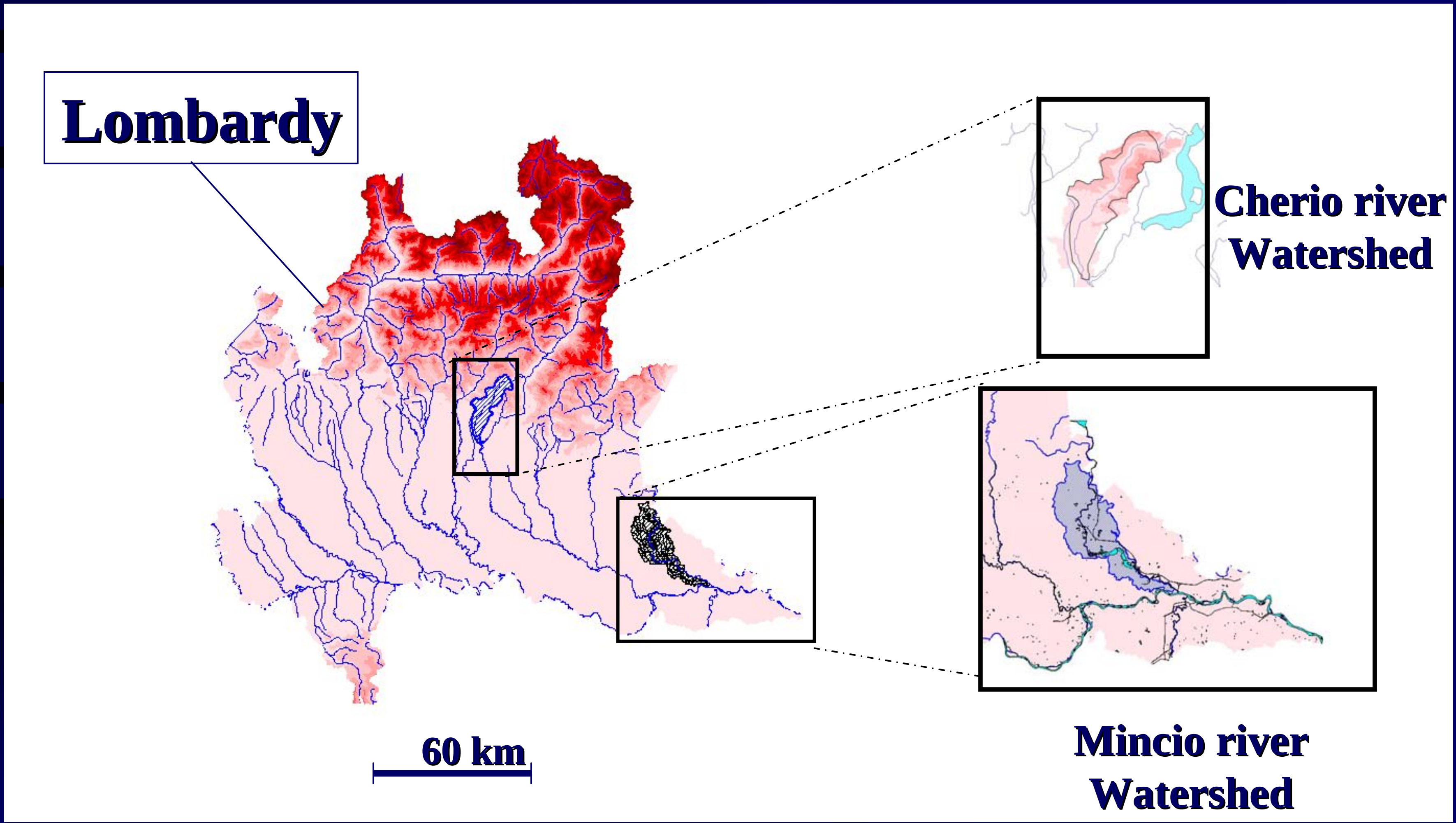
Aim of the Study:

Validation of the source apportionment

- Validation studies on diffuse pollution are not easy to design
  - no readily available tool enables to simulate the river water quality during rainfall events at large scales (i.e. basin-scale) and over the instantaneous temporal scale which is typical of water quality direct measurements

- Average annual basis
  - Dry-weather scenario (i.e. point emissions over the mean annual flow regime)
  - Wet-weather scenario (i.e. point and non point emissions during rainfall events)

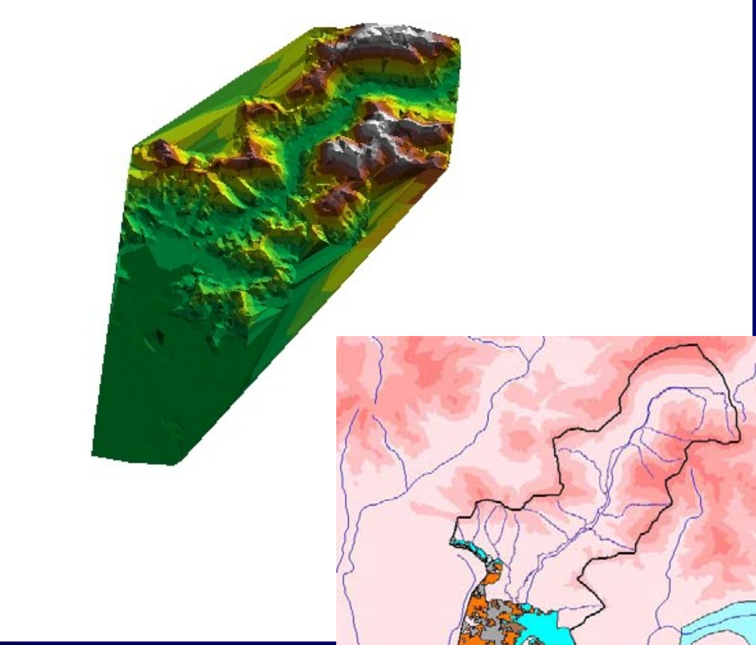
Study Area

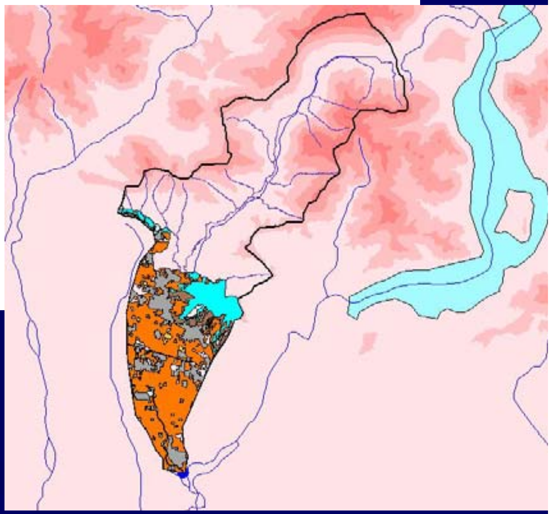


Lombardy
Cherio river Watershed
Mincio river Watershed
60 km

Cherio River Watershed

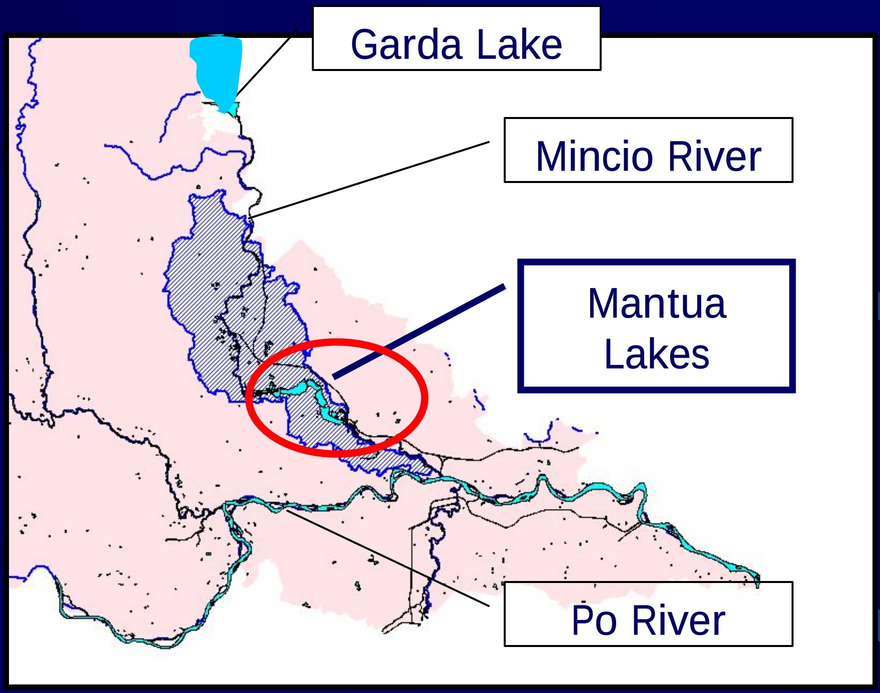
- Drainage area: 150 km^2
- Watershed covers both the mountainous and the plain zone (approximately half and half of the percentage area)
- Dominant coltures:
    - Maize (59%), Wheat (30%) Other (11%)



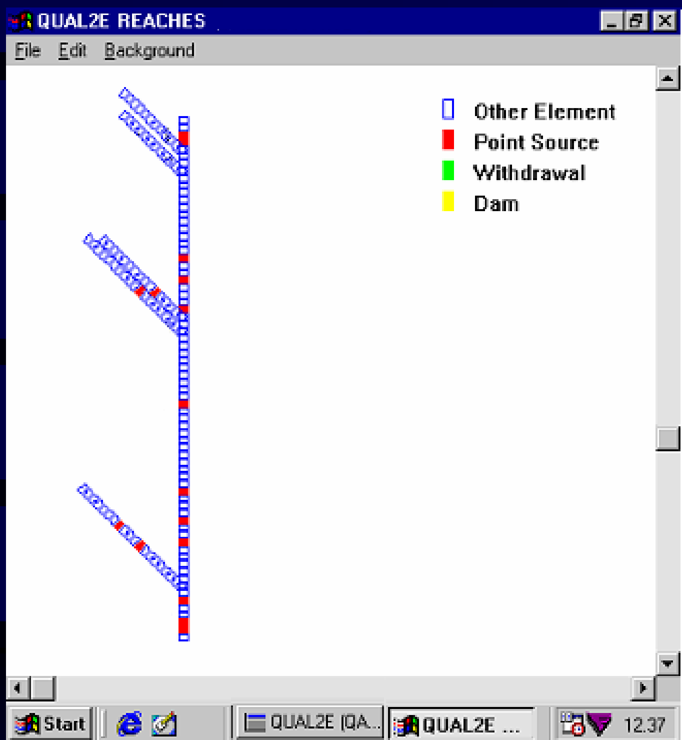


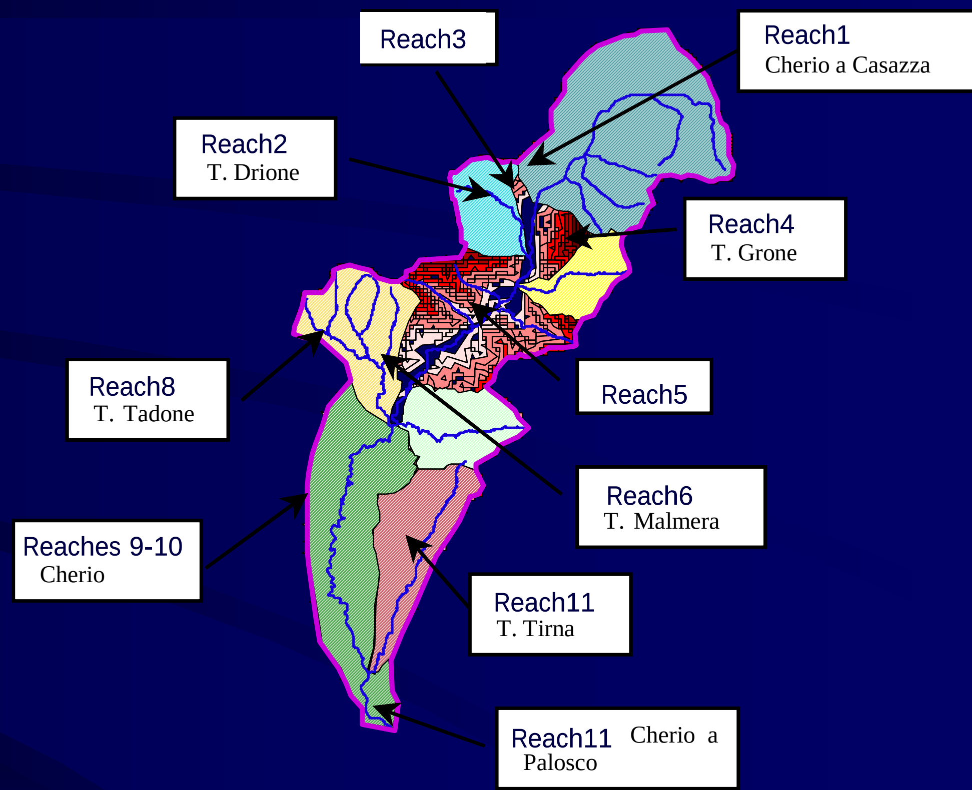
Mincio River Watershed

- Drainage area: 310 km^2
- Plain zone within the Po and Mincio Rivers, dominated by a very intensive agricultural land use
- Dominant coltures:
  - Maize (70%), Wheat (30%)



QUAl2E Modeling





ASSUMPTIONS

- Constant streamflow (i.e. Median of 3 years monthly measurements)
- Constant emissions (point loads calculated on the basis of annual emission factors)

Input for Point Emissions

Point Sources Emission Factors and Average Treatment Removals used to estimate the domestic wastewater loads.

Pollutant	Emission	Imhoff Removal	A.S.* Removal	A.S + N Removal	A.S. + N, P Removal
		%	%	%	%
BOD_5	60 g BOD PE^{-1} d^{-1}	25	90	92	92
COD	129 g COD PE^{-1} d^{-1}	25	85	85	85
Total-N	12.3 g N PE^{-1} d^{-1}	15	35	65	65
Total-P	1.8 g PE^{-1} d^{-1}	20	35	35	85

*A.S.: Activated Sludge

PE: Population Equivalent

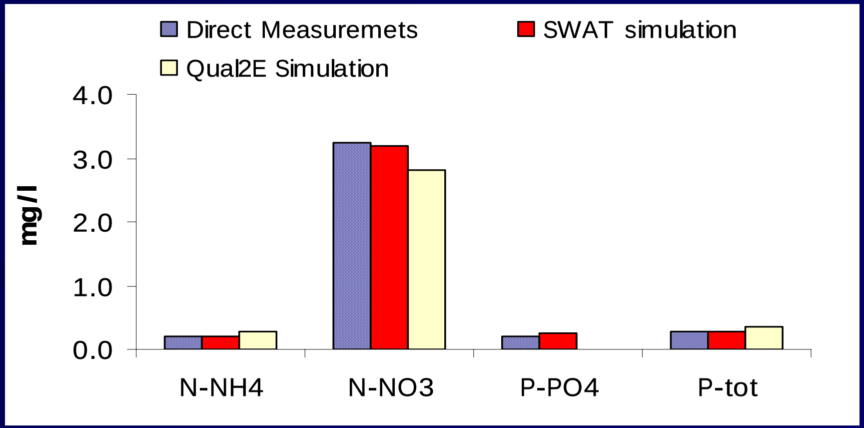
QUAL2E Validation

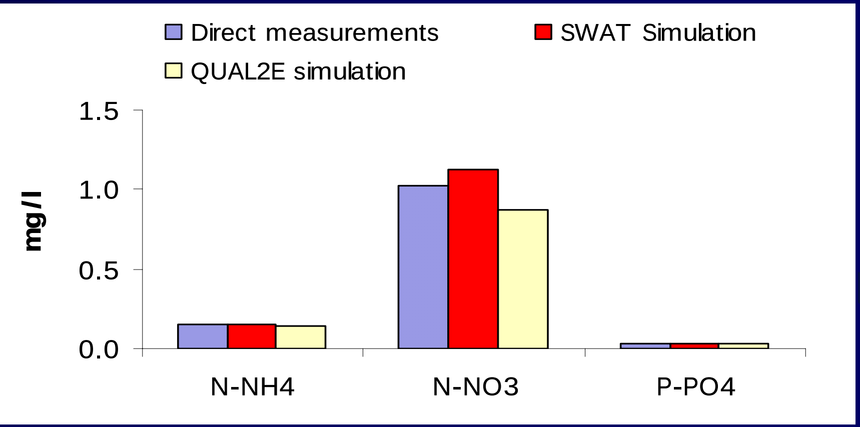
Mean Annual Dry-weather Scenario

Cherio River

- Point load effect simulation was validated for every parameter considered by comparing simulated values with the median of 3 years monthly monitoring campaign (ARPA)

- Then the same emission factors for point loads, validated with QUAL2E, were used for the SWAT modeling





Mincio River

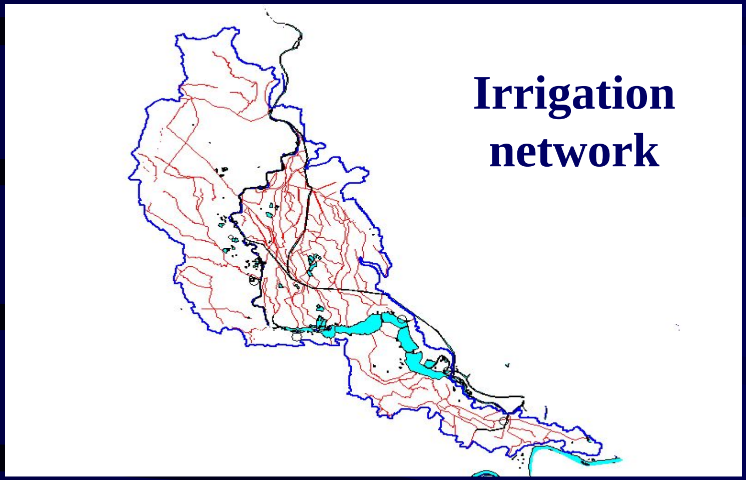
Point loads control the river quality even in watershed characterized by extensive agricultural land use

SWAT SIMULATION:
INPUTS

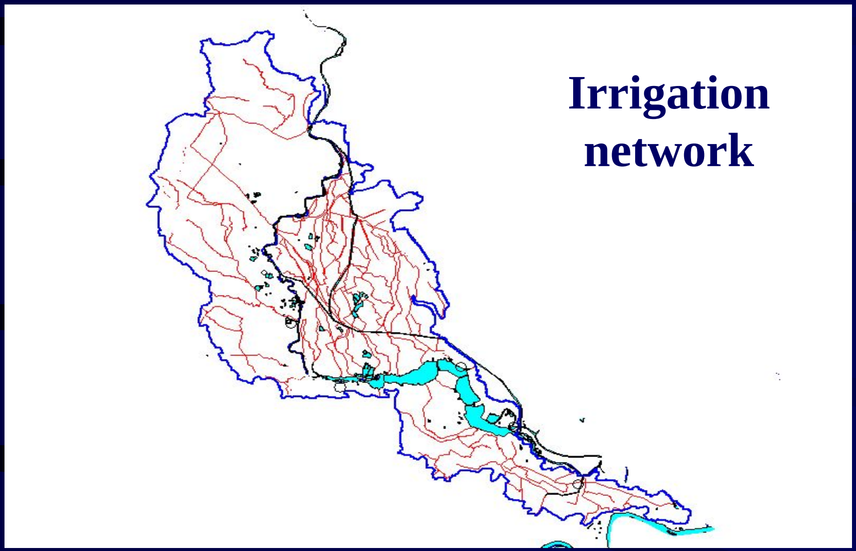
- DEM grid at a 40 m spacing
- ERSAL maps on land use and soil characteristics.
  - ERSAL land use codes were translated into the SWAT classes of land cover
- Weather database
  - generated on the basis of site specific average monthly temperature and precipitation parameters (i.e. min, max, std deviation)
- Three lakes:
  - Endine and Garda Lakes headwaters of Cherio and Mincio rivers
  - Mantoa lakes within Mincio Watershed.

SWAT SIMULATION:

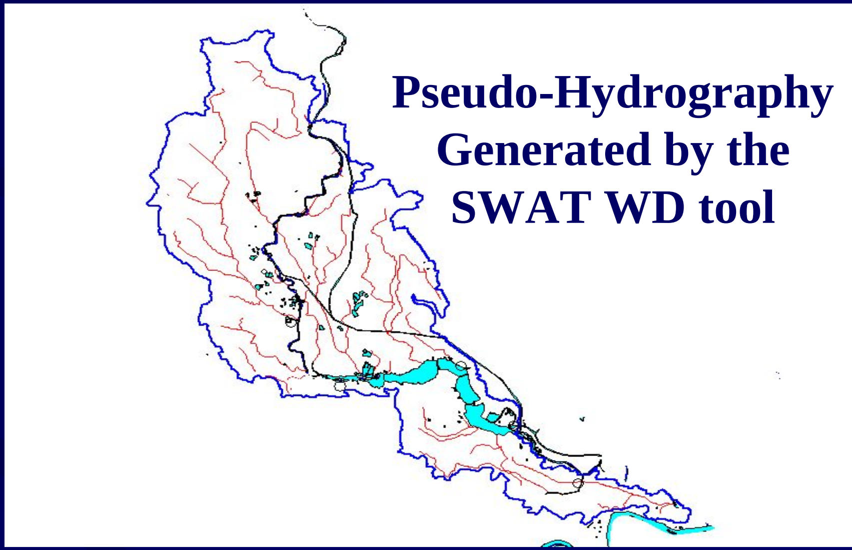
Irrigation network



SWAT SIMULATION:
METHODS



- The plain zone of the study area, and particularly the Mincio Basin area, is characterised by a very complex system of irrigation channels that overlays the natural hydrographic network.



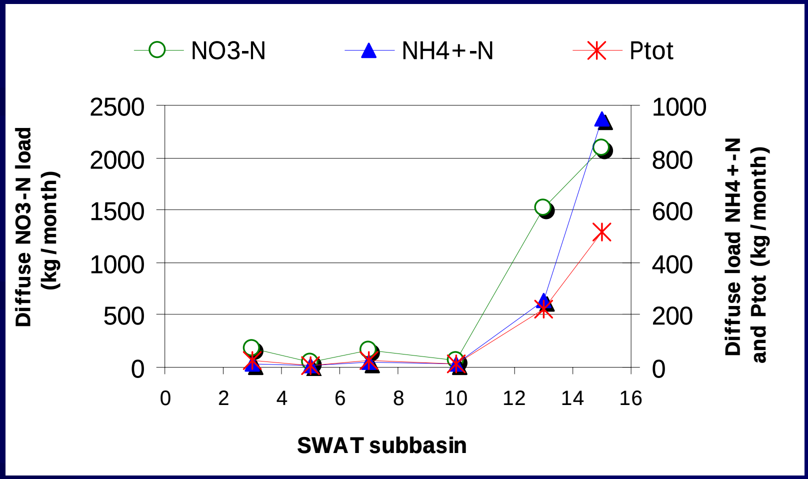
- A pseudo-hydrography was generated by means of the Watershed Delineation tool ("Burn In" option).
- Such a simplification reflects reasonably the average pathways of the diffuse pollutants to the main stream

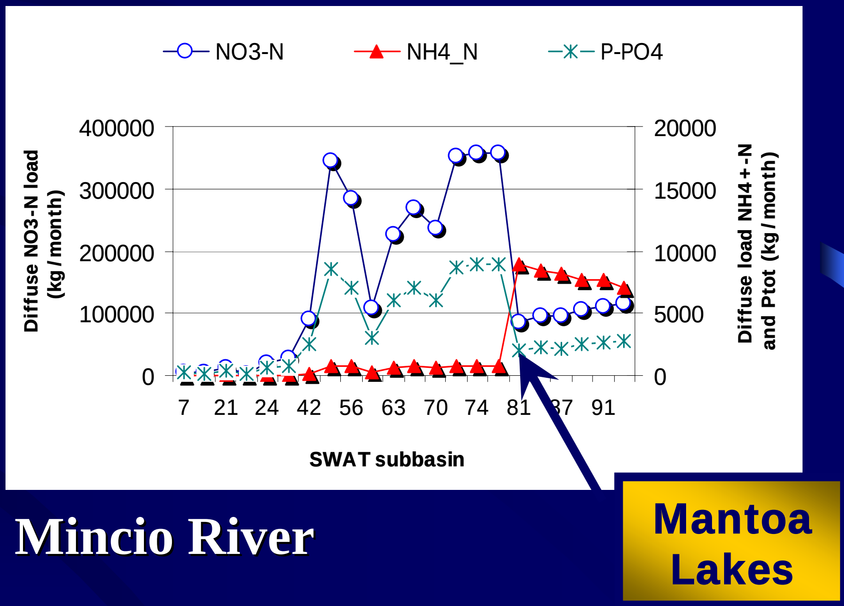
Results

SWAT simulations

- Diffuse load is much lower in Cherio than in Mincio Basin
- Diffuse loads increase downstream
- The presence of Mantoa lakes within Mincio basin smoothes the downstream trend

Cherio River

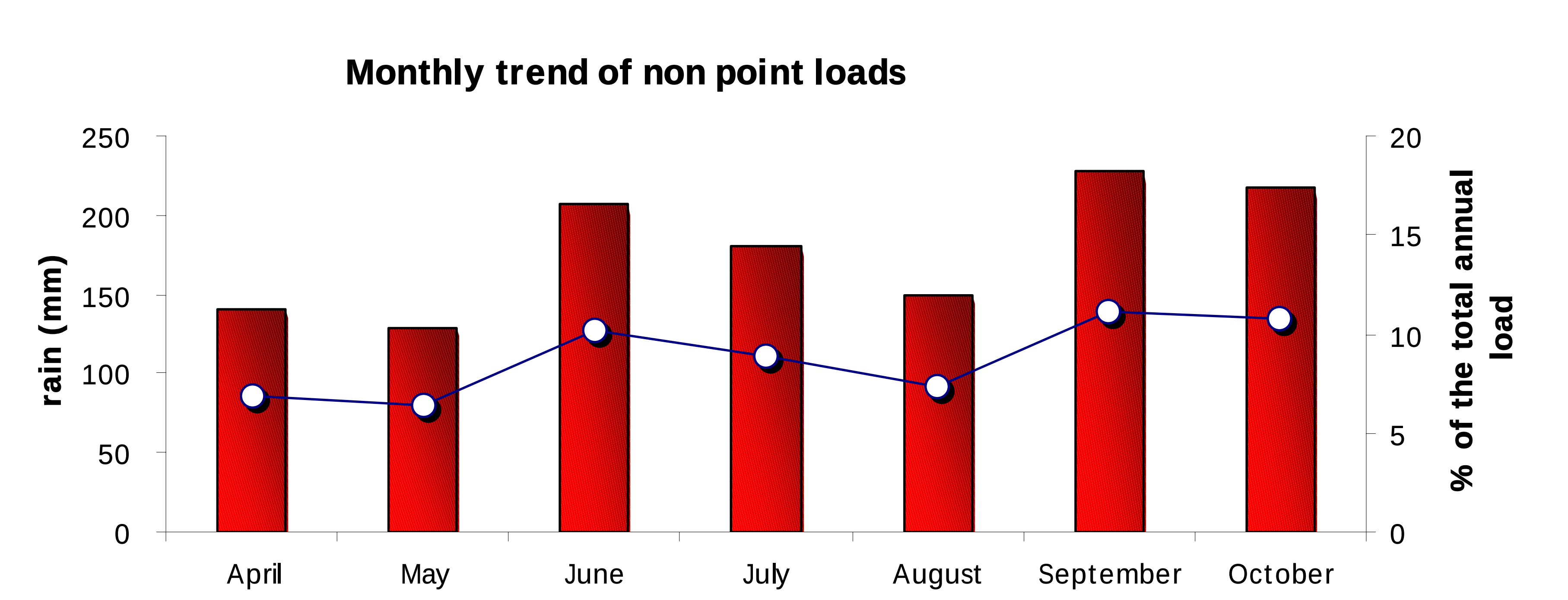




Mincio River

Results

Comparison with the indirect emission estimates approach

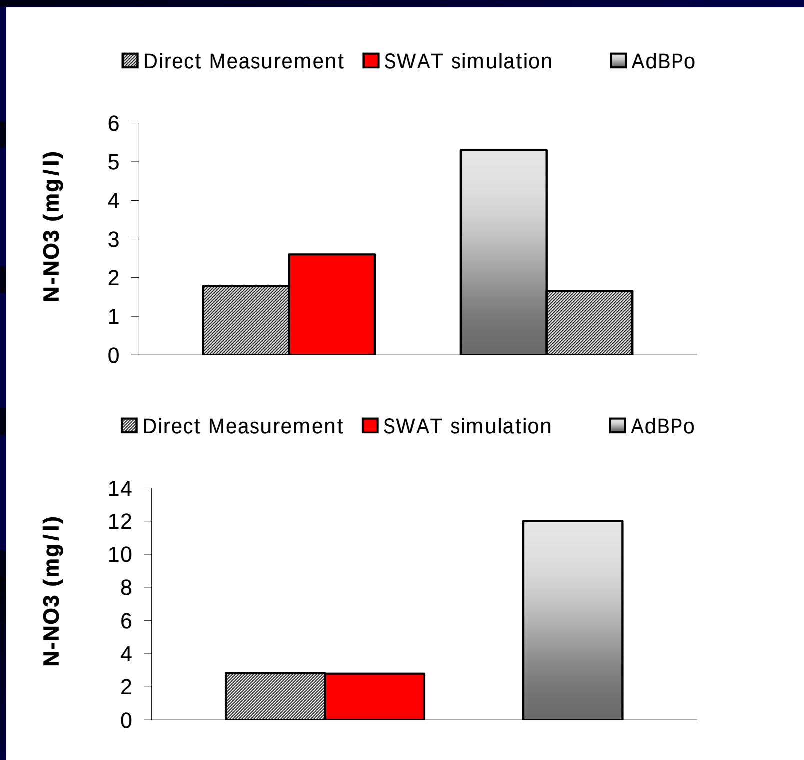


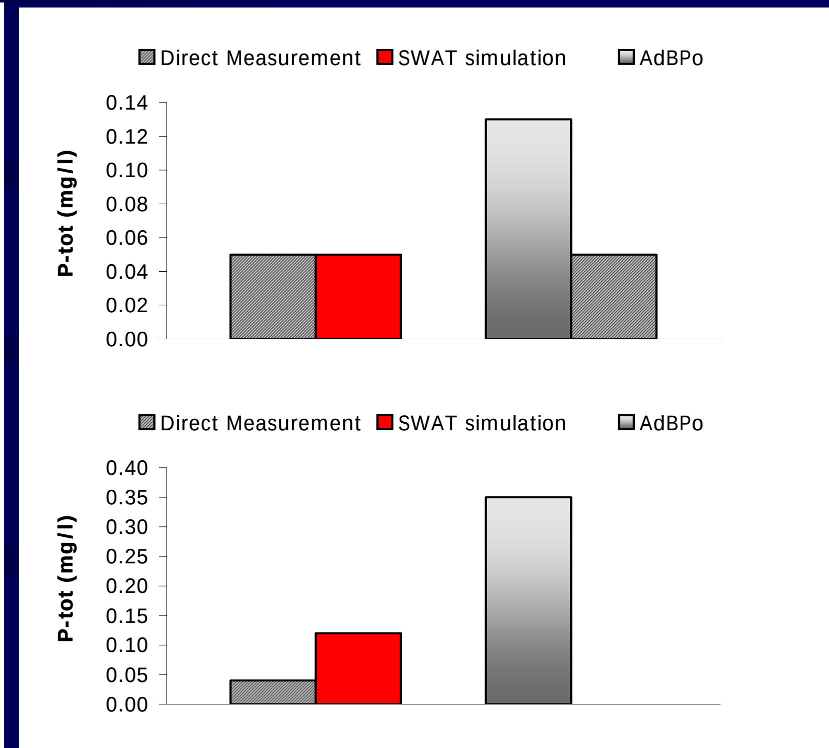
- AdBPo diffuse loads, being evaluated on an annual basis, were distributed following the monthly precipitation trend over the monthly average of rainy days. Similarly the SWAT predictions were distributed over the same interval of rainy days.

Results

Comparison with the indirect emission estimates approach

Cherio River





Mincio River

Indirect emission factors may lead to remarkable overestimations

Conclusions

- The integration of QUAL2E and SWAT enabled to quantify overestimations of the diffuse loads contribution
- It offers the opportunity to adjust the source apportionment of point and non point contributions to the instream total load within the SWAT model.
- SWAT predictions resulted to be much more accurate than the indirect emission estimates for both the studied watersheds.