WE-NEED

WatEr NEEDs, Availability, Quality and Sustainability

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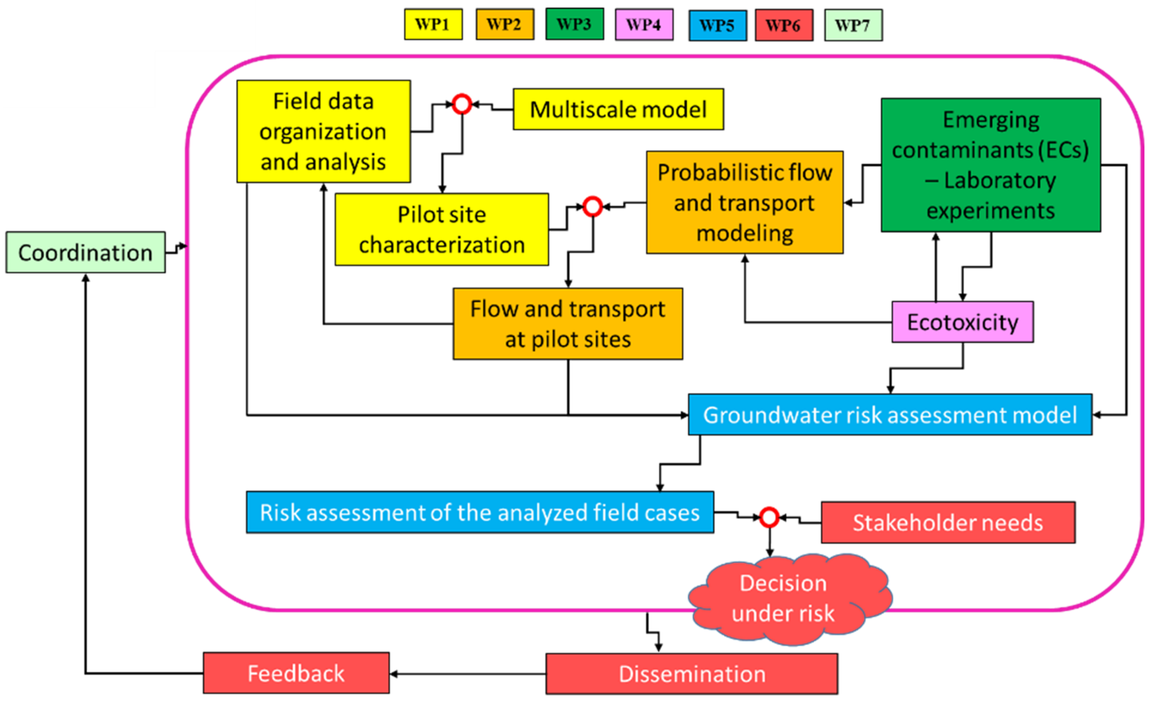
SCOPE: Develop new management strategies to assist the sustainable use of groundwater resources (springs/wells).



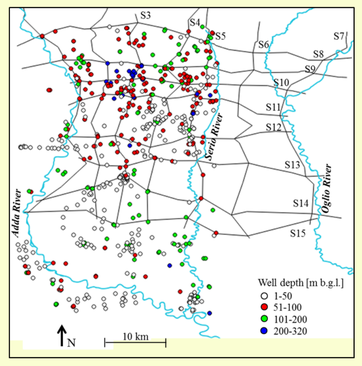
WP1: Pilot sites characterization

Two heavily exploited sites in the alluvial Po plain representing diverse environmental settings :

- CREMONA aquifer: its natural high-quality water springs are the main supply to agriculture and a key environmental driver.
- BOLOGNA aquifer: it is a key source of water for industrial and urban supply in the metropolitan area of Bologna.

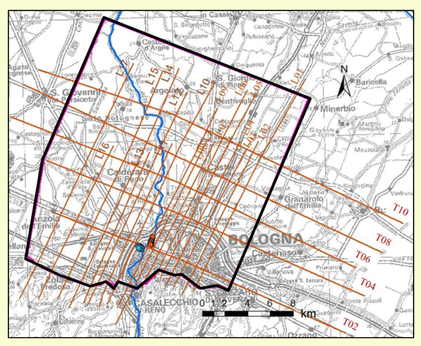
CREMONA

- Clay and silt 37%
- Sand 5%
- Gravel 33%
- Compact conglomerates 15%
- Fractured conglomerates 10%



BOLOGNA

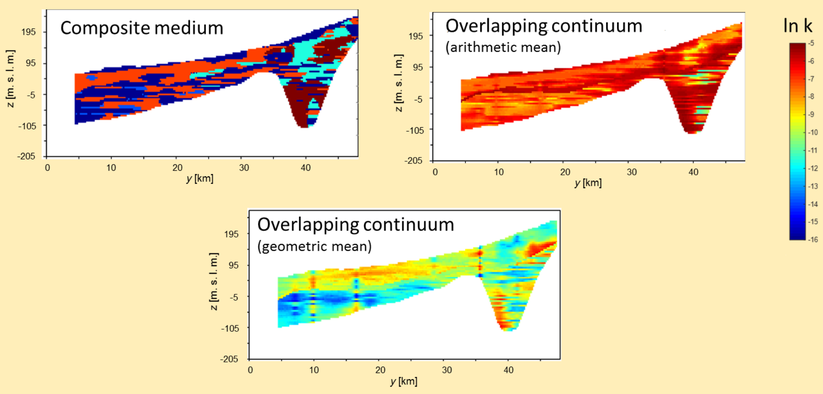
- Clay 52%
- Silt 13%
- Sand 7%
- Gravel 28%



WP2: Probabilistic flow and transport modeling

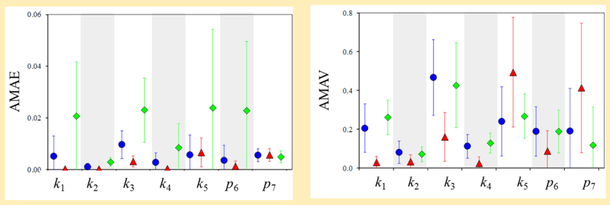
CREMONA

Facies reconstruction



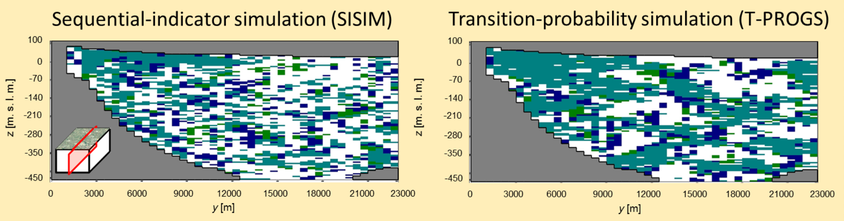
Sensitivity analysis

	Description	Unit
k_1	Clay and silt	m/s
k_2	Sand	m/s
k_3	Gravel	m/s
k_4	Compact conglomerate	m/s
k_5	Fractured conglomerate	m/s
p_6	Flow rate from north boundary	m^3/s
p_7	Height of the river	m



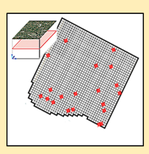
BOLOGNA

Facies reconstruction

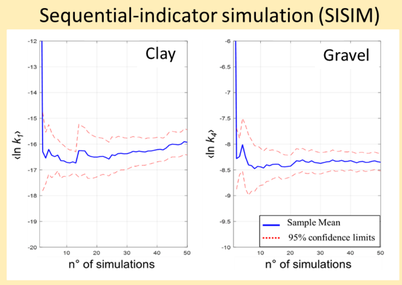


Model calibration in a Monte Carlo framework (100 realizations)

Parameter	Type	Value/Range [m/s]
k_1 (Clay)	Adjustable	$10^{-10} \div 10^{-6}$
k_2 (Silt)	Fixed	10^{-6}
k_3 (Sand)	Fixed	10^{-5}
k_4 (Gravel)	Adjustable	$10^{-4} \div 10^{-2}$



k_1 and k_4 are calibrated on the basis of available piezometric data in each realization.

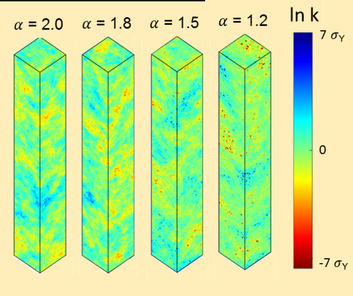


Synthetic media

Generation of sub-Gaussian random fields

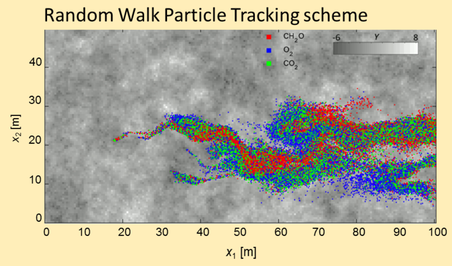
$$Y(\mathbf{x}) = \ln k = U(\mathbf{x})\, G(\mathbf{x})$$

$U(\mathbf{x})$ has a log-normal distribution with zero mean and variance $\sigma_U^2 = (2-\alpha)^2$ α varying in the range [0, 2).



Reactive transport simulation

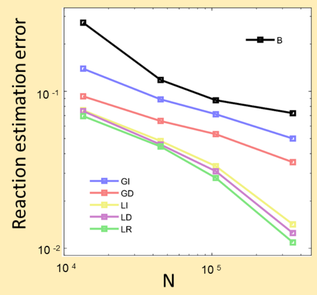
Random Walk Particle Tracking scheme



A locally-adaptive particle support controls the probability of reaction, improving accuracy and increasing efficiency.

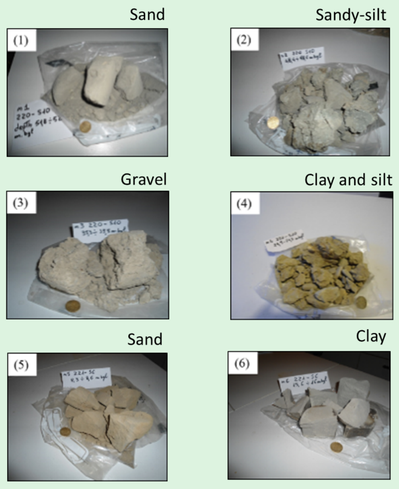
REACTION $CH_2O + O_2 \rightarrow CO_2$

Dissolved organic carbon reacts with dissolved oxygen to form carbon dioxide

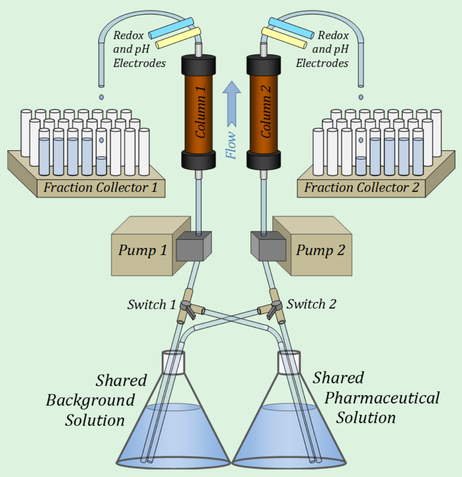


WP3: Emerging contaminants (ECs) laboratory experiments

Cores drilled from the Bologna site

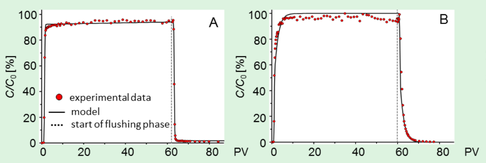


Set up 1: fully-saturated conditions



BTCs and model fits of total oxaliplatin species

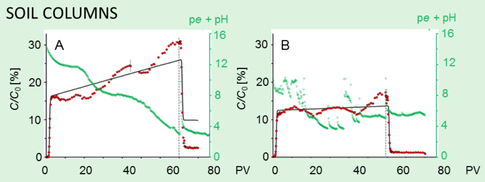
SAND COLUMNS



SAND: 7% oxaliplatin retention, affected only mildly by added humic acid under buffered pH.

A. Oxic conditions.
B. Oxic conditions with added humic acid at buffered pH 9.8.

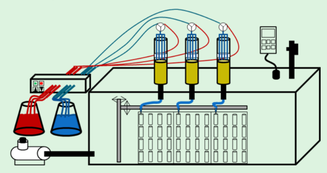
SOIL COLUMNS



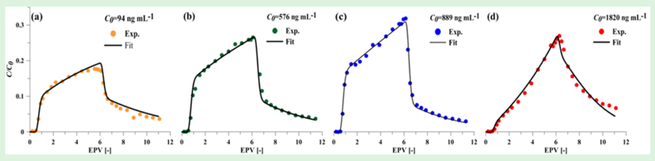
SOIL: nonlinear, reversible oxaliplatin retention of about 85%. The strongest retention observed under iron reducing conditions

A. Oxic conditions.
B. Iron reducing conditions.

Set up 2: partially-saturated conditions



BTCs of Ag-NP transport in partially-saturated soil columns



Silver nanoparticles at concentration of 500 ppb have substantial mobility in soil. When the concentration of the Ag-NPs is increased to almost 2000 ppb the pattern of the breakthrough curve changes and fewer particles elute from the column.

WP4: Ecotoxicity

Assessment of toxicity of groundwater samples

Groundwater composition

	BOLOGNA	CREMONA
	Concentration (mg/L)	Concentration (mg/L)
$CaCO_3$	475	158.3
$MgSO_4$	138	46.1
$Ca(HCO_3)_2$	673	224.2
NaCl	67	22.4
$NaNO_3$	34	11.3
Humic acid (sodium salt)	5	5
	µg/L	µg/L
tetrachloroethylene (PCE)	30	10.0
Sodium fluoride (NaF)	75	25
Ammonium hydroxide ($(NH)_4OH$)	100	33.3
Boric acid (H_3BO_3)	800	266.7

Anthropogenic contaminants

Toxicity to *Daphnia magna* of individual species of ECs (48 h exposure). LC_{50} values (i.e. concentration causing 50% effect on mortality, mg/L).

	ASTM medium	BOLOGNA	CREMONA
Boric acid	705.73 (479.49-792.14)	686.5 (651.17- 724.95)	668.4 (632.52- 706.97)
Ammonium hydroxide	99.31 (89.54-108.91)	322.6 (293.01-359.54)	111.2 (107.63- 114.95)
Sodium fluoride	649.4 (553.33-808.26)	587.62 (538.22-646.05)	508.06 (487.88- 529.77)
Acetaminophen	2.66 (n.d.)	4.52 (3.83-5.37)	3.26 (2.91-3.64)
Triclosan	*	1.43 (1.27-1.69)	0.98 (0.9-1.1)
Phenanthrene	*	2.73 (2.28-2.90)	>2.83
PFOA	*	*	428.7 (363.7-506.9)

Analysis of fish embryo exposed to Sodium Fluoride

ASTM medium

Tail malformation

Cremona

Cardiac edema

Bologna

Inflated bladder

Toxicity to *Daphnia magna* of mixtures of ECs species (boric acid, ammonium hydroxide, sodium fluoride and acetaminophen)