Thermal Remediation as a First Step to a Nature-Based Solution

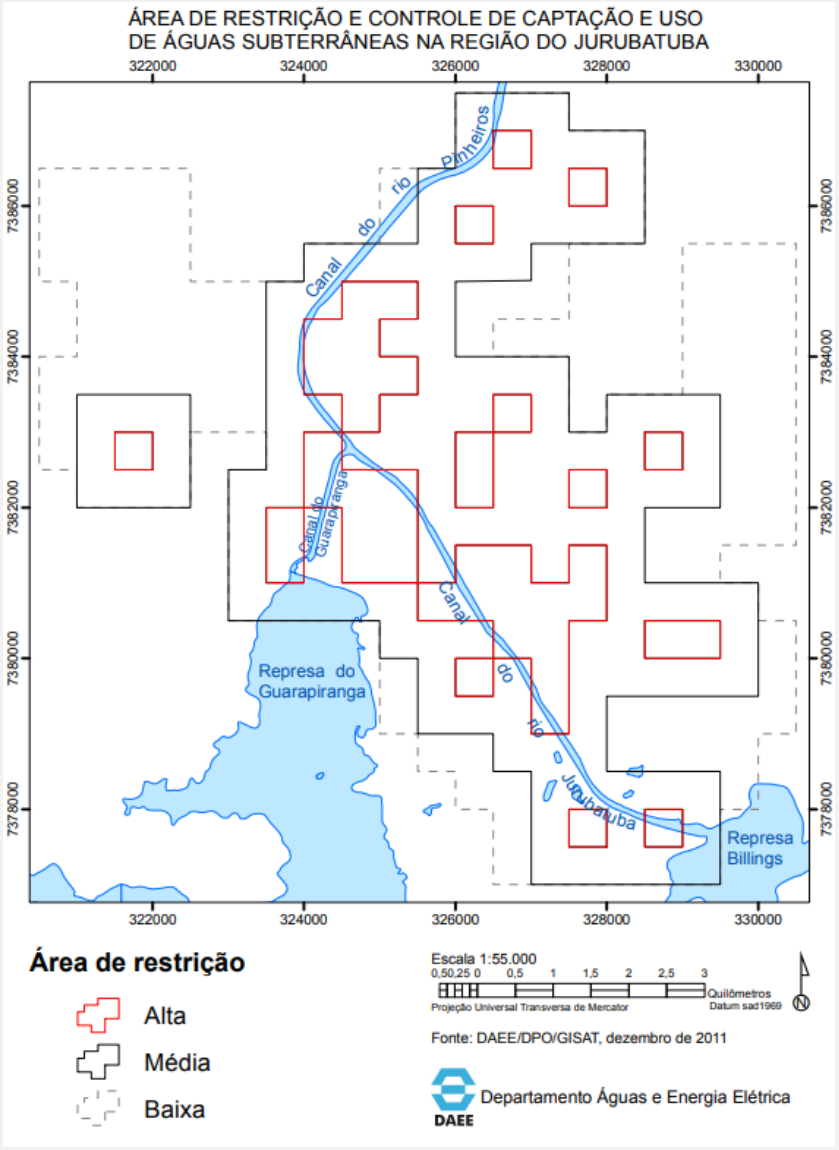
Ellen Caroline P. Leite, Fábio M. Rodrigues, Mirian C. Shinzato, **Juliana G. Freitas***

Universidade Federal de São Paulo - Brazil
(jgfreitas@unifesp.br)

GQ 19
Groundwater Quality 2019

Groundwater contamination by organics

- What is being done:
  - Restriction of use
  - Pump & treat, dig and dump...
  - Agressive solutions: resource intensive techniques (thermal)



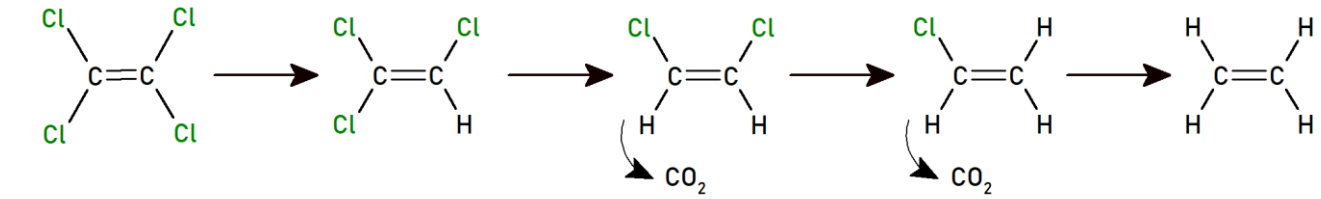
Nature Based Solutions

- Inspired and supported by natural processes
- Environmental, social and economic benefits
- Increased resilience
- Interventions adapted to local conditions

Change porous medium
to enhance natural attenuation processes

Natural Attenuation

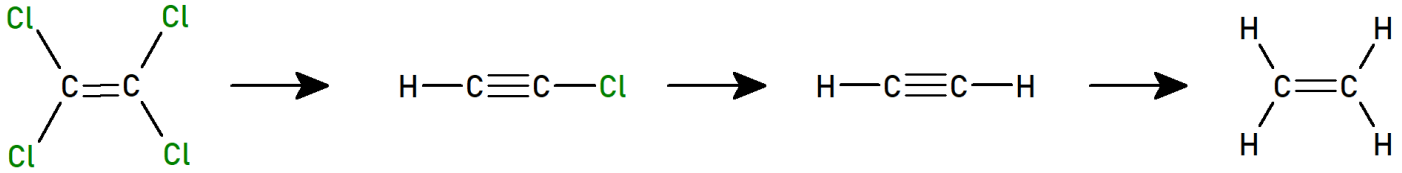
Biotic degradation



Tetracloroeteno (PCE) → Tricloroeteno (TCE) → *cis*-1,2-Dicloroeteno (*cis*-1,2-DCE) → Cloreto de Vinila (CV) → Eteno

Adapted from Badin et al (2016)

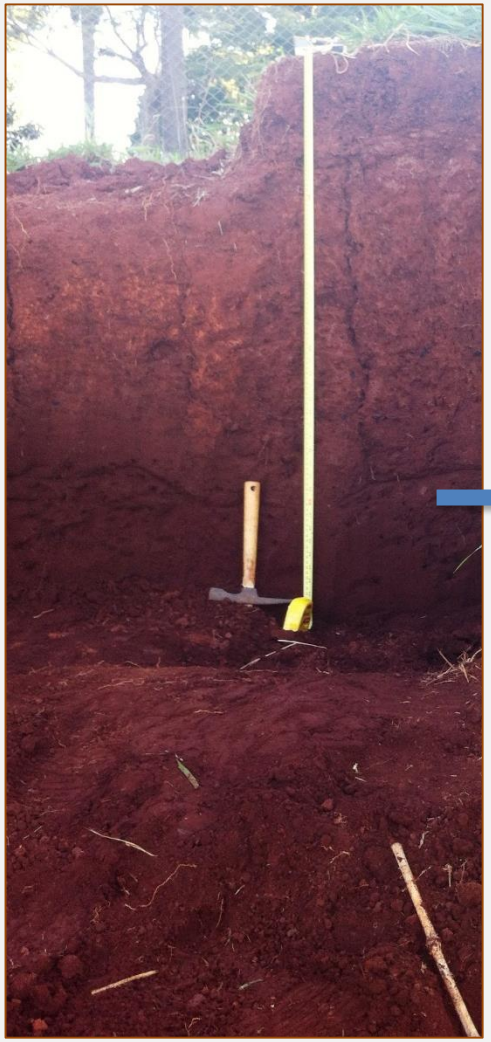
Abiotic degradation

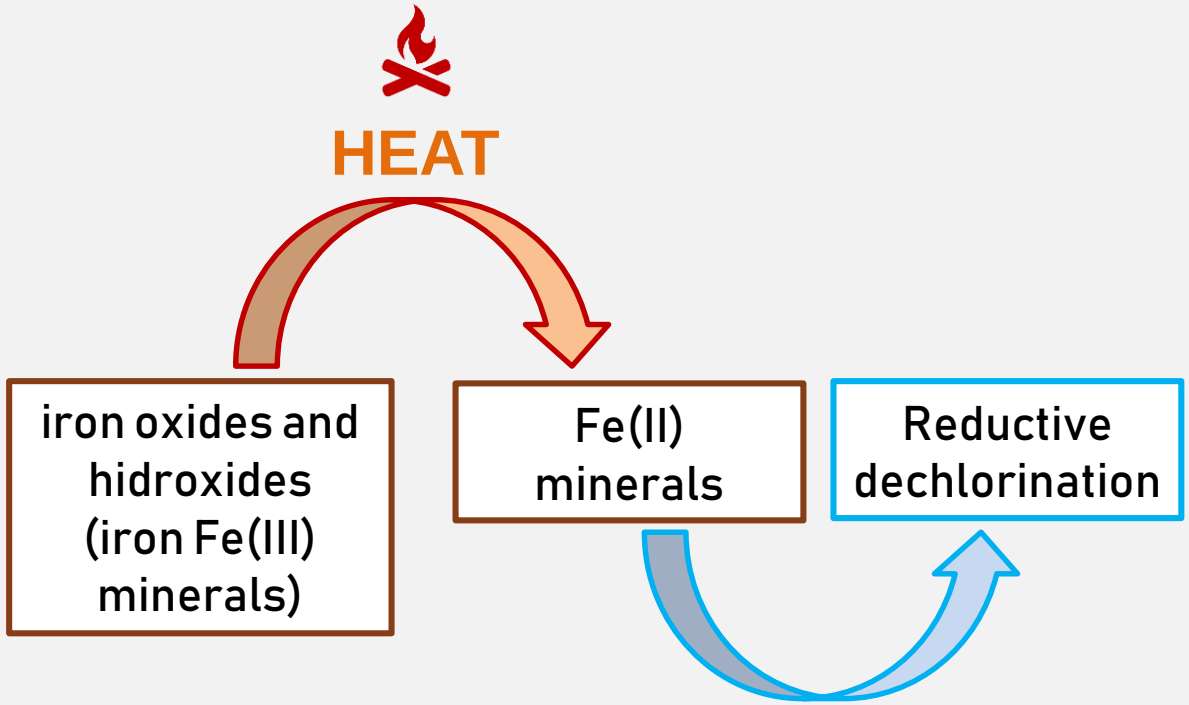


Tetracloroeteno (PCE) → Cloroacetileno → Acetileno → Eteno

Adapted from He et al. (2015)

Increase the potential for abiotic degradation

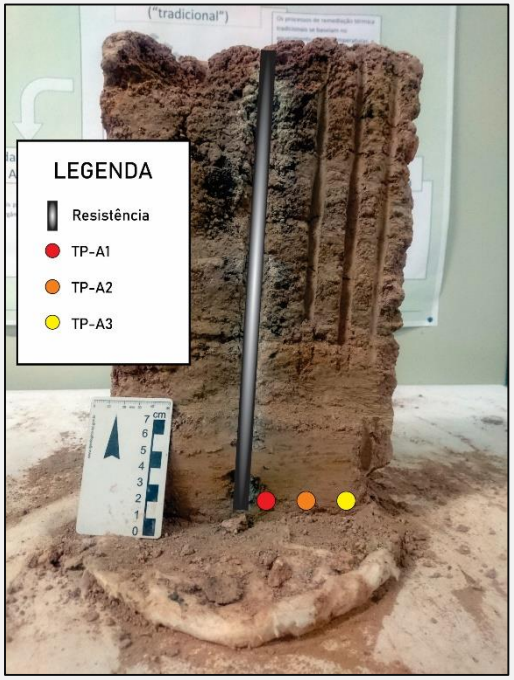




Methods

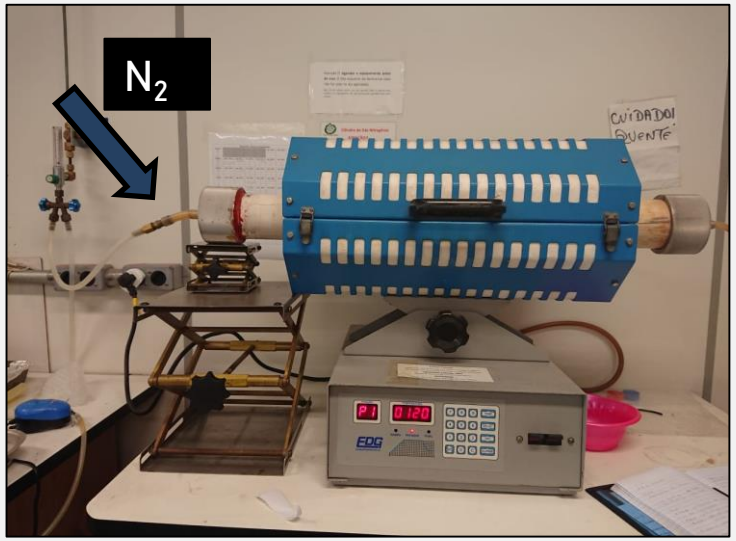
- Effects of thermal remediation to soil properties
  - bench tests (disturbed samples)
  - 3D physical models (undisturbed samples)

SiO_2	58%	29%
Al_2O_3	25%	26%
Fe_2O_3	5%	26%
Main minerals	Quartz, Kaolinite, Gibbsite, Muscovite, Hematite	Kaolinite, Gibbsite, Goethite, Hematite, Magnetite
Fe (II) (g/kg)	0,0139 ± 0,001	0,0226 ± 0,0027



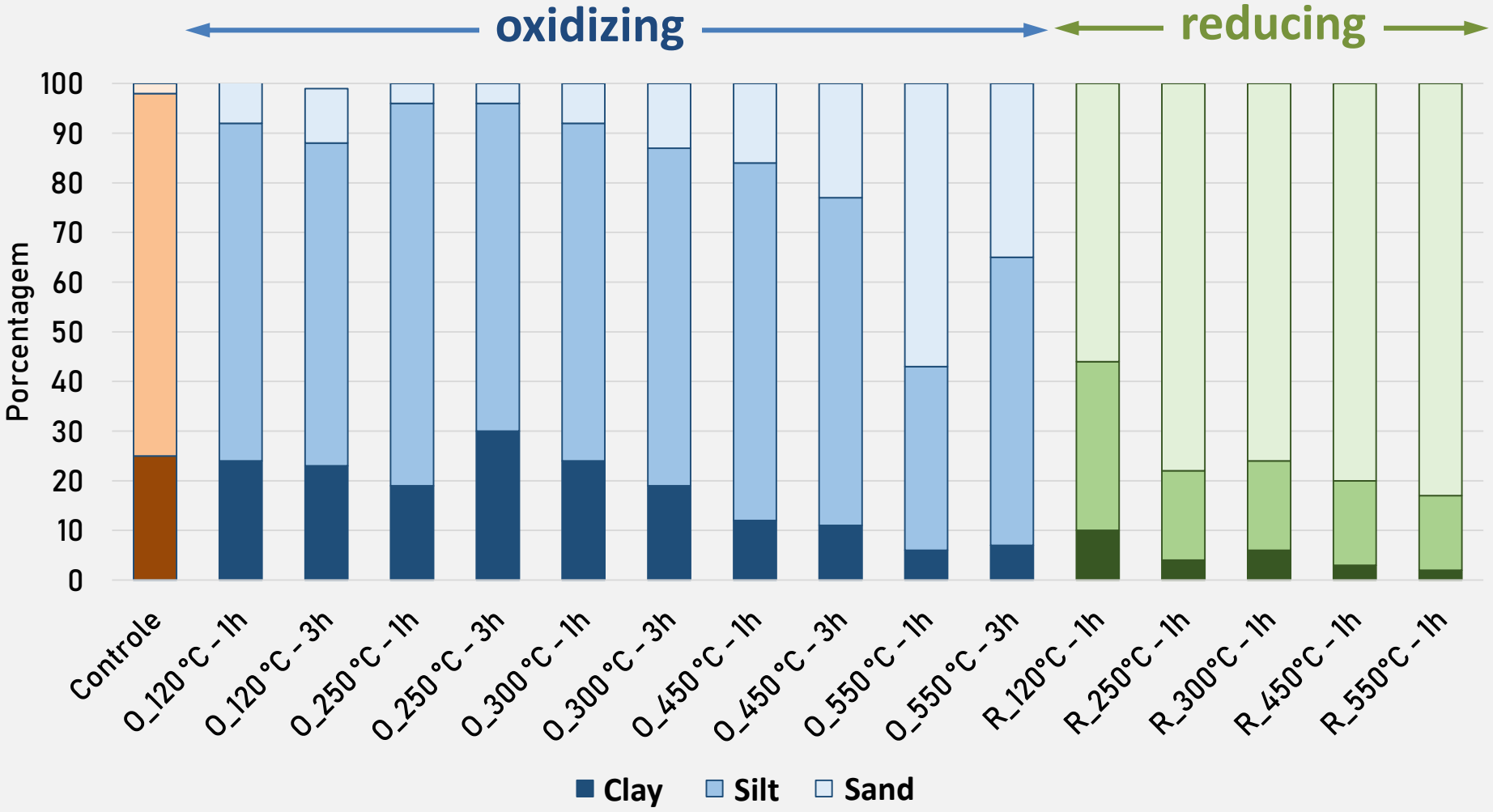
Methods

- 120°C < T < 550°C
- Oxic and anoxic atmospheres
- Grain size distribution, soil density, morphology, hydraulic conductivity, iron concentration and mineralogy



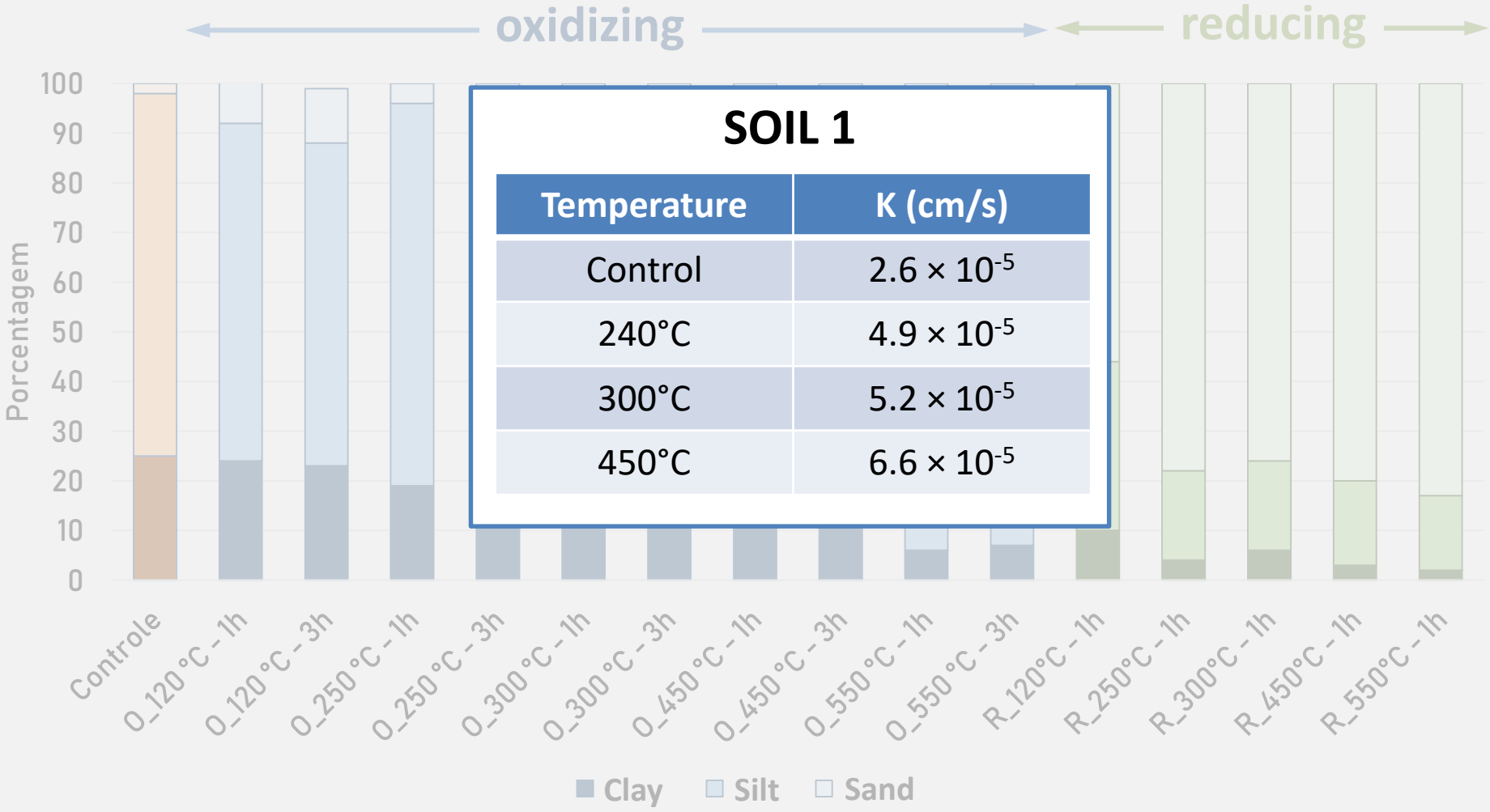
Physical properties

SOIL 2



Physical properties

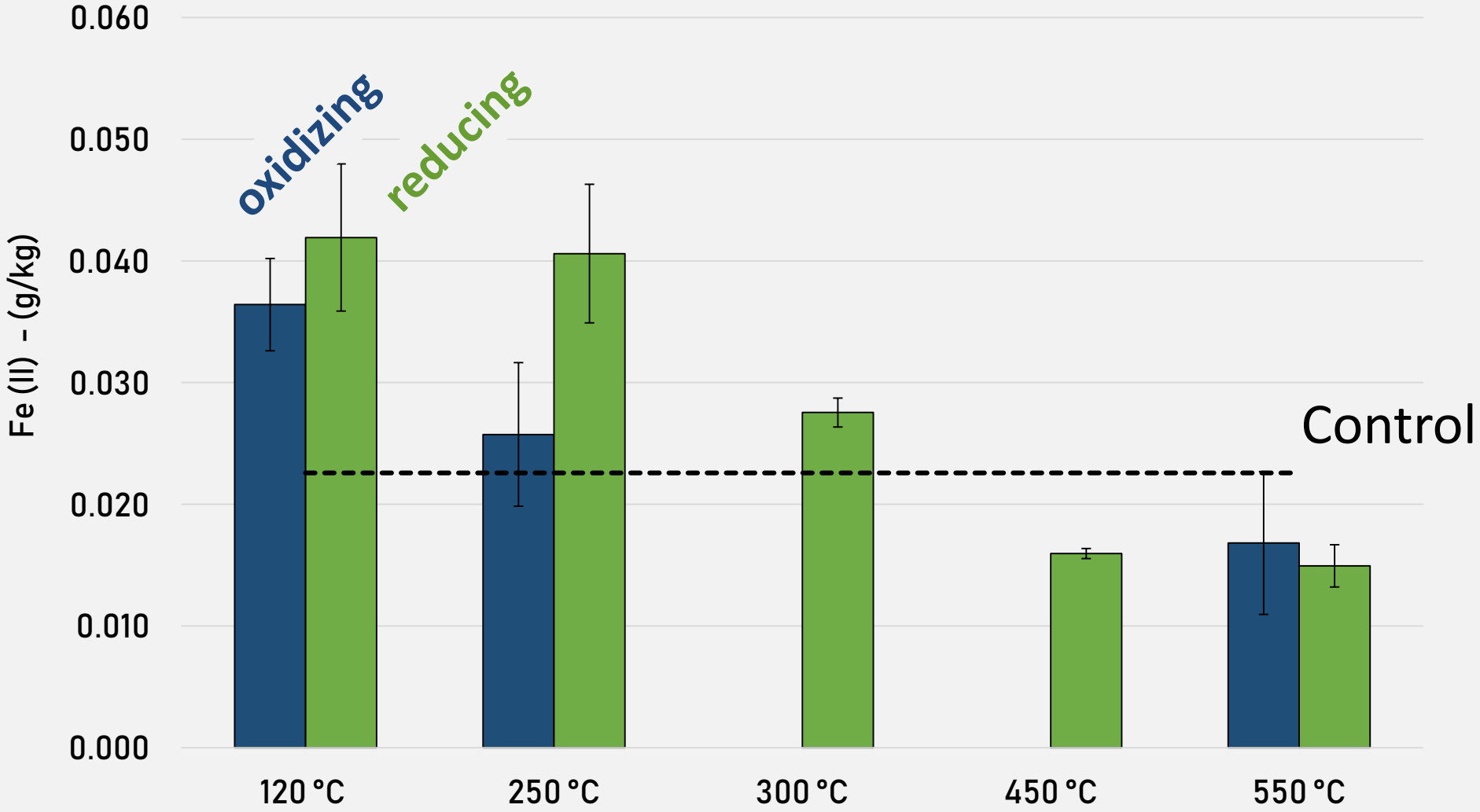
SOIL 2



SOIL 1

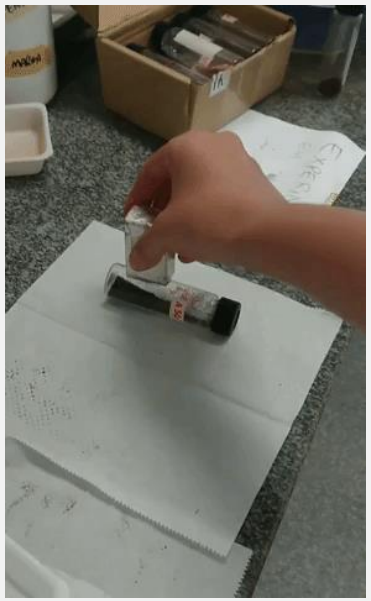
Temperature	K (cm/s)
Control	2.6×10^{-5}
240°C	4.9×10^{-5}
300°C	5.2×10^{-5}
450°C	6.6×10^{-5}

Fe(II) – Soil 2


0.060
0.050
0.040
0.030
0.020
0.010
0.000
Fe (II) - (g/kg)
oxidizing
reducing
Control
120 °C
250 °C
300 °C
450 °C
550 °C

Fe(II) – Soil 2

Goethite dehydroxylation → Hematite reduction and recrystallization = Magnetite (Fe(II))



$$2\alpha FeOOH_{(s)} \rightarrow \alpha Fe_2O_{3\,(s)} + H_2O_{(g)}$$

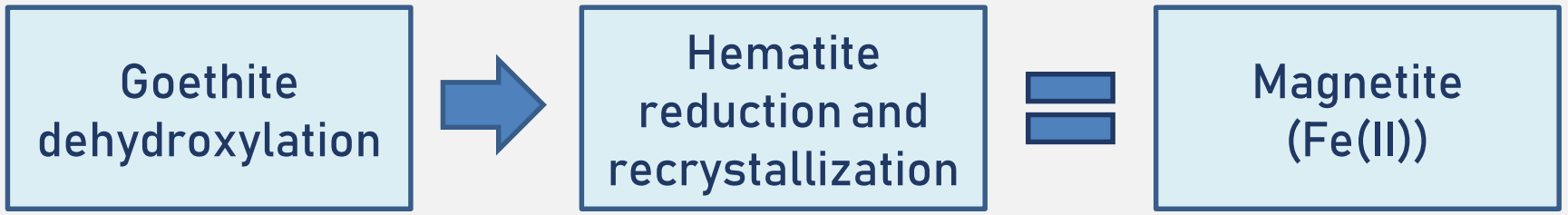
$$3\,\alpha Fe_2O_3\,(s) + CO_{(g)} \rightarrow 2\,Fe_3O_4\,(s) + CO_2\,(g)$$

Hematite

Reducing Atmosphere

Magnetite

Fe(II) – Soil 2



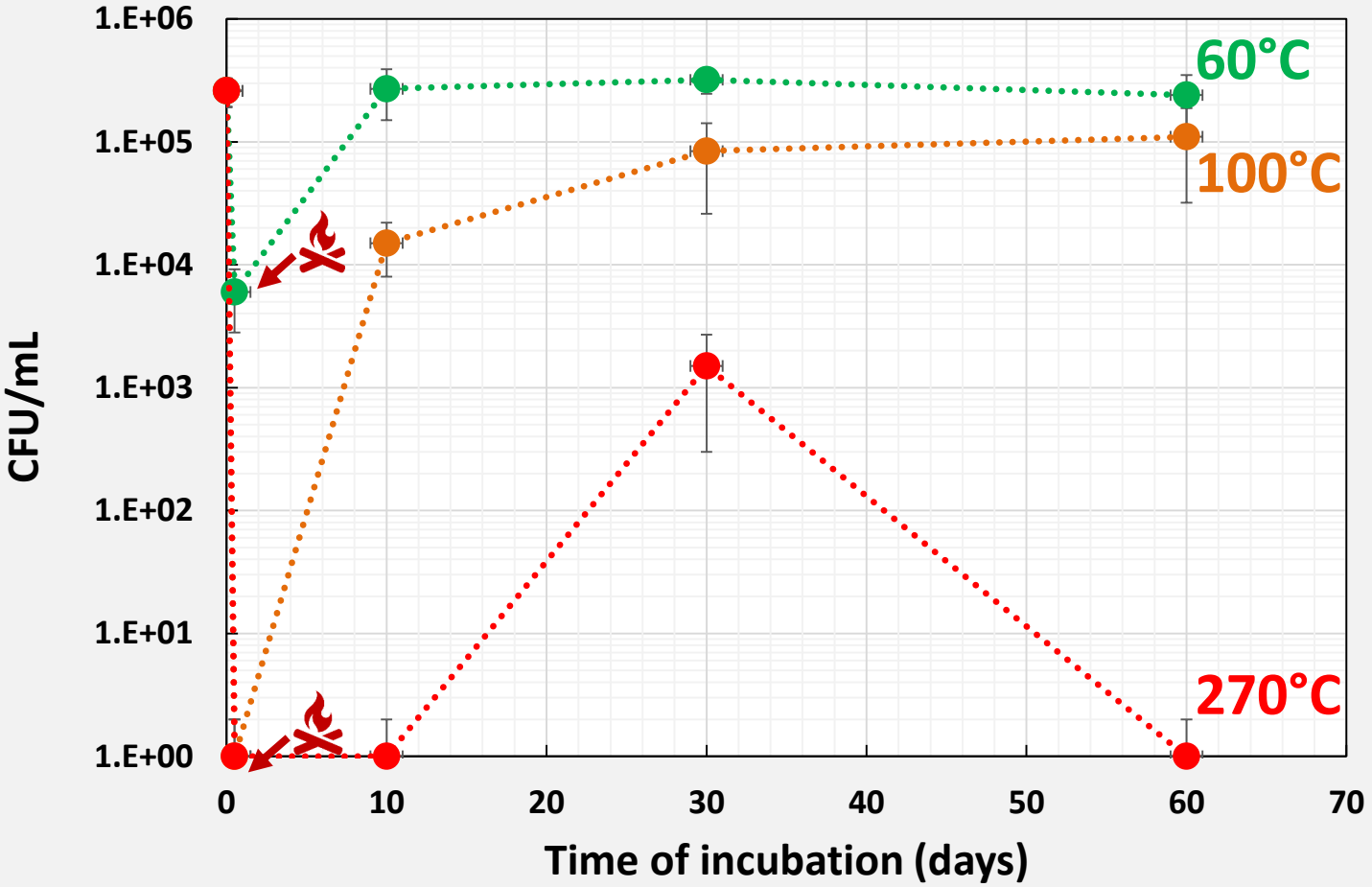
$$2\alpha FeOOH_{(s)} \rightarrow \alpha Fe_2O_{3\,(s)} + H_2O_{(g)}$$

$$3\,\underbrace{\alpha Fe_2O_3}_{\text{Hematite}}\,_{(s)} + CO_{(g)} \rightarrow \underbrace{2}_{\text{Magnetite}} + CO_{2\,(g)}$$

Burning of organic matter

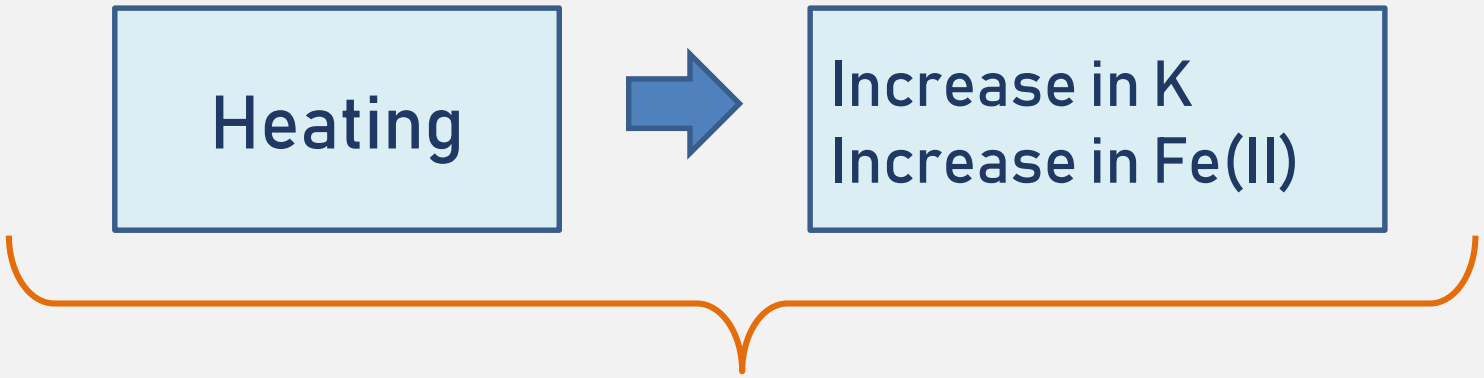
Reducing Atmosphere

Impact on biodegradation



Tatiana Satiko , Cristina R. Nakayama

Conclusions



- Thermal remediation: Consider the possibility of improving abiotic natural attenuation
- Heating as an option to create a reactive zone?

Acknowledgements

FAPESP

CNPq

programa interunidades de pós-graduação em
ANÁLISE AMBIENTAL INTEGRADA
UNIVERSIDADE FEDERAL DE SÃO PAULO