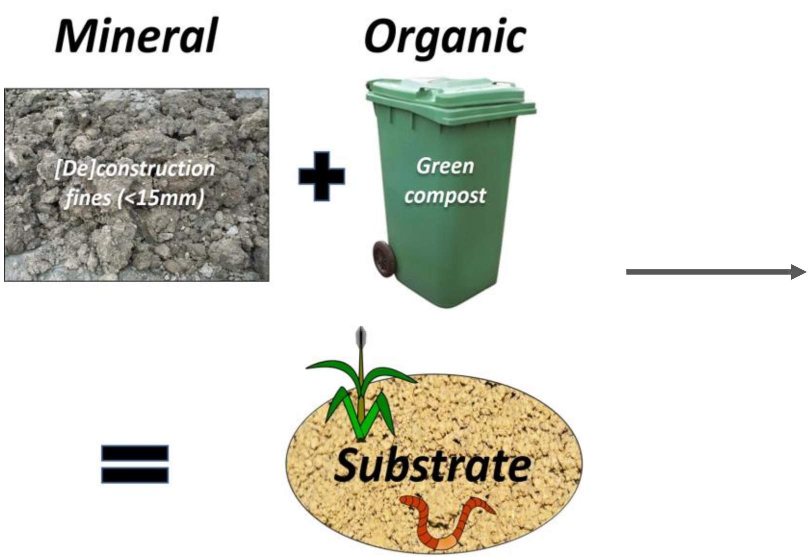
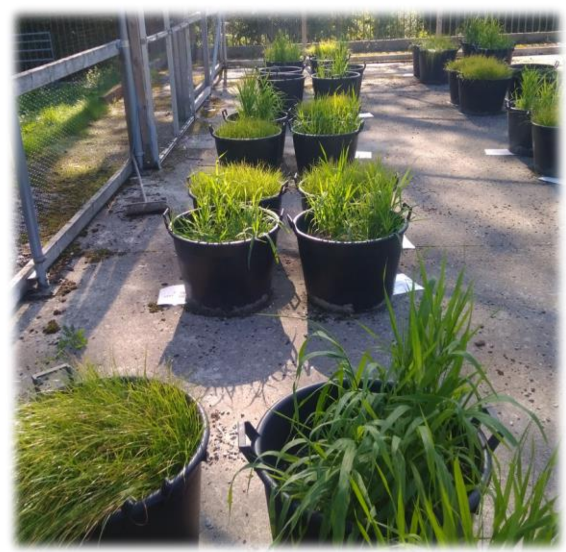
A geochemical and agronomic evaluation of technosols made from construction and demolition fines mixed with green waste compost

D Boldrin, M Coull, B.M Butler, R.L Hough, L Beesley

Why use waste to make soil?

- **Reduce** material sent to landfill
- **Extract** unused geochemical value
- **Create** cover for sealed surfaces





Technosol recipe

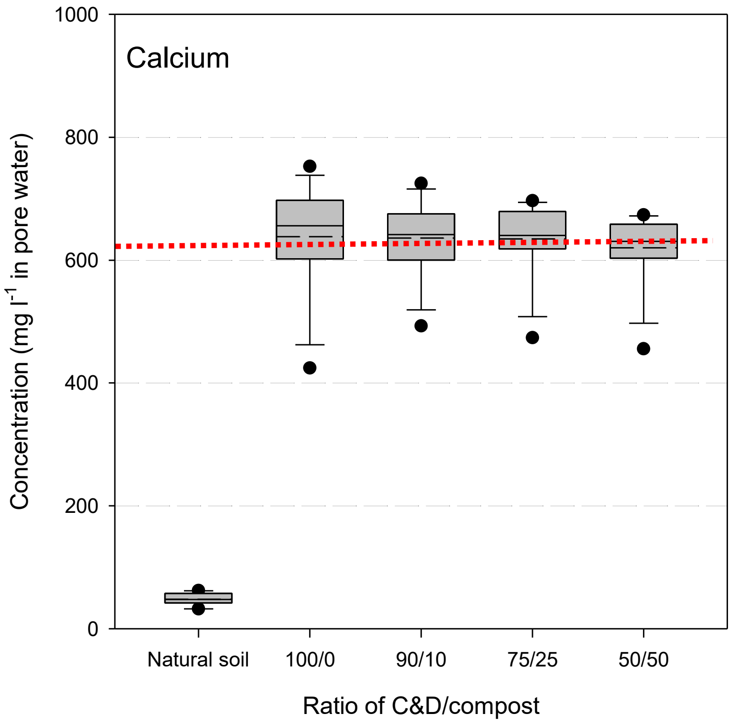
Green Waste Compost (GWC)

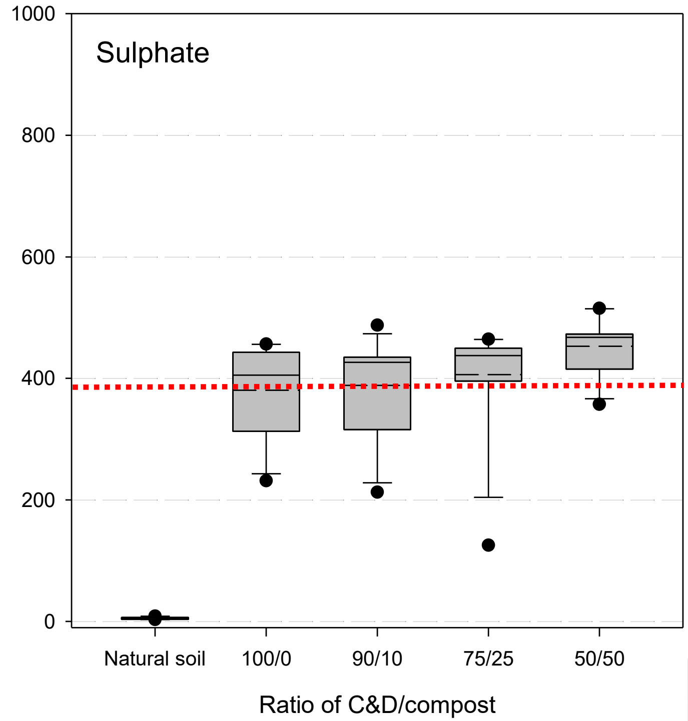
Construction and demolition waste (C+D)

Zero intervention…

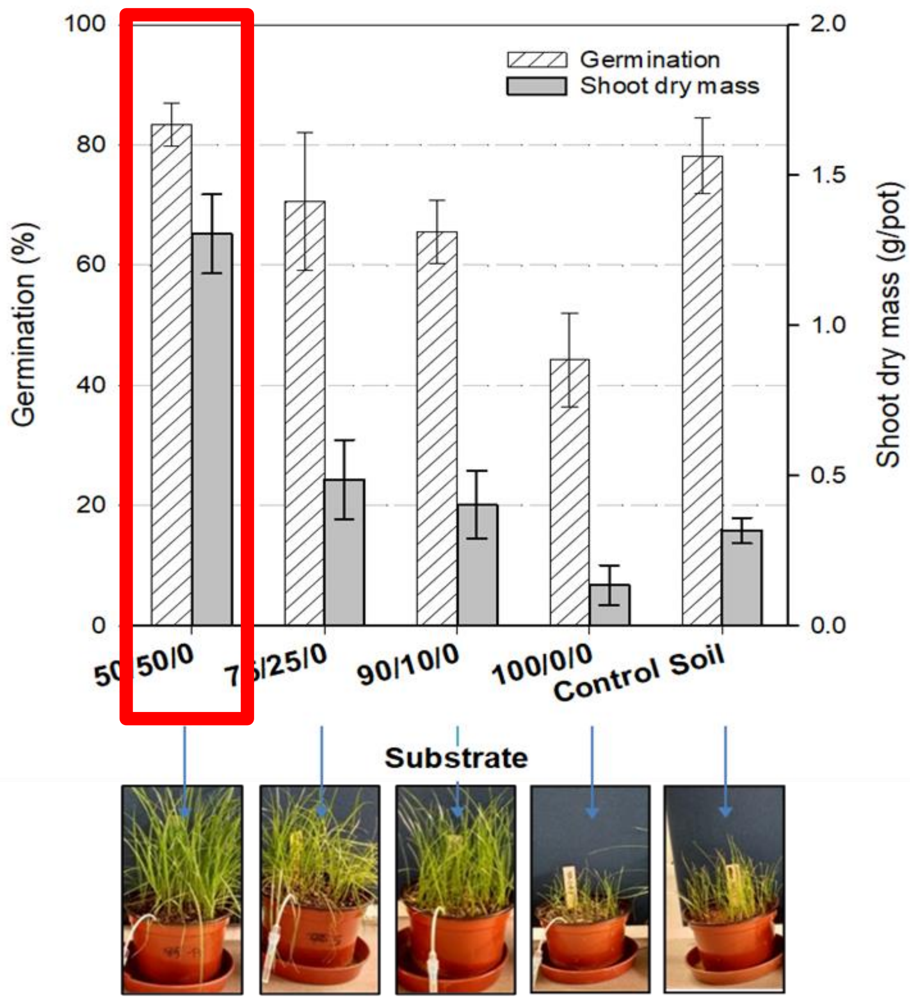
Treatments	Acronym
Agricultural topsoil	Soil
100% C&D	100/0 (Mix)
50% C&D / 50% Compost	50/50
75% C&D / 25% Compost	75/25
90% C&D / 10% Compost	90/10
Species	
Reed Canary Grass	RCG
Rye Grass	RG

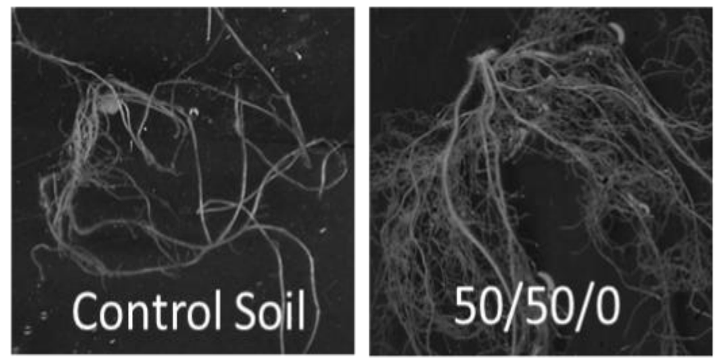
Pore water chemistry



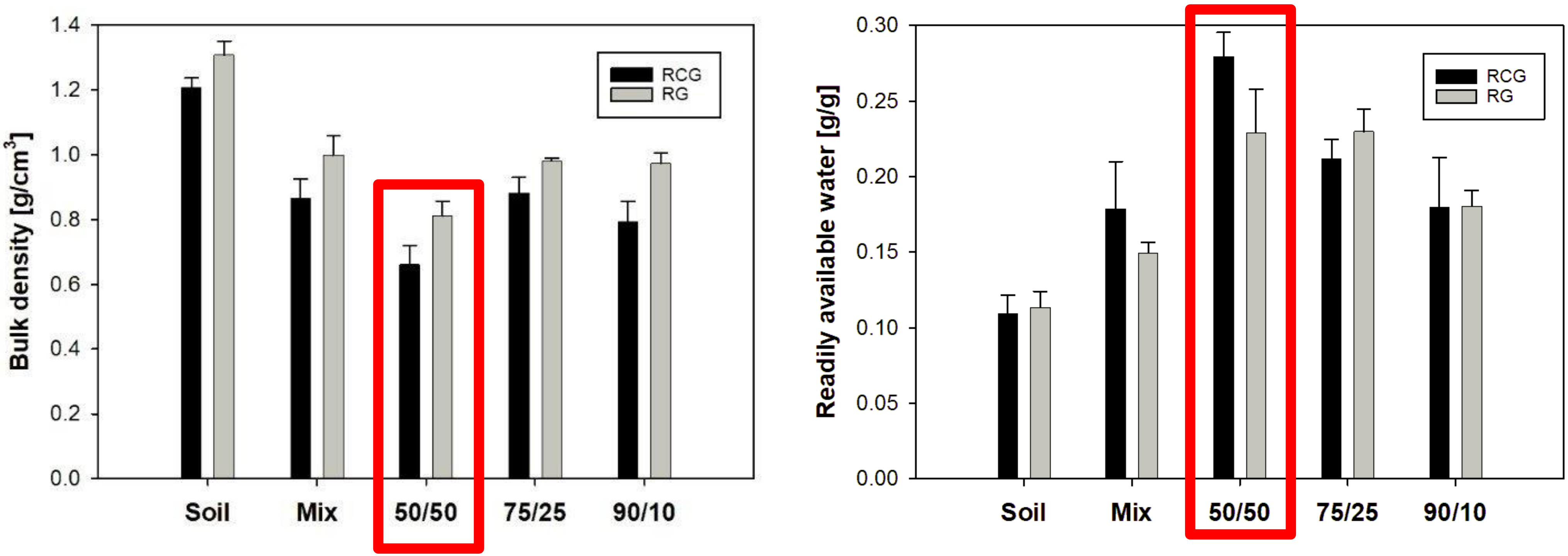


Plant biomass & root density





Bulk density and water retention



Headline points

- Substrate mineralogically **distinct from 'natural soil'** given presence of gypsum

- **Favorable bulk density and water holding capabilities** achieved by equal parts C&D and compost aid plant growth and rooting

- Further **sourcing/sorting of wastes** likely required to produce 'high end' technical soil for a wide range of applications.

RESAS
Rural & Environmental Science and Analytical Services

Scottish Government Strategic Research Program (2022-2027) under project JHI-D3-1, Healthy Soils for a Green Recovery

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

NATIONAL BIODIVERSITY FUTURE CENTER

Effect of a Constructed Technosol on the Microbial Functional Diversity in an Urban Afforestation Site

Simon Masson

SUITMA 13

Pisa, 6/10/2025

SUITMA 13 PISA 2025

UNIVERSITÀ DI TORINO

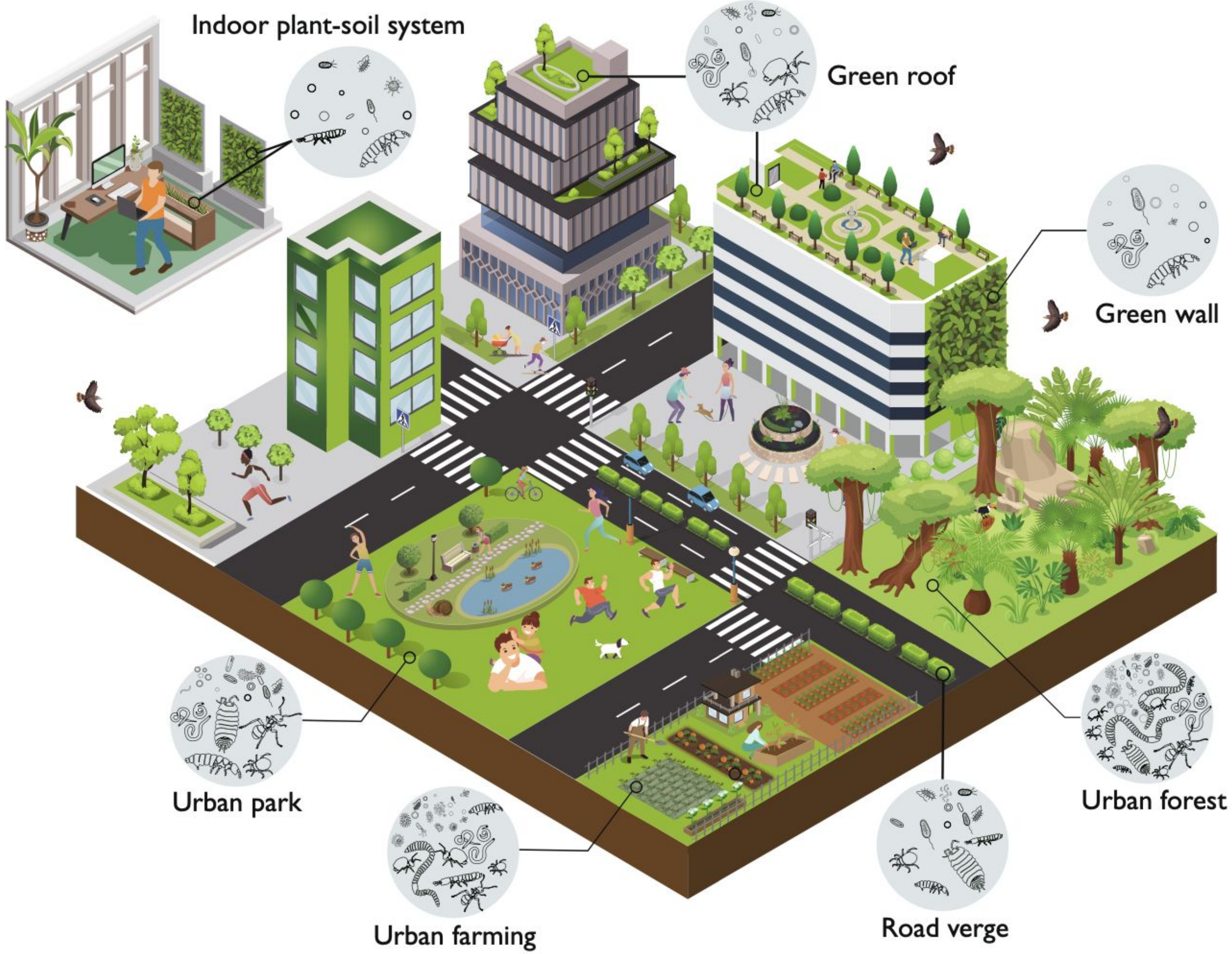
DBios

DISAFA Università degli studi di Torino

State of the art

§ About **70%** of the human population will live in cities by **2050**

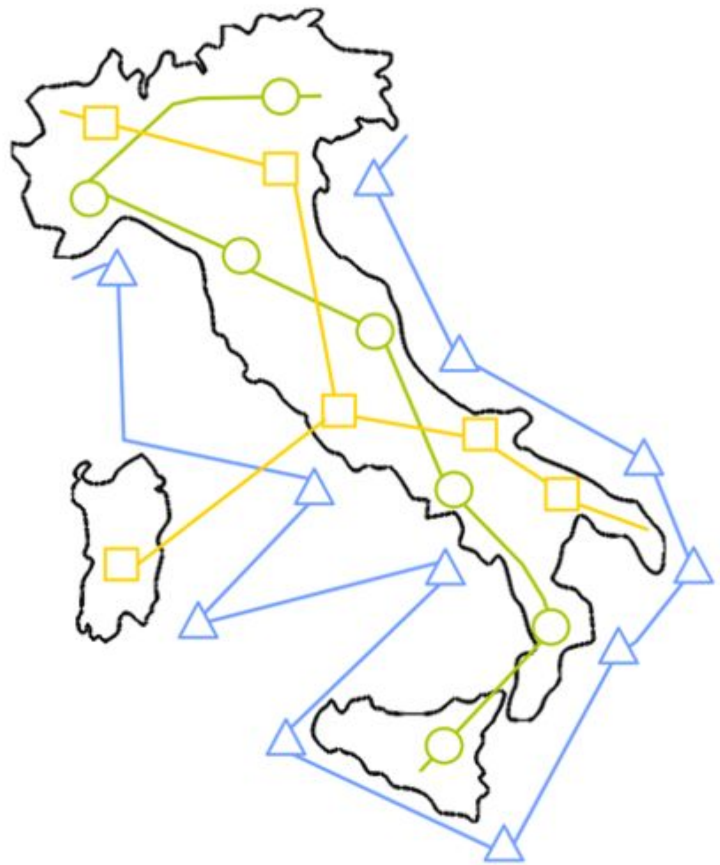
§ Urban green areas are diverse and provide many **ecosystem services** and **benefits** to citizens



Sun et al. 2023

§ Objectives of the NBFC

- § Understand and address direct drivers for biodiversity decline at marine, terrestrial and urban level
- § Valorise biodiversity to make it central element for sustainable development



SEA

LAND

URBAN

Aim of our team

§ Characterise **taxonomic** and **functional** diversities of microbial communities in urban soils with the long-term aim to support design of more resilient urban greenspaces and restoration programs

The study case: **Sangone Park**

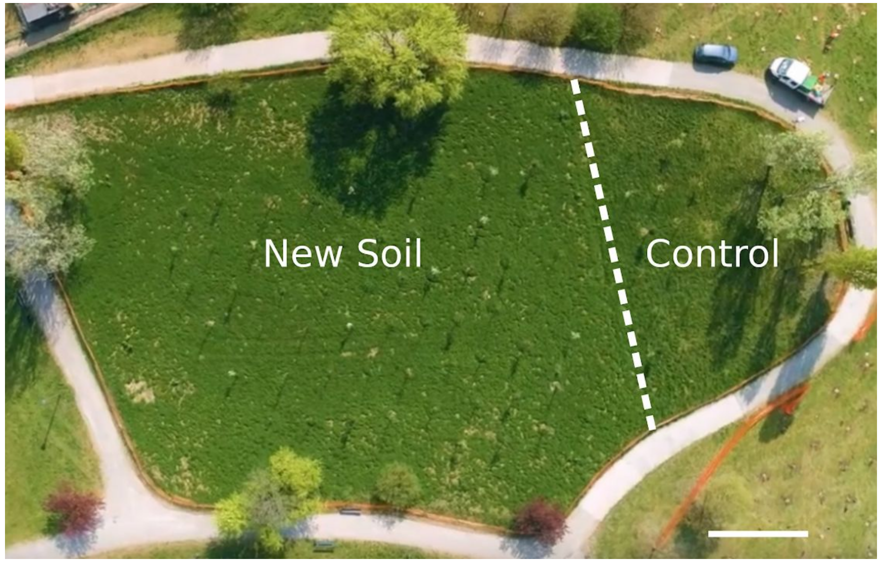
AIM: to characterise the **taxonomic** and **functional microbial diversities** of a **constructed technosol** used as a **NbS**

Area resulting from a European project funded in 2021 (**ProGIreg**) whose objective is to assess the ability of plant species to grow on a new matrix (5 trees and 5 shrubs selected for their low maintenance requirements and high resilience to extreme climatic conditions)

Area of 2000 m^2 divided in two plots

New soil = Constructed technosol

- Secondary **raw material** (deep excavation soil from construction sites)
- **Zeolites**
- **Compost** from urban and green waste
- Commercial **microbial biostimulant** (including arbuscular mycorrhizal fungi and plant-growth promoting bacteria)



Control soil
Original soil of the park

Sampling & analyses

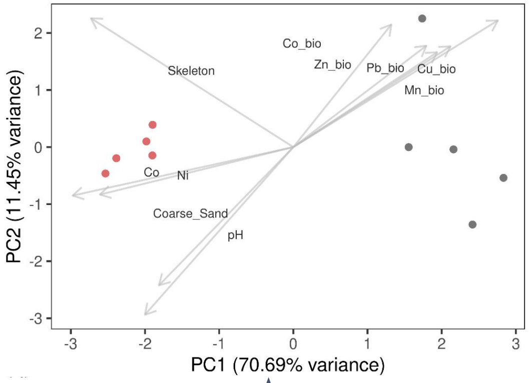
Five 16 m^2 plots by condition

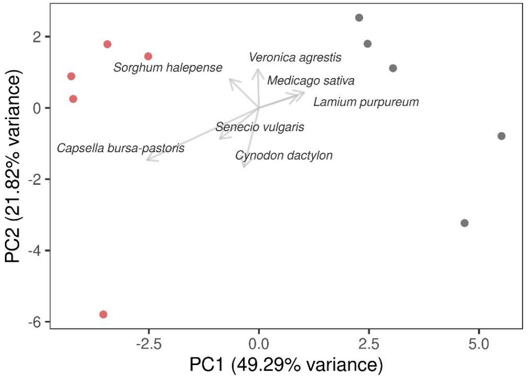
Soil analyses
- Texture
- pH
- Macro/Microelements
- Heavy metals

Vegetation assessment
- Cover
- Composition
- Relative abundance

Topsoil DNA extraction
Metagenome sequencing

Bioinformatic analyses
Integration of all data

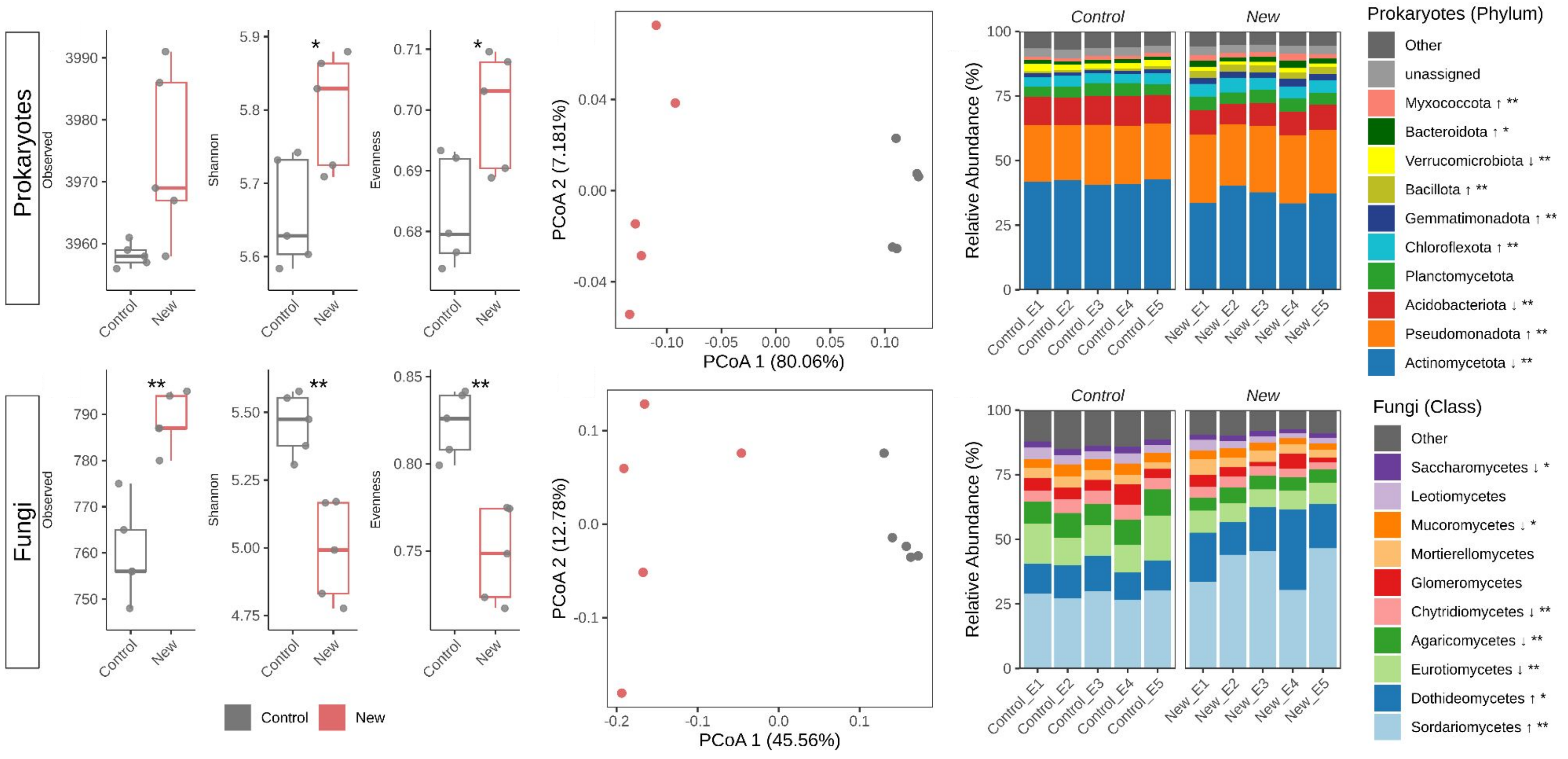




Impact on microbial communities diversity and assembly

Prokaryotic **diversity** higher in “New” soil with a more **uniform** distribution of species

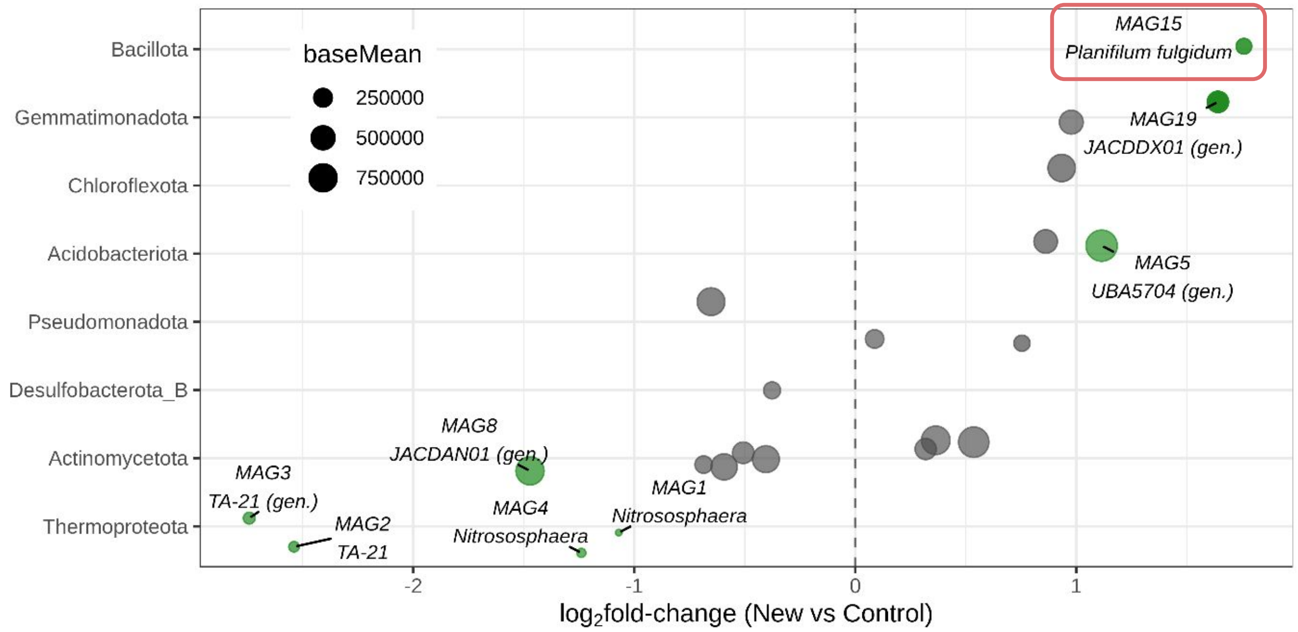
Conversely, significantly lower Pielou’s **evenness** values for fungi, highlighting that few taxa dominated the community in the “New” soil

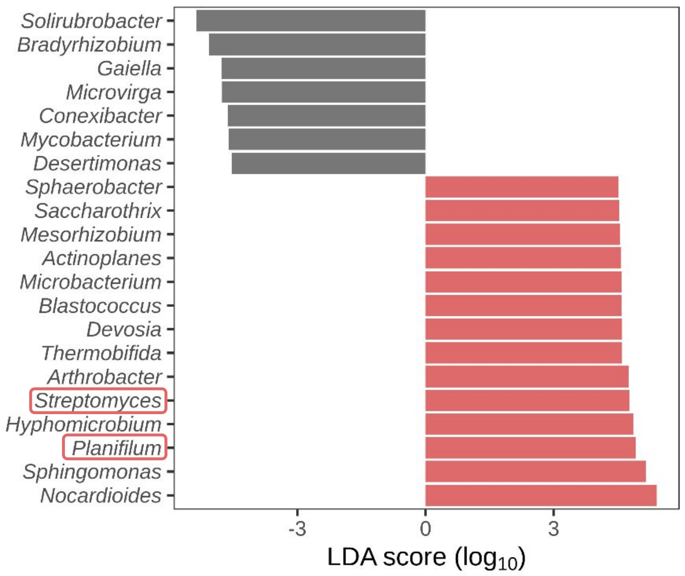


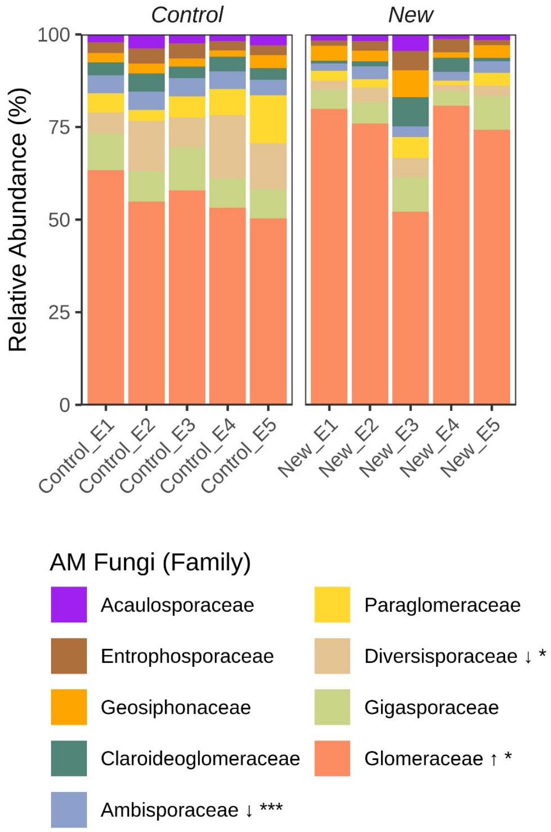
Chialva, Masson et al., Submitted

For both communities, soil type had a significant impact on the **community compositional profiles** (PERMANOVA, $p<0.01$, 9999 permutations, 79.16% and 43.16% variance explained, respectively)

Impact on microbial communities diversity and assembly





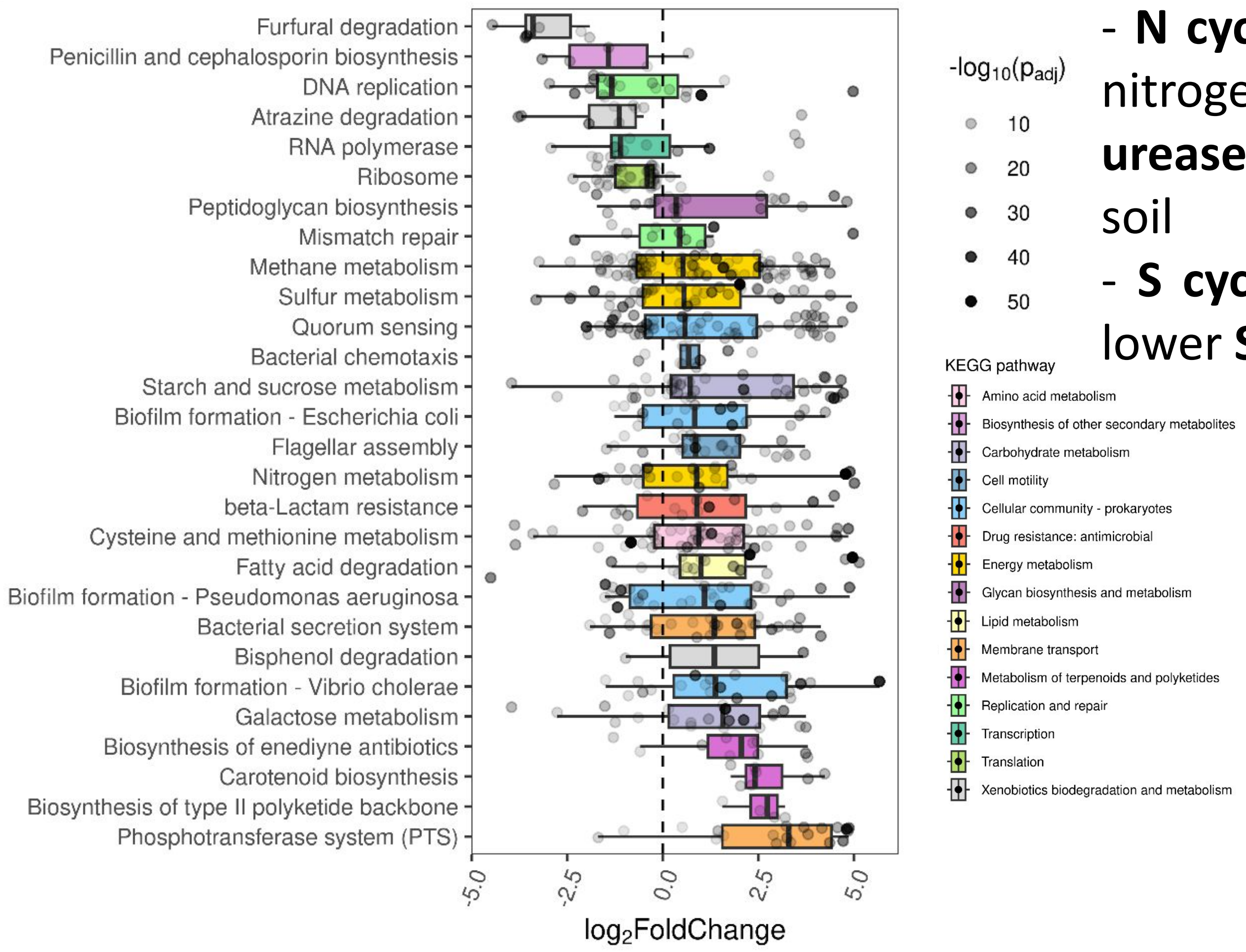


Chialva, Masson et al., Submitted

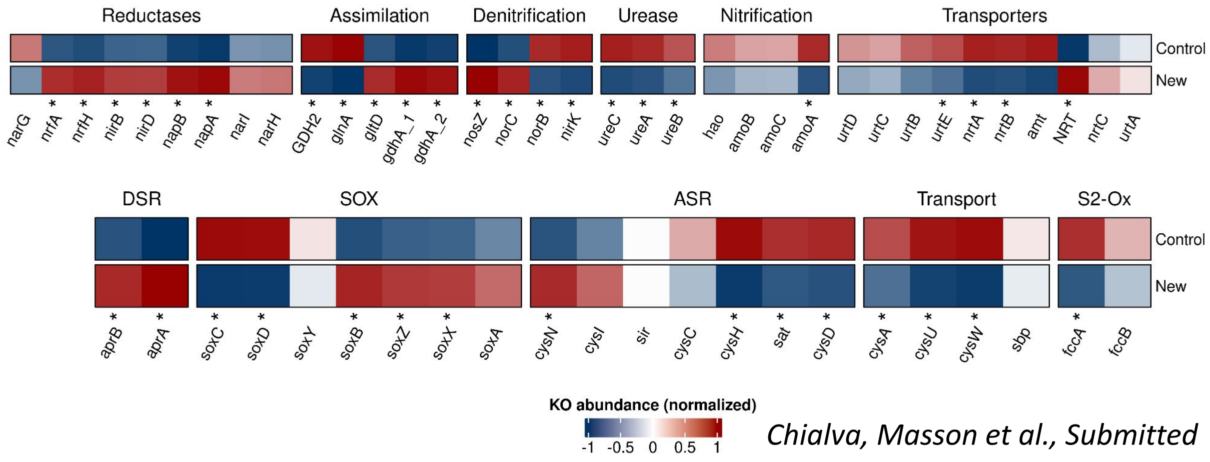
Among the Metagenome Assembled Genomes (MAGs) enriched in “New” soil: ***Planifilum fulgidum*** (Bacillota, MAG15, completeness 89.6%, contamination 1.8%), a species previously isolated from **compost**

Some components of the initial **microbial inoculum**, such as ***Streptomyces*** genus or **Glomeraceae** family, seem to persist after the 3 years

Impact on microbial functional profiles



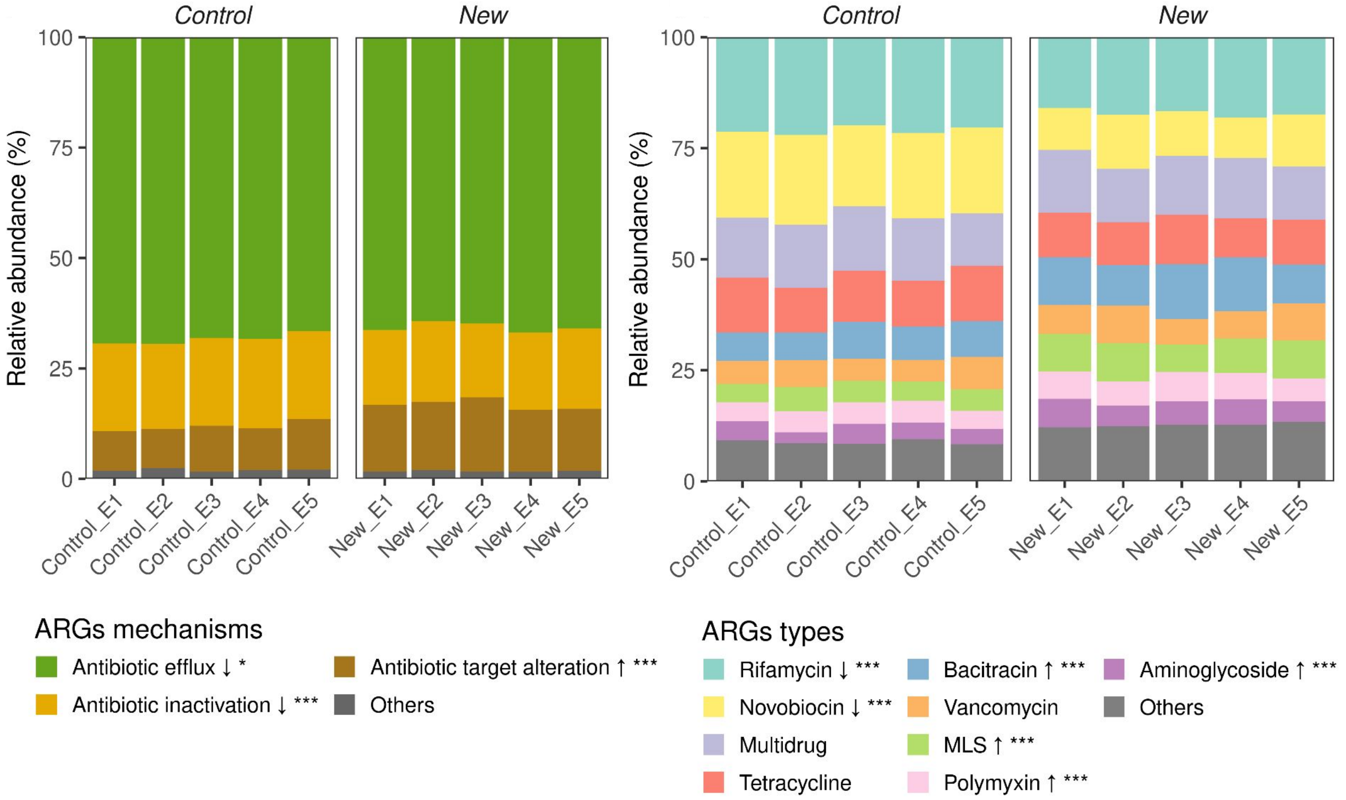
- **N cycle**: Higher abundance of orthologs involved in reducing nitrogen compounds (**reductases**) and lower abundance of **ureases**, **nitrification** and **transporter-encoding-genes** in "New" soil
- **S cycle**: higher **dissimilatory reduction** and **S oxidation** but lower **S^{2-} oxidation** and **assimilatory reduction** in "New" soil



Chialva, Masson et al., Submitted

Differential abundance analysis (DESeq2, FDR<0.05) at KO level: **higher number of enriched genes** in the "New" soil condition => KOs mostly belonging to **energy** and **macronutrients metabolism**, some **secondary metabolism** pathways, and **biofilm formation** and **flagellar assembly**

Impact on Antibiotic Resistance Genes (ARGs-OAP)



Chialva, Masson et al., Submitted

Difference in **mechanisms**: less inactivation and efflux and more target alteration in the "New" soil

Among the **targeted types**: less Rifamycin and Novobiocin resistances but Bacitracin, Macrolides/Lincosamides/Streptogramins (MLS), Polymyxin, and Aminoglycoside resistances more abundant in the "New" soil

Conclusions

- **The constructed urban technosol drives microbial community assembly**

- **Inoculated microbial consortia seem to persist years after their application**

- **Soil biogeochemical cycles and functioning are impacted by the constructed urban technosol**

Thanks to

My tutor: Luisa Lanfranco, and my colleagues involved in this project: Matteo Chialva, Valentina Fiorilli, Davide Bongiovanni, Cristina Votta, Elena Barni, Irene Stefanini, Federica Larcher, Elio Padoan…

… for support, soil and data collection,
DNA extraction, preparation and dispatch, data pre-processing,
scripts and bioinformatics help, reading, corrections…

and YOU for your attention :)

Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.4 - Call for tender No. 3138 of 16 December 2021, rectified by Decree n.3175 of 18 December 2021 of Italian Ministry of University and Research funded by the European Union – NextGenerationEU; Award Number: Project code CN_00000033, Concession Decree No. 1034 of 17 June 2022 adopted by the Italian Ministry of University and Research, CUP D13C22001350001, Project title "National Biodiversity Future Center - NBFC"

An optimal recipe for constructed soil?
A review

Julia Oblin, Sophie Joimel, David Montagne, Laure Vieublé Gonod

SUITMA13 - 6-8 october 2025

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SUITMA 13 PISA 2025

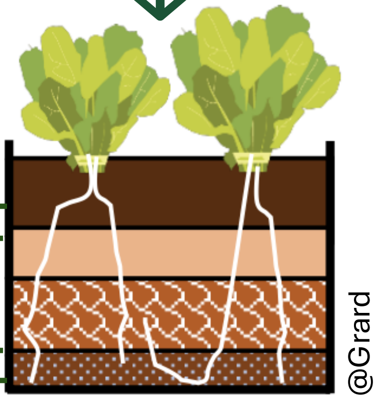
Degraded soils

60 à 70 % of European soils **degraded**

Characterize soil threats

Preserve soils

Restore degraded soils



Constructed soils

Horizons ?

Thickness ?

Composition ?

Is there an optimal recipe for constructed soils ?

Data acquisition : ROSES process *(Haddaway et al. 2018)*

Identification – Selection of publications

Web of Science (november 2023)

Anthropized soils ← **Technosoil* OR Technosol* OR Anthroposoils* OR Anthroposol***

AND

Artificialized soils intentionally ← **manufactur* OR construct* OR build* OR built* OR "man-made soil*" OR "engineered soil*"**

Selected publications (N_P = 97)

Constructed soils data extraction

Constructed soils described (N_{CS} = 578)

Redundancy management

Different constructed soils (N_{CS} = 427)

Horizon data extraction

Horizon characterization (N_H = 599)

Constructed soils :
Any superposition of one or more layers (horizons) of particular thickness or composition

Horizon :
Any assembly of organic and inorganic waste or products, alone or mixed in particular proportions

Soil profile

Publication date

Location

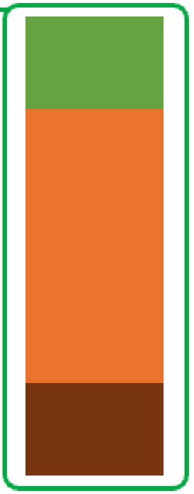
Context

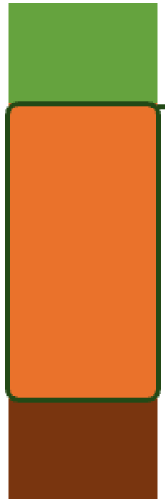
End of use

Type of experiment

Total number of horizons

Total thickness





Horizon

Type

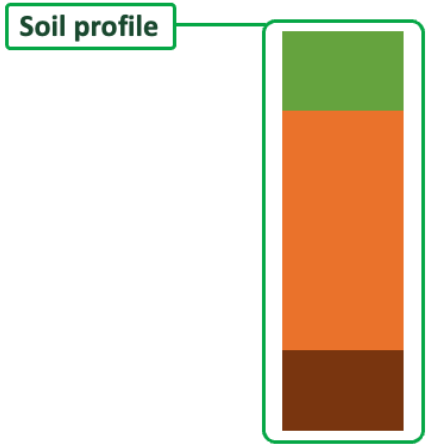
Thickness

Number of materials

Type of materials

Proportions of materials

Data acquisition : ROSES process *(Haddaway et al. 2018)*



Data extraction

Soil profile

Publication date

Location

Context →

End of use

Type of experiment

Total number of horizons

Total thickness

Coastal developments

Urban developments

Rehabilitation of brownfield

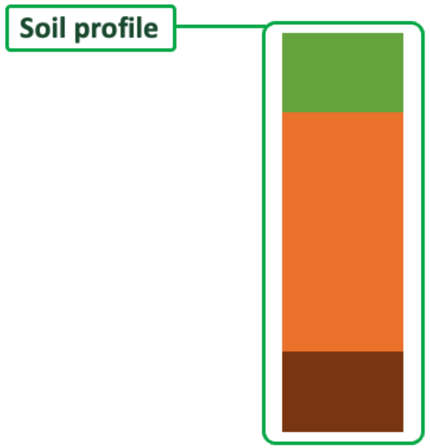
Multiple purposes

No informations

5 categories to characterize the context in which the soils are constructed

Rodriguez-Espinosa et al. 2021

Data acquisition : ROSES process *(Haddaway et al. 2018)*



Data extraction

Soil profile

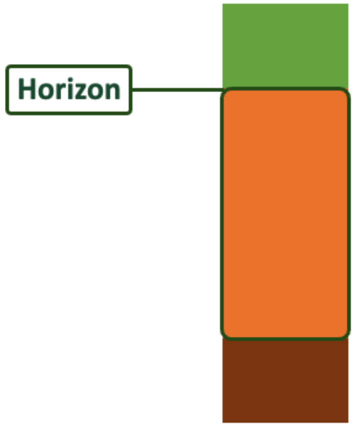
- Publication date
- Location
- Context
- **End of use**
- Type of experiment
- Total number of horizons
- Total thickness

End of use →

- Forests
- Semi-natural environments
- Field crops
- Other crops
- Urban green spaces
- Open spaces for sports
- Other open spaces
- Multi-use
- No information

9 categories to characterize the planned land-uses of the constructed soils

Data acquisition : ROSES process *(Haddaway et al. 2018)*



Data extraction

Horizon

Type

Thickness

Number of materials

Type of materials

Proportions of materials

→ 3 types of horizons defined by their functions

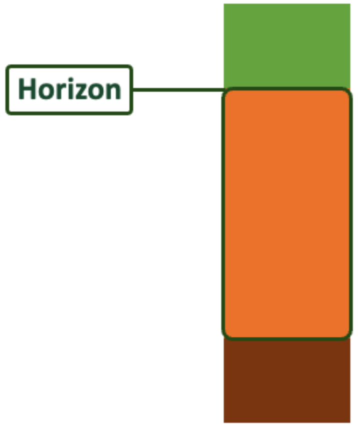
Growth : allow germination and initial plant development

Development : allow root development and provide mineral and water nutrition as well as anchorage

Technical : ensure water managment by draining excess water or providing additional storage

Damas and Coulon, 2016

Data acquisition : ROSES process *(Haddaway et al. 2018)*



Data extraction

→ 3 materials families for 7 materials types

Horizon

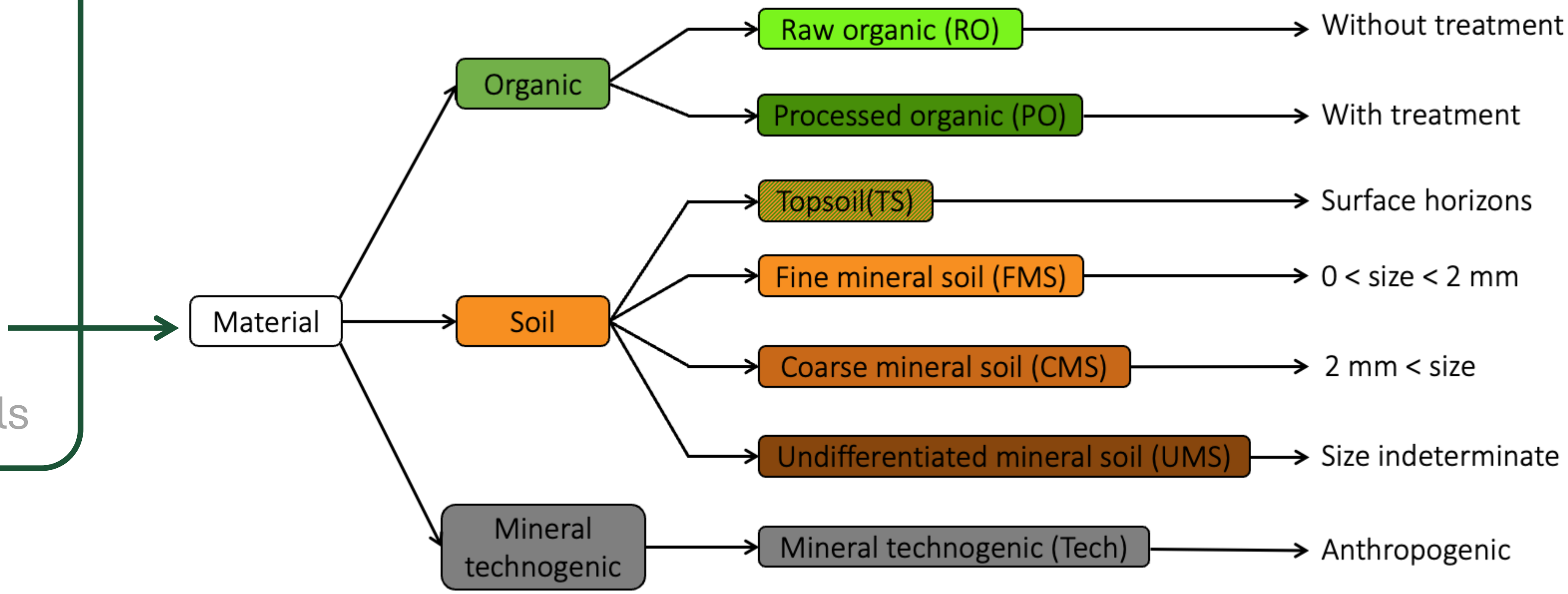
Type

Thickness

Number of materials

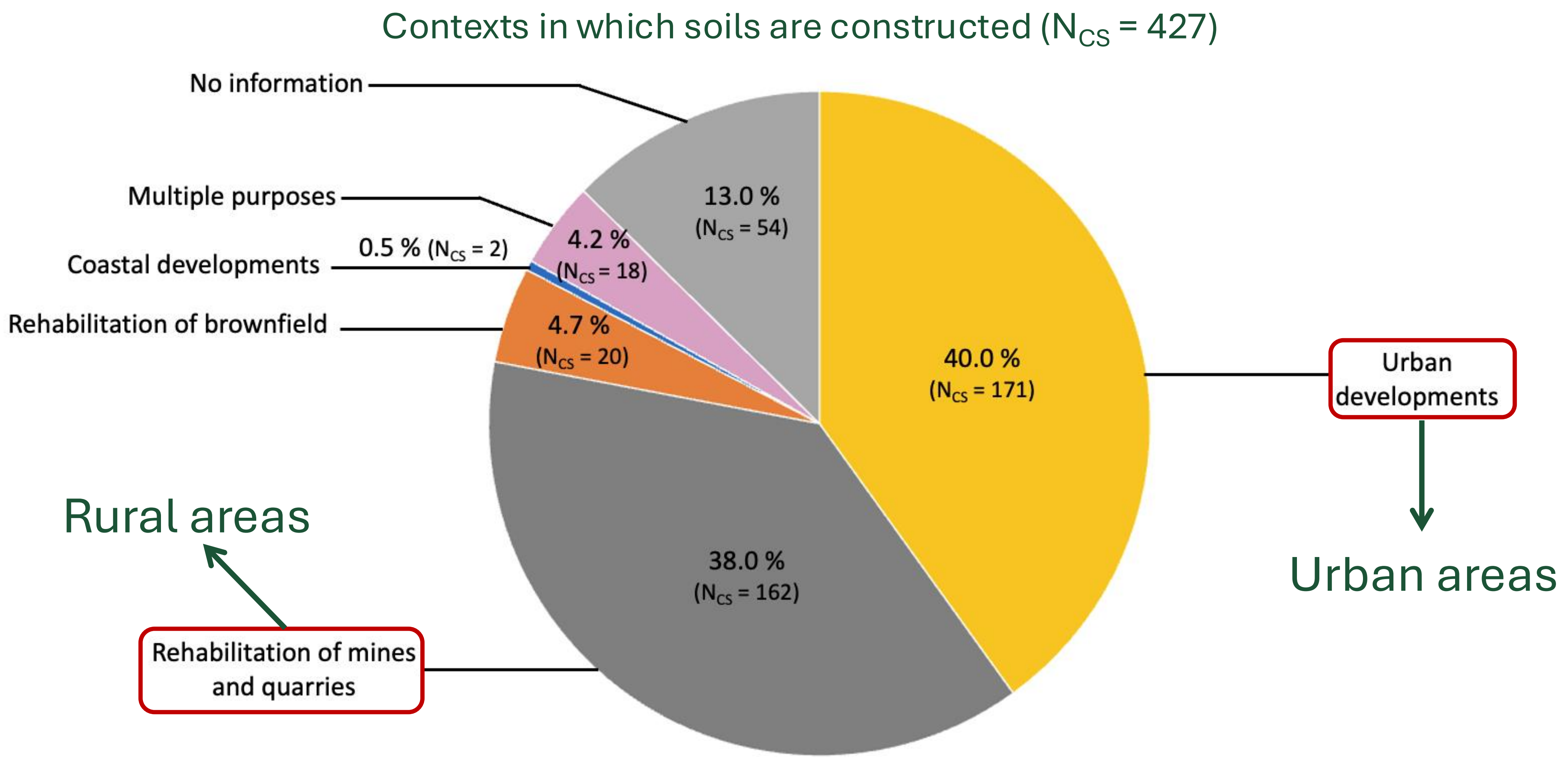
Type of materials

Proportions of materials



Damas and Coulon, 2016 ; Deeb et al. , 2020 ; IUSS Working Group WRB, 2014

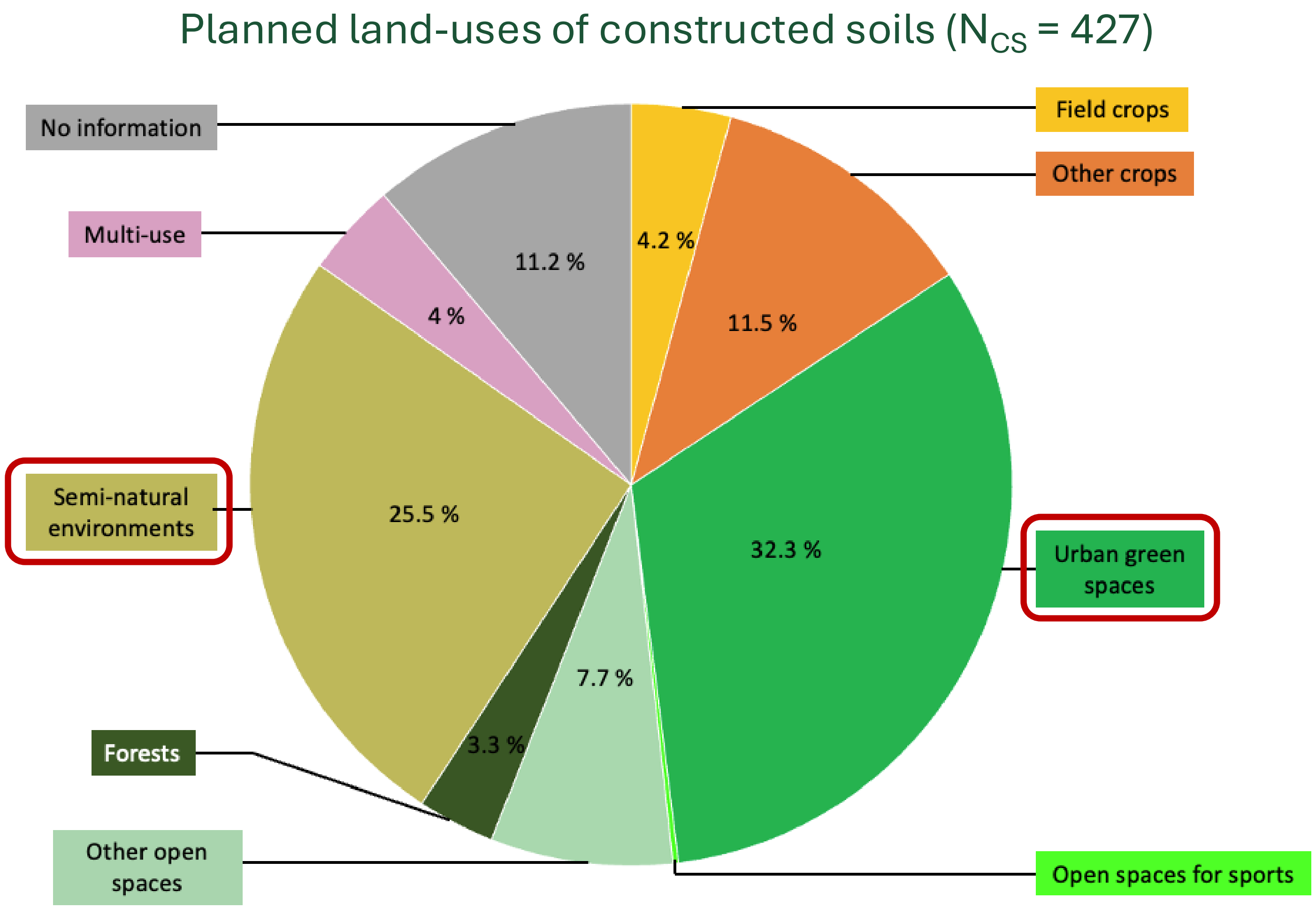
Various construction contexts



2 dominants contexts representing 80% of the CS
→ Majority of soils localized in urbanized, industrial and mining activities countries (France, Italy, USA) *(Mcallister and Milioli, 2000 ; Shaw et al., 2020)*

Oblin et al. in prep.

Various planned land uses of constructed soils



2 dominants land uses representing 66%

→ **Use of mining waste easier in semi-natural area** *(Ahirwal and Maiti, 2018)*

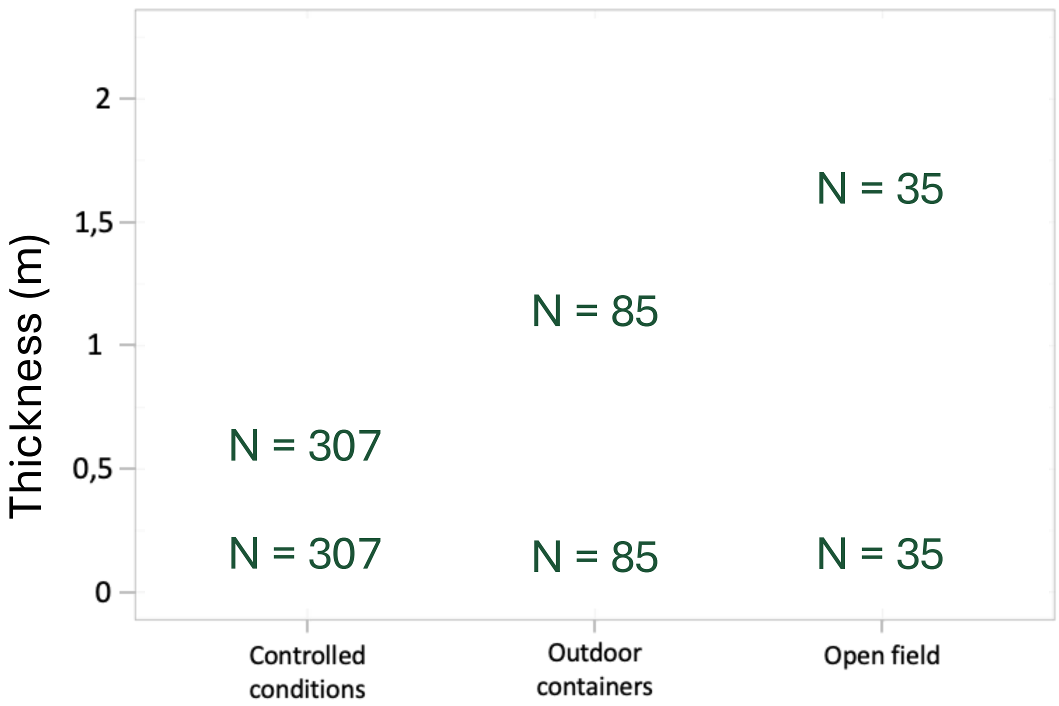
→ **Green spaces most popular and developped in urban space** *(Kabish and Haase, 2014)*

Oblin et al. in prep.

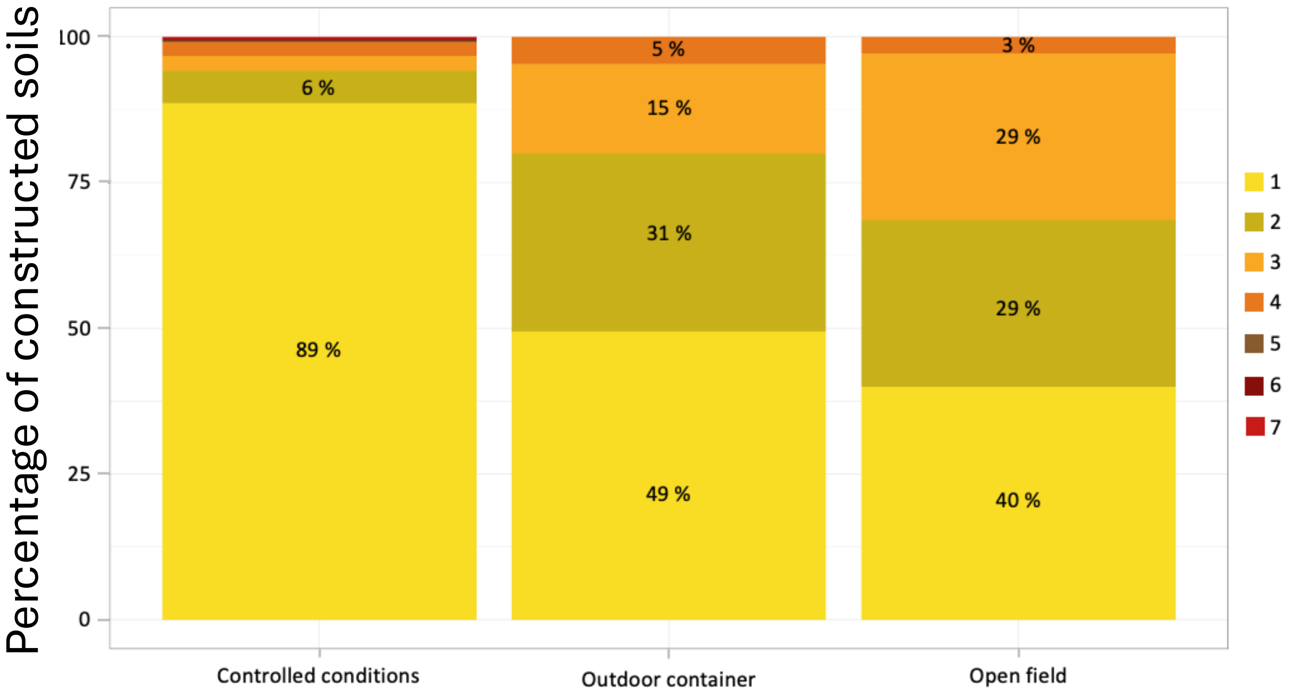
Characterization of constructed soils (CS) and their horizons

$N_{CS} = 427$

Average thickness of CS according to experimental conditions



Percentage of CS according to experimental conditions and number of horizon



Controlled conditions:
- **many experiments**
- **tens of cm-depth**
- **single horizon**

→ Study of precise mechanisms, limited space, easier monitoring *(Aran et al., 2018 ; Prado et al., 2020 ; Rees et al., 2020)*

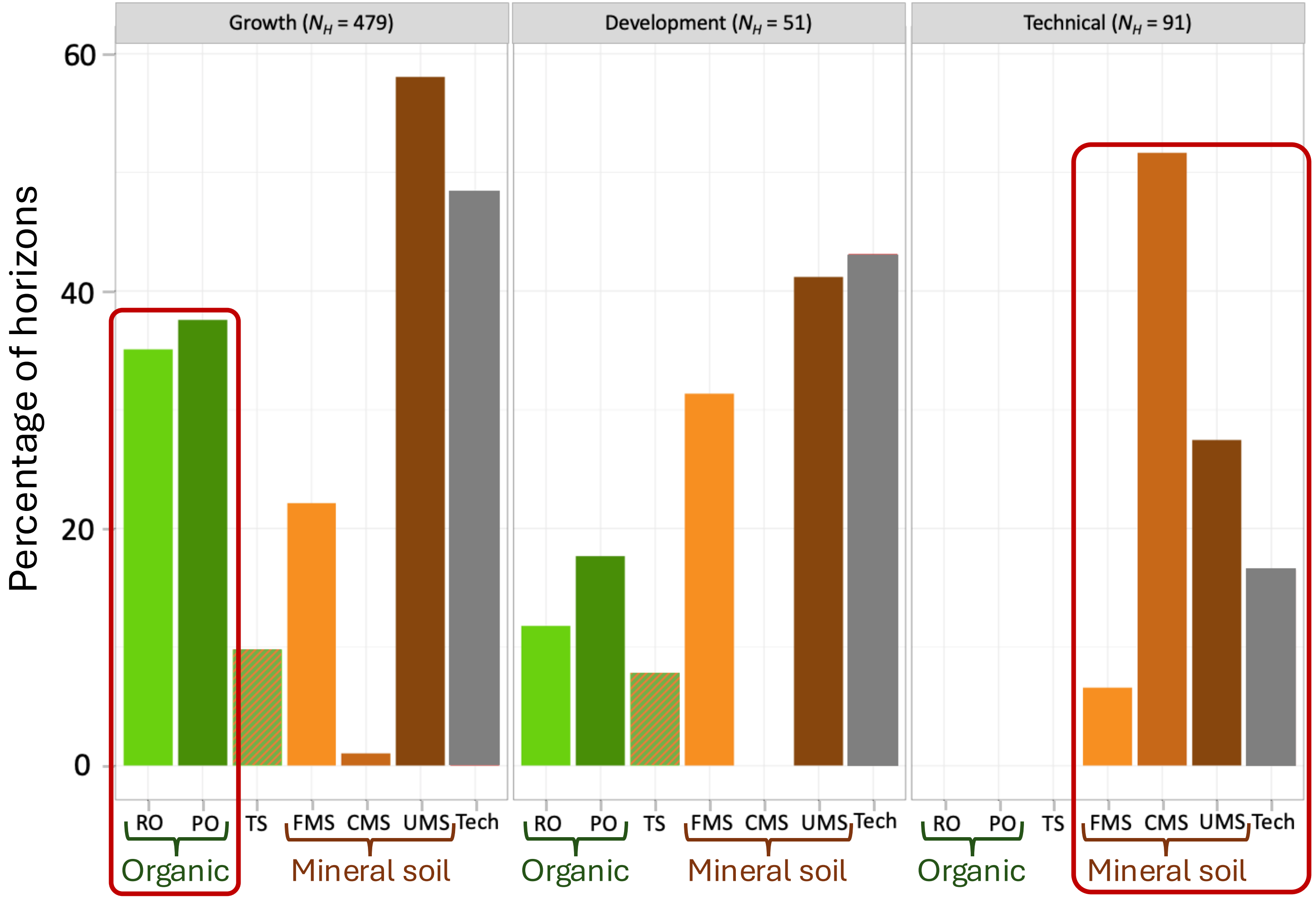
Open field :
- **few experiments**
- **one meter-depth**
- **complex horizonation**

→ Recent applications, complex implementation, more space and materials *(Grard, 2017)*

Oblin et al. in prep.

Characterization of materials used

Nature of materials used in the 3 types of horizons (N_H = 599)



Materials

- RO : raw organic
- PO : processed organic
- TS : topsoil
- FMS : fine mineral soil
- CMS : coarse mineral soil
- UMS : undifferentiated mineral soil
- Tech : mineral technogenic

Organic: RO, PO. Mineral soil: FMS, CMS, UMS, Tech.

OM in growth horizons
→ Growth conditions required to mimicking the O horizon of the soil *(Damas and Coulon, 2016)*

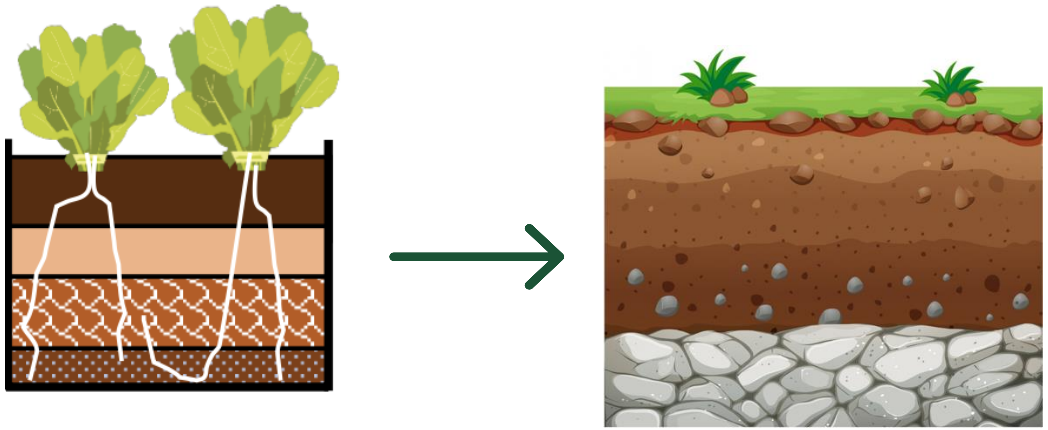
Mineral soil in technical horizons
→ Characteristics necessary for drainage and anchoring *(Damas and Coulon, 2016)*

Diversity of materials used and tested
→ Few waste ratios have been well investigated and step required to develop pedological engineering *(Rokia et al. 2014)*

Oblin et al. in prep.

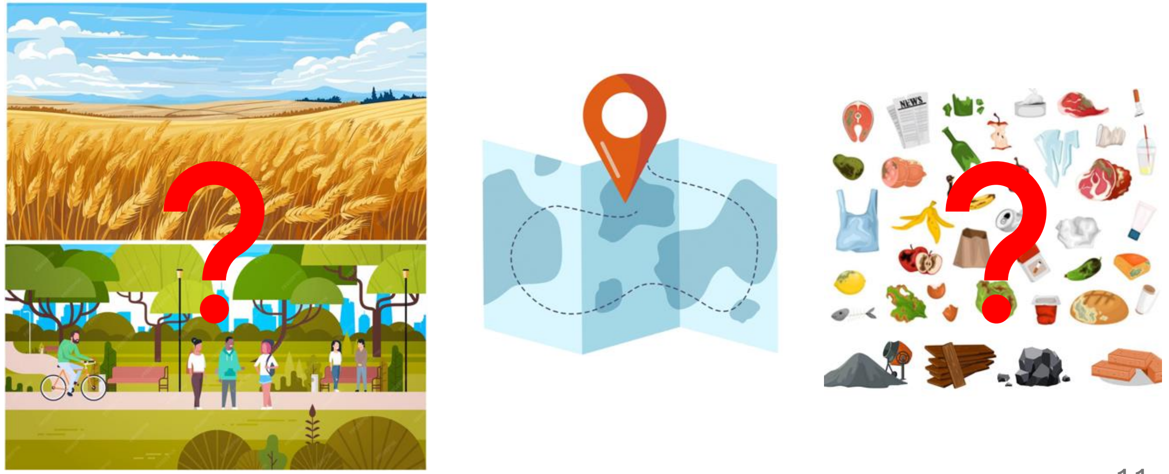
State of scientific knowledge on construction

- **Controlled condition VS real conditions**



- **Optimal recipe aims to mimic natural soils**
  - → Horizonation
  - → Soil thickness
  - → Organic matter concentrated in surface horizon

- **This recipe must be adapted according to**
  - → End of use
  - → Geo-pedo-climatic context
  - → Local availability of materials



Thank you for your attention

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Circular Economy and Urban Gardens: Formulations of Local Inorganic and Organic Waste to Minimize Harmful Trace Elements Exposure and Pollution

Medina Veliu, Giuseppe Picca, Martin Guillon, Nadège Caubrière, Nazaret Ocaña-de Nova, Rocio García-Montero, Marco Panettieri, Laetitia Pineau, Liliane Jean-Soro, Johnny Gasperi, Denis Courtier-Murias

Pisa, 6th October 2025

Funded by the European Union

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1 – Introduction and objectives

By 2050,
68 %
of the global population in cities

More green spaces

Urban Agriculture

Peat reduction

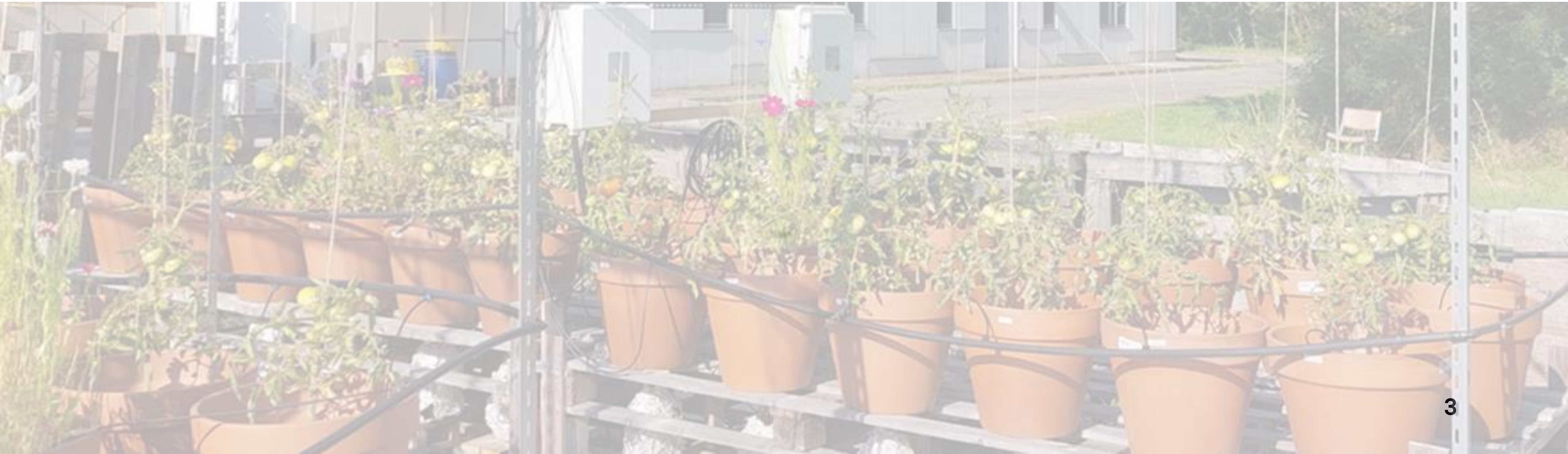
Circular economy

Local waste

Pollution

2 – Research questions

- Are locally available materials suitable for alternative growing substrates?
- Up to which ratio is the peat substitution safe in substrates and edible crops?



2 – Materials and methods

Local materials selection for growing media

- Increased urban population and urbanisation
- High production of CD waste
- CD waste to be re-employed at 70 % (French norms)

compostri

Waste management company

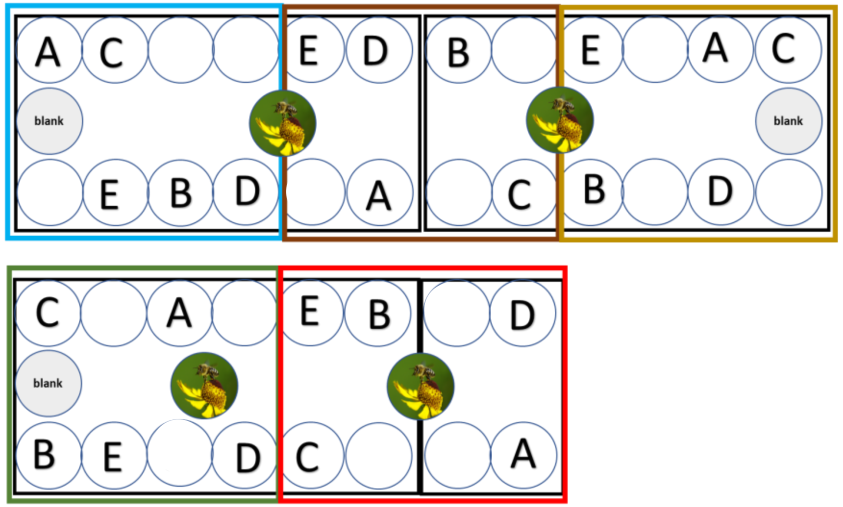
2 – Materials and methods

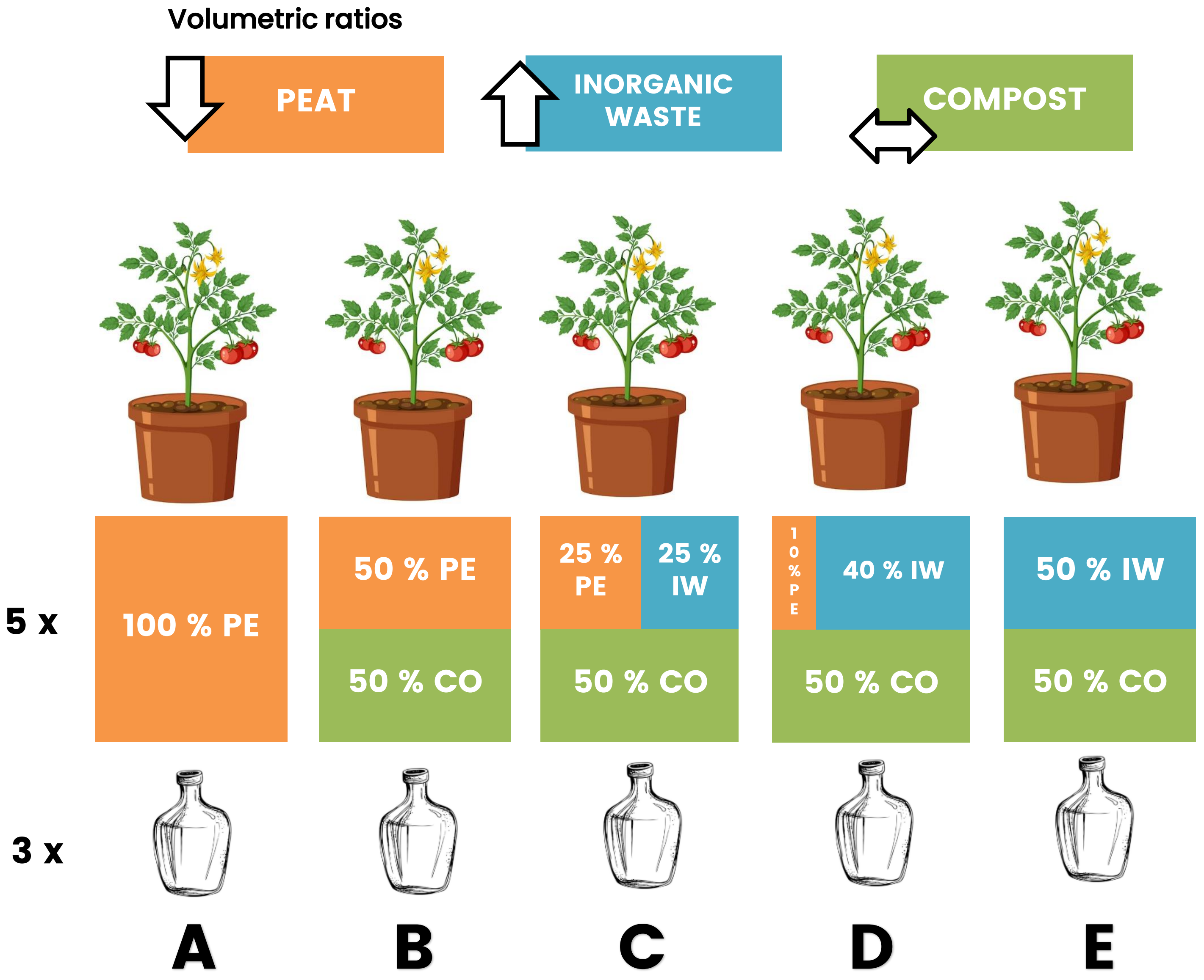
Tomato plant cultivation

- *Solanum lycopersicum*, Marmande variety
- 1 summer season (June – September 2024)
- No additional fertilization

+ 3 blank pots as control

Randomly disposed pots (5 blocks x 5 replicates)





2 – Materials and methods

Tomato fruit
Productivity
TEs

Tomato plant
TEs

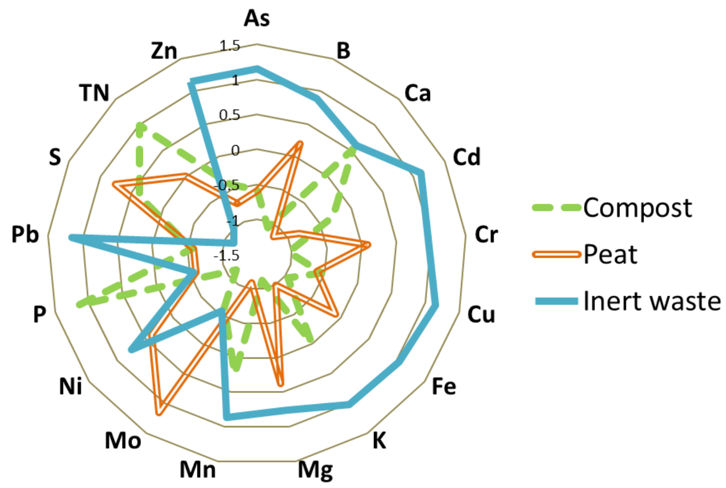
Substrate (T0 and T4)
Bulk Density
pH and EC
TEs

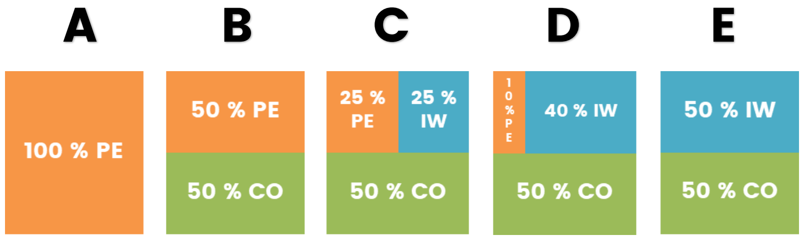
Tomato roots
TEs

Leachate (4 months monitoring)
Volume
pH, EC
TEs

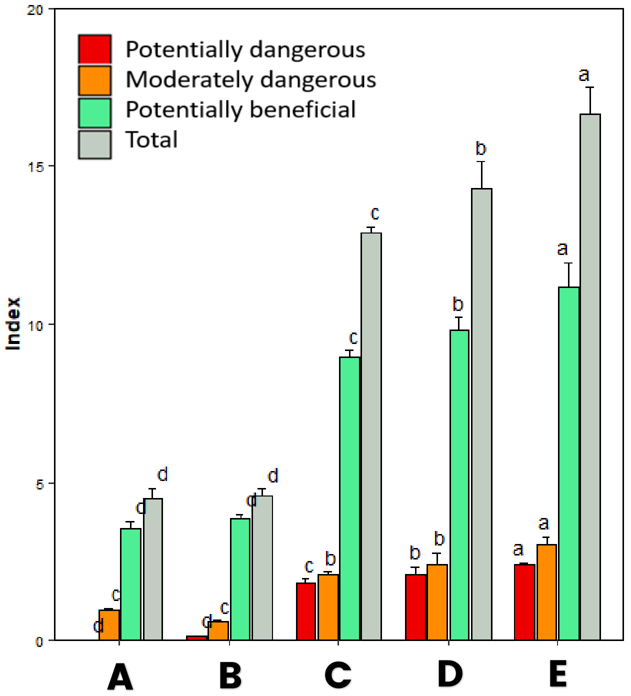
3 – Results: Raw materials and substrate mix

Raw materials

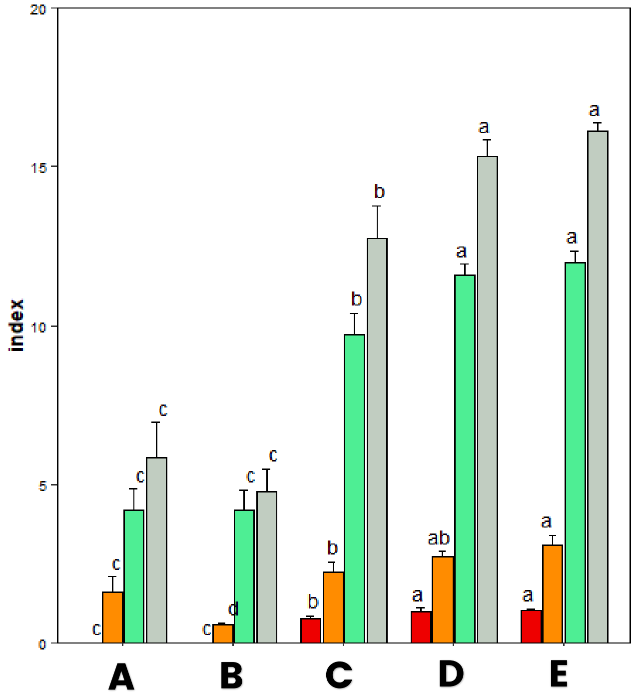




Substrate T0



Substrates T4



pH: from 6 (A) to 8.4 (E)

EC (µS/cm): from 769 (A) to (E)

BD (g/cm^3): from 0.14 (A) to 0.53 (E)

Increase of pH, BD, TEs

Decrease of EC (50%)

NF U44-551

D, E > 100 mg/Kg Pb

NF U44-551

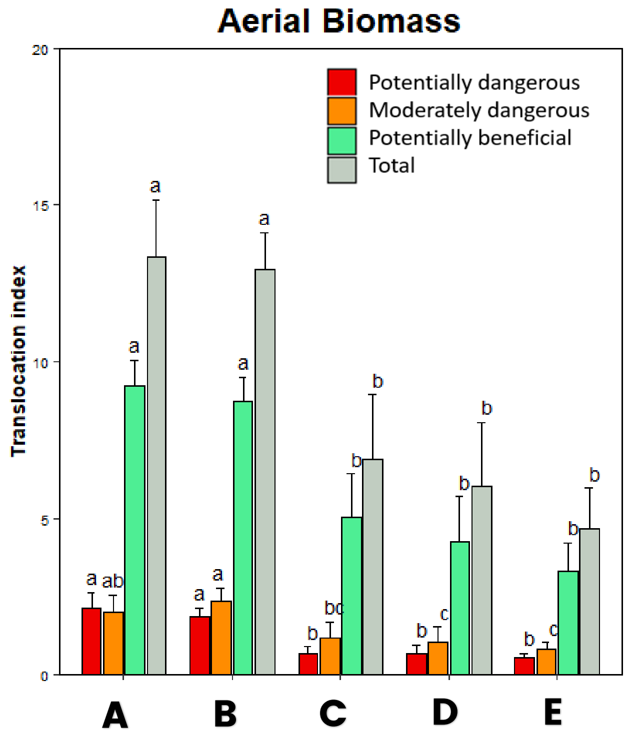
C, D, E > 100 mg/Kg Pb

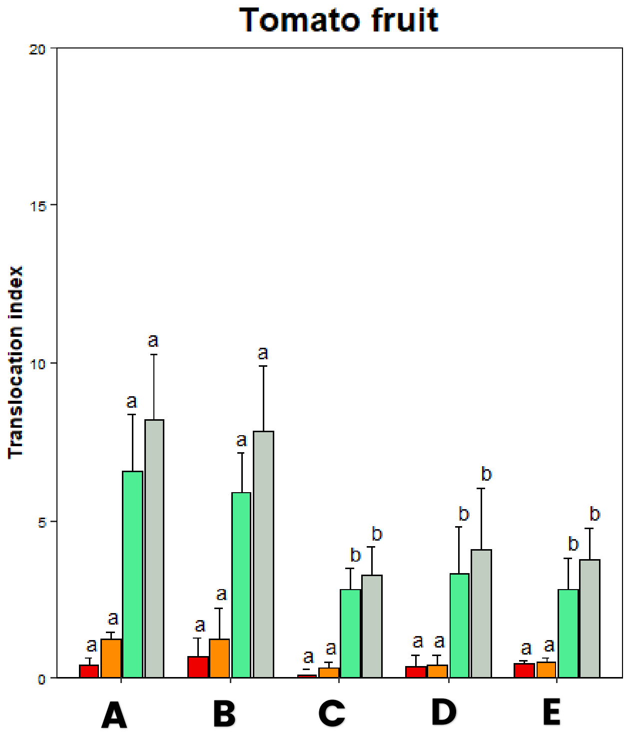
3 – Results: Tomato biomass

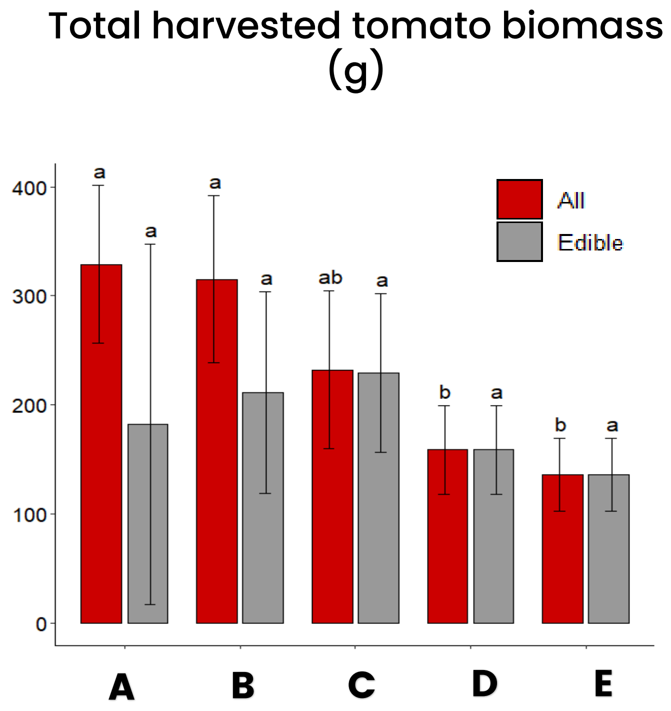
Potentially Dangerous **(PD):** As, Cd, and Pb,

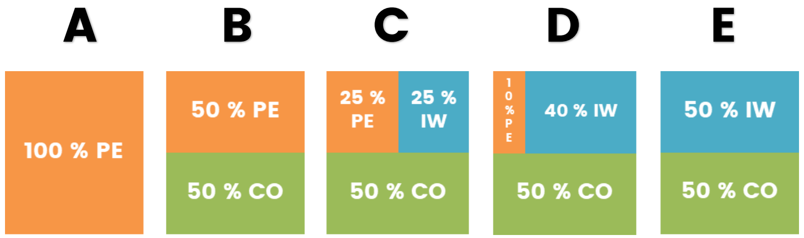
Moderately Dangerous **(MD):** Cr, Mn, Ni, and V

Potentially Beneficial **(PB):** Al, B, Ba, Ca, Co, Cu, Fe, K, Li, Mg, Mo, Na, P, S, Sr, Zn



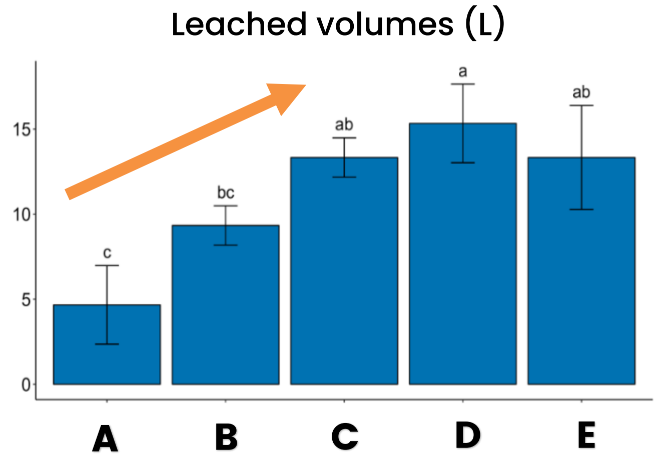


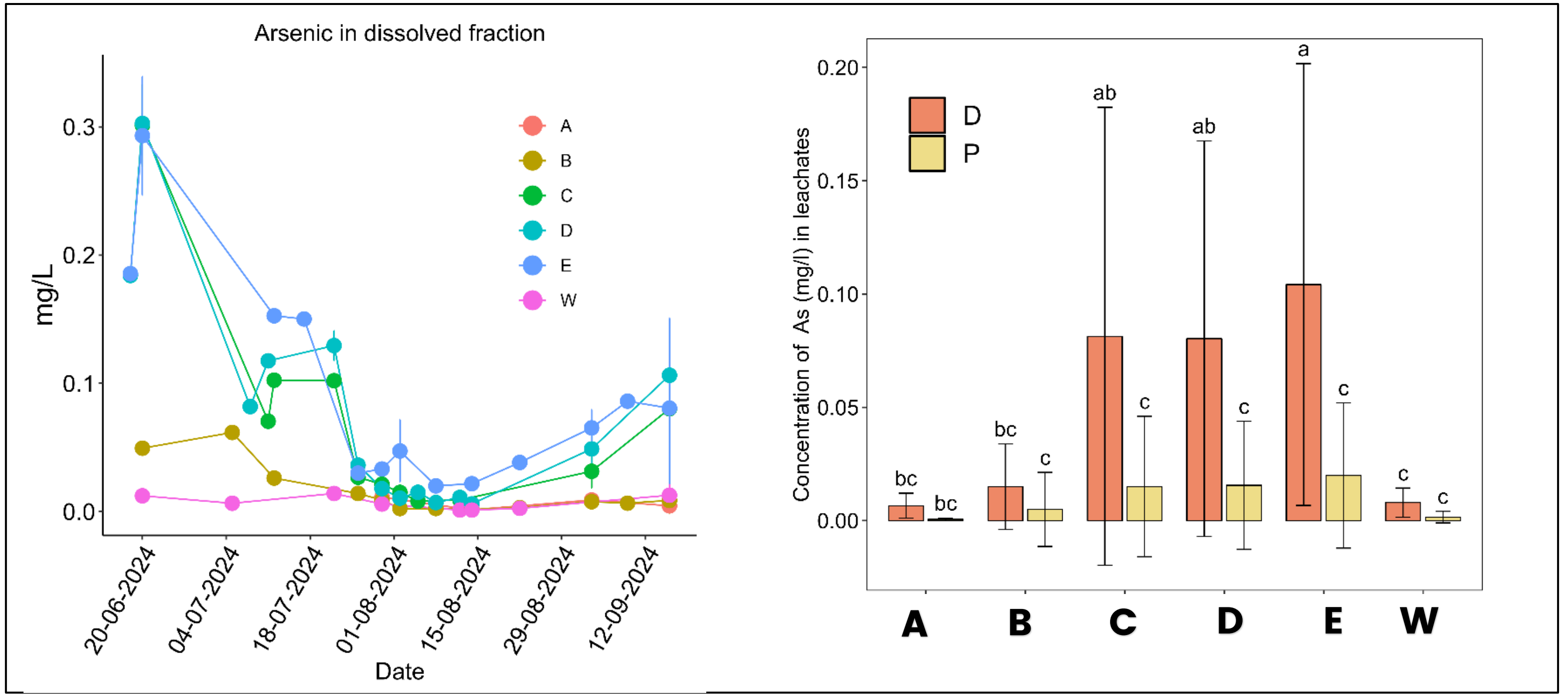




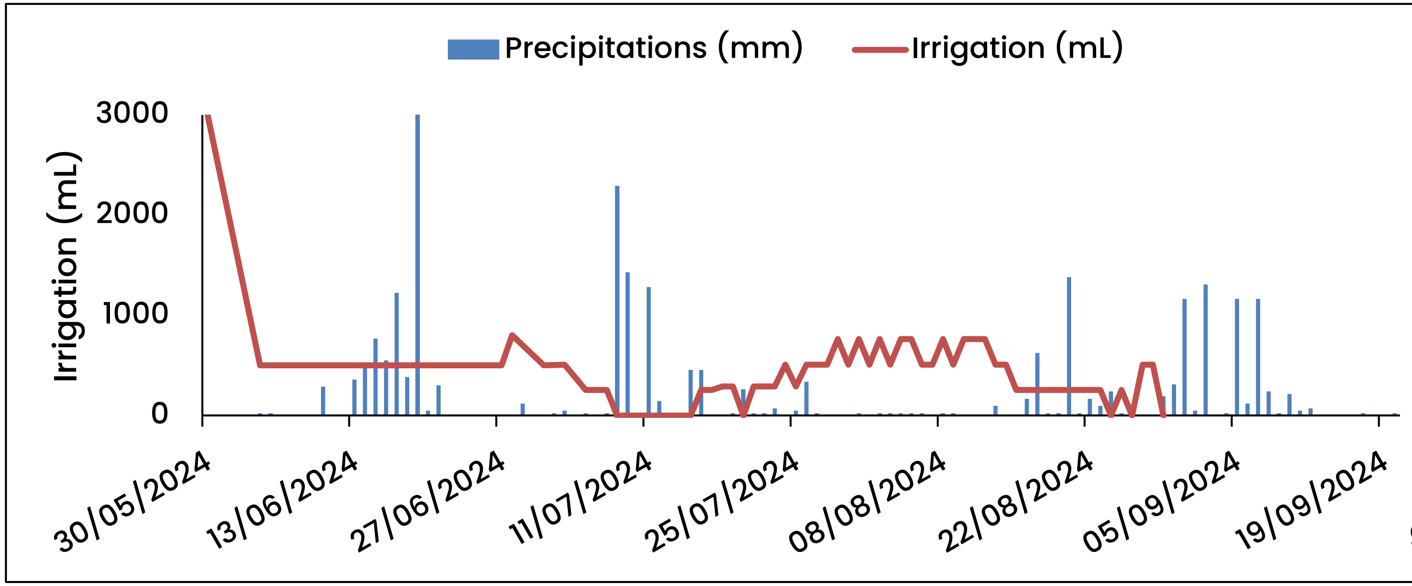
Cd and Pb concentrations below EU limits (<0.05 mg/Kg FW)

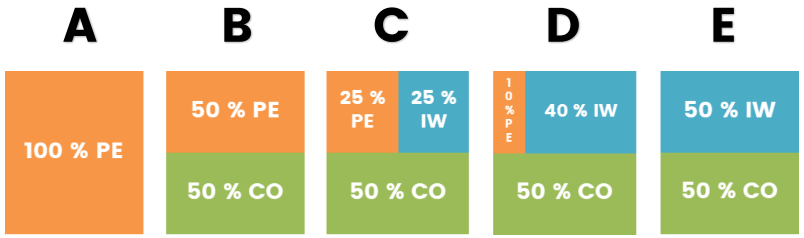
3 – Results: Leachates





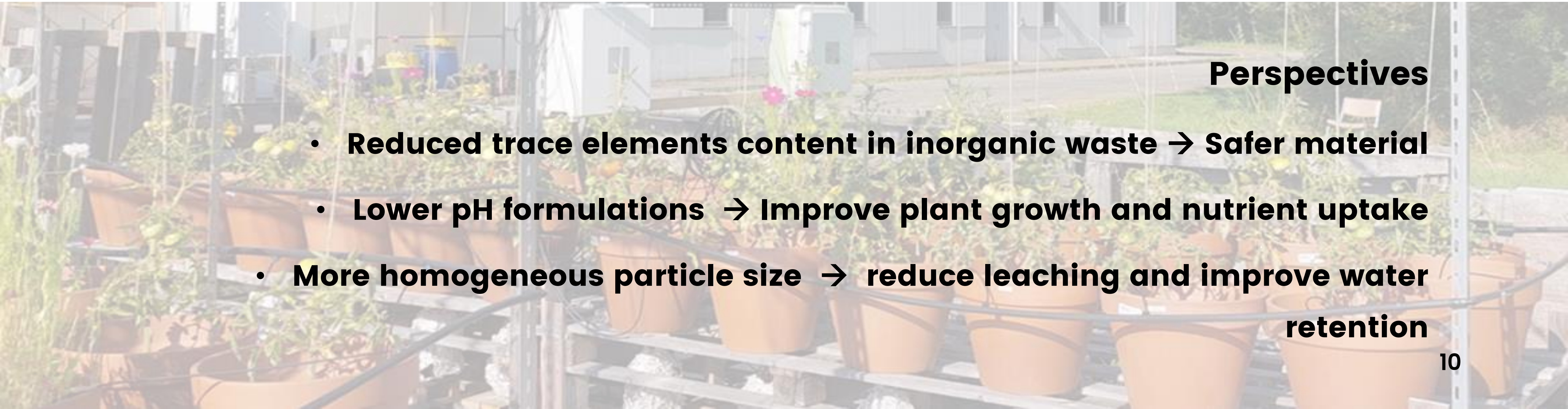
- Higher leachate production could contribute to nutrients and trace elements levels in cities
- Overall reduction of most parameters from T0 to T4





4 – Conclusions

- **Inorganic waste** addition acceptable **at 25 %** (at T0, substrate C below NF U44-551 limits)
- Basic pH of substrate mixtures (> 8)
- Substrate parameters changed after 4 months → Pb limits exceeded also for substrate C
- Inorganic waste reduced tomato production
- **Cd and Pb levels were always below EU limits for fresh fruits**



Perspectives

- **Reduced trace elements content in inorganic waste → Safer material**
- **Lower pH formulations → Improve plant growth and nutrient uptake**
- **More homogeneous particle size → reduce leaching and improve water retention**

Take home messages

- Progressive peat substitution tested
- At T0, substrate mix with **peat at 25 %, inorganic waste 25 %** and **compost 50 %** within NF U44-551 **limits** (French growing media norm)
- After **4 months,** substrates **evolved** in pH, EC, and TEs content (limits exceeded for Pb)
- The **high pH** of compost and inorganic waste **reduced TEs uptake**
- **Cd and Pb levels** in tomato fruits were always **below EU limits**

Questions?

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