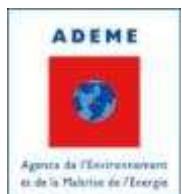




# FROM WASTE TO FERTILE TECHNOSOL THE CIRCULAR APPROACH OF THE FRENCH RESEARCH PROJECT SITERRE

Laure Vidal-Beaudet AGROCAMPUS OUEST  
for the Consortium Siterre



# Urban context and problematic

→ The urban ecosystem presents a « linear metabolism »

Raw materials :

**782 Mt used in 2012  
in France**

- Construction (e.g. wood, bricks, metals, petrol and gas)
- Urban greening (e.g. *arable earth, aggregates quarry*)



- Decrease export outside the town
- Reused the waste as second raw materials

?

This « linear metabolism » must evolve to a « CIRCULAR METABOLISM »

→ Management policies must promote the best way to mimic natural ecosystems and favor circulation and reusing of resources in city.

# A need for vegetation in cities ?



Social and environmental demand of citizens for closeness of nature, improvement of quality of life, local agriculture, urban agriculture

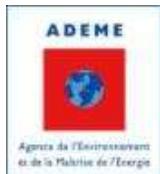


Cities must develop greening and renaturation strategies whose success depends on the quality and functions of soils supporting vegetation.

January 2011 - december 2015

Following objectives

- (i) to find substitutes for arable earth and quarry stones with local materials resulting from the urban activity and demolition of urban structures (**by-products and wastes**),
- (ii) to optimize the valorization of **wastes resources**.



French Environment and Energy Management Agency  
(ADEME)

## QUESTION ?



Is it possible to **create fertile substrates**, which mimic natural soils, **exclusively with wastes to produce urban biomass?**

# 1- Inventory of the main urban land uses for greening the cities

Based on the land use typology of the French urban landscape services

Type of land uses	Soil typology
Squares and parks	Horticultural soils
Support of traffic lanes	Technical constructed soils
Support of public building	Soil amended
Designed natural spaces	Native soils or transported soils
Street trees	Constructed soils, pit soils

→ 2 model land uses of « green space » :

square and park



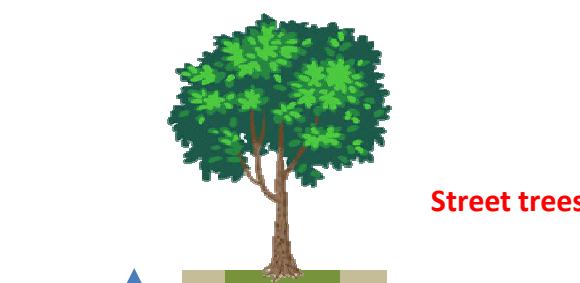
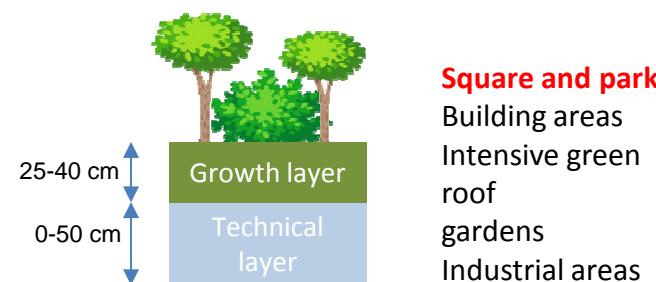
Street trees



## 2- Profiles and properties expected of the constructed soils

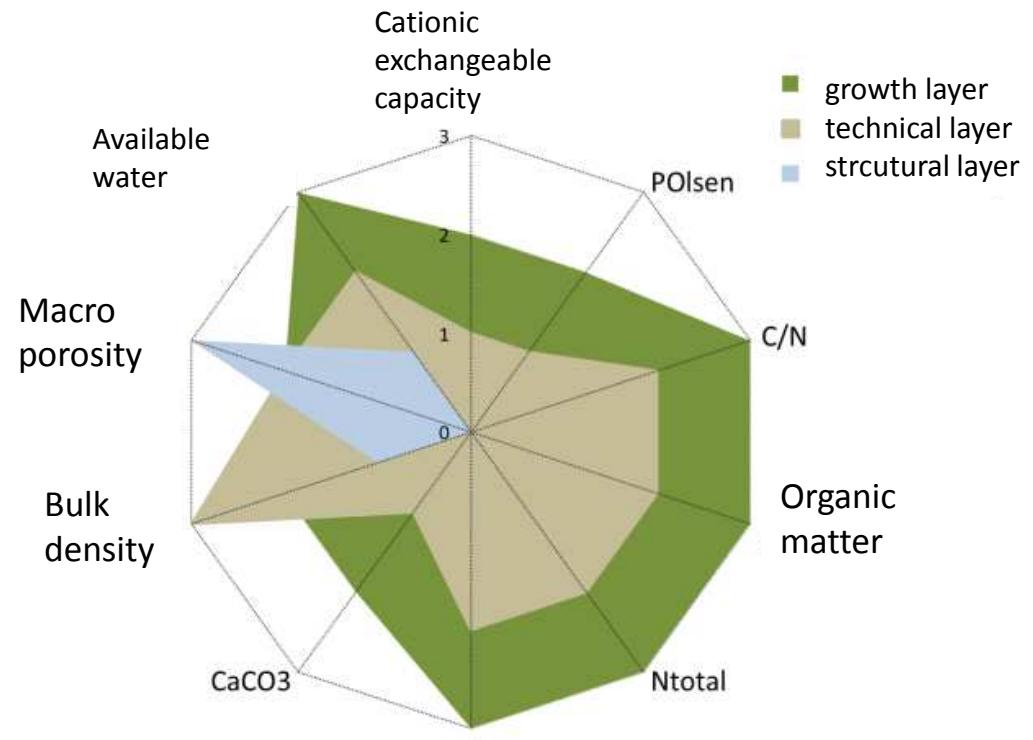
### Constructed soil design?

#### Number and type of layers



### Soil layer fertility → Expected parameters ?

- 3 parameters of physical fertility
- 7 parameters of bio-chemical fertility



### 3- Alternative selected materials

EUROPEAN WASTE CATALOGUE (836)

Eliminatory  
filters

11 MODEL WASTES



track  
ballast



concrete



bricks



demolition  
rubble



excavated  
basic soil

6 « mineral » wastes  
5 « organic » wastes



paper-mill  
sludge



green  
wastes



street  
sweeping  
wastes



compost

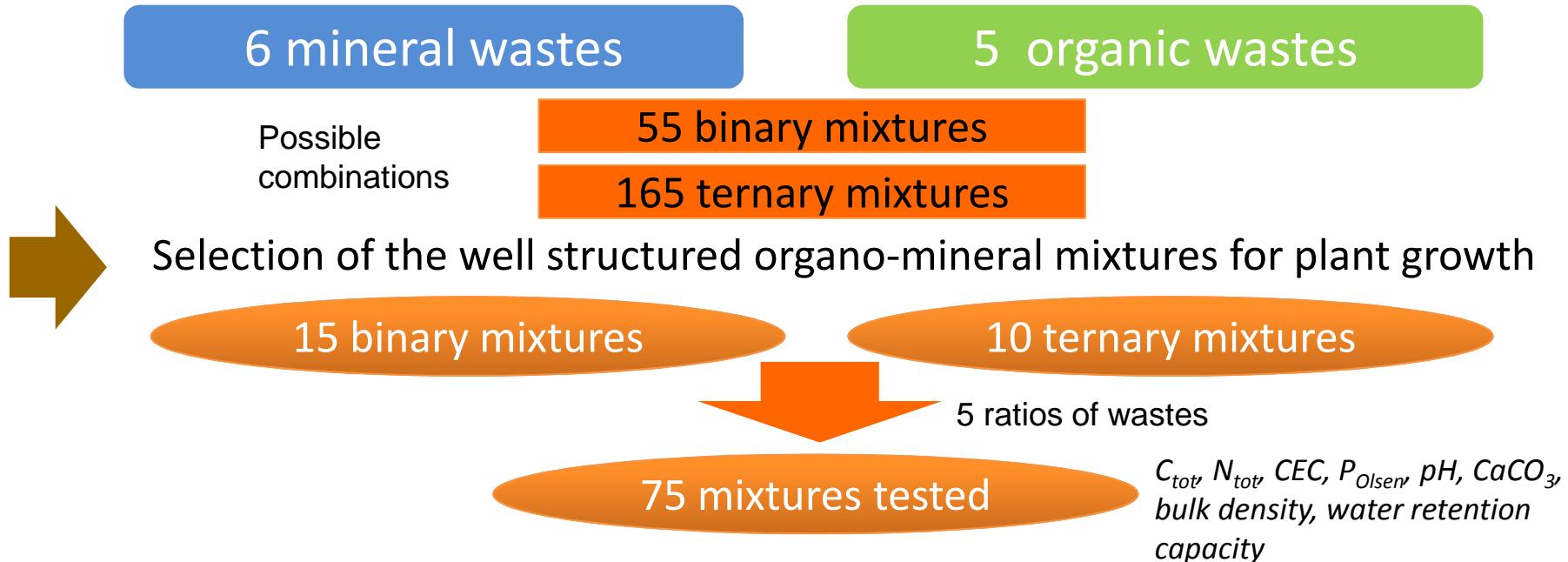


urban sludge



Physical, chemical, biological  
and ecotoxicological characterisations

## 4- Fertile mixture formulation ?



### Prediction of the mixture fertility modelled by

- 
- Regression curves for  $C_{tot}$ ,  $P_{Olsen}$ , CEC
  - Polynomial models for all the parameters ( $R^2$  entre 0.86 et 0.99)

Are these  
mixtures fertile ?

6 mixtures selected for pedogenesis process study  
3 growth-layers, 1 technical-layer, 2 structural layers

## 5- Evaluation of constructed soil quality

### Station lysimétrique du GISFI

Localisation : Homécourt (Meurthe-et-Moselle)

Experimental type : *in situ*

Duration : 24 months

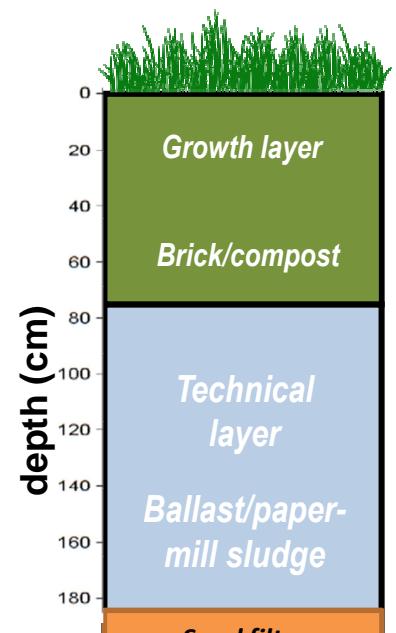
Vegetation : Ray-grass (*Lolium perenne*)

Use type: square and parc  
street tree

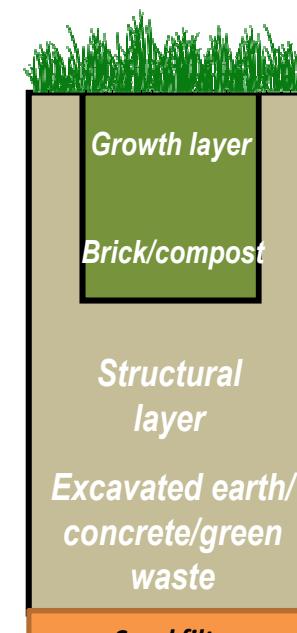


#### Measured parameters :

- Water balance,
- Physico-chemical properties,
- Hydraulic properties,
- Ecotoxicology,
- Aerial biomass,
- Root profile.

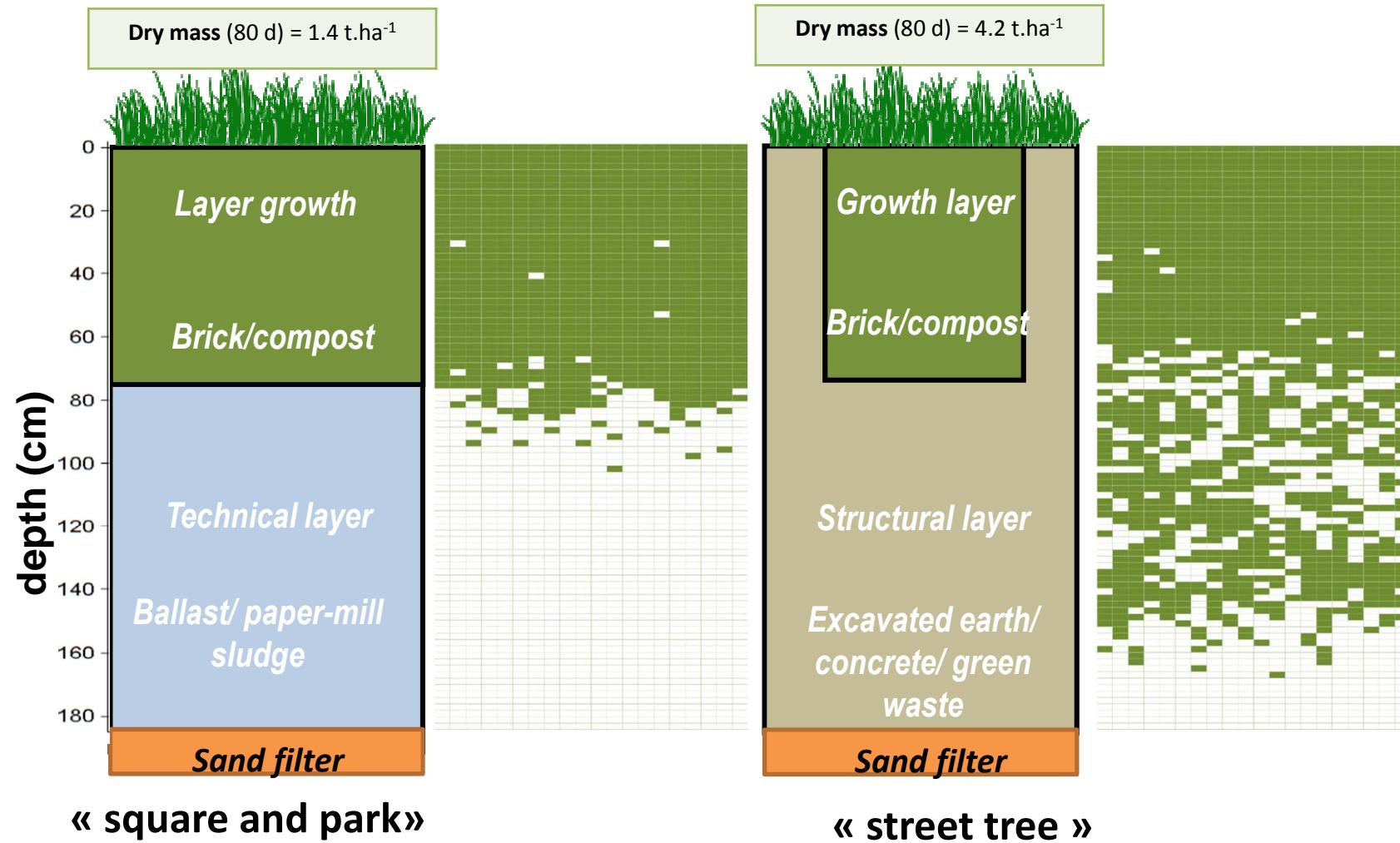


« square and park »



« street tree »

## 5- Evaluation of constructed soil quality



- High root density
- Biomass production equal to extensive grassland (2 to 4 t ha<sup>-1</sup>)

## 5- Evaluation of constructed soil quality

**Plateform : Agrocampus Ouest**

**Localisation :** Angers (Maine et Loire)

**Experimental type :** *in situ*

**Duration :** 36 months

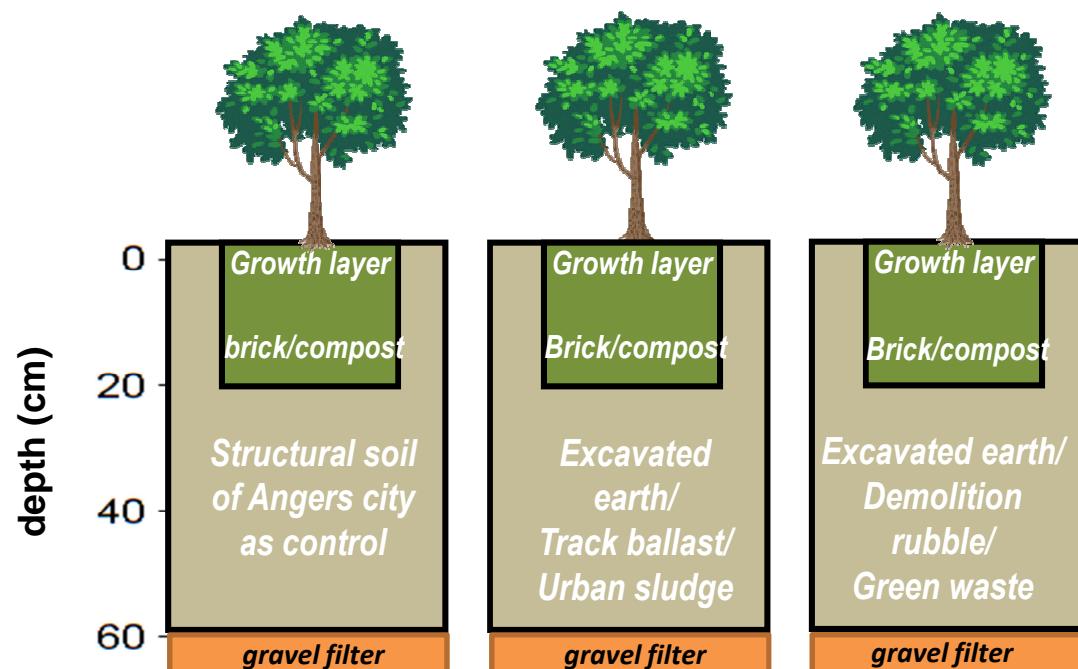
**Vegetation :** érable (*Acer platanoides*)

**Use type :** street tree

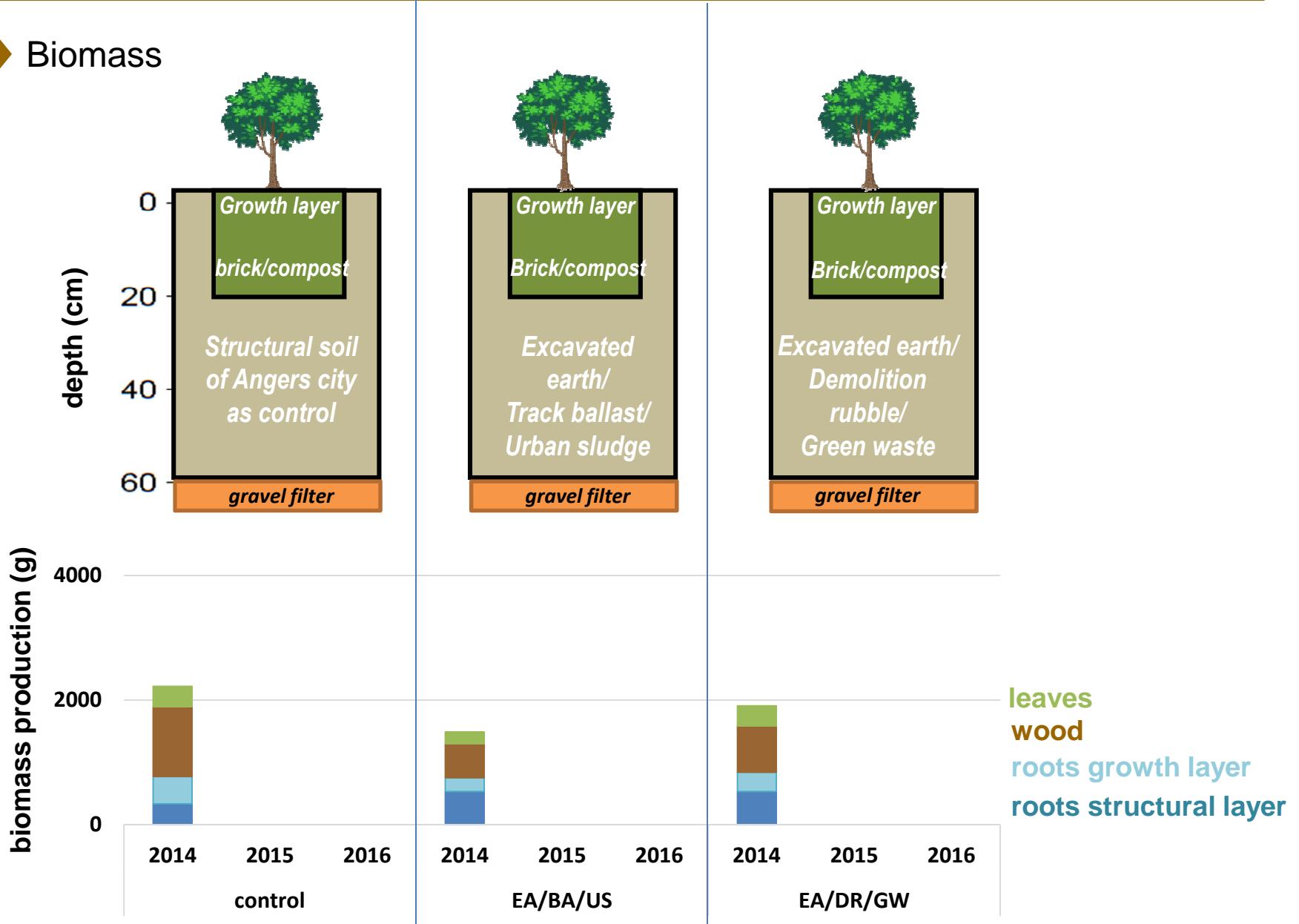


### Measured parameters :

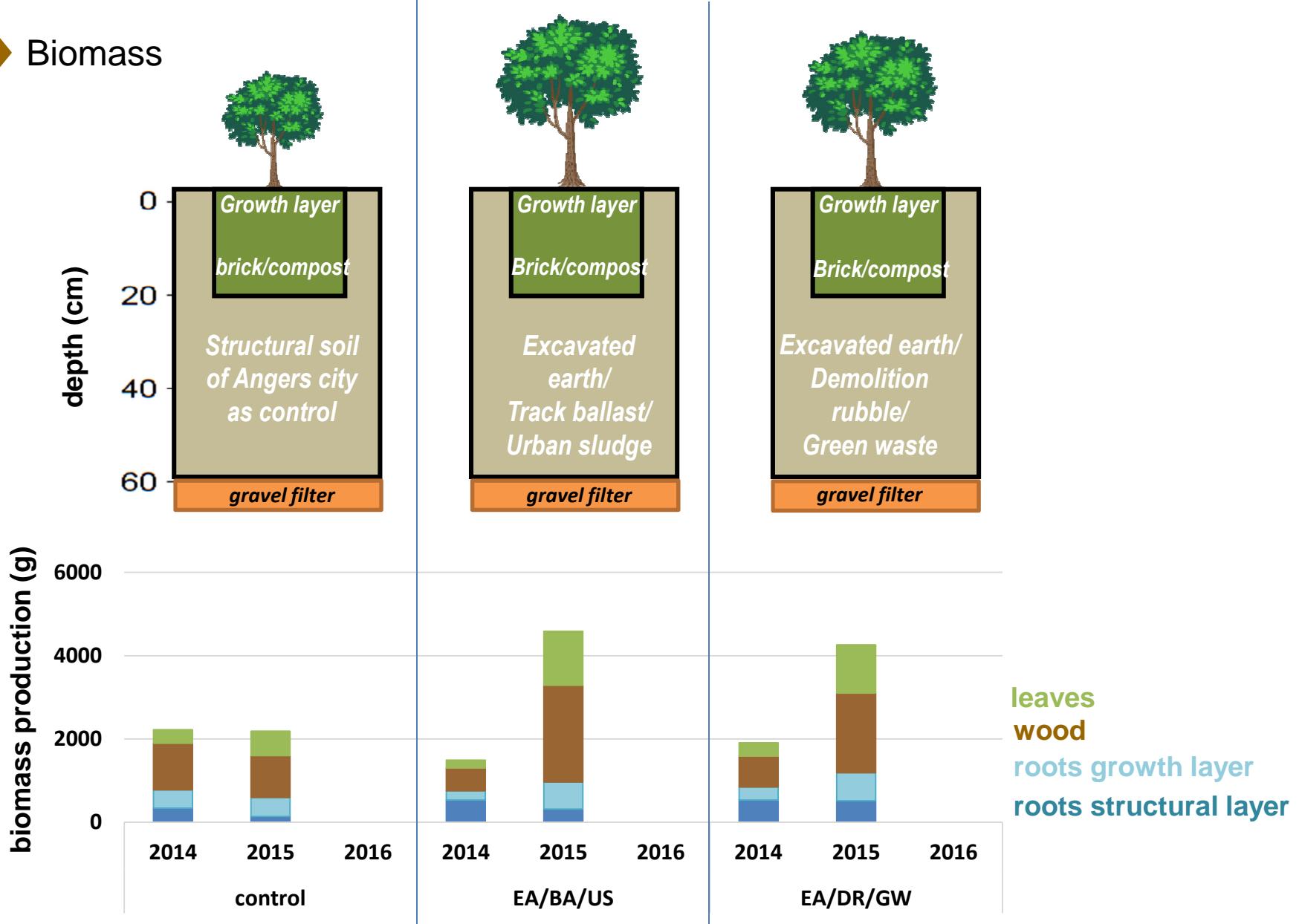
- Water balance,
- Physico-chemical properties,
- Hydraulic properties,
- Aerial architecture
- Shoot and root biomass,
- Root profile.



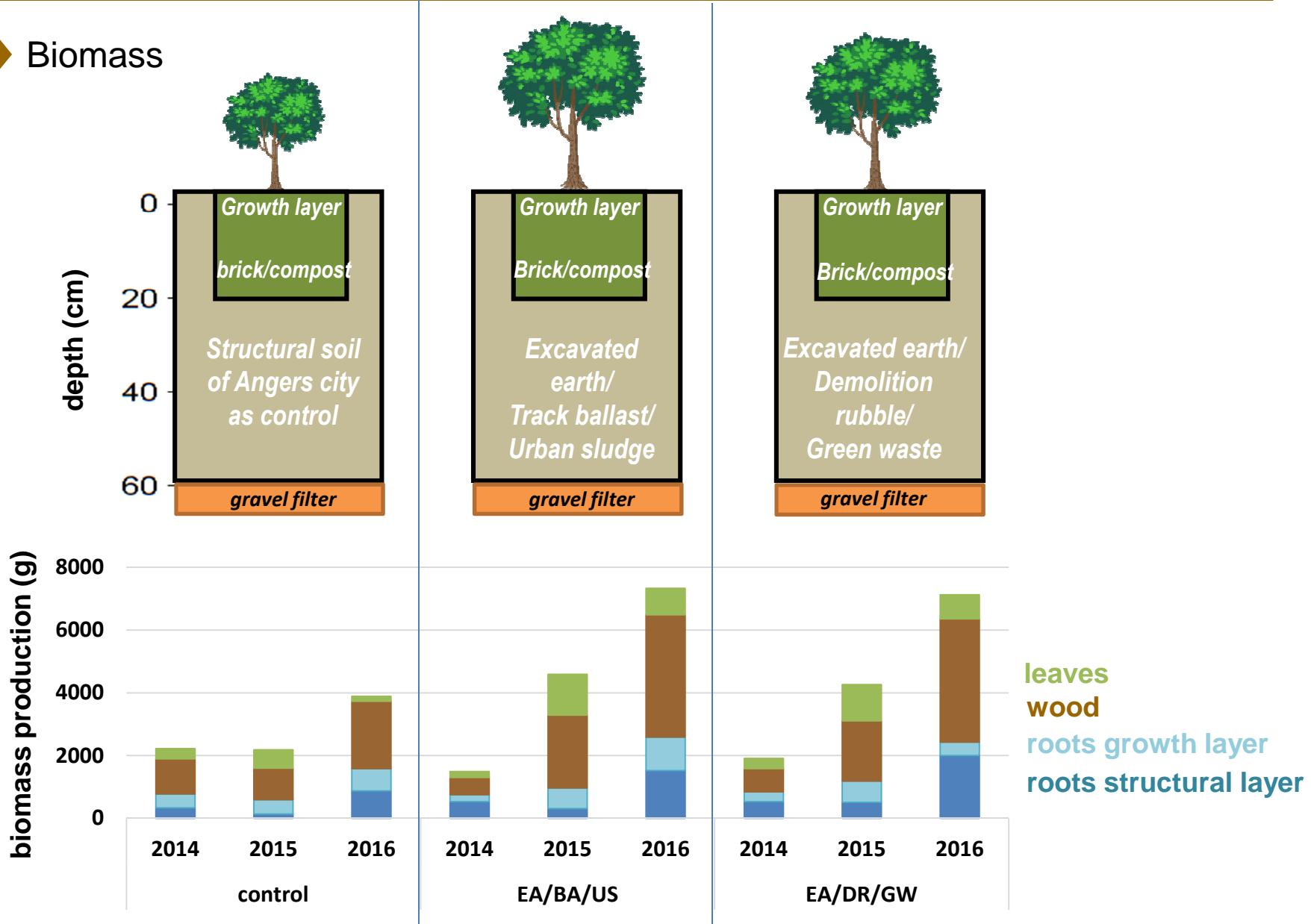
## 5- Evaluation of constructed soil quality



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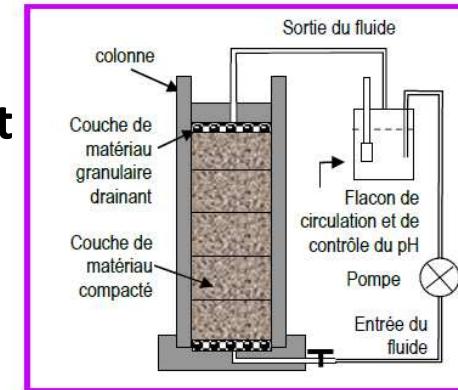
## 6- Safety assessment for health and the environment

### 1. Traces elements in mixtures

The content values are low and below the limit value of the culture medium standard **NF U 44-551**.

### 2. Contamination and release in the waters percolation test

- No waste and mixture with truly problematic contents  
Sb (Antimony), Mo (Molybdenum), sulphates (bricks)



### 3. Ecotoxicological assessment : for aquatic and terrestrial ecosystems

- Aquatic ecosystem: toxic effect 1 indicator (daphnia) for 2 mixtures /6  
Terrestrial ecosystem ± toxicity according to mixtures, high pH et electrical conductivity for some mixtures

### 4. Quantitative assessment of health risks

3 targets : children, adult walker, maintenance worker

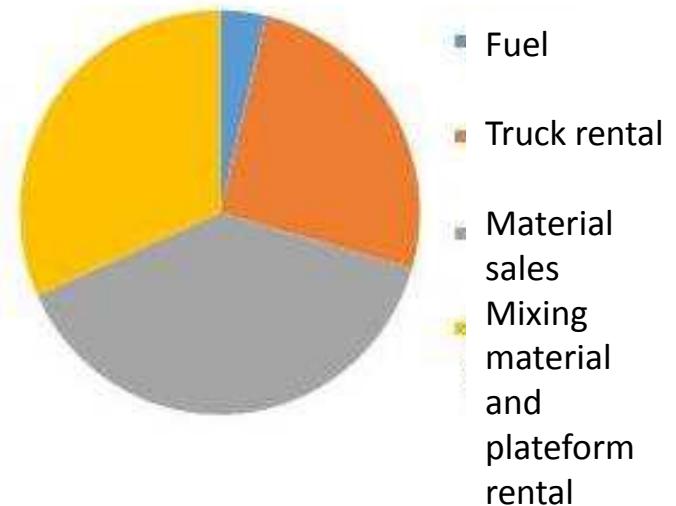
Scenarii : exposure 365 days / year, elements considered in their most toxic form

- Little or no risk to users,  
Overrun for chromium and arsenic : to be relativized relative to urban geochemical

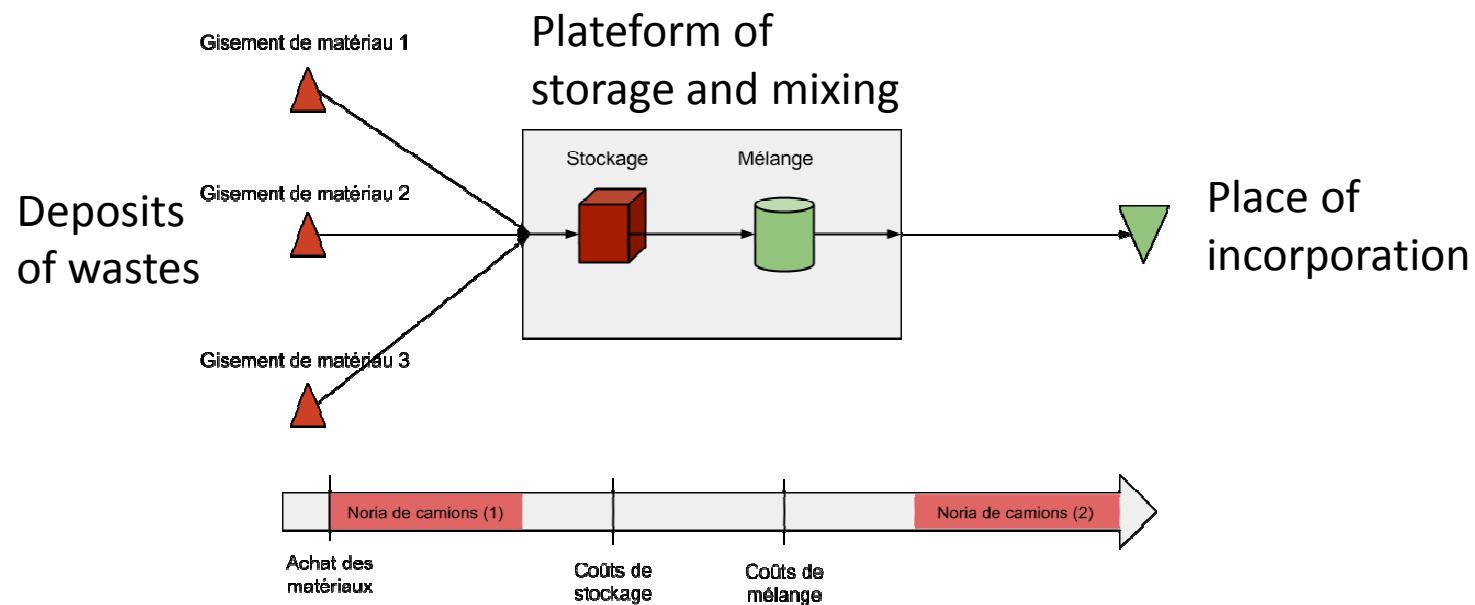
## 7- A multicriteria tool for decision-making

- Constraints of local availability of materials,
- Technical constraints and usages,
- Cost information,
- Environmental and acceptability information

Sources of costs



### The economic model and the cost estimate



## 8- The regulatory framework for the construction of soil

### ➤ The obstacles to the recovery of waste

- A degraded image,
- Specific regulatory management procedures, sometimes not explicit,
- The responsibility of the developer in case of dysfunction.

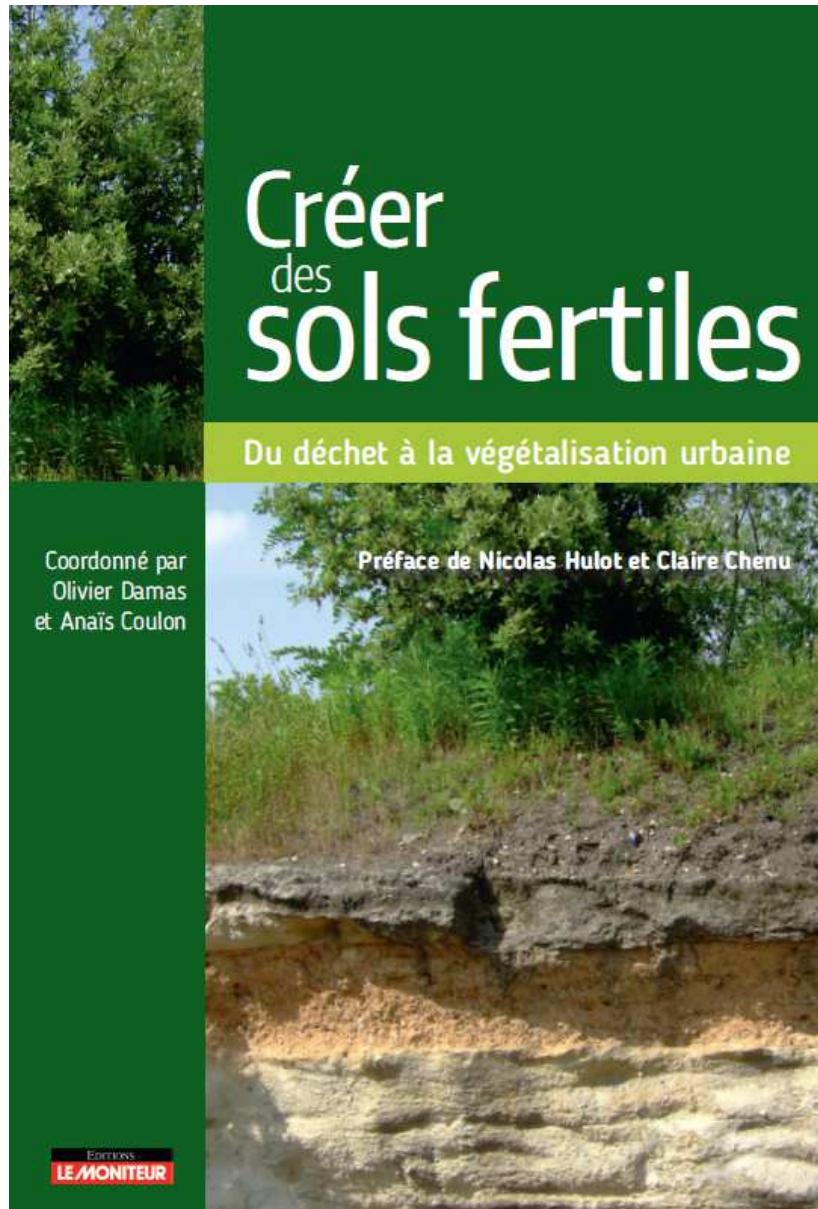
### ➤ The structuring of the sector

At the request of the stakeholders

- Constitute a working group
- Consolidate data acquired by pilot sites
- Meet with the Ministries (ecology and agriculture)

**At this stage, the installation of demonstrators is therefore necessary. These pilots must be conducted with rigor and in consultation with the State services.**

One book, 30/11/2016, Editions Le moniteur, 49 €



## **CHAPITRE 1**

Construct soils for greening the city

## **CHAPITRE 2**

Designing a constructed soil

## **CHAPITRE 3**

Assessment of constructed soil quality

## **CHAPITRE 4**

Moving from concept to practice

## **CHAPITRE 5**

Structuring a birth chain

## **CHAPITRE 6**

Technical notes



# FROM WASTE TO FERTILE TECHNOSOL

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## 7- Evaluer les fonctions et services rendus par les sols construits

Services	Usage « square et parc »		Usage « arbre d'alignement »	
	terre végétale	Sol construit	mélange terre-pierre	Sol construit
Régulation de la qualité de l'air CO2	++	++	++	++
Régulation du climat local	+++	+++	+++	+++
Traitement des déchets - recyclage	0	+++	0	+++
Purification de l'eau	++	+	++	+
Régulation des nuisances sonores	0	0	+	+
Régulation des inondations	+++	+++	+++	+++
Aliments	0	0	0	0
Matériaux de remblais	+	0	++	0
Ressources ornementales	++	++	++	++
Support d'infrastructures piétons	+	+	++	++
Réservoir pour la biodiversité	+++	++	++	++
Activités sportives et de loisirs	+	+	0	0
Paysage/esthétique	+++	+++	+++	+++

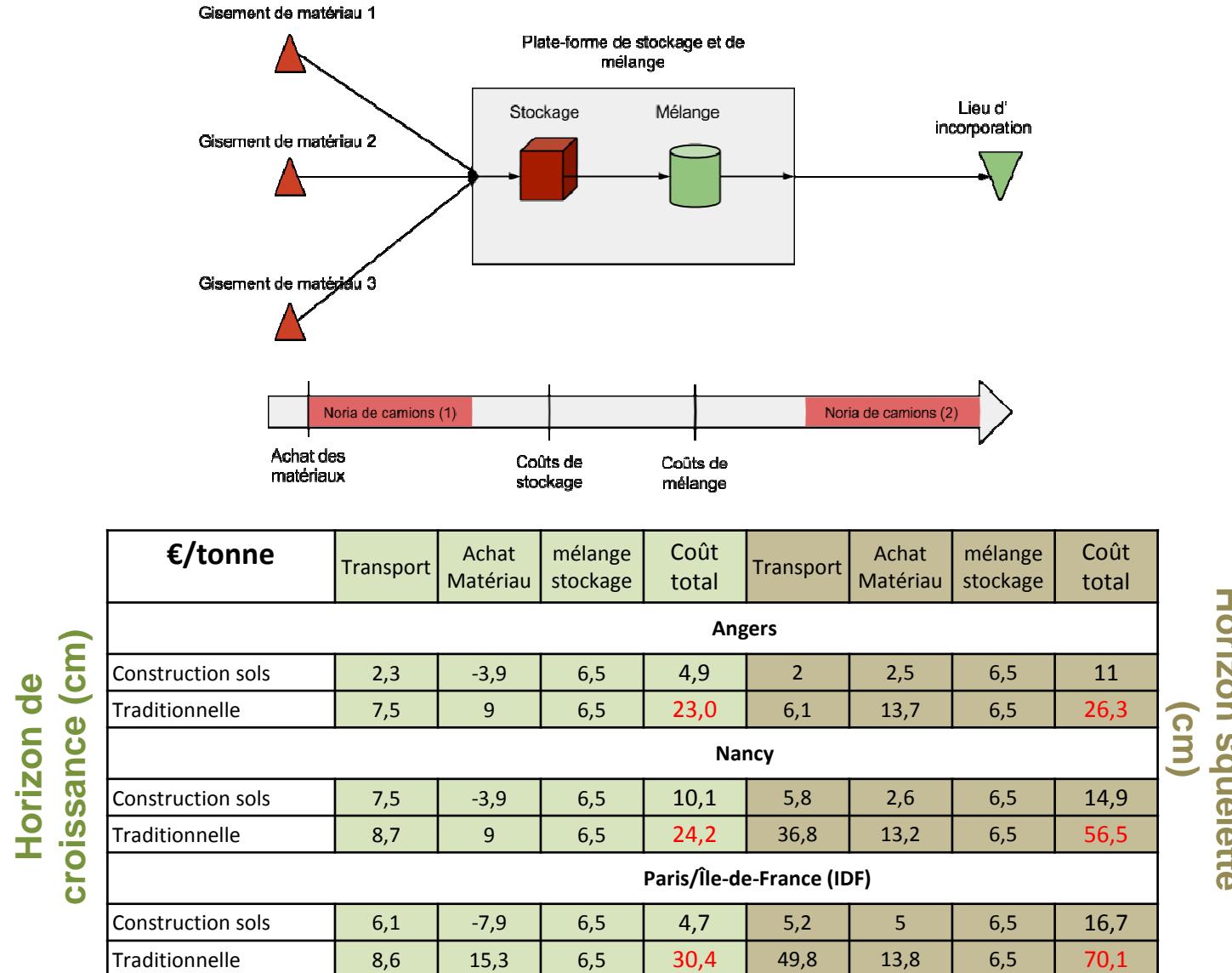
régulation  
Approvision  
culturel



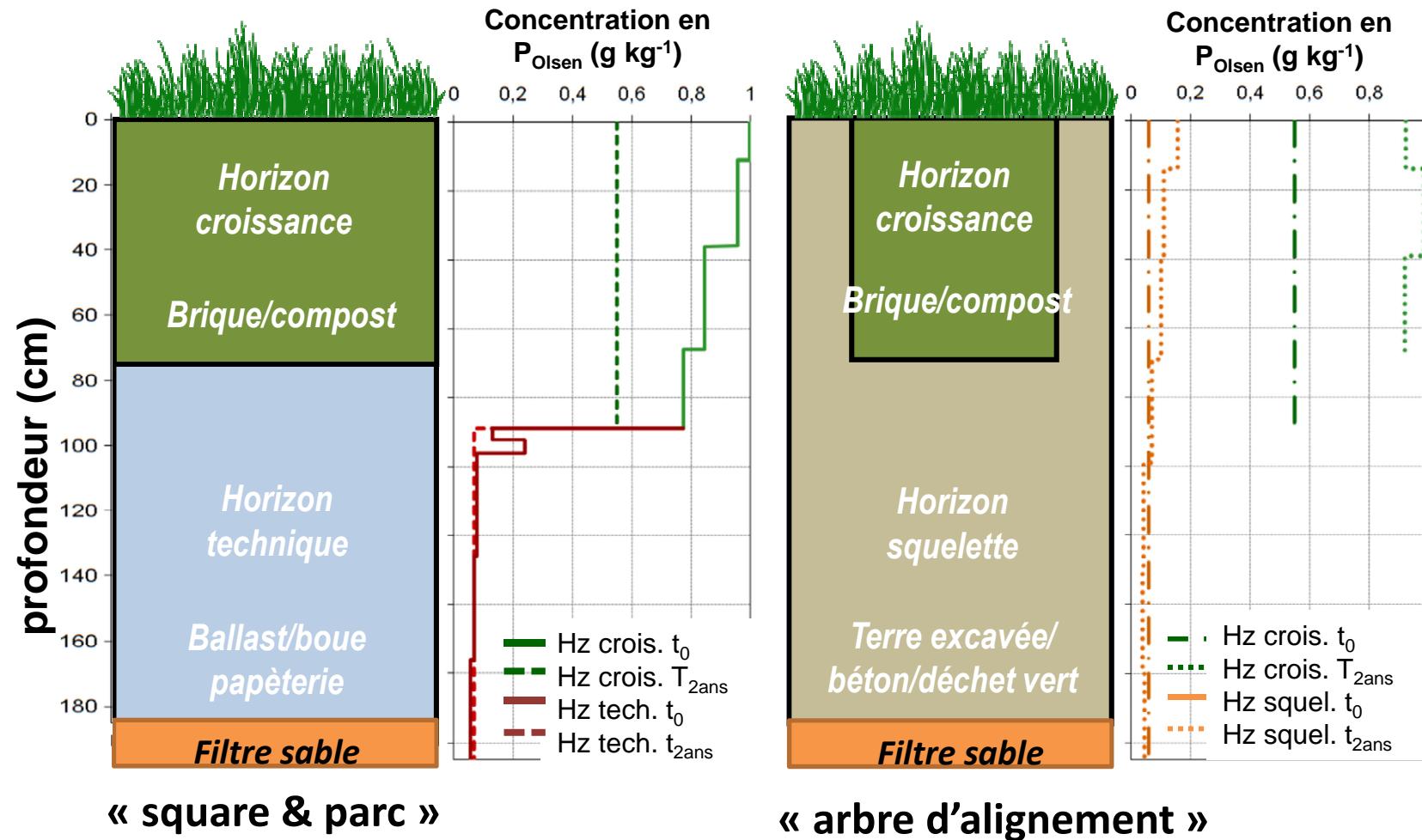
les mélanges à partir de déchets produisent des services favorables au fonctionnement durable de l'écosystème urbain

## 7- Structurer un outil multicritère d'aide à la décision

### Le modèle économique et l'estimation des coûts



## 5- Evaluer la qualité des sols construits



« square & parc »

« arbre d'alignement »

- 
- Très forte teneur en P disponible dans l'horizon de croissance
  - Teneur en P supérieure à la moyenne des sols français dans mélange squelette