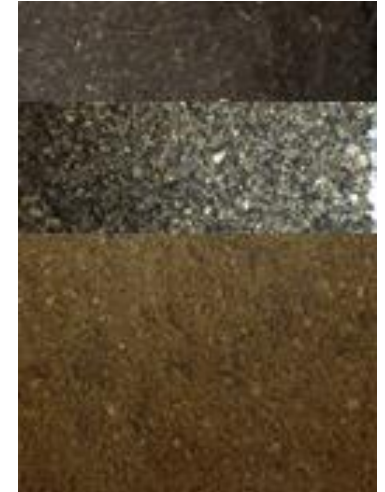




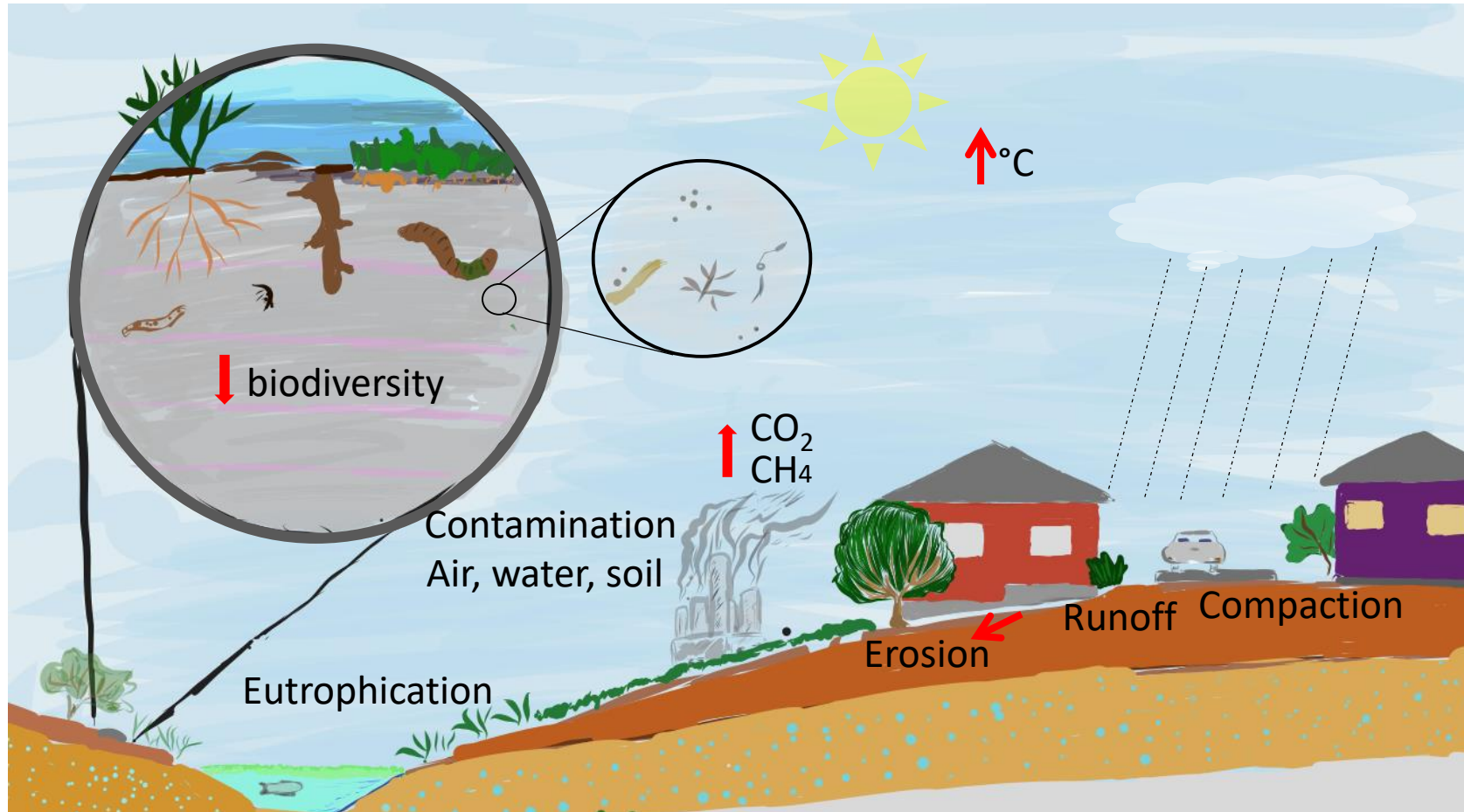
# Potential ecosystem services provided by constructed Technosols

Maha Deeb, Peter Groffman, Sara Perl Egendorf, Alan Vergnes, Daniel  
Walsh, Tatiana Morin, Manuel Blouin, Geoffroy Séré  
[maha.deeb@ird.fr](mailto:maha.deeb@ird.fr)





# Urban ecological concerns



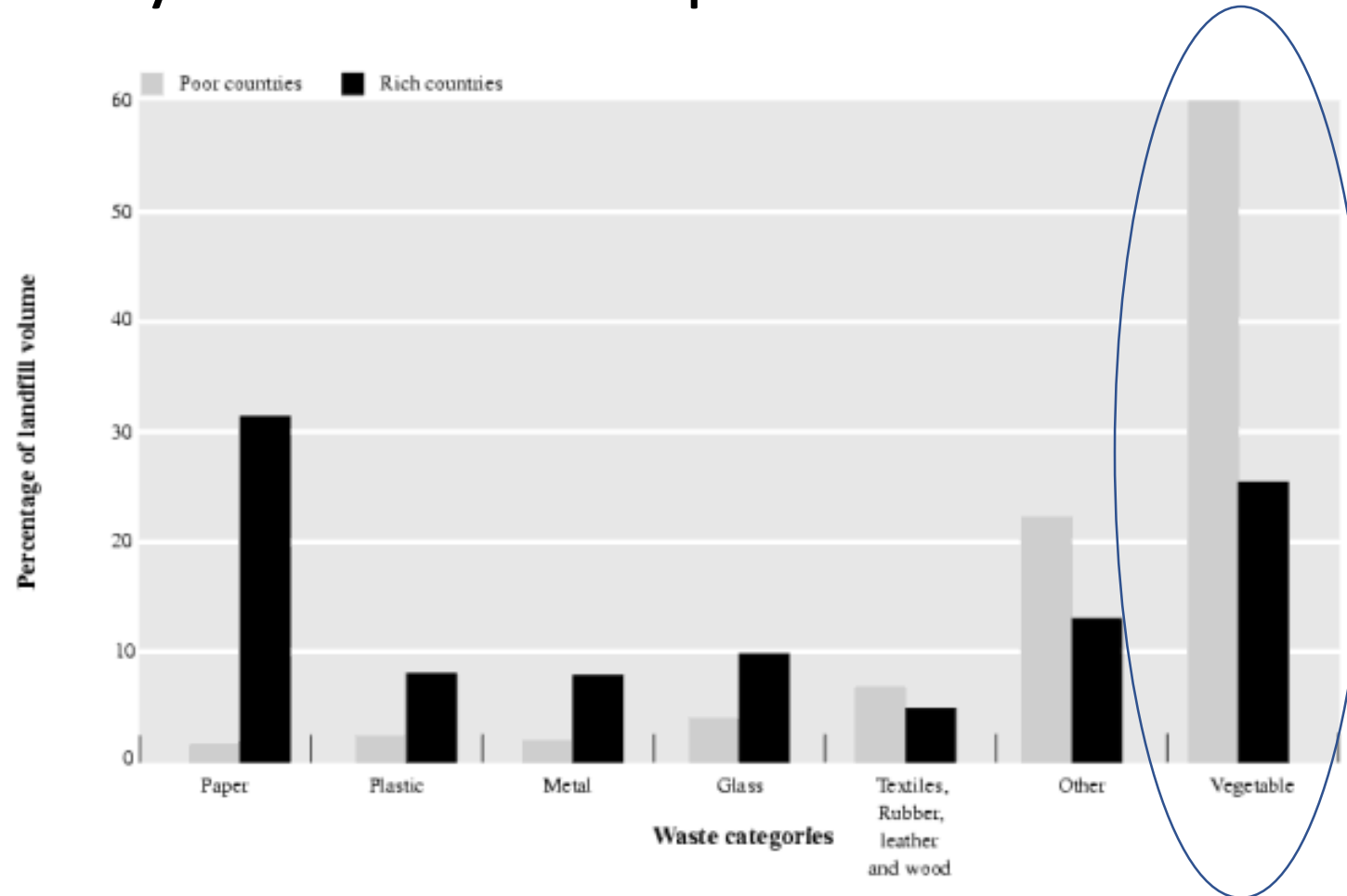
Urban areas emits about 80% of the global CO<sub>2</sub> emissions (Heinonen and Junnila, 2011)  
Construction sector is one of the major sources of CO<sub>2</sub> emissions (Weber et al., 2007)

# Mineral solid waste in the world

Country	C&D as % of Total Solid Waste	Annual Volume of C&D Waste	Soil % of C&D Waste	References
Australia	20-30%			Craven et al., 1994
Canada	27%			Yeheyis et al., 2013
EU	62%			Eurostat 2010
France	70%	245 million tons		Construction waste in France (2012)
Hong Kong	38-65%	20 million tons		EPD of Hong kong, 2006
India	22%		35%	Vilas and Guilberto, 2007
Iran	50%		11%	Najafpoor et al., 2014
Israel	60%	7.5 million tons	16-38%	Katz and Baum, 2011
Malaysia	28.00%		27.33%	Hassan et al., 1998
New Zealand	17%			Minsistry for the environment 1997
Spain	70%		55.80%	Hendriks and Pietersen, 2000
Sweden	56%			Frandegard et al., 2013
Thailand	7.70%	1.1 million tons		Kofoworola and Gheewala, 2009
UK	50%	70 million tons		Ferguson et al., 1995
US	30%	100 million tons		Mills et al., 1999
Global	35%			Yeheyiset et al., 2013

# Organic waste

## Recyclable waste in poor and rich countries



Source: Cairncross (1993)



Composting as a treatment of organic waste is common in developed countries but needs to be popularized in developing countries.

# Current solutions

## Solutions

1. Using organic amendments present in the city.

## Limits

1. Toxic bioavailability.
2. Sustainability of the reclamation.
3. Composting is not widely practiced or integrated in policies worldwide regardless of the amount of available organic waste.

# Current solutions

## Solutions

Adding phosphate amendments to retrieve nutrients in urban agriculture

## Limits

1. Expensive
2. Negative environmental impact in long term
3. Not necessary available
4. Affect another element's availability
5. Depend on the source of contamination

# Current solutions

## Solutions

Using native prairie garden plants instead of typical non-native grasses in urban landscape as a solution for stormwater management

## Limits

1. Not a general solution for urban soil degradation.
2. Native plants will not necessary grow in such low soil fertility compared to natural soils with insignificant anthropogenic impact.

# Current waste management system

City

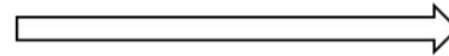


Deep soil excavation



Green spaces

Deep soil excavation



\$ + CO<sub>2</sub> +

Degradation arriving site

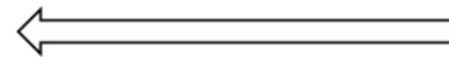
Countryside



Agriculture Soil



Agriculture Soil



\$ + CO<sub>2</sub> +

Degradation depart site



# Constructed Technosols as a solution

## Definition

The result of the voluntary action of building a "soil" by using technogenic materials considered as waste, for vegetation growth purpose. (Baize et Girard, 2009)



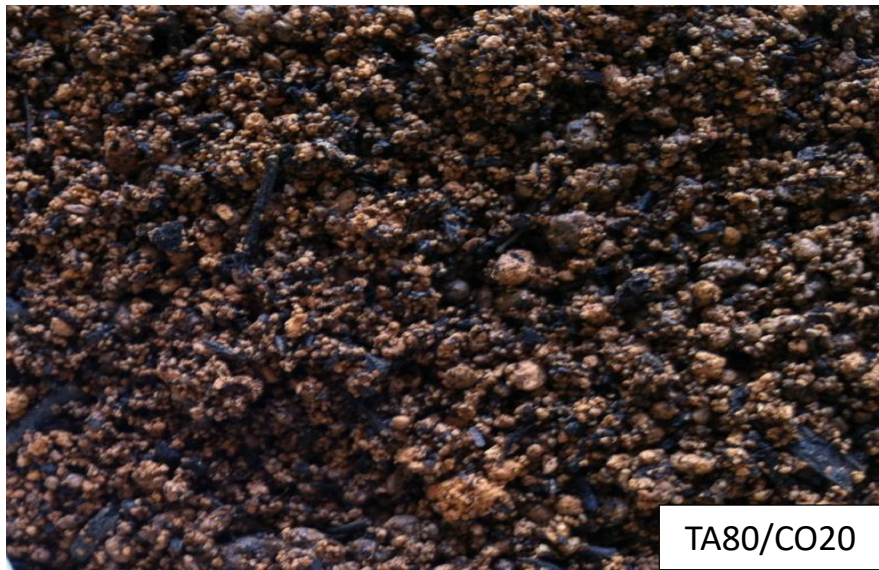
Construction and demolition waste

+

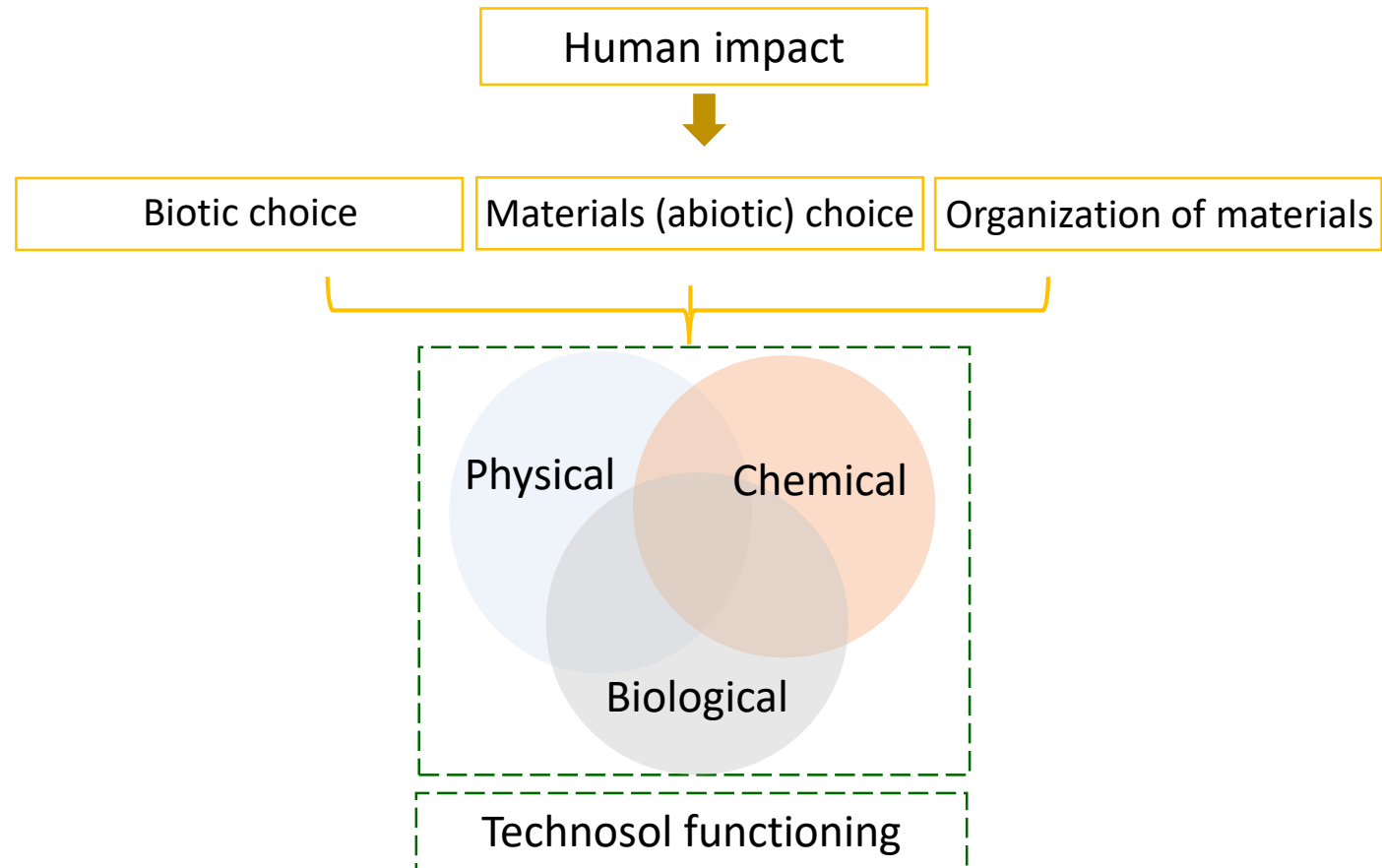


Organic waste

Technosol

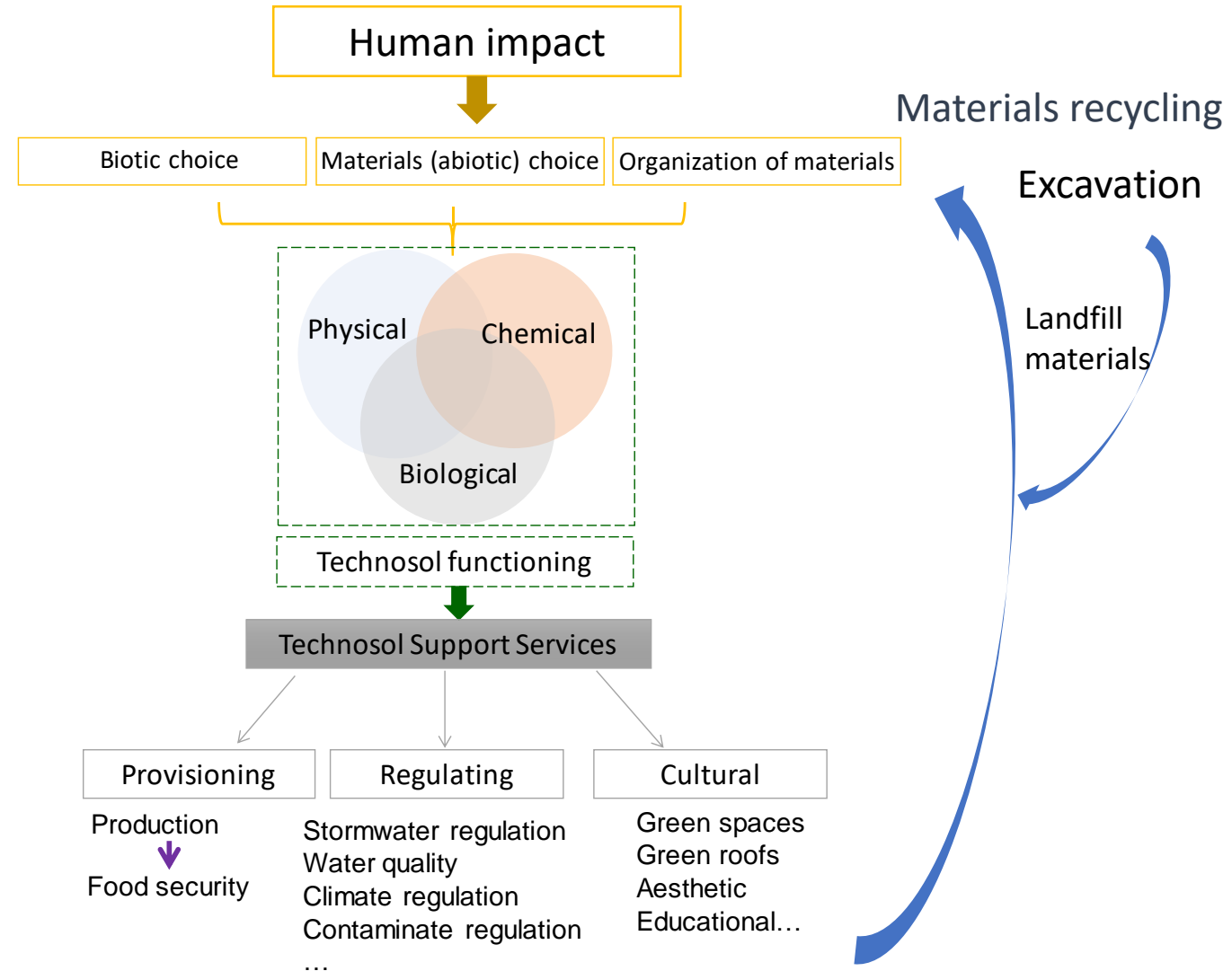


# How create a constructed Technosols?



		Technosol Support Services											
		Provisioning			Regulating						Cultural		
		Production	Fresh water retention	Clean compost	Stormwater, erosion & flood control	Water quality	Gas regulation	Contamination	Waste regulation	Carbon sequestration	Aesthetic	Educational	Recreation ecotourism
Technosols properties													
Physical	Organic waste	*	*		*		*	*	*	*	*		*
	Mineral waste	*	*		*	*	*	*	*	*			
	Bulk density	*	*		*	*					*	*	
	Available water	*	*		*	*	*						
	Hydraulic conductivity & infiltration	*	*		*	*	*						
	Porosity	*	*		*	*	*				*		
Chemical	Aggregation	*	*		*	*	*						
	pH	*											
	Cation exchange capacity	*				*							
Biological	Available phosphor	*											
	Macrofauna and flora activities	*		*		*				*			
	Microfauna activities	*	*	*		*				*			
	Biodiversity habitat	*		*	*	*				*	*		*

# Technosols as a link between natural processes and human activities

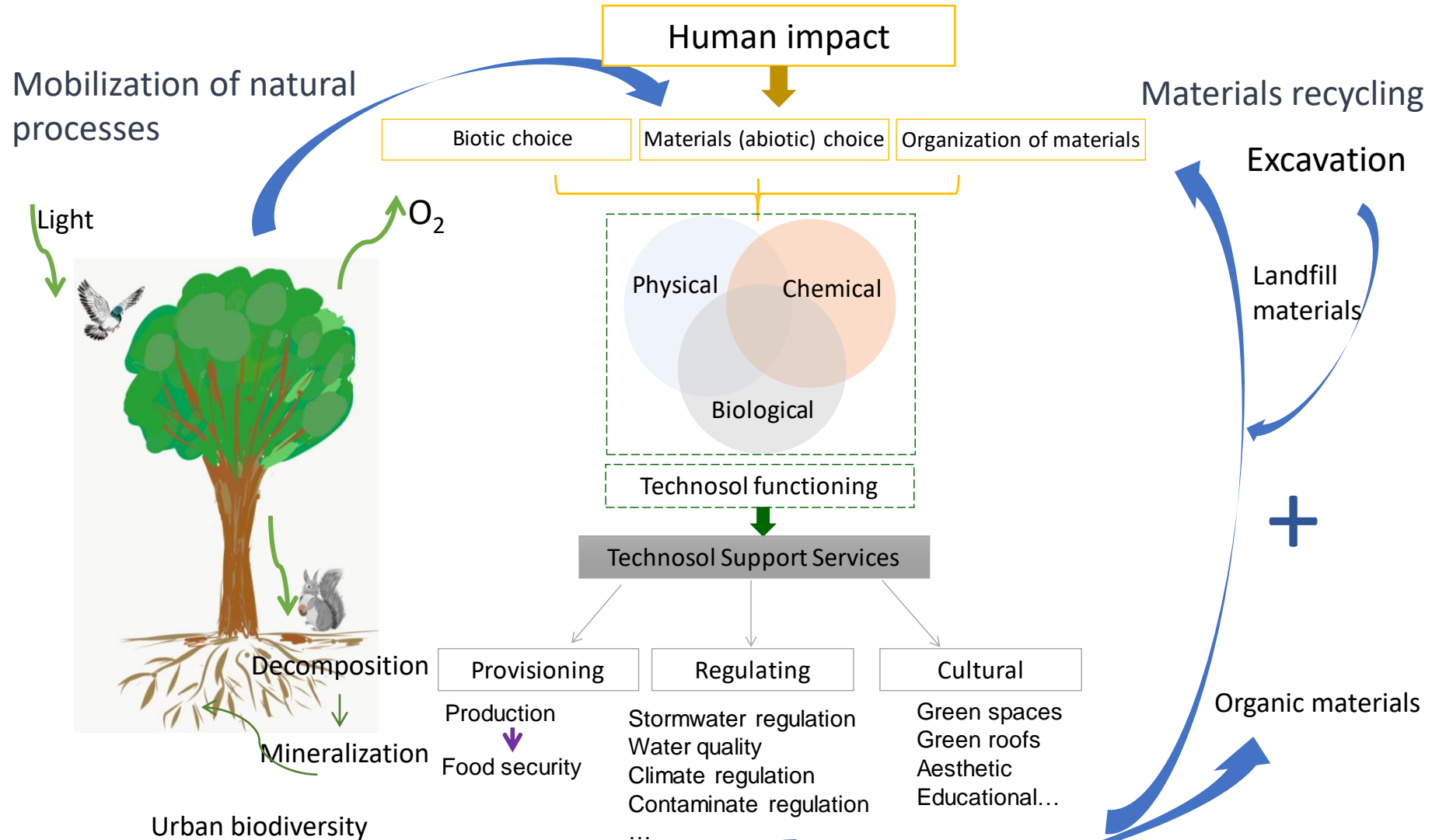


Morel et al.,2014

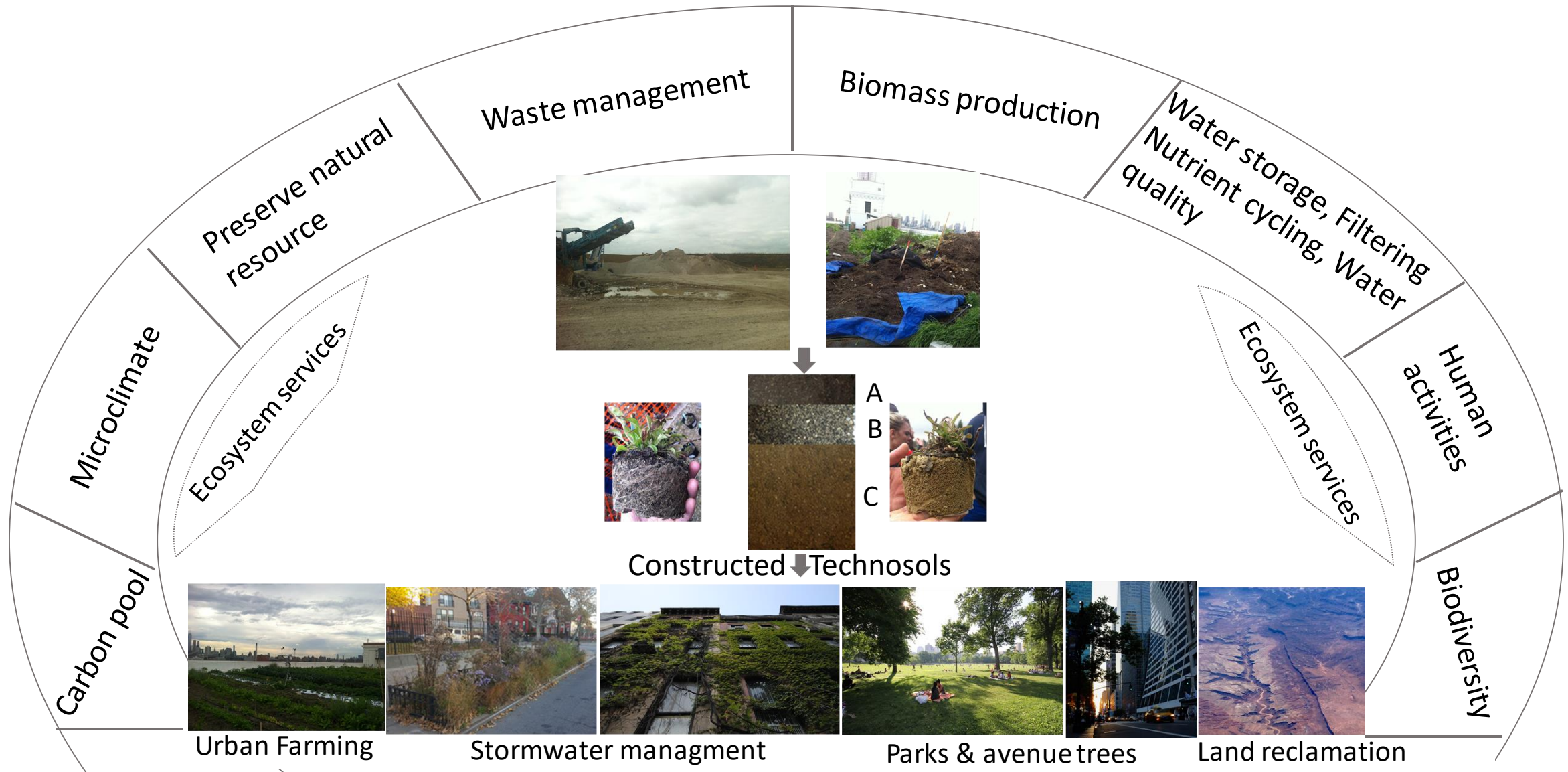
Deeb, 2015



# Technosols as a link between natural processes and human activities

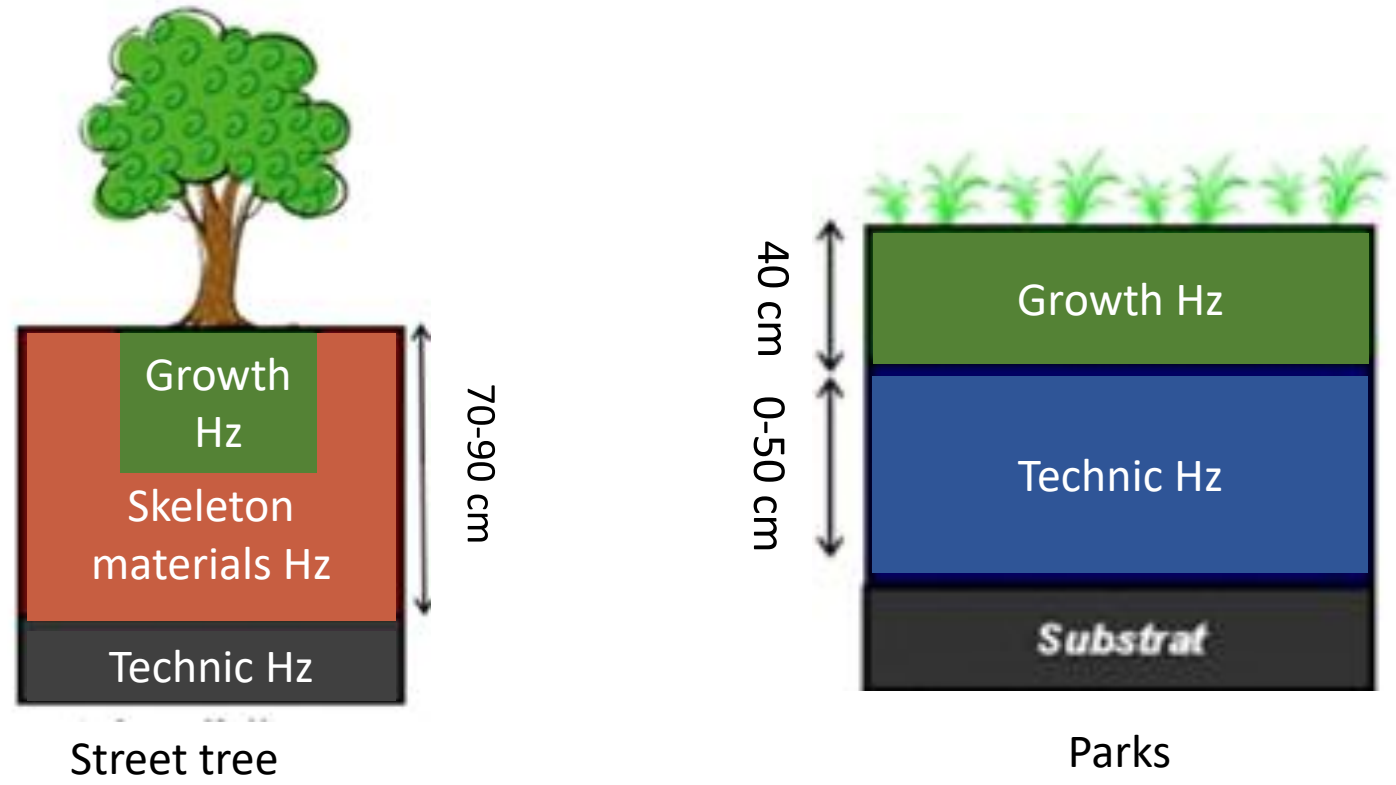


# Diagram linking constructed Technosols to ecosystem services



# Constructed Technosol design in relation with the expected land use

## 1. Street trees and parks

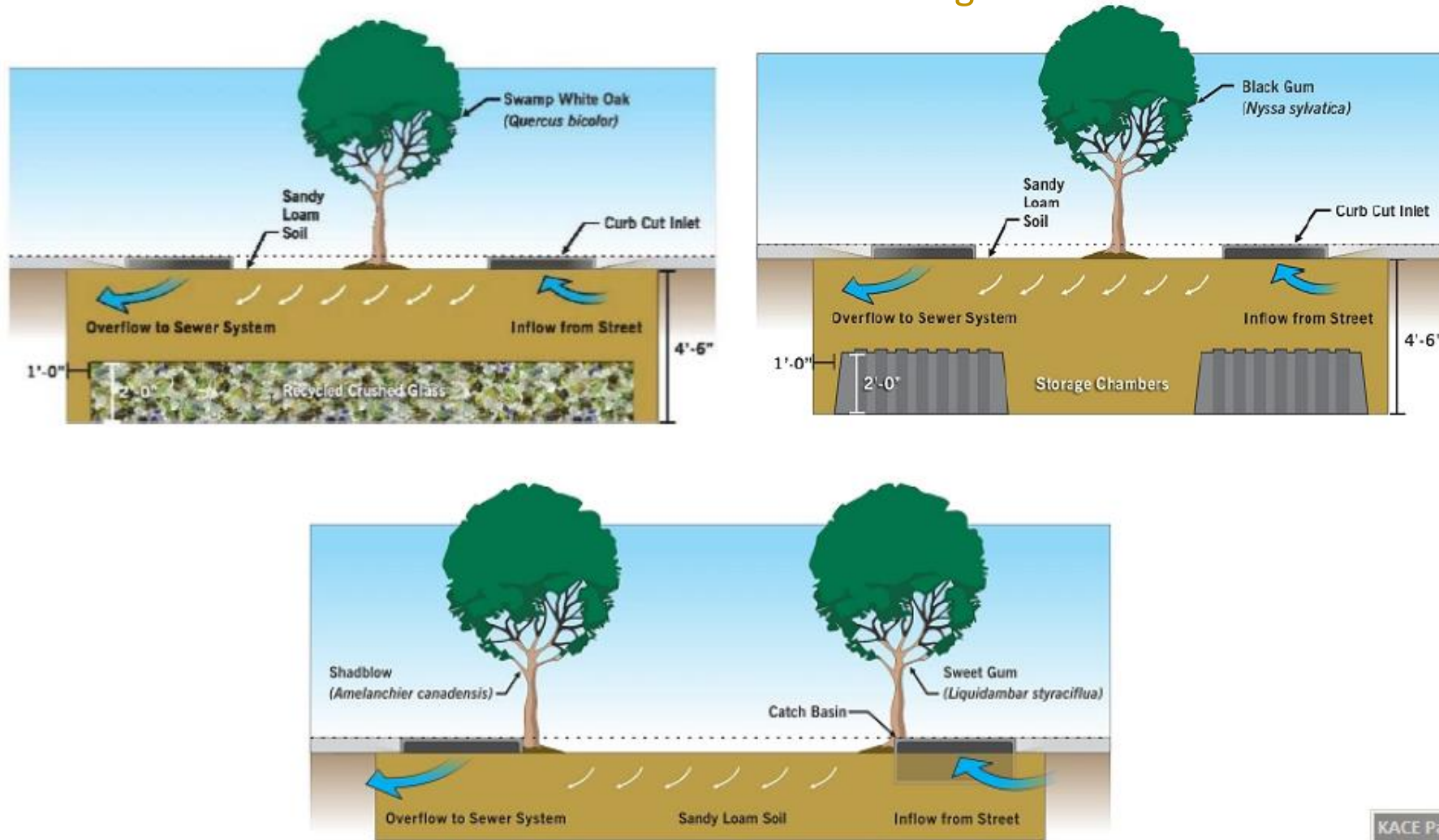


SITERRE Project, France

Raw materials have been used according to application requirements

# Constructed Technosol design in relation to expected land use

## 2. Constructed Technosols for stormwater management

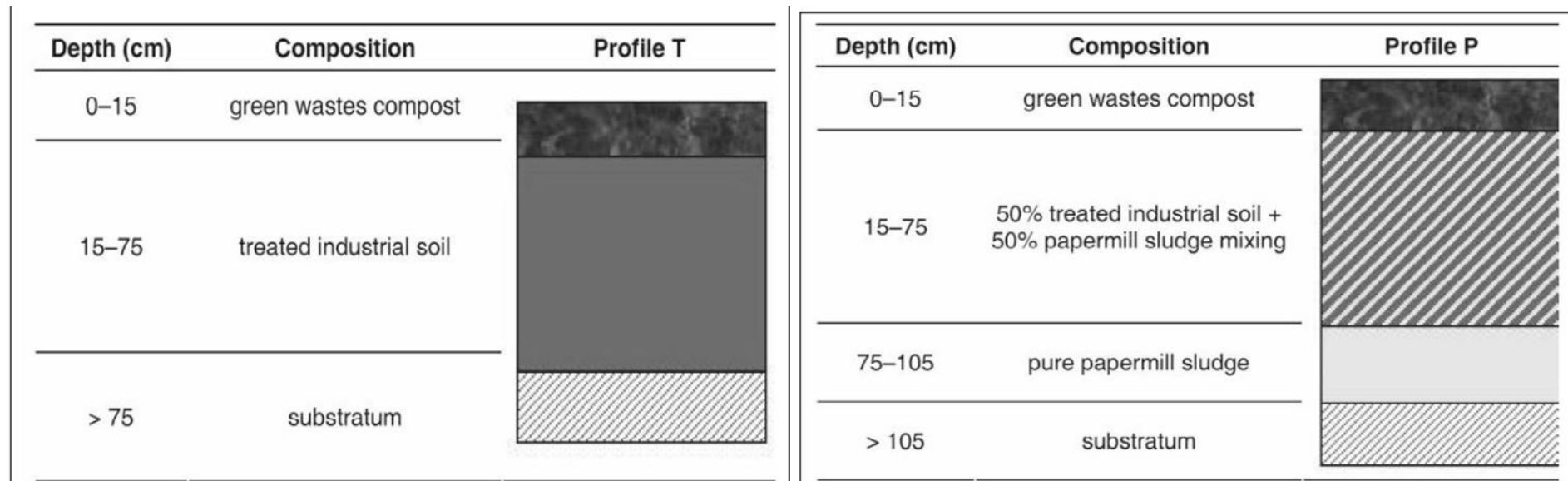


Green infrastructure project, NY



# Constructed Technosol design in relation to expected land use

## 3. Contaminated soils



Séré et al., 2008

# Grassland installation



Séré et al., (2007-2012)

# Example of ecosystem services provide by constructed Technosol

Ecosystem services		References
Provisioning	Habitat for the biodiversity	Joimel et al., 2018; Yilmaz et al., 2018; Vergne et al. 2017; Amossé et al. 2016; Hafeez et al., 2012a,b
	Food	Perl et al., 2018; Grard et al., 2018
	Non-food biomass	Yilmaz et al., 2018; Grabosky et al., 2009
Regulating	Regulation of water runoff	Deeb et al; 2018; Grard et al., 2018
	Recycling of organic waste	Grard et al., 2018; Deeb et al., 2016; Rokia et al., 2014; Cannavo et al., 2014
	Recycling of mineral waste	Deeb et al., 2016; Rokia et al., 2014; Cannavo et al., 2014; Macia et al., 2014
	Reclamation of limestone quarries	Buondonno et al., 2018
	Reclamation of degraded land by erosion	Capra et al., 2015
	Reclamation of contaminated soils	Macia et al., 2014; Shein et al., 2009, Séré et al., 2008
	Stormwater management	Deeb et al., 2018; Yilmaz et al., 2016
	Water retention and infiltration	Yilmaz et al., 2018
	Carbon sequestration	Yilmaz et al., 2018
	Nutrient cycle	Rokia et al., 2014
	Hydraulic conductivity	Cannavo et al., 2014
Microclimate	Djedjig et al., 2013	
	Preserve the natural resource	Cannavo et al., 2015

# Why constructed Technosols can be a strong solution for both developing and developed countries?

1. Water and agriculture soil are **limited** resources.
2. **Food security** and **quality of life**.
3. Public **health issues** due to **uncollected waste**. Health data (UN-Habitat,2009: p. 129).
4. Excess waste blocks drains and causes **flooding** (Wilson et al., 2013).
5. Organic waste accounts for high percentage (**67%**) of total waste compared to developed countries (**28%**) (Wilson et al., 2012).
6. Municipal solid waste contains high amount of organic materials and subsequently **moisture**, thus rendering waste unsuitable for thermal processing without pre-treatment or use of support fuel, Zhao et al. (2012).
7. **Dump sites** cause water -air- soil **pollution**.
8. Engineered dump sites are **expensive** and not well studied. Dump sites could have slope stability problem e.g. Istanbul, Turkey in 1993 (Kocasoy and Curi, 1995), Manila, Philippines in 2000 (Kavazanjian and Merry, 2005) and Bandung, Indonesia in 2005 (Koelsch et al., 2005)
9. Delayed construction of engineered landfill in some cities in low-income countries (e.g. Bamako, Mali) due to financing problems for transport and operation (Keita et al., 2010).



# Limitation of applied constructed Technosol

<b>Limits</b>	<b>Solutions</b>
Erosion and runoff as mixed waste materials need a specific time to reach a stable structure similar to natural soils	Covering with plants with high density of root system or building walls surrounding the constructed Technosols
Fast degradation of waste materials	Observation and good understanding of biotic and abiotic effects (and interaction)
Waste degradation depends on its origin and climate conditions	Manipulate constructed Technosols design
There is no macrofuna activity in young Technosols	Enhance landscape connectivity
Some waste such as glass or sediment is not favorable for macrofauna activities	Initial topsoil addition
Fresh organic waste cannot be planted directly as it has a toxic effect on plant growth	Pre-cultivate organic waste before planting to avoid anoxic conditions
Applying organic waste (sewage) could be a source of bad smell	Manipulate constructed Technosols design
Unpopular image of using waste for developing green spaces	Education and observation over time to assure healthy Constructed Technosols
Not all plant species can grow directly in such soils	Plant choice guided by constructed Technosols characteristics

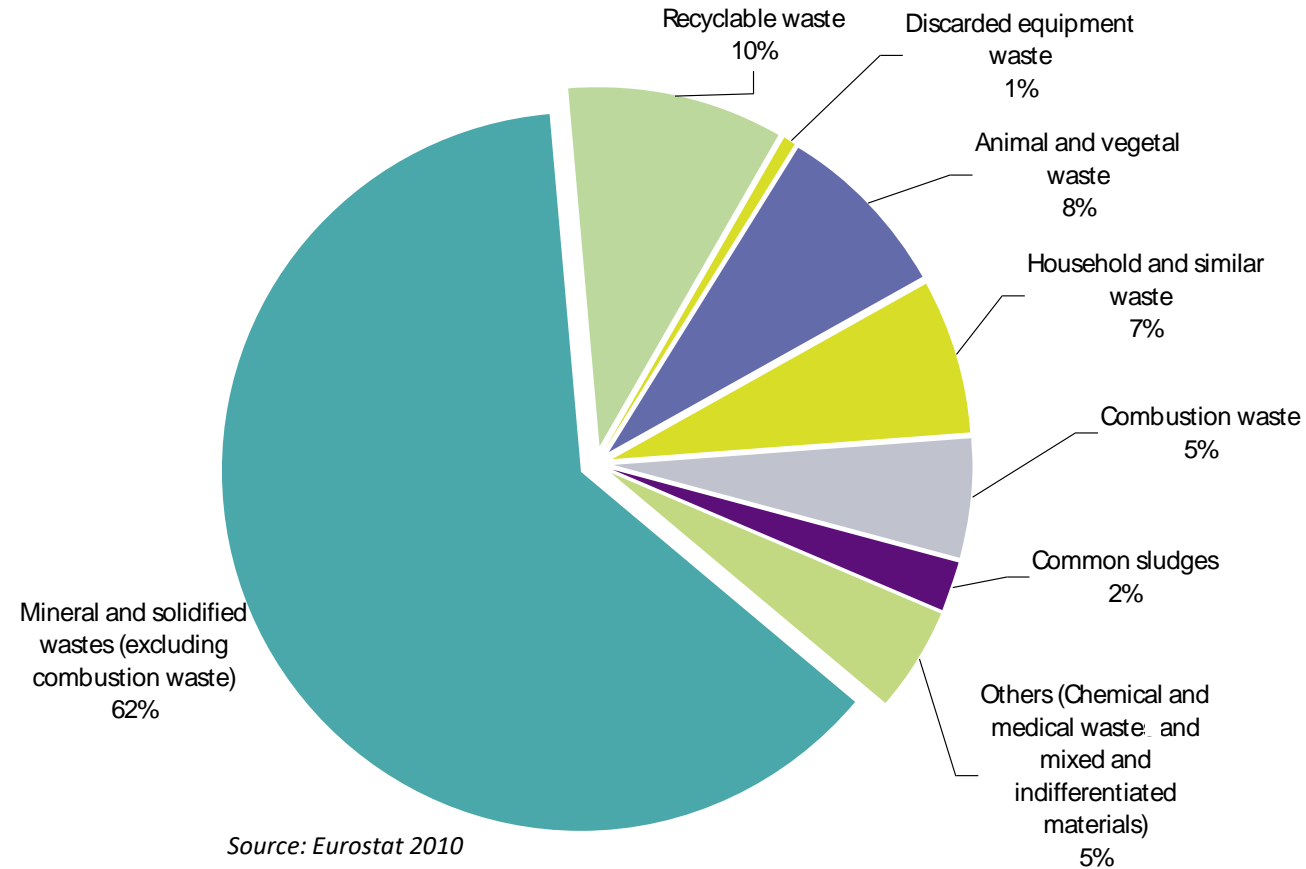
# Special thanks to

Landry COLLET (Photographies)

Dr. Anthony D. Cak ( associate director, Environmental sciences initiative)



# Composition of waste in the EU



## C&D Waste arising in EU by 1.74 tons/capita

Source: TuTech Innovation GmbH Af. Study construction and demolition waste management in Germany. Hamburg: EU-ASIA PRO ECO II B Post-Tsunami PROGRAMME; 2006.