4th World Bamboo Workshop

Bamboo for Green Life and Sustainable Development

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Applications of the bamboo crop for environmental engineering: Prospective Natural-Based Solutions

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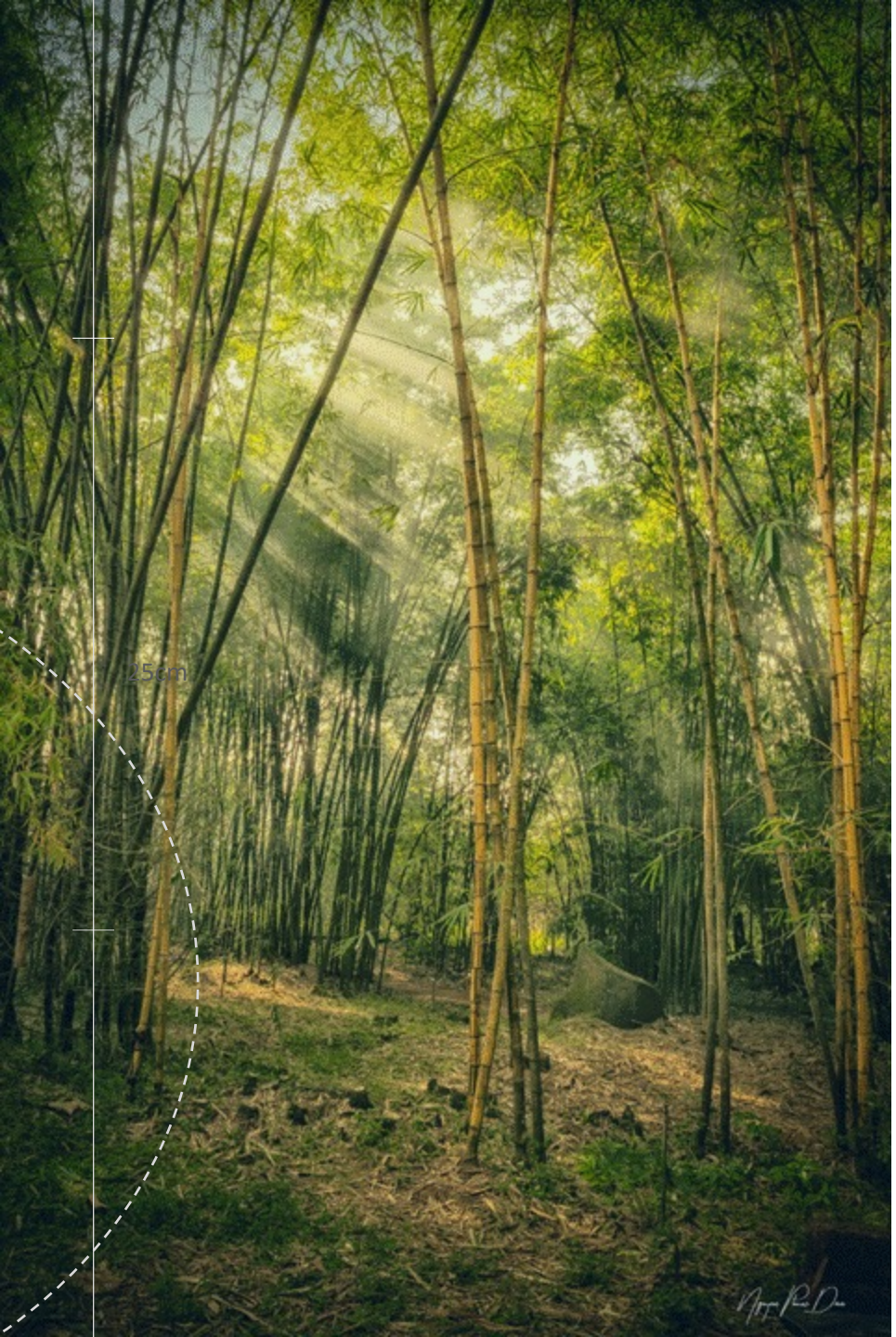
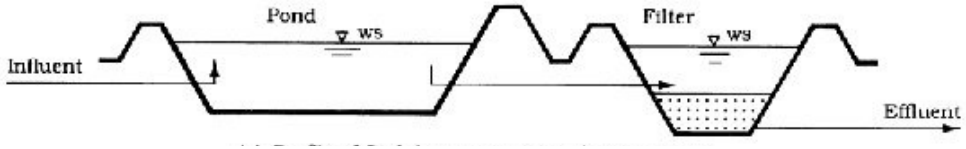
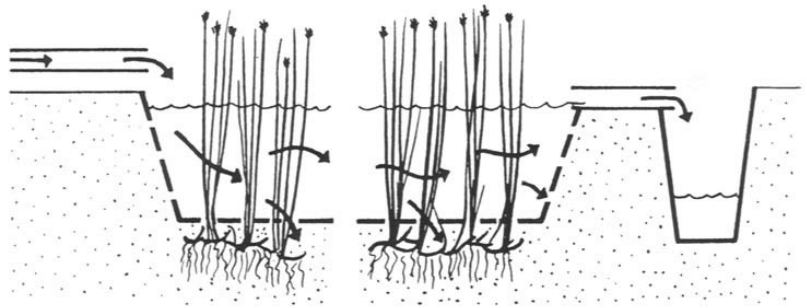
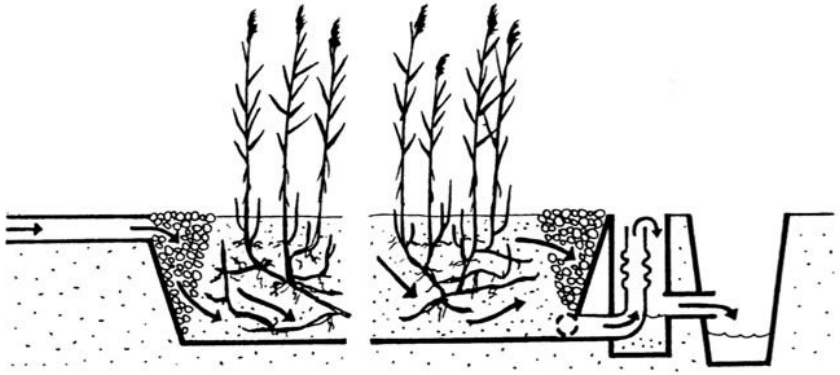


Content

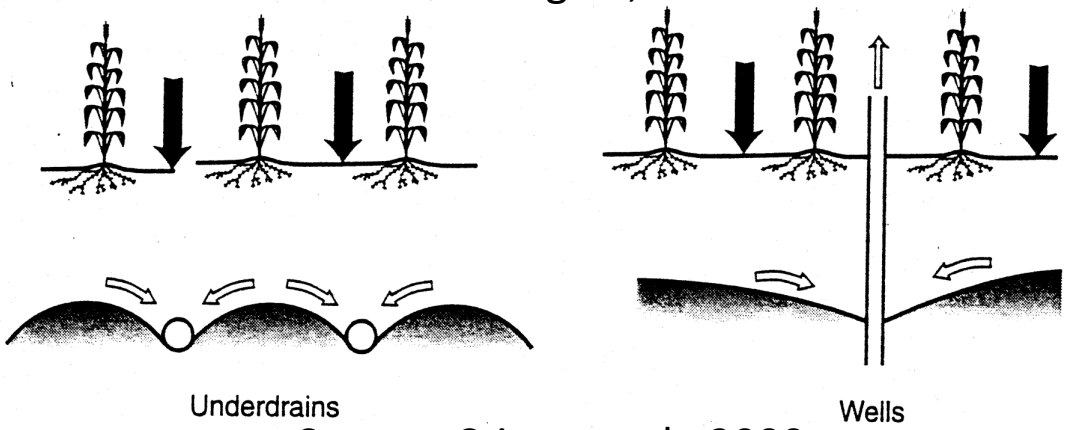
- Bamboo crop for wastewater treatment
- Bamboo crop as a prospective NBS:
  - Urban water management
  - Urban Greening







Source: Chongrak, 2000



Source: Crites, et al., 2000

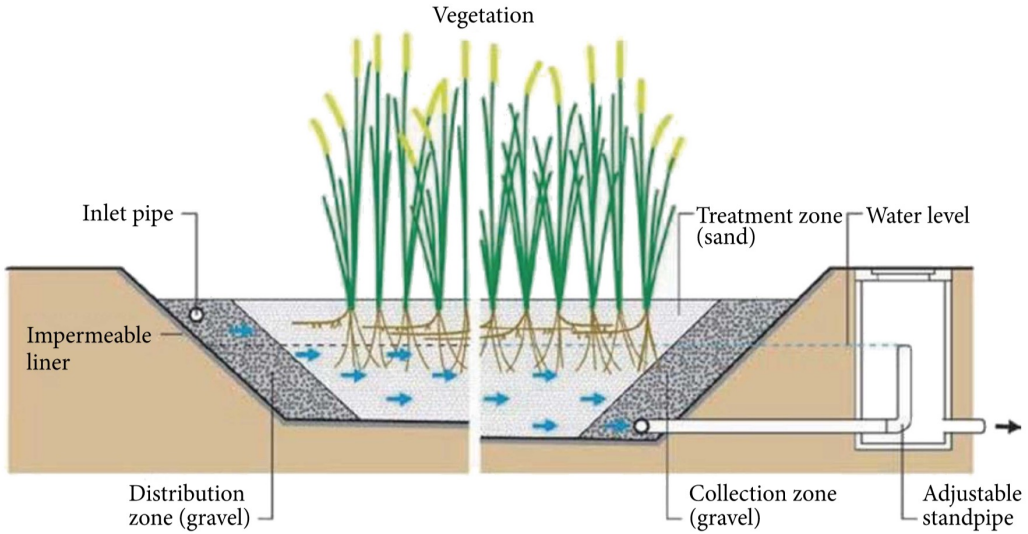
Natural treatment systems

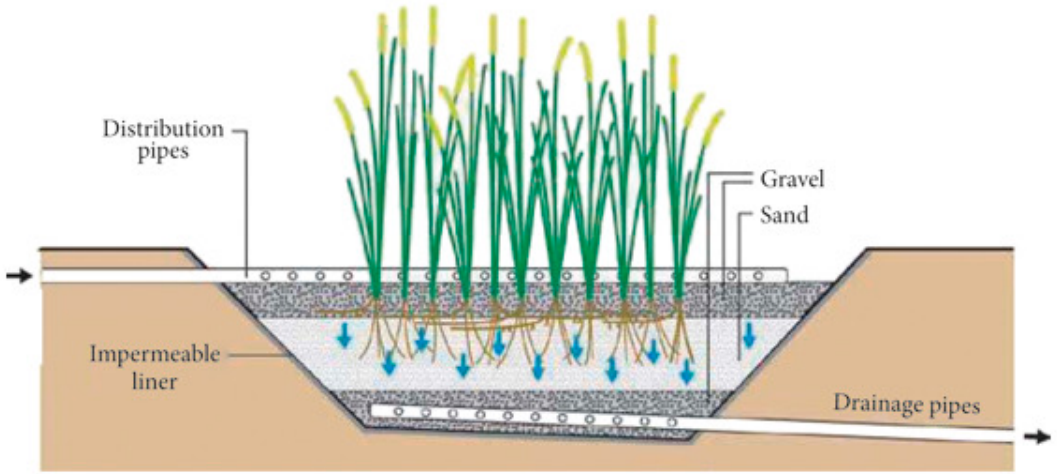
Natural treatment systems following phytoremediation principles (Adams et al. 2000); McCutcheon and Schnoor, 2003) for wastewater treatment and reuse:

- Stabilization ponds (WSPs)
- Constructed wetlands (CWs),
- Slow rate (SRs)

7cm

Unsaturated constructed wetlands





Source: Dübendorf (EAWAG), 2006

Unsaturated constructed wetlands (UCW):

- Horizontal flow constructed wetlands
- Vertical flow constructed wetlands

UCWs are **operated with intermittent feeding** throughout the operational day (Platzer, 1999; Tsihrintzis, 2017).

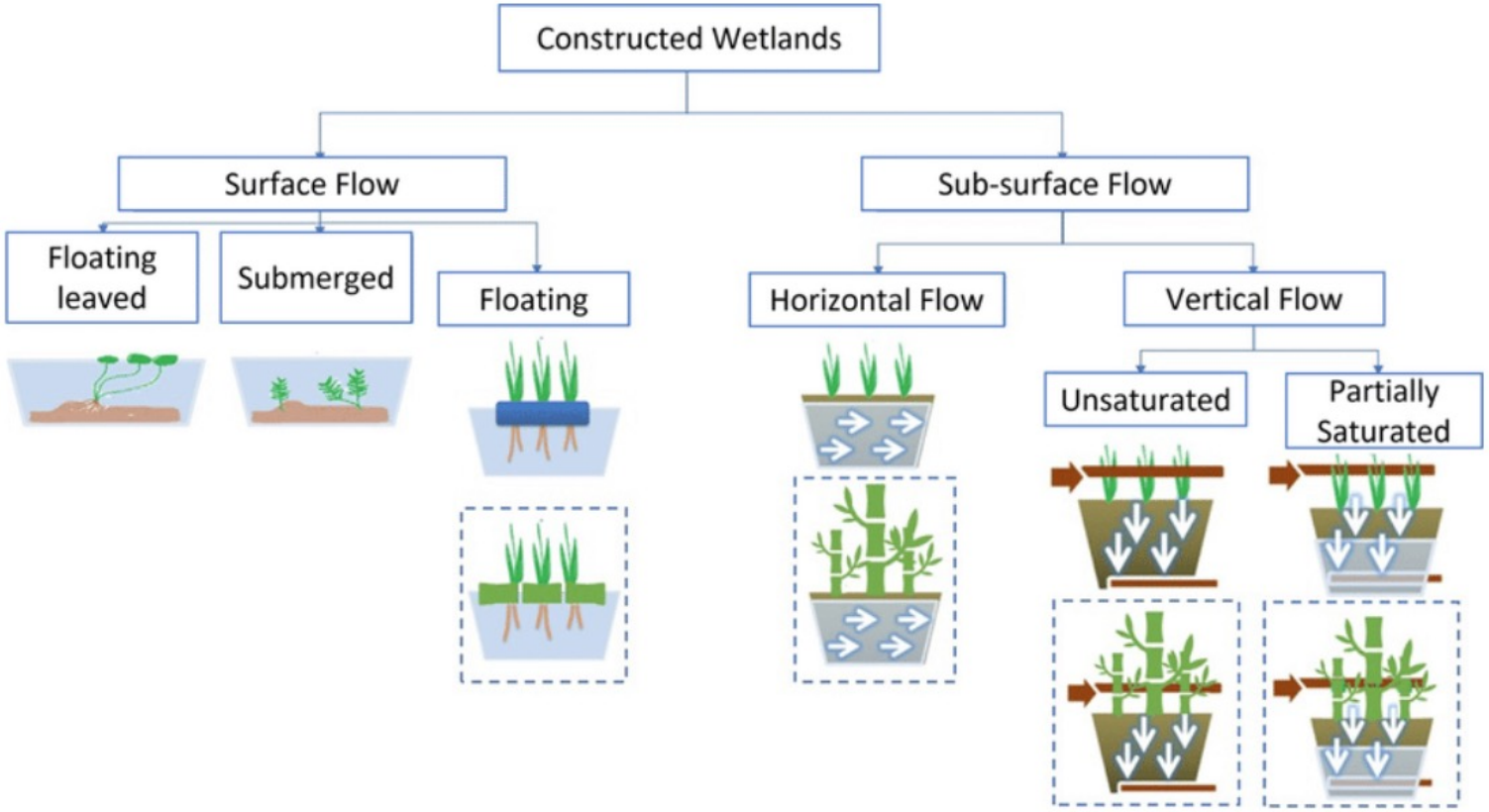
Emergent plants such as bulrushes (*Scirpus*), cattails (*Typha*), and common reeds (*Phragrnites*) are most often used

Bamboo constructed wetlands

Bamboo:

- fast growth and perennial biomass,
- rich rhizospheric diversity, and commercial utility (Singh et al, 2020)
- High nutrient absorption abilities (Mailly et al. ,1997; (Ramakrishnan and Toky, 1981)
- Heavy metal removal.

➔ emerged as an ideal plant for UCW



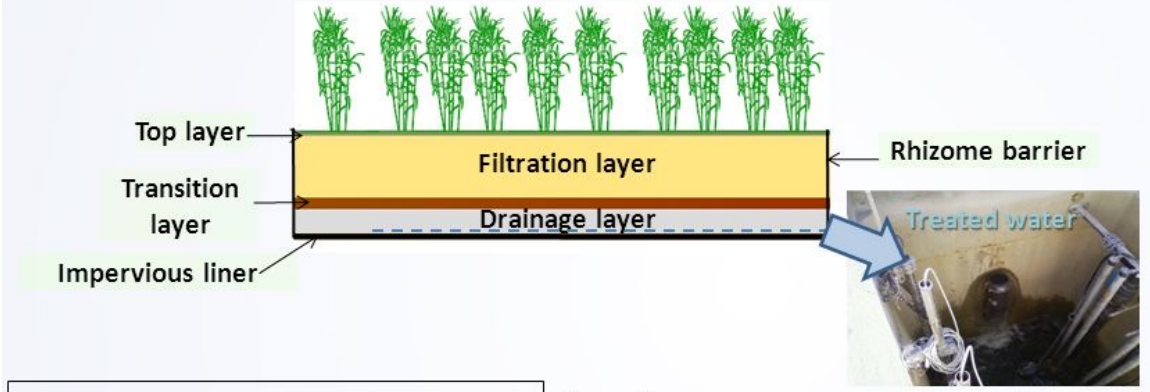
Schematic diagram of the types of CWs (Nast et al., 2020)

Bamboo constructed wetlands

23cm

- BAMBOU-ASSAINISSEMENT technology, which used temperate bamboo to treat winery wastewater (Arfi et al., 2009) ➔ E% COD = 99% and 98% of the nutrients (N, P)

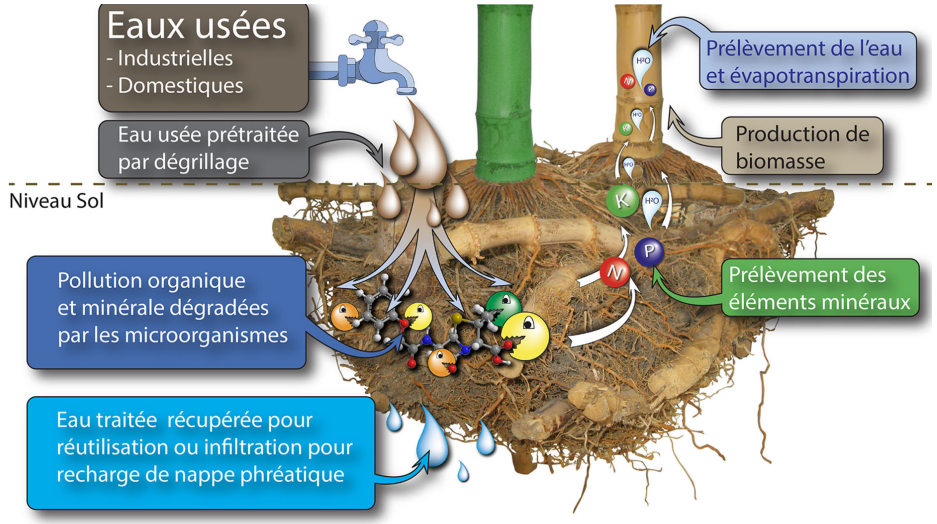
- CW with bamboo *Cyperus Papirus* run with anaerobic baffled reactor´s effluent: HRT of of 1.1 days ➔ average removal efficiency of COD of 15 ± 56%, 33 ± 54% of BOD, 60,8 ± 40,2% of TSS, and turbidity 48.4 ± 17.1 NTU



In this system bamboos are not planted in existing soil but in filtration materials

➔ Smaller treatment surface than 1st BA ® system (1 to 3 m^2/P.E.)

➔ All the treated water is collected



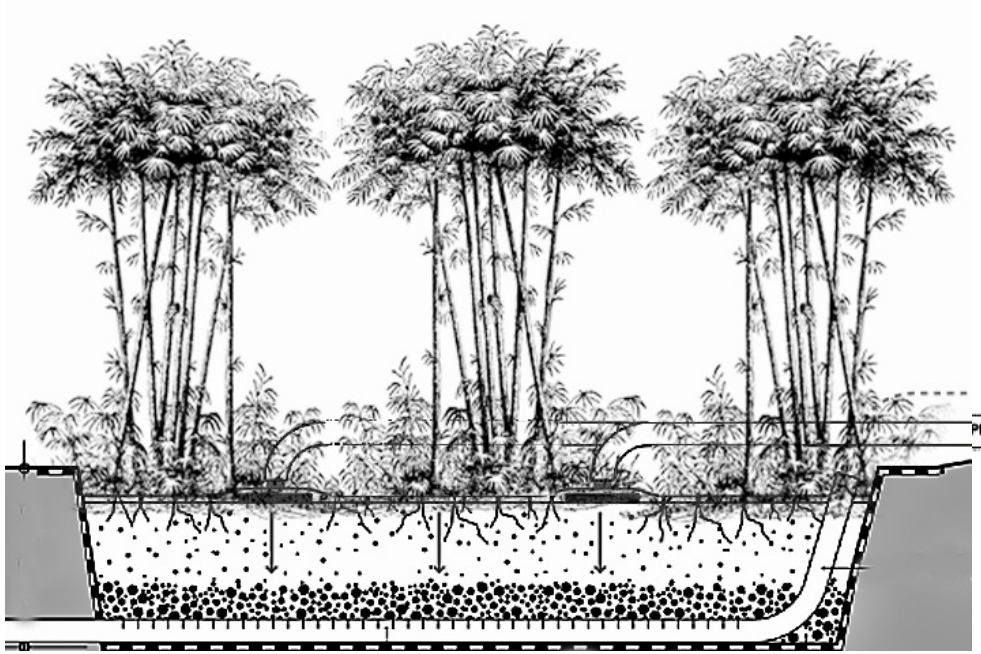
Source: Arfi et al., 2009

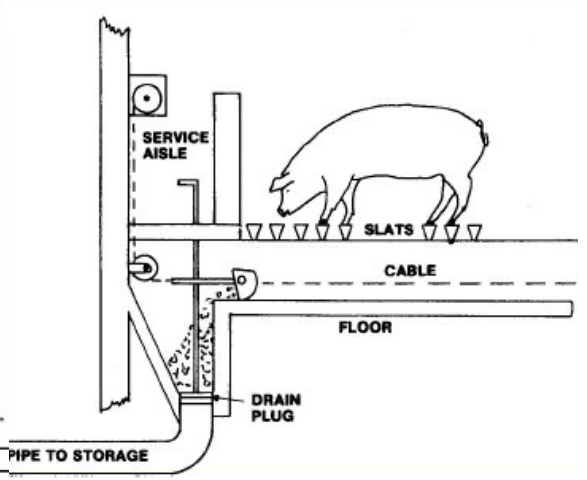
Bamboo constructed wetlands

23cm

The EU-funded BRITER-WATER project: used a bamboo filter bed (1,500 m^2) to treat food processing wastewater and **reused the effluent for irrigation** → The biomass formed in the filter bed can be used locally as fuel for boilers, and for heating administrative buildings or schools

Piouceau et al. (2020) used bamboo groves for pig slurry treatment ➔ **high nutrient uptake into the bamboo biomass** (Nutrient uptake of *G. wrayi, B. oldhamii, B. vulgaris* ranged from 432 - 810 kg TN ha^{-1} $year^{-1}$, 42 - 134 kg TP ha^{-1} $year^{-1}$ and 282-597 kg K ha^{-1} $year^{-1}$)





Bamboo- NBS for urban water management

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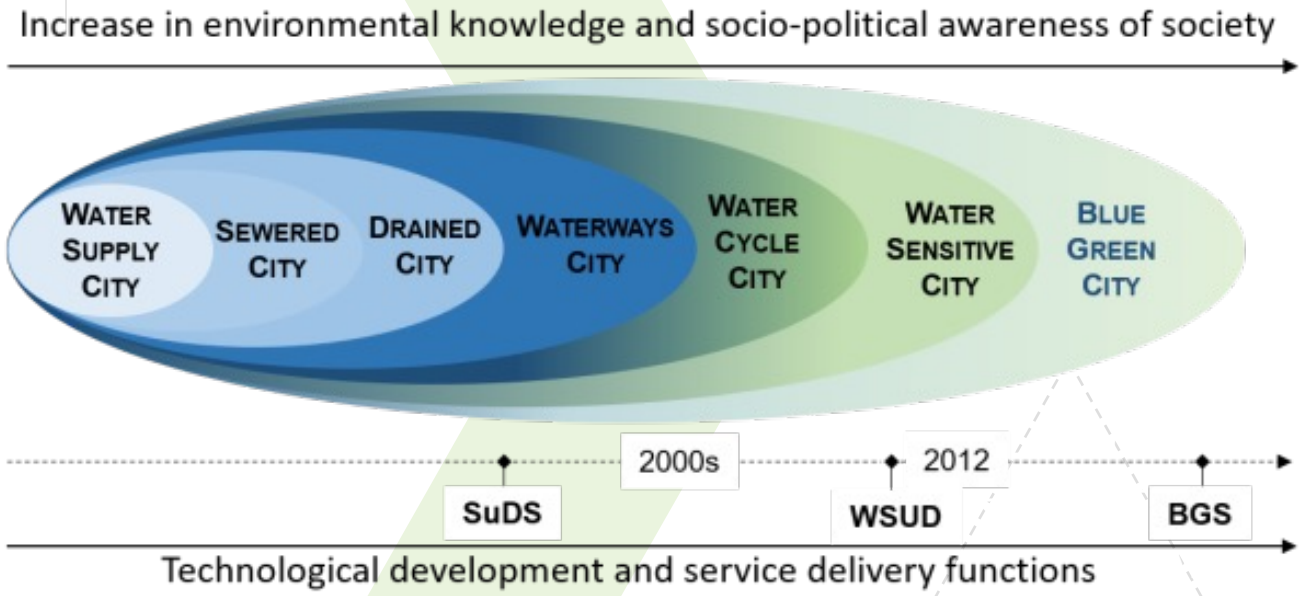
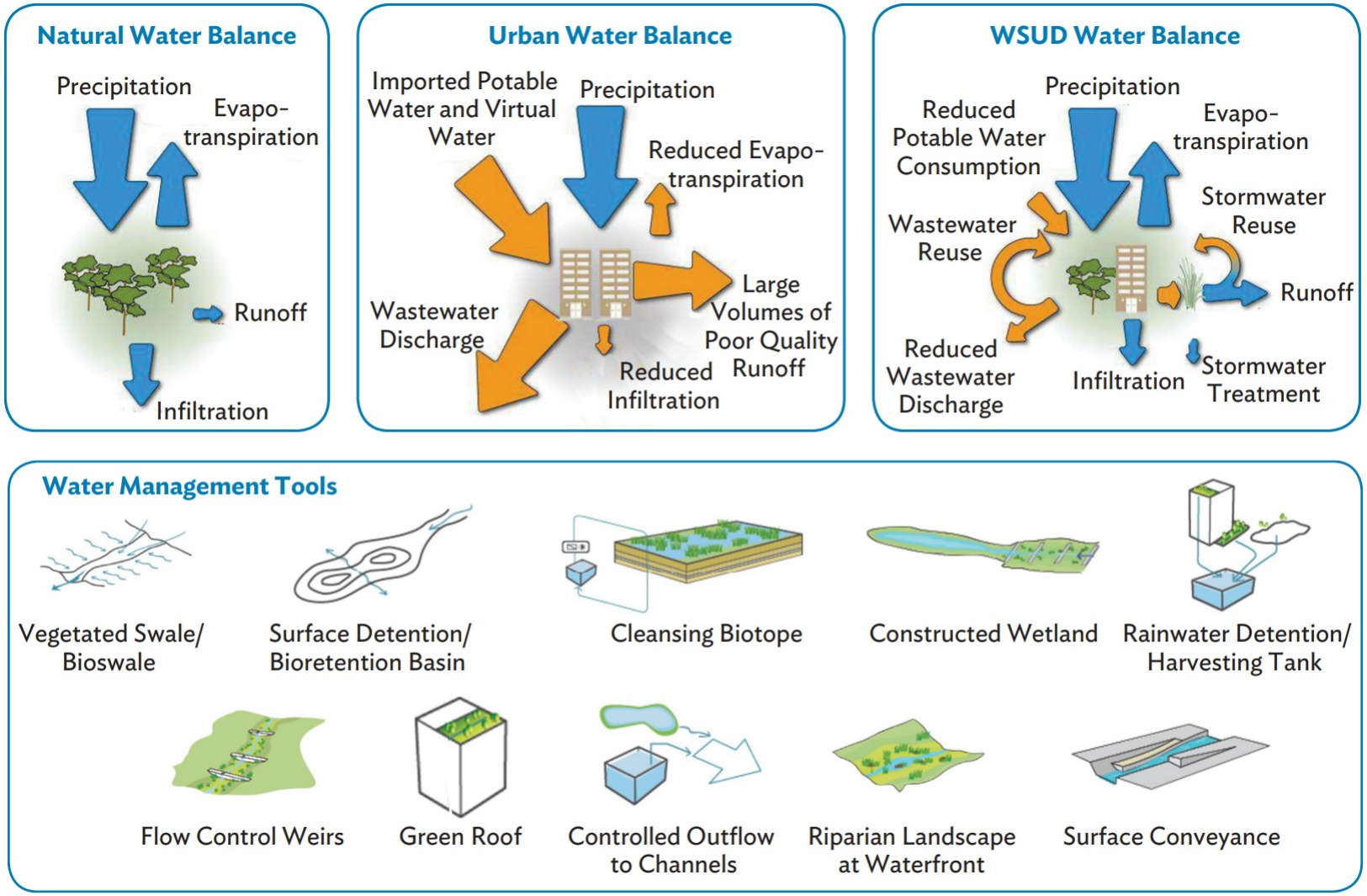
- UWM as a combination of water supply, urban drainage, wastewater treatment and water-related sludge handling.
- Natural based-sollution offers untapped potential for Water Sensitive Urban Design (WSUD) and Blue green City approaches.



Source: ICLEI – Local Governments for Sustainability, 2017)

Urban water management

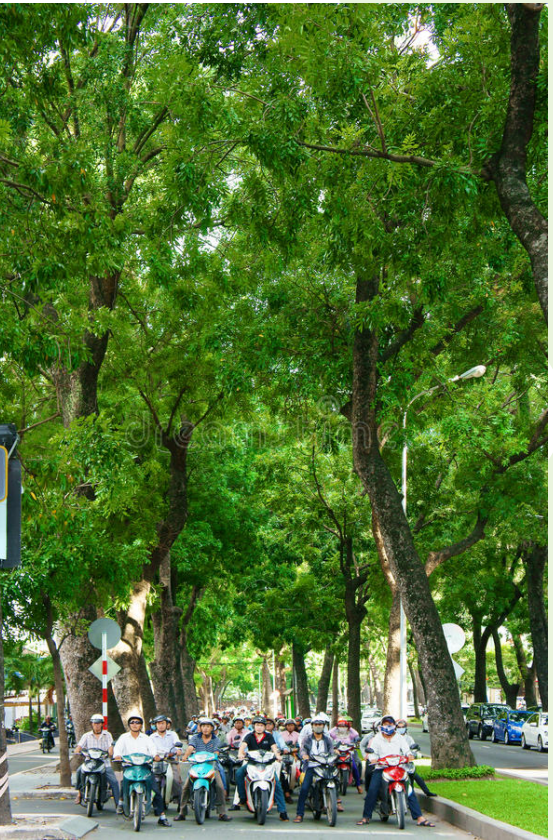


Source: A. Hoban and T.H.F. Wong. 2006. *WSUD Resilience to Climate Change*. Paper presented at the first Australian National Hydropolis Conference. Perth. 8–11 October.

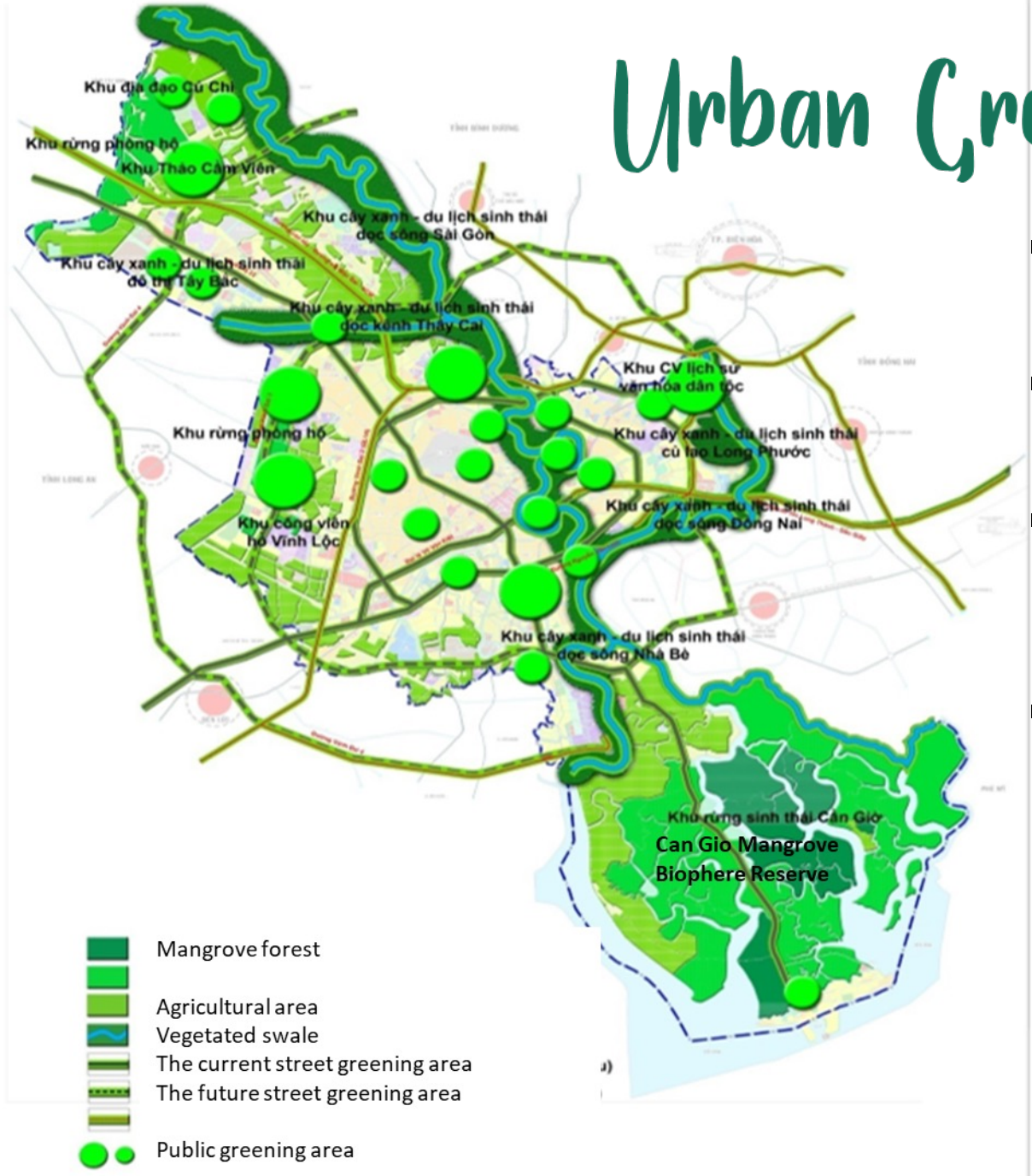
- Long-term urban planning bases on WSUD approaches that mimic the water balance of nature.
- ➔ enhance livability values for city dwellers and improve urban biodiversity.
- WSUD/NBS tools include designing vegetated swales, wetlands, bioretention basins or artificial lakes, rain gardens, green roofs, permeable pavements, infiltration wells, etc.

Urban water management

- NBS offers untapped potential for urban water pollution control, can mitigate environmental stresses in urban areas such as air and water pollution, green space loss, ambient temperature increase



Urban Greening in Ho Chi Minh City



- Ho Chi Minh City currently has a high urbanization rate (≅ 10 million in 2021) and population growth rate (2.7%).
- Investment of new large-scale parks in recent years has been large challengies for urban greening in HMC.
- At the present, the total area of land for planning green parks = up to more than 11,400 ha, corresponding to the target of 7m^2/person,
- The fact that the total existing park area is currently only about 500 ha, ≅ of 0.55m^2/person, while standard of green land for public use is 12-15 m^2/person

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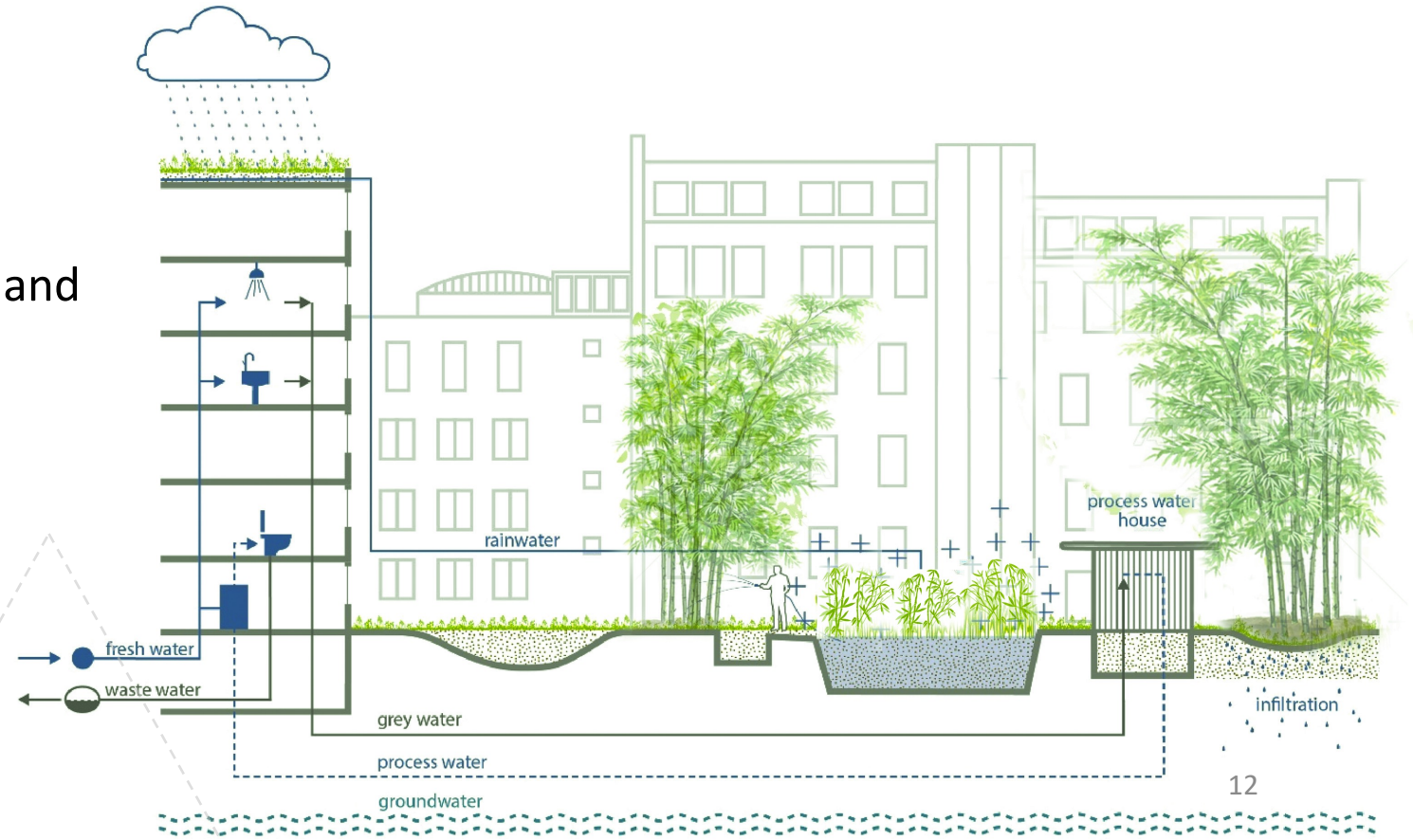
Bamboo- NBS for urban water management

- Bamboo crops can be considered as a multipurpose NBS, for water pollution control in UWM coupled with urban greening
- Bamboo can significantly contribute to urban greening due to its ecological benefits:
  - carbon sequestration,
  - particulate matter absorption,
  - water and soil conservation,
  - Urban run-off water pollution control and
  - Water reuse



Bamboo- NBS for urban water management

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- the bamboo application can be a promising approach for Water Sensitive Urban Design (WSUD),
- Bamboos can be selected as a potential macrophyte for multi-edge treatment such as natural edge/vegetated swales, rain gardens, and riparian landscapes at the waterfront.
- resilient erosion control and slope stabilization in urban infrastructures (Wu et al, 2020).

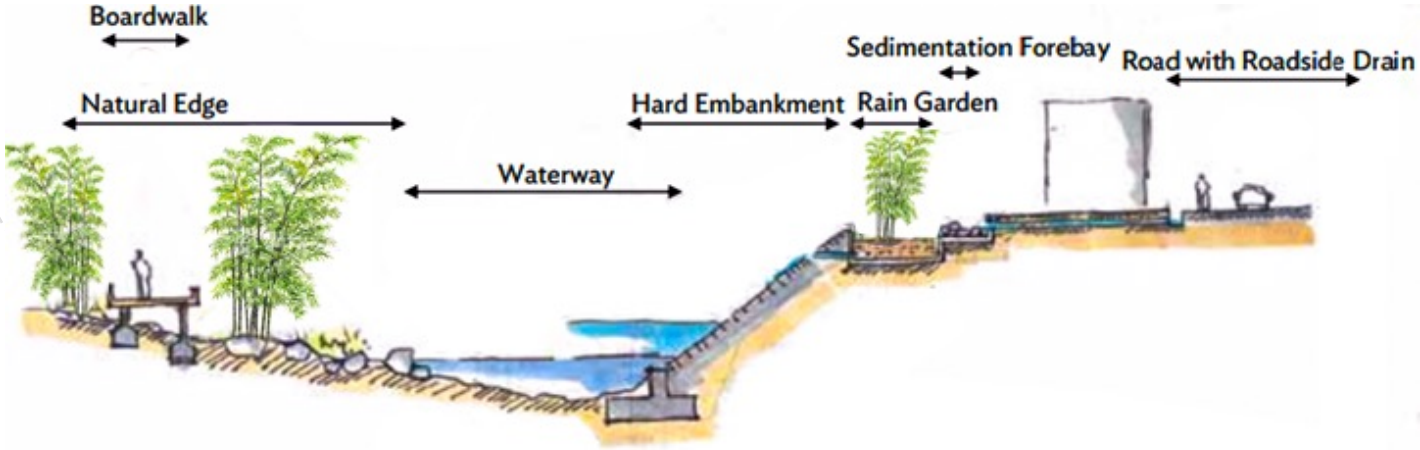


Figure 2. Multi-edge treatment type (ADB, 2019)

Experiment -Bamboo Vertical constructed wetland

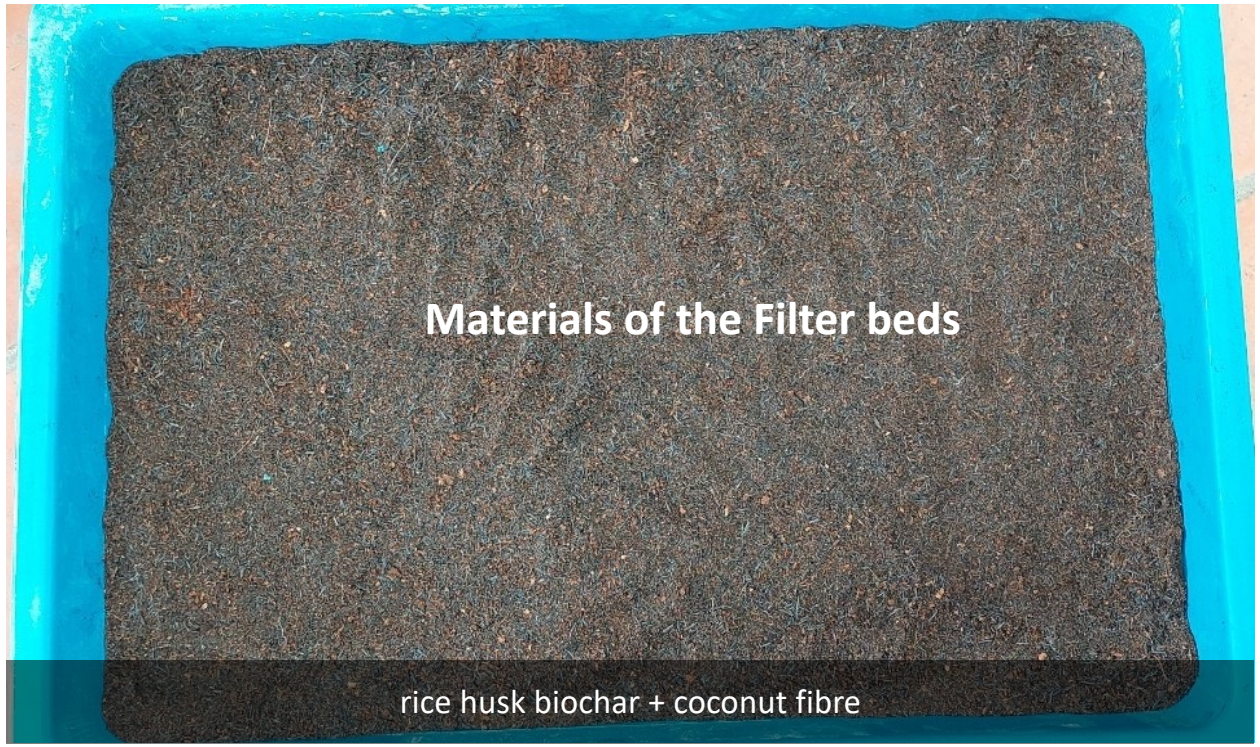
23cm

Bamboo vertical constructed wetland = green roof
Feed wastewater = Grey water from the office building

Experiment -Bamboo Vertical constructed wetland


perlite gravels with size 2 – 6 mm


perlite gravels with size 1 – 2 cm



rice husk biochar + coconut fibre

Operating conditions

Q	120 $L.d^{-1}$
COD	250 $mg.L^{-1}$
Hydraulic loading rate (HLR)	1.7 $L.m^{-2}.min^{-1}$
Organic loading rate (OLR)	40 g $COD.m^{-2}.d^{-1}$
Specific pulse volume (SPV)	41.7 $L.m^{-2}$
Specific hydraulic loading rate applied (SHLR)	1.7 $L.m^{-2}.min^{-1}$
Number of feeding per day	4 $pulses.d^{-1}$
feeding duration	10 min

Conclusion

- Bamboo species were proven as suitable plants used in a CW for polluted water treatment and nutrient recovery.
- Bamboos can be selected as a potential macrophyte for NBS design in sustainable urban water management.

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Thank you