From Detection to Removal of Bisphenol A (BPA): Nature-Based Living Wall Systems for Septic Effluent Treatment and Water Security

Event / Session: NAC-06:

Emerging Micropollutants in the Environment

24 April 2026 | 13:30 – 15:30 hrs.

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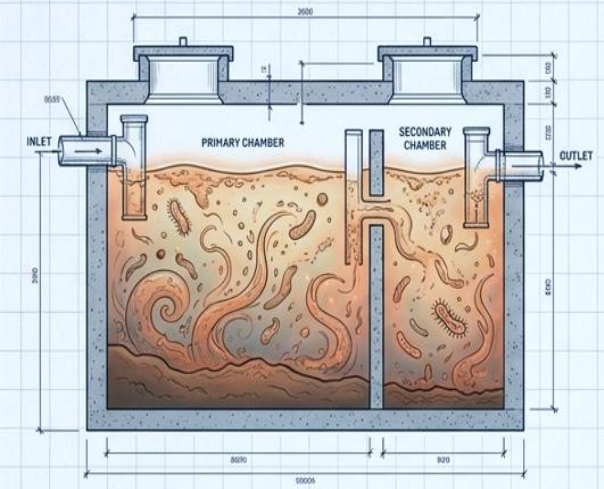
Tanatvanit, Somporn, Thammarat Koottatep, Tatchai Pussayanavin, Rawintra Eamrat, and Chongrak Polprasert. 2025. “Evaluation of a Living Wall Garden System for Septic Effluent and BPA Removal in Urban Environments.” *Water Conservation Science and Engineering* 10: 98.

Background / Problem

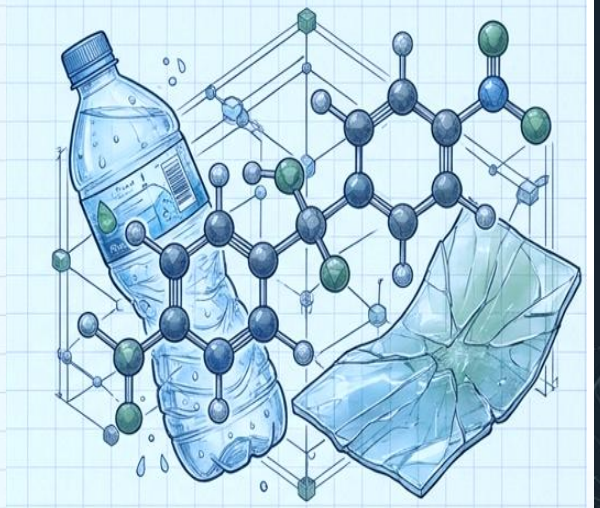
- Decentralized wastewater systems still face performance limitations
- Micropollutants (e.g., BPA) increasingly detected in wastewater
- Conventional systems are not designed for emerging contaminants
- Need for compact, sustainable, urban-compatible solutions

The Biological Overload



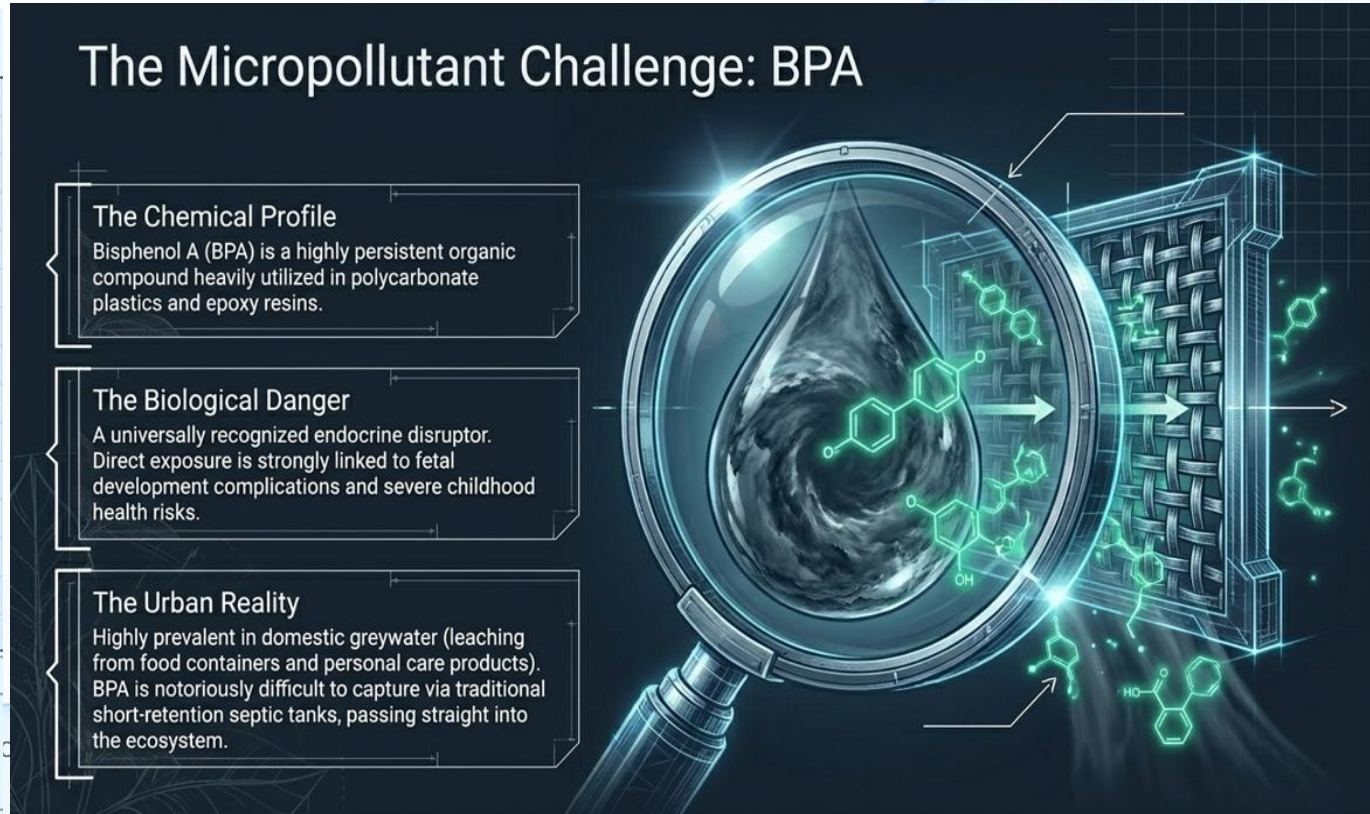
MACRO CRISIS	MECHANISM OF FAILURE
Over 4.2 billion people globally lack sufficient sanitation.	Short retention times and variable organic loading rates leave septic effluent packed with highly reactive organics (COD) and nitrogen, rapidly overwhelming local environments.

The Chemical Threat



EMERGING THREAT	MECHANISM OF FAILURE
Increasing, ubiquitous detection in domestic grey and blackwater.	BPA is a persistent endocrine-disrupting micropollutant. Conventional decentralized 'end-of-pipe' systems lack the physical or biological mechanisms required to capture or degrade it.

The Micropollutant Challenge: BPA



The Chemical Profile

Bisphenol A (BPA) is a highly persistent organic compound heavily utilized in polycarbonate plastics and epoxy resins.

The Biological Danger

A universally recognized endocrine disruptor. Direct exposure is strongly linked to fetal development complications and severe childhood health risks.

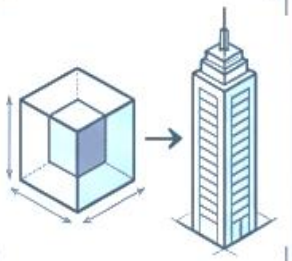
The Urban Reality

Highly prevalent in domestic greywater (leaching from food containers and personal care products). BPA is notoriously difficult to capture via traditional short-retention septic tanks, passing straight into the ecosystem.

Research Objectives

- ✓Evaluate a Living Wall Garden (LG) system for septic effluent treatment
- ✓Assess removal of conventional pollutants and BPA
- ✓Investigate effects of hydraulic retention time (HRT)
- ✓Examine role of media and plant species

The Living Wall Garden (LG): A Nature-Based Post-Treatment System



Value Pillar: Spatial Efficiency

A **vertical-flow constructed wetland** designed specifically to overcome land-**scarcity** in dense urban centers without sacrificing treatment volume.

Biological Filtration

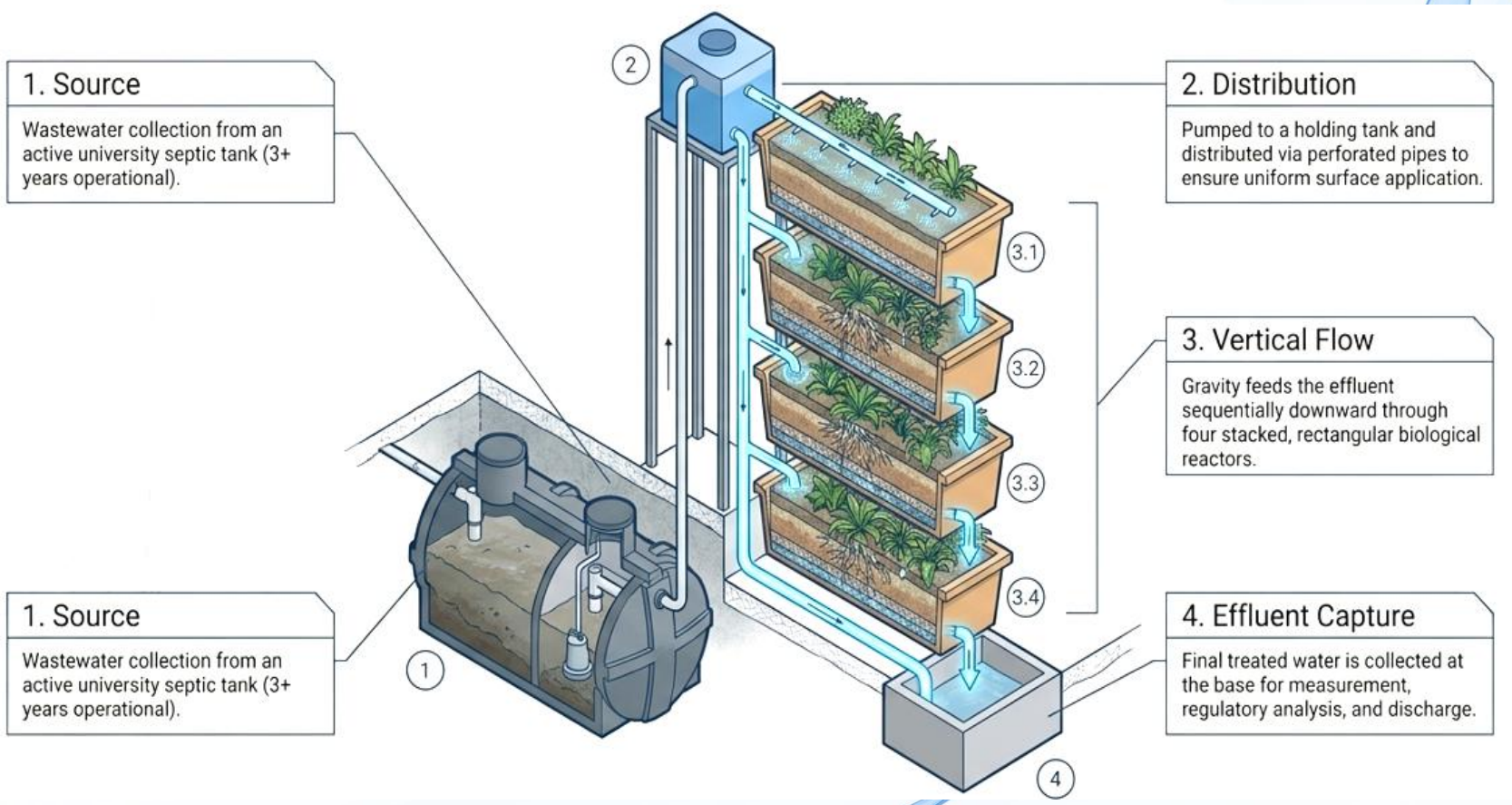
Leverages deep plant root lattices and diverse substrate microbiomes to passively degrade high-load organics.

Micropollutant Trapping

Engineered with built-in physical and chemical adsorption capacities spefifically targeted to halt endocrine disruptors like BPA.

System Design (Methodology)

- Vertical multi-layer system with 4 reactors in series
- Media: clayey soil + zeolite + gravel
- Planted with ornamental species (e.g., Pandanus, Chlorophytum)
- Operated under HRT = 3–12 hours

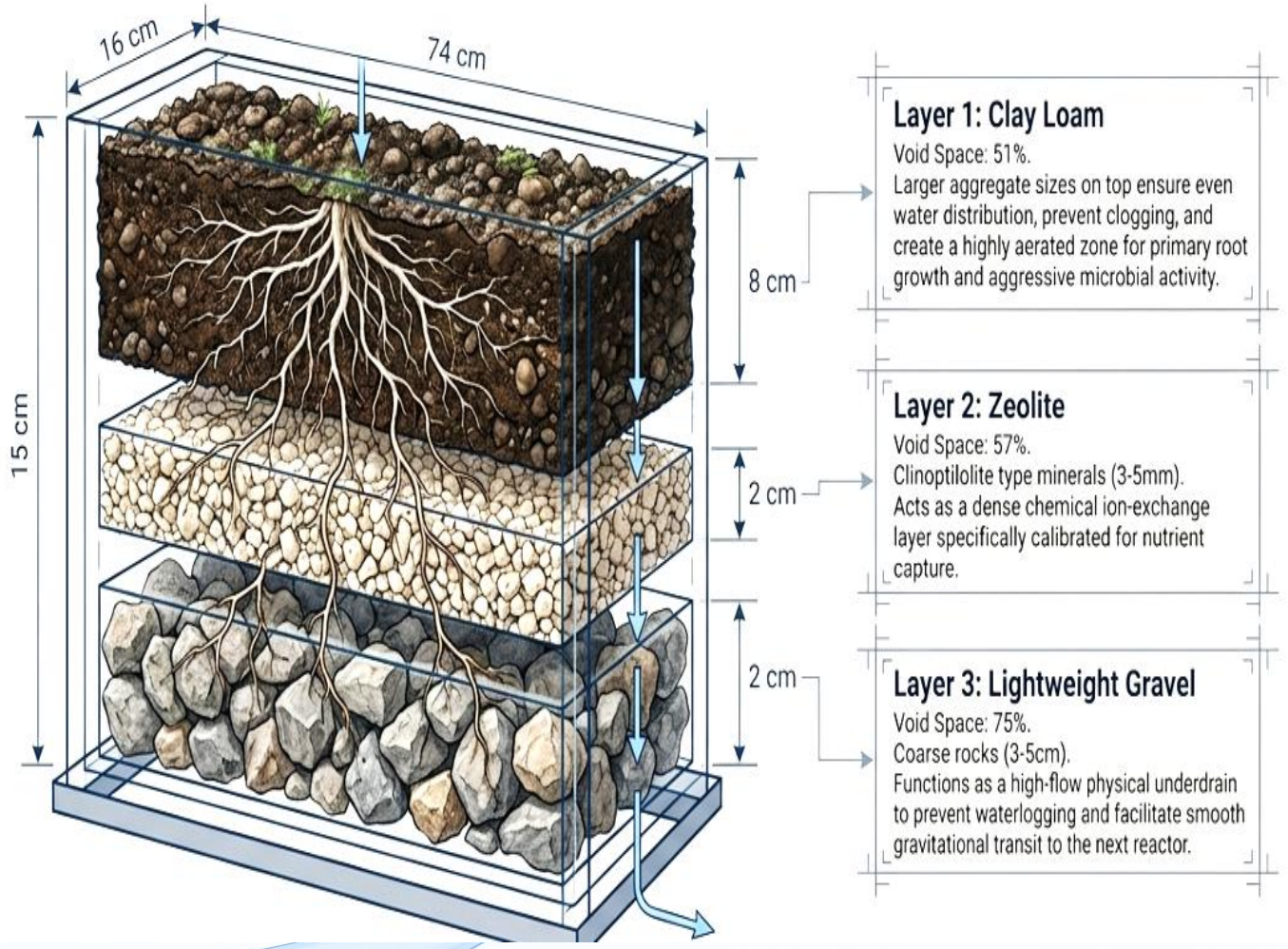


System Design (Methodology)

Hydrocotyle umbellata

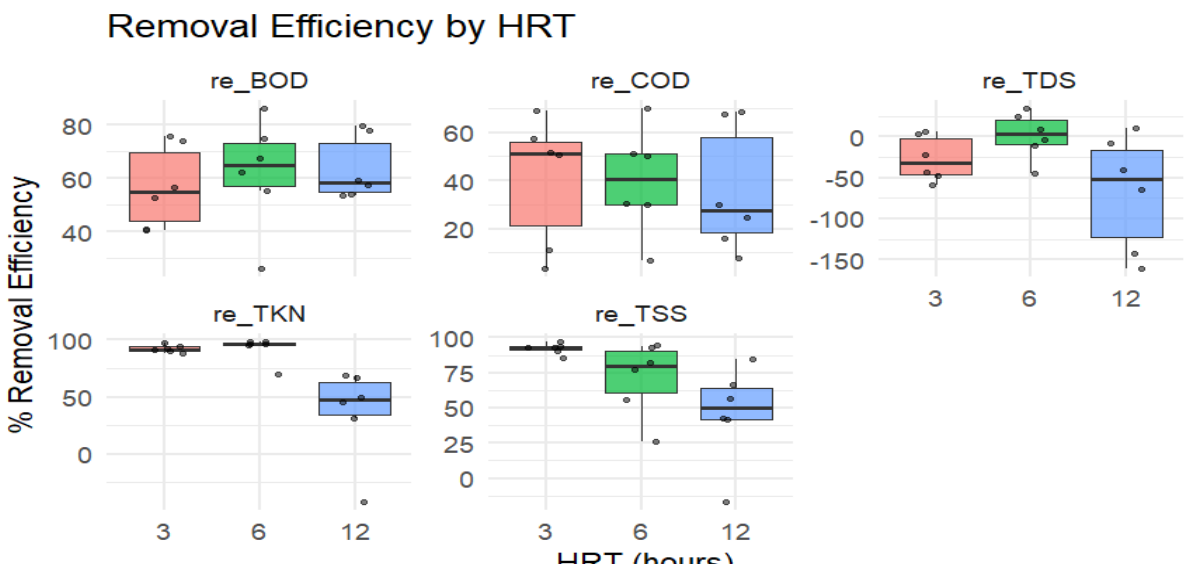
Chlorophytum comosum

Pandanus sanderi Sander ex M.T. Mast



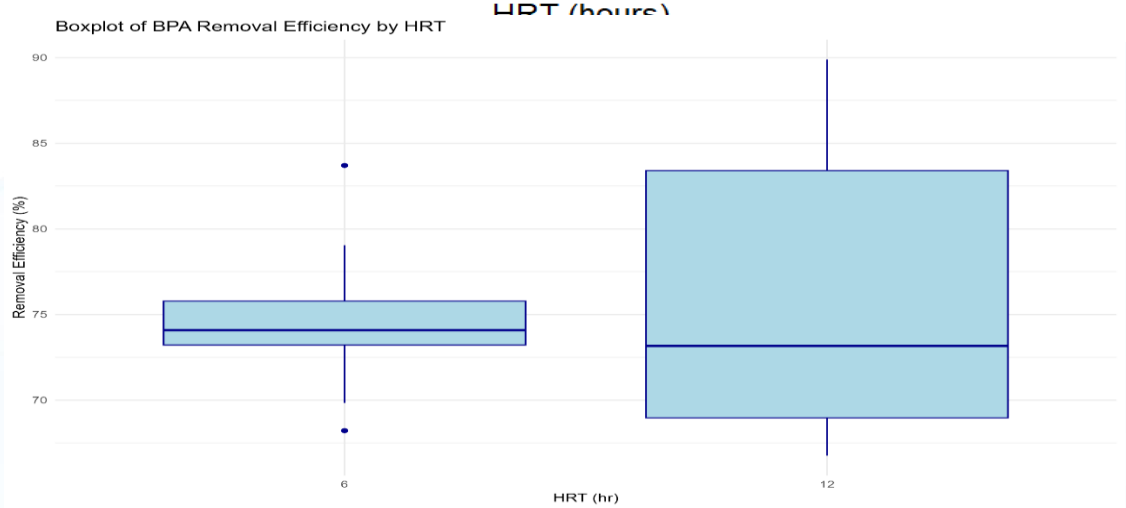
Key Results – Conventional Pollutants

- COD removal: up to ~87%
- BOD removal: up to ~63.7%
- TSS removal: 58.5–92.1%
- Effluent met Thai & international standards



Key Results – BPA Removal

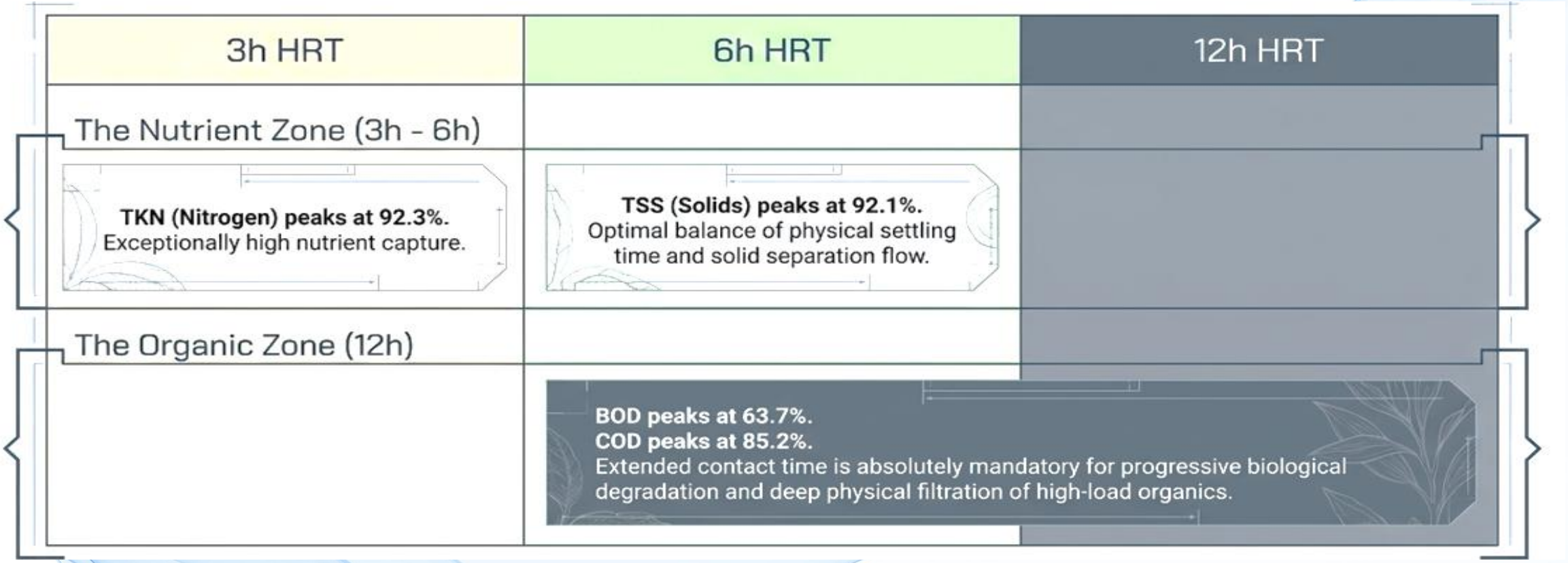
- BPA removal efficiency: 67.1–89.7%
- Average ~75% at 12 h HRT
- Effective under both 6 h and 12 h conditions
- Demonstrates capability for emerging contaminant removal



HRT	Mean_removal	SD_removal
6	74.66	3.5
12	75.91	8.45

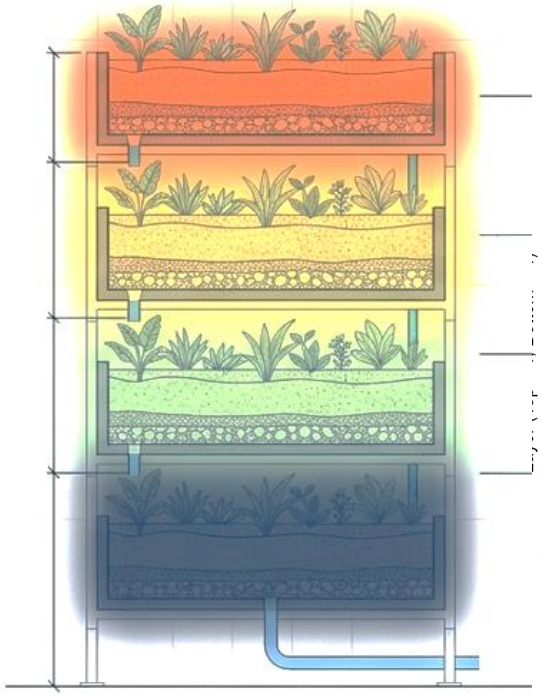
Role of HRT (Important Insight)

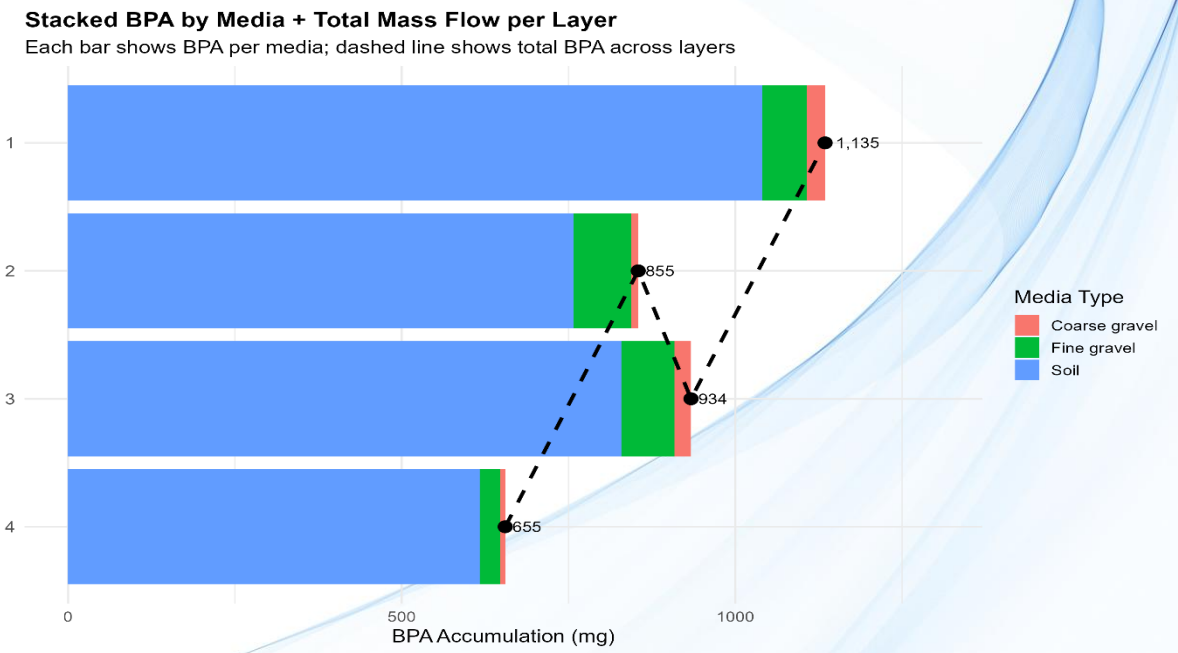
- Short HRT (3–6 h) → better nutrient removal (TKN, TSS)
- Long HRT (12 h) → better organic removal (COD, BOD)
- Trade-off → system can be optimized based on objective

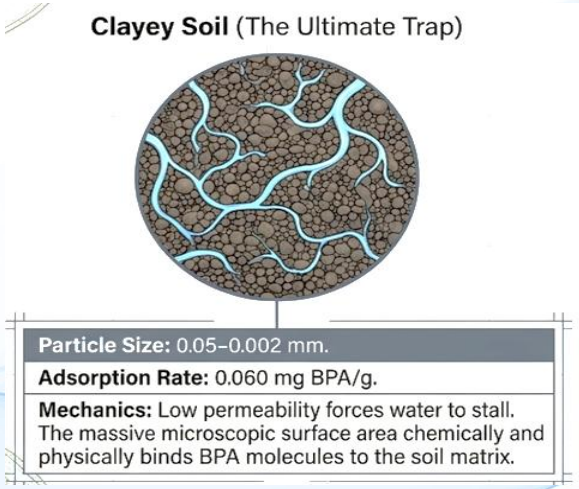


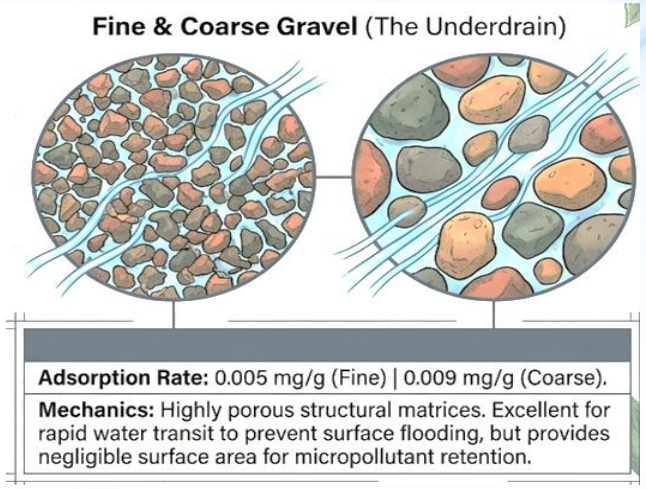
Role of Media

- Clay soil showed highest BPA adsorption
- Fine particles - higher surface area and retention
- Upper layers captured most BPA
- Media selection - critical design factor



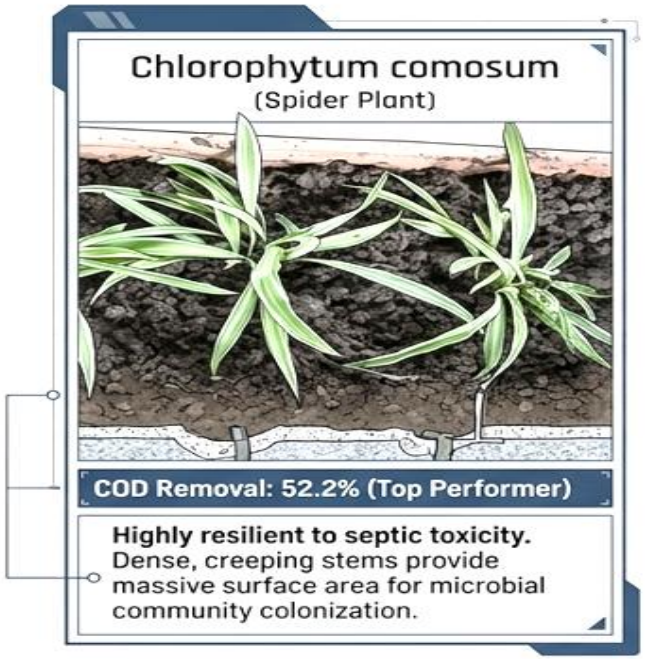


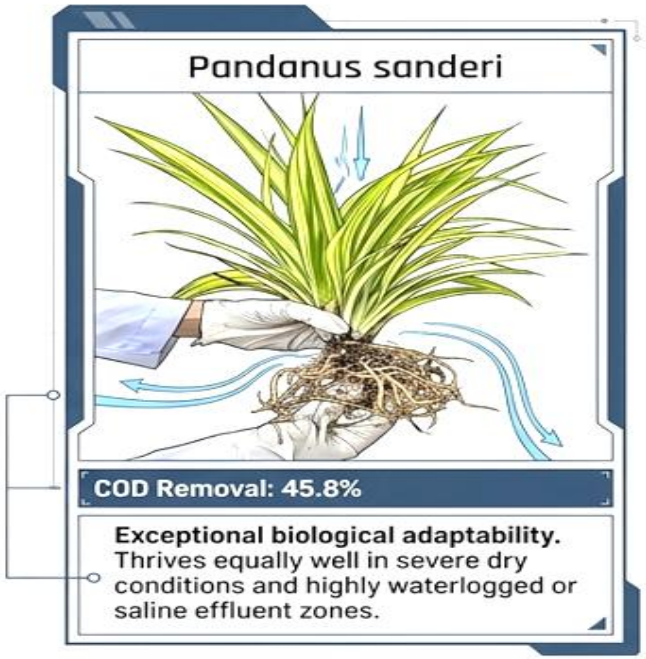


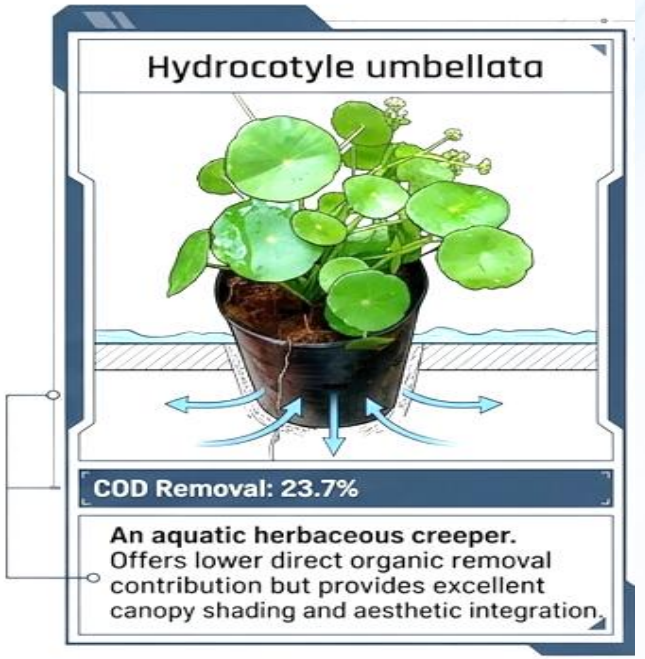


Role of Plants

- Plants support:
  - Microbial activity
  - System stability
- Limited direct BPA uptake
- Suitable species: Chlorophytum and Pandanus







Treatment Mechanisms

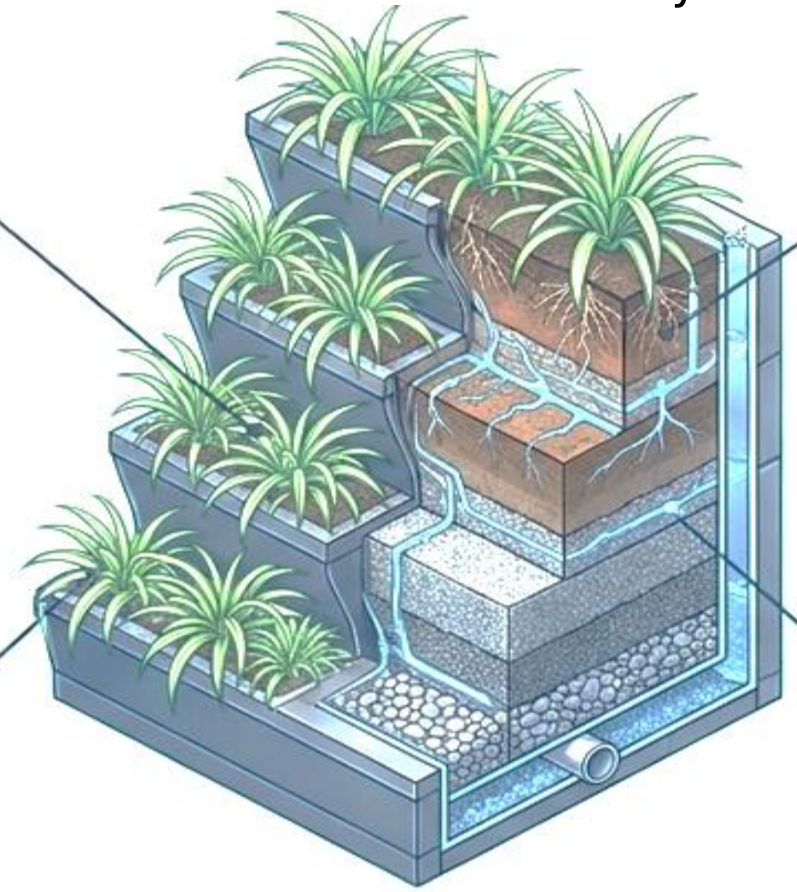
- ✓ Physical: filtration and sedimentation
- ✓ Chemical: adsorption (especially in clay)
- ✓ Biological: microbial degradation
- ✓ Plant–microbe interactions support system stability

✓ Hydraulic Target

Set the HRT dial rigidly to 12 Hours for maximum organic stabilization and regulatory compliance.

✓ Botanical Engine

Plant highly resilient *C. comosum* (Spider Plant) and *P. sanderi* for unparalleled microbial root-support.



✓ Media Configuration

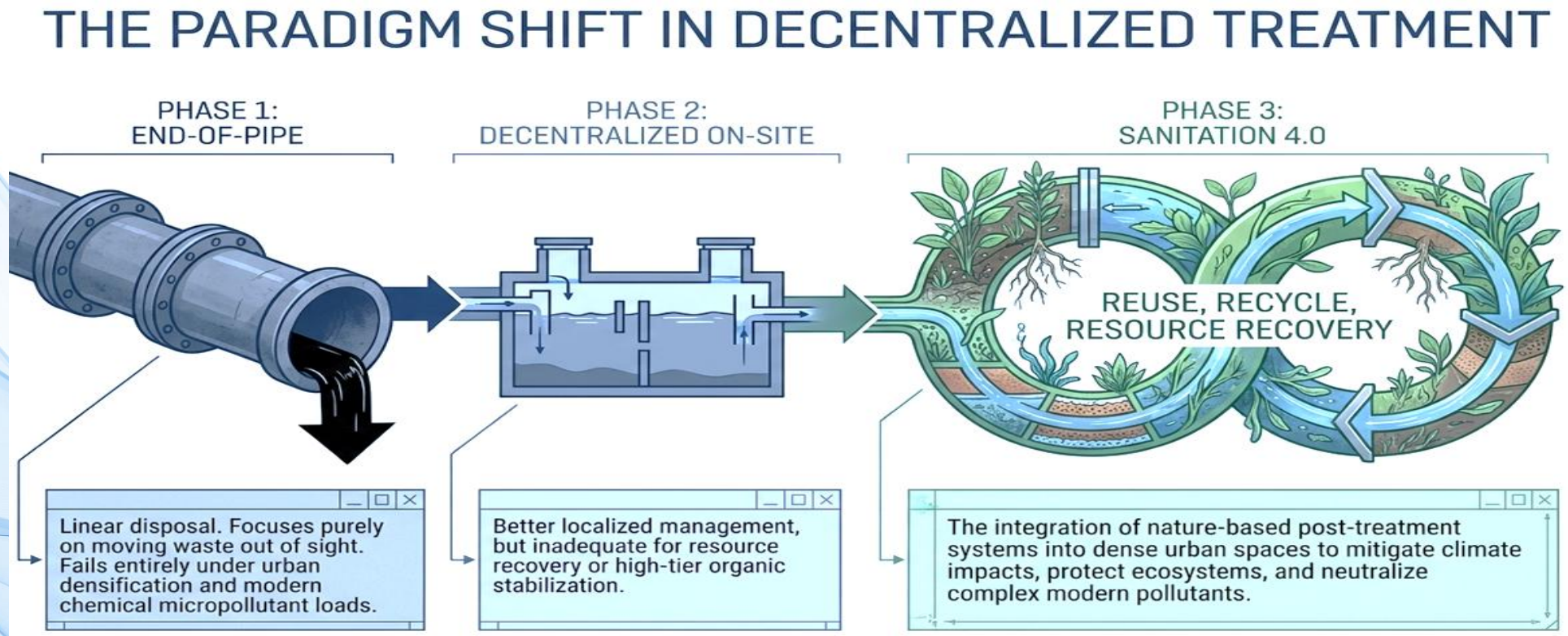
Maximize Clay Loam volume in the topmost tiers to aggressively drive early-stage BPA physical adsorption.

✓ Operational Mandate

Implement a strict 6-8 week biomass harvesting schedule to prevent structural root clogging and maintain system equilibrium.

Implications

- Compact solution for urban and land-limited areas
- Suitable for decentralized wastewater systems
- Supports nature-based and circular approaches
- Potential for real-world application and scaling



Key Message

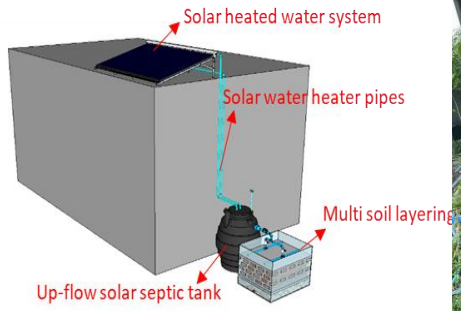
- ✓Living wall systems can bridge the gap between detection and removal
- ✓Effective for both conventional and emerging pollutants
- ✓A promising nature-based solution for sustainable water management

Thank you

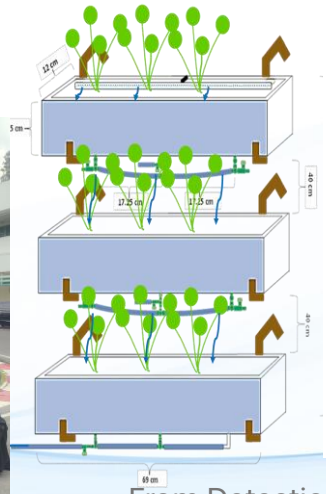
Future Research Directions

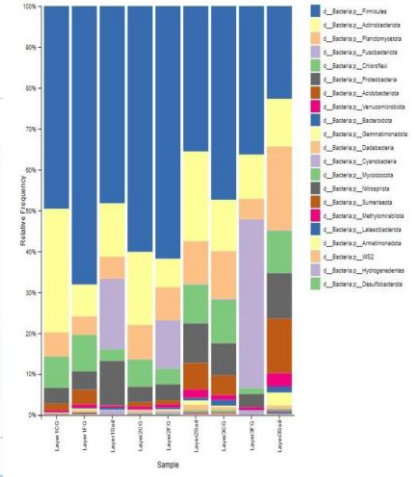
- ✓ System Optimization
- ✓ Advanced Contaminant Removal
- ✓ Media Development
- ✓ Integration with Nature-Based Solutions

Nouveau Design Solar Septic Tank: Reinvented Toilet Technology for Sanitation 4.0



Performance Evaluation of Modified Living Wall Garden (LW) for Treating Septic Tank Effluent





From Detection to Removal of BPA

Vertical Garden Constructed Wetland vs Vertical Garden Multi-Soil Layer-based Constructed Wetland

Vertical Garden Constructed Wetlands (VGCWs) with Diverse Plant Species and Modified Media