# Watercare Winnovators 2025

## Solve Challenge

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## Our Brief:

The development of a climate-resilient and sustainable wastewater management solution to combat the critical issues faced by the healthcare facilities in the Kampong Tralach District forms the basis of this challenge

## Solution Synopsis

Decentralized Wastewater Treatment Systems (DEWATS) are modular, low-energy treatment solutions designed to function without constant external power or chemicals. For healthcare facilities in rural Cambodia, we propose an Anaerobic Baffled Reactor (ABR) for primary treatment, and optional modules including constructed wetlands. We go in depth, covering technical principles, implementation steps, cost and resource optimisation, and detailing long term climate resilience and sustainability feasibility in Cambodia. We believe our solution will deliver reliable, climate-resilient wastewater treatment for healthcare facilities, improving public health and environmental outcomes in Kampong Tralach.

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## 2 Background

WaterAid Cambodia is working with Operation Health District and 15 health centres in the Kampong Tralach and Sameakki Mean Chey Districts of Kampong Chhnang Province. Their focus is to strengthen climate-resilient and inclusive water, sanitation and hygiene (WASH) in healthcare facilities (HCFs). These initiatives directly support the Cambodian Health Care Accreditation Standards (CHCAS) and the National Roadmap for WASH in HCFs, aiming to create safer and more sustainable healthcare environments.

Within the Kampong Tralach Operational Health District about five health centres lack adequate septic tanks, leading to untreated wastewater seepage that contaminates groundwater and elevates health risks for both patients and healthcare personnel. This is a significant challenge, further complicated by the lack of established national technical standards for septic systems.

Climate change intensifies most things, sanitation and hygiene are not an exception. Higher temperatures, increased rainfall, and flooding overwhelm wastewater, sanitation, and hygiene infrastructure. In contrast, droughts exacerbate water scarcity and groundwater pollution which cause unsafe and possibly contaminated conditions for Cambodian HCFs.

This collaboration aims to develop a climate-resilient septic tank, promote national wastewater management standards, and pilot a model system in Kampong Tralach District. By creating a scalable solution for broader implementation, we will be strengthening healthcare, and public health overall.

## 3 The Challenge

The development of a climate-resilient and sustainable wastewater management solution to combat the critical issues faced by the healthcare facilities in the Kampong Tralach District forms the basis of this challenge.

Our solve challenge will attempt to address the severe management challenges resulting from inadequate septic systems and untreated wastewater contamination. All of which directly compromises on the health and safety of healthcare workers, patients and the wider community.

# 4 Potential Solutions

## 4.1 Septic Tank

Simple underground septic tanks (STs), usually two compartments, allow solids to settle, and facilitates anaerobic digestion (Figure 1). Well-designed tropical STs remove roughly 50–70% of organic load and solids (Anh Viet Nguyen, Nga Thuy Pham, Thang Huu Nguyen, Antoine Morel, & Karin Tonderski, 2006), but effluent contains high biological oxygen demand (BOD), nutrients and pathogens. They require *no power*, only periodic desludging (every 3–5 years). Construction can use local concrete, at low cost. In Cambodia's flood zones, STs must be watertight and sealed (top sealed or elevated) to prevent floodwater ingress or overflow (MINISTRY OF RURAL DEVELOPMENT, 2019).

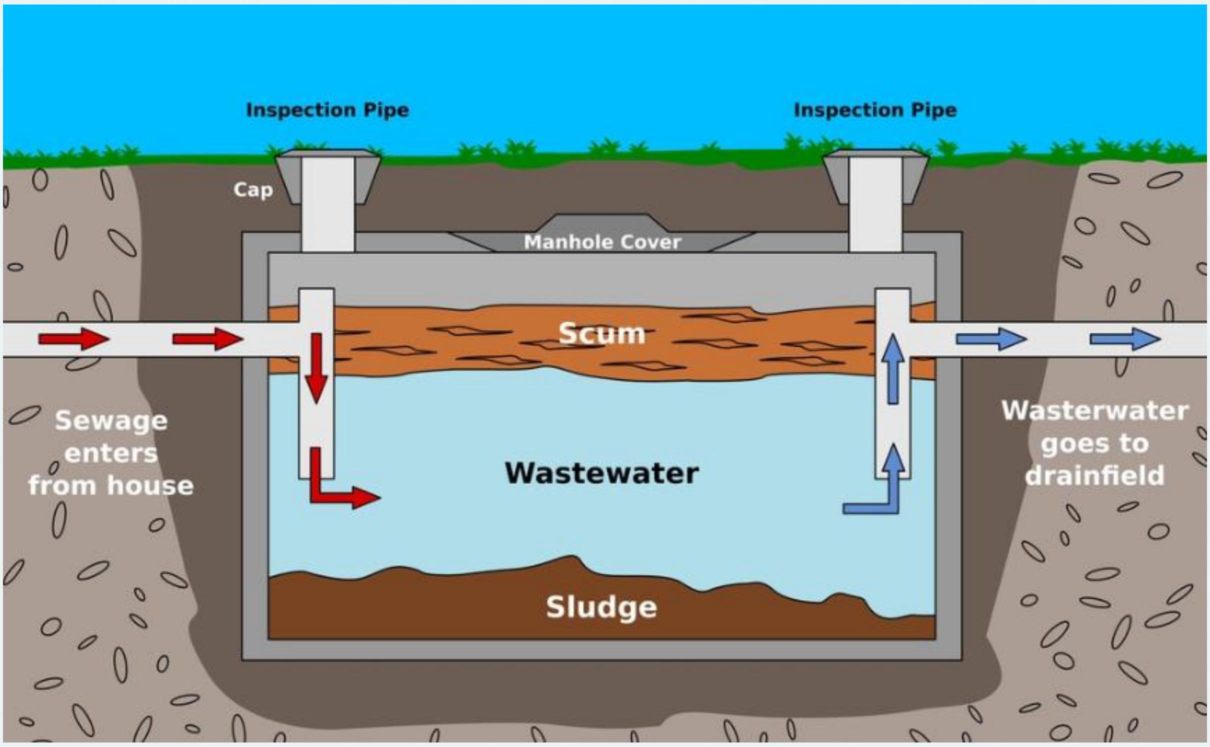


**Figure 1. Wastewater simple STs solution (MINISTRY OF RURAL DEVELOPMENT, 2019).**

### 4.1.1 Advantages

- proven technology
- low power

### 4.1.2 Disadvantages

- Moderate treatment only, sensitive to floods
- Must be properly sited (≥1.5m above water)

## 4.2 Anaerobic Baffled Reactor (ABR - Improved Septic)

These are multi-chamber concrete systems that force wastewater through successive baffles (Figure 2). Compared to a single ST, ABRs greatly increase contact time with sludge and improve solids capture. Studies in Vietnam (Anh Viet Nguyen, Nga Thuy Pham, Thang Huu Nguyen, Antoine Morel, & Karin Tonderski, 2006) show ABR-like baffled designs can achieve 80–90% removal of BOD, chemical oxygen demand (COD) and total suspended solids (TSS), versus ~50% for STs. The Cambodian flood guidelines explicitly recommend multi-chamber sealed pits (simplified ABRs) in flood/high-groundwater areas. Construction: concrete rings with internal baffles or partitions or stacked closed tanks. No power needed. Operation & Maintenance (O&M): periodic de-sludge, generally every few years. Cost: modestly above a septic (concrete/labour).

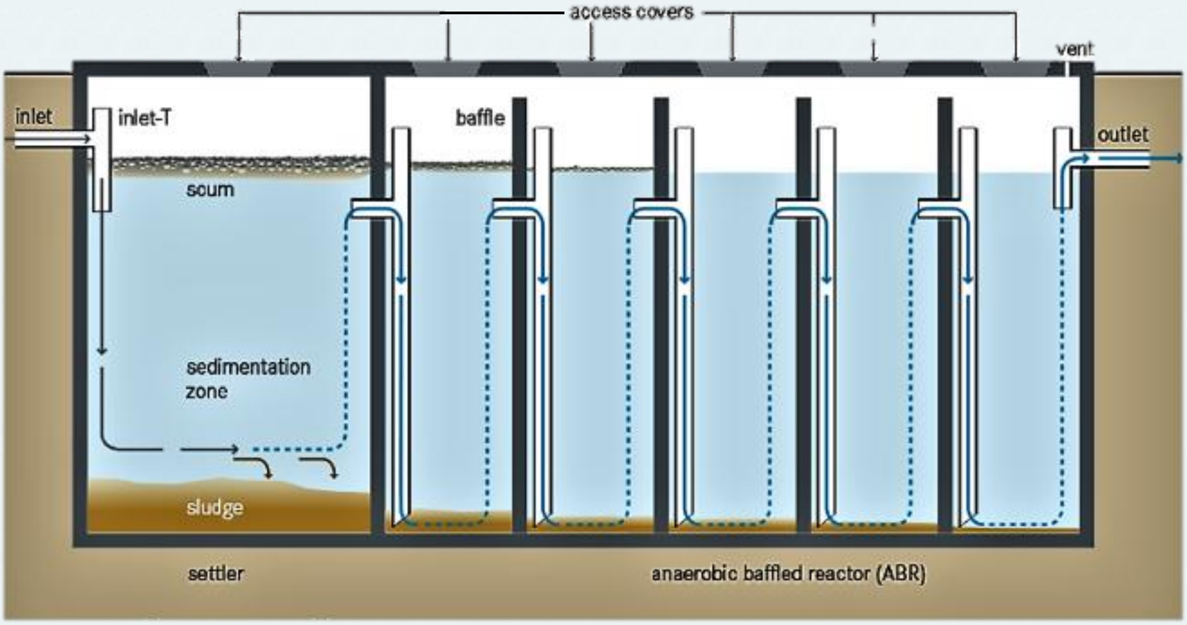


**Figure 2. Anaerobic Baffled Reactor (ABR) processes (Anh Viet Nguyen, et. al., 2006).**

### 4.2.1 Advantages

- Improved performance, more robust compared to conventional STs
- Can incorporate an anaerobic filter stage

### 4.2.2 Disadvantages

- More complex to build
- No disinfection step
- May require polishing for effluent to meet strict pathogen standard

## 4.3 Constructed Wetlands (CWs)

Planted treatment beds use wetland plants (e.g. Typha bulrush, Phragmites reed) and substrate to provide aerobic and anaerobic biofiltration. Two main types: vertical-flow (intermittent dosing, passes through gravel) and horizontal subsurface-flow (Figure 3). Very high pathogen and BOD removal (Parashar V, et al., 2022). Combined with a primary tank, CWs reliably meet discharge standards. CWs need no mechanical energy (except feeding pumps if gravity is infeasible). They require land area (5–10 m² per person-equivalent) and must be above floodwaters or designed to survive inundation.

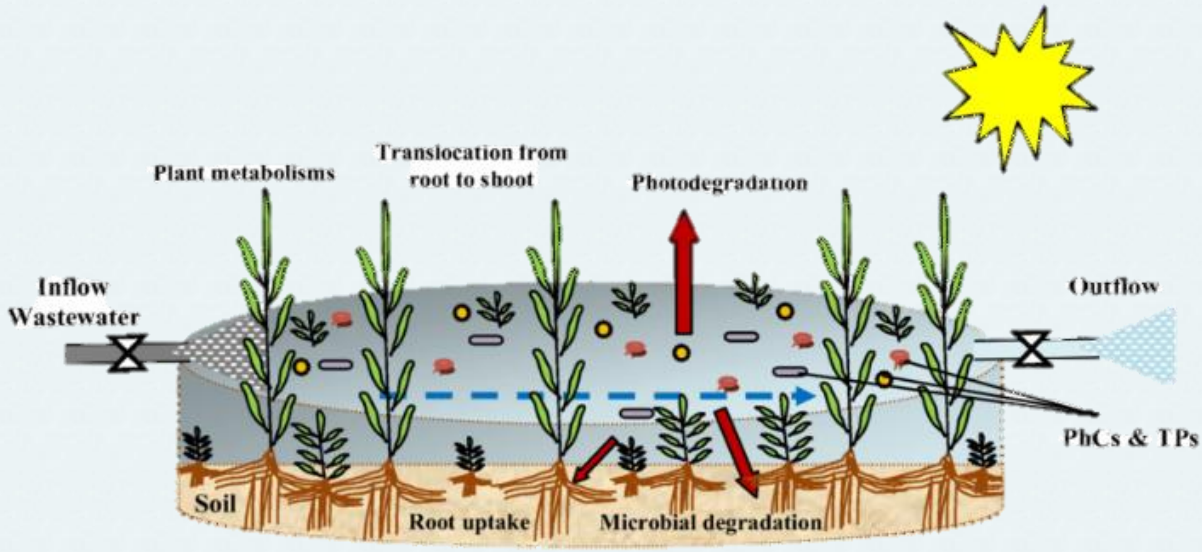


**Figure 3. Horizontal flow constructed wetland (Parashar V, et al., 2022).**

### 4.3.1 Advantages

- Passive
- Sustainable
- Good pathogen kill
- Low maintenance

### 4.3.2 Disadvantages

- Land-intensive (may not suit tight clinic sites),
- Slower startup (plants must establish population)
- Seasonal performance can vary

## 4.4 Packaged/Compact Sewage Treatment Plant (STP)

Membrane Bioreactors (MBR) and Sequencing Batch Reactors (SBR) are prefabricated, modular aerobic treatment STP units (Figure 4). These “plug-and-play” units can treat domestic sewage to high quality. Manufactures claims ≥90% BOD removal, producing effluent ~20 mg/L BOD (KUBOTA Corporation, 2025). Such systems typically need electricity for aeration and pumps. They have small footprints and fast startup. O&M; STPs need trained technicians, power supply, and membrane cleaning. STPs can be costly, involving equipment, membranes, and installation.


**Figure 4. Example of a prefabricated STP (KUBOTA Corporation, 2025)**

### 4.4.1 Advantages

- Reliably meet stringent standards
- Compact

### 4.4.2 Disadvantages

- Not low power/cost
- O&M challenges in remote clinics

# 5 The Solve

## 5.1 Solution overview

Decentralized Wastewater Treatment Systems (DEWATS) are modular, low-energy treatment solutions designed to function without constant external power or chemicals (Figure 5). For healthcare facilities in rural Cambodia, we propose an ABR for primary treatment with optional modules such as anaerobic filters, constructed wetlands, and polishing ponds or planted gravel filters. These rely on biological processes, primarily anaerobic digestion and filtration to treat wastewater close to its source. The technology is scalable and adaptable, well-suited for facilities ranging from small clinics to district hospitals.

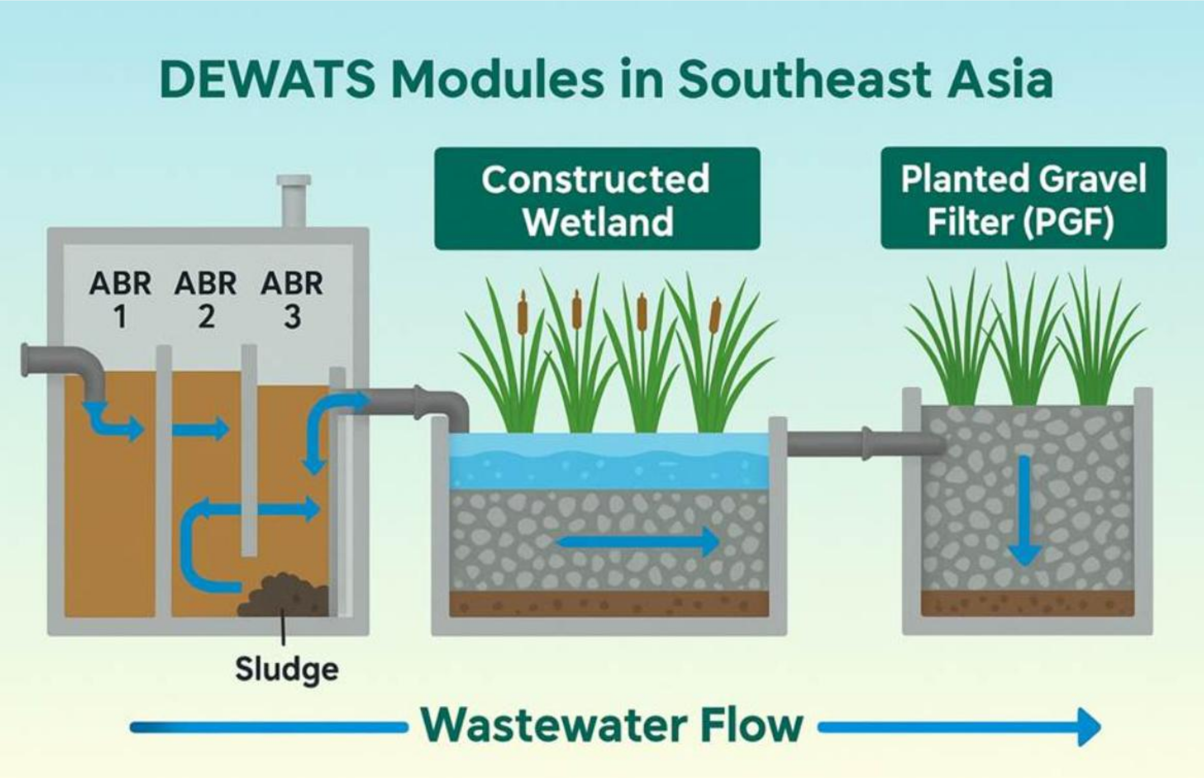


**Figure 5. Diagram of DEWATS Modules (MINISTRY OF RURAL DEVELOPMENT, 2019)**

## 5.2 Technical Performance and Design Principles

DEWATS achieves high pollutant removal without mechanical aeration. An ABR can remove 65–90% of BOD, ~85% of COD, and 80–95% of TSS. Pathogen removal is moderate at the ABR stage but increases significantly with post-treatment wetlands, achieving BOD levels of <20 mg/L and faecal coliform counts of <1,000 CFU/100ml, meeting Cambodia's Class A discharge standards (MINISTRY OF RURAL DEVELOPMENT, 2019).

Design principles include:

- Modularity – start with ABR, add wetlands, polishing ponds as resources allow.
- Gravity-fed hydraulics – eliminates pumps.
- Robust construction – reinforced concrete chambers with watertight plastering.
- Local adaptability – choice of climate change tolerant plants such as Typha or Phragmites.

## 5.3 Core Implementation Steps

- Site Assessment – Evaluate soil type, available land, slope, water table, and flood history.
- Stakeholder Engagement – Involve hospital managers, local authorities, and community leaders from the outset.
- System Sizing – Calculate wastewater flow based on patient numbers, staff, and water use rates.
- Phased Design – Begin with ABR; add anaerobic filters or wetlands later.
- Construction – Use local masons and materials to reduce cost and improve repair capacity.
- Training – Train facility staff in monthly inspections and annual sludge depth checks.
- Monitoring – Effluent testing at least twice a year for BOD, TSS, and pathogens.

## 5.4 Cost and Resource Optimisation & O&M

Typical costs for a small clinic ABR (2–5 $m^3$/day capacity) are USD 2,000–3,000, with wetlands adding USD 1,500–2,500. O&M costs range from USD 80–180/year for inspections, vegetation management, and occasional desludging (every 3–5 years for ABR; 5–7 years for wetlands) (Bluewater Lab Pte. Ltd, 2025).

Cost savings can be achieved through:

- Local sourcing of bricks, cement, gravel, and plants.
- Community labour for excavation/landscaping.
- Phased investment, deferring wetland construction until budgets allow.

## 5.5 Climate Resilience and Suitability in Cambodia

Kampong Tralach experiences seasonal flooding and droughts that can damage conventional septic systems. DEWATS can be adapted for climate resilience by:

- Elevating treatment units above historical flood levels.
- Using sealed chambers to prevent floodwater ingress.
- Selecting wetland species that survive inundation and low-water periods.
- Maintaining passive operation during power outages, ensuring continuous treatment.

## 5.6 Case Study – Vietnam (ABR + Wetland)

### 5.6.1 Kampong Speu Provincial Hospital

BORDA Cambodia installed a DEWATS with a 40 $m^3$/day capacity, comprising ABR, vertical flow constructed wetland, and polishing pond. Costing ~USD 130,000, it reduced BOD by >90% and achieved discharge suitable for irrigation (BORDA, 2025).

### 5.6.2 Hanoi, Vietnam

CEETIA and EAWAG tested an ABR + wetland for an institutional site. With ~48-hour HRT, the system met Class A discharge standards, cost ~USD 4,000–6,000 for small-scale deployment, and required only 1–2 hours of monthly maintenance (Anh Viet Nguyen, Nga Thuy Pham, Thang Huu Nguyen, Antoine Morel, & Karin Tonderski, 2006).

## 5.7 Relevance to Kampong Tralach District

For rural clinics in Kampong Tralach, DEWATS offers:

- Technical Fit – Handles variable loads and clinical wastewater.
- Economic Feasibility – Low CAPEX and OPEX within district health budgets.
- Climate Resilience – Adaptable to flood/drought cycles without mechanical failure risk.
- Local Ownership – Built and maintained with local resources, ensuring sustainability.

By combining proven design principles with phased investment and local engagement, DEWATS (ABR and constructed wetlands) can deliver reliable, climate-resilient wastewater treatment for healthcare facilities in Kampong Tralach, improving public health and environmental outcomes.

# 6 References

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