CASE STUDY 2

Constructed wetland for faecal sludge treatment

Khulna,
Bangladesh

SNV

UTS Institute for Sustainable Futures

Background

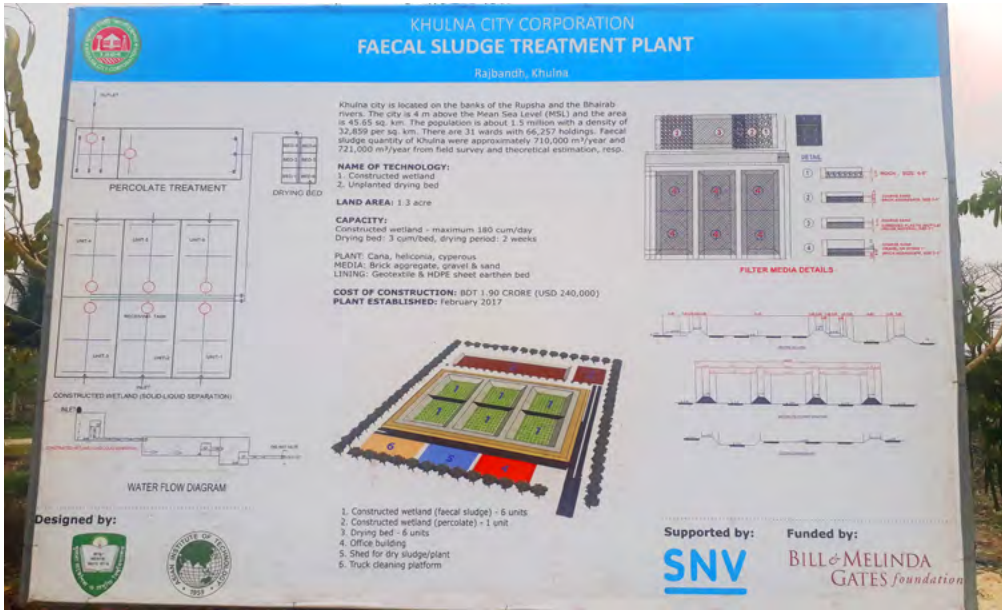
Treatment selection and purpose

The Faecal Sludge Treatment Plant (FSTP) in Khulna, Bangladesh – owned and managed by the Khulna City Corporation (KCC), a local government body – was built in 2016 and began operation in 2017. The constructed wetland (CW) and unplanted drying beds at the FSTP were selected for their low maintenance, operation, and construction costs, and because they offer an environmentally friendly system.

The design and construction of the treatment plant was a collaborative effort. The Khulna University of Engineering and Technology (KUET) and SNV provided technical assistance in design selection by implementing an informed choice process, with KCC making the final decision on the design. Khulna University of Engineering and Technology and the Asian Institute of Technology in Thailand designed the plant. SNV, with financing from the Bill & Melinda Gates Foundation, funded the construction of the plant; with KCC taking responsibility over the plant's construction, and operation and maintenance. To support the effective functioning of the plant, SNV and KUET offer regular trainings and refreshers.

> *We have chosen [this design] because it is more cost effective. It is environmentally friendly also. We have to wear masks at other plants, we all need to wear it here too, but there is no bad smell here. You will also not find any flies here.*
>
> **CHIEF WASTE MANAGEMENT OFFICER, KCC**

KCC FSTP constructed wetlands



Overview of KCC FSTP

Manual bar screen to remove garbage from sludge discharging into vertical flow constructed wetland

Description of the system

The KCC FSTP was built on what used to be a landfill site, which contained close to 15,000 tonnes of solid waste. Prior to construction, a study was conducted to investigate potential risks associated with building the FSTP on a passive landfill site. Once the site was cleared for use, the linear constructed wetland system was built, including six units or basins of vertical flow constructed wetlands, and one subsurface horizontal flow constructed wetland. Treated effluent was designed to discharge into a nearby canal. Six unplanted drying beds were built to collect dry sludge for end-use purposes.

Vacuum trucks (known as vacutugs in Bangladesh) transport sludge to the FSTP, discharging this into a holding-mixing tank that is fitted with a bar screen, which retains coarse material and garbage and prevents the clogging of CW beds. This manual bar screen is fitted at each side of the vertical flow CW in the Khulna FSTP. For the unplanted sludge drying beds, a locally made large plastic container is used to separate sludge from other types of waste.

Table 1. Khulna FSTP capacity and operating costs of constructed wetland and unplanted drying beds

	Constructed wetland (CW)	Unplanted drying beds
Design capacity	180 m^3 of sludge/day	3 m^3 with a drying period of two weeks
Operating capacity	10-15 m^3 of sludge /day	
Operating costs	US$ 2,311/year (salaries and electricity costs)	

BOD levels of treated water are significantly lower than canal water beside the FSTP

Dried sludge in planted constructed wetland

Regulatory environment and compliance

The Khulna FSTP was designed to meet the effluent quality standards set by the Government of Bangladesh's Ministry of Environment and Forests, as per the Environment Conservation Rules 1997. Biochemical Oxygen Demand (BOD) levels at the treatment plant for treated effluent are consistently between 26 mg/L and 33 mg/L, with the allowable disposable limit set at 40 mg/L for inland surface water bodies. The treatment system maintains this BOD level, even with sludge BOD levels of 400-500 mg/L received from household septic tanks.

Operation and maintenance: realities, challenges, and opportunities

Realities of running the treatment plant

Measuring quantities of sludge and maintaining performance

Khulna FSTP has developed a low-technology approach to measure quantities of sludge and to ensure the performance of the treatment plant. To record the quantities of sludge received by the plant, the vacutugs that discharge sludge are used as the measurement standard. The volume is calculated according to the volume of each tanker and the number of trips completed, all of which are registered.

A key activity to maintain performance of the FSTP is to ensure that plants in the constructed wetland are healthy and thriving. Regular weeding and cleaning are required to ensure this. The performance of the treatment plant is measured by closely monitoring the faecal sludge solid matter in the drying beds, as explained by one of the operators. More sophisticated testing is conducted by the Khulna University of Engineering and Technology, as the Khulna FSTP does not currently have a laboratory.

> *We keep an eye on the solid matter at [the] drying bed. We count how many days it needs to dry. From this, we can measure the performance of the filter materials. We measure the moisture also.*
>
> **OPERATOR, KCC**

Vacutug in Khulna city

Sludge drying beds

Construction and operating costs

The largest costs associated with the FSTP have been the capital expenditure and ongoing salary costs. Construction costs for the FSTP alone were initially estimated at US$ 58,930. Due to civil construction works, such as access roads to and around the treatment plant, establishment of testing facility, landscaping needs, and installation of a security system, the final cost was US$ 235,715. The funds were provided through donation by an SNV project financed by the Bill & Melinda Gates Foundation, who have continued to support improvements to the FSTP at an estimated value of US$ 30,000 per year.

The largest ongoing cost for the treatment plant is the salaries of the staff, which consists of one caretaker, the vacutug driver, and helper. Engineers from SNV and KUET provide technical support related to installing or repairing machinery, and monitoring the performance of the FSTP. The operators of the treatment plant have received Occupational Health and Safety (OHS) training from SNV, as well as instructions on operation procedures.

Treatment plant coverage area and future growth

The treatment plant was designed for a 30-year lifespan, with sewerage connections planned to cover the majority of the Khulna population in the future. At present, the FSTP is estimated to cover 13% of Khulna's 1.5 million inhabitants, with the wetland expected to be emptied after seven years to support the intended 30-year lifespan. There are possibilities to expand the treatment plant, if necessary, with additional land that is available and adjacent to the current wetland.

Operators discharging influent directly to planted constructed wetland bed

Challenges of construction, and operation and maintenance

Discharge and screening of sludge

Challenges related to the manual screening of effluent discharge required modifications to the screening systems. Due to the high flow of influent discharge from vacutugs and the insufficient size of filter screens and pipes, the manual screening units in the planted constructed wetland could not handle the inflow rate. This resulted in the spillage of sludge around the units.

To cope with these challenges, operators and vacutug operators have often bypassed the screening units and discharged influent directly to the wetland bed. This practice, however, has led to clogging the constructed wetland filter media. As a result, the plant's filter pipes were replaced with higher quality, larger diameter pipes, and the gate valves were replaced with ball valves. While these changes have improved the performance of the system, according to one of the operators the '*vertical flow constructed wetland is not so sophisticated*'.

Construction challenges

Lack of availability of required materials and reliance on low-cost materials presented challenges to the Khulna FSTP design and construction team. As the treatment plant site was previously filled with municipal garbage, it was not possible to water seal the structure with concrete or locally available materials. Therefore, high density polyethylene sheets were required at the base of the basins. These were not available in Bangladesh and needed to be imported, which involved additional cost and time. The use of compacted soil and rocks to form the walls of the planted constructed wetland also led to structural issues, particularly during rainy season, and due to holes formed by tunnelling rats. This is an engineering challenge that will need to be continuously monitored and addressed.

Treatment plant operating under capacity

The plant is currently operating below its design capacity. This can affect treatment efficiency and requires efforts to increase community demand for emptying. The treatment plant has a design capacity of 180 m^3/day of sludge but is currently receiving between 10 and 15 m^3/day.

The lack of consistency in collected and received sludge could hamper the growth and health of the plants in the constructed wetland and could degrade treatment performance. In discussions, the treatment plant designers and operators acknowledged that the scale was actually too large; development and investment should have been staged and organised incrementally. Increasing the demand for desludging from communities could assist but presents its own challenges in facilitating behaviour change communication initiatives. One of the operators of the treatment plant stated that: '*increasing the demand for desludging is a challenging matter*'.

> *The pipes of this plant were not so wide. The diameter of these pipes was three inches. The quality of the pipes was not good also. After discussing the matter with SNV, we've changed the pipes. Gate valves [have been] replaced by ball valves.*
>
> **CONSERVANCY OFFICER, KCC**

Briquettes on KCC drying racks/trays

Opportunities for reuse

Co-composting and briquette production

Research is currently underway into the possible profitable use of the solid faecal matter from the treatment plant for co-composting, aquaculture, and the production of both non-carbonised and charcoal briquettes. National government funds have recently been secured by KCC and SNV to undertake further research, and to develop and expand briquette production.

> *Solid matter [reuse] is in research level. We want to co-compost it. Actually, we want to do aquaculture. We're researching on the matter. Recently we have made briquettes. And the liquid flows directly to the water body. We have no option to reuse it. We make sure that the liquid is not harmful and is environment friendly, then it flows to the waterbody.*
>
> **CHIEF WASTE MANAGEMENT OFFICER, KCC**

Informed choice considerations	Constructed wetland for faecal sludge treatment in Khulna, Bangladesh
Operating & design capacity	Design capacity = 180 m^3/day Operating capacity = 10-15 m^3/day
Operating costs	US$ 2,311 per year (salaries and electricity costs)
Input characteristics	BOD = 400-500 mg/L
Output characteristics	BOD = 26-33 mg/L (discharge limit: 40 mg/L)
Reuse	Investigating options for co-composting, aquaculture, and the production of both non-carbonised and charcoal briquettes
Skills & human resources requirements	One caretaker, a vacutug driver, and helper; engineers from SNV and KUET provide technical support related to installing or repairing machinery and monitoring the performance of the FSTP
Technology/material (local) availability	All materials are locally available

This paper is a chapter in a publication of nine case studies presenting real-life faecal sludge and wastewater treatment practices. The stories were narrated by plant owners, operators, SNV staff, and partners in Indonesia, Bangladesh, Kenya, Zambia, Malaysia, India, South Africa, and Benin. The full publication was reviewed by Antoinette Kome and Rajeev Munankami, and available for download at: https://snv.org/cms/sites/default/files/explore/download/2021-treatment-technologies-in-practice-snvisf-uts-full-publication.pdf.

Citation: ISF-UTS and SNV, *Treatment technologies in practice: On-the-ground experiences of faecal sludge and wastewater treatment*, The Hague, SNV Netherlands Development Organisation, 2021.

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Photos: SNV

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