Post treatment of anaerobically treated domestic wastewater in a vertical flow constructed wetland: Experience from first DEWATS in South Africa

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Background

Post treatment of domestic wastewater in constructed wetlands (CWs) is a cost-effective, feasible option for the decentralised approach to sanitation. In vertical flow constructed wetlands (VFCWs), the wastewater is fed on the surface and percolates through the filter media by gravitation producing nitrified effluent (the oxidation of ammonium to nitrate) which can be reused for irrigation. Furthermore, VFCWs have a smaller footprint than other CWs which is advantageous where land is restricted.

The Newlands Mashu decentralised wastewater treatment system (DEWATS) owned by eThekwini Water and Sanitation (EWS) is the first pilot DEWATS in South Africa which was designed by the Bremen Overseas Research and Development Association (BORDA), Germany guidelines. Commissioned in 2010, it serves 84 *low-middle* income households. Raw domestic wastewater is first anaerobically treated in a settler, anaerobic baffled reactor and anaerobic filter followed by post treatment in a VFCW (Figure 1).

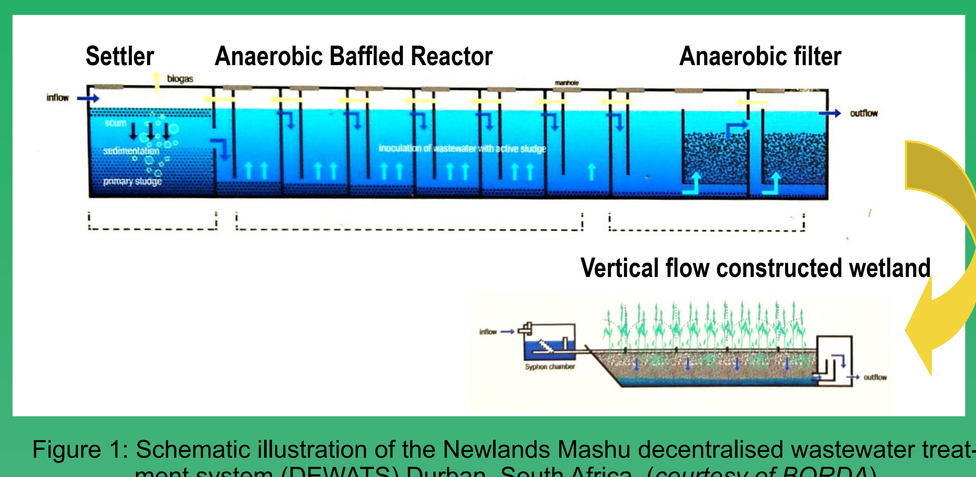

Figure 1: Schematic illustration of the Newlands Mashu decentralised wastewater treatment system (DEWATS) Durban, South Africa (*courtesy of BORDA*)

Aim

In 2015, EWS began a Water Use Licence Application (WULA) for the DEWATS to be permitted to discharge the final effluent into a water course. The aim of this study was to evaluate the performance of the VFCW to determine if the final effluent meets the National discharge limits set by the Department of Water Affairs.

Figure 2: Vertical flow constructed wetlands at the NLM DEWATS (taken December 2016)

Bed characterisation and analyses

- The VFCW (9.8 m x 9.8 m; *l* x *b*) was monitored from September 2015–May 2017 (Figure 2)
- It is fed from Train 1 of the anaerobic baffled reactor (ABR) designed to treat 13.87 m^3/d
- The VFCW was constructed at half of its recommended depth of 1.5 m due to site restrictions
- It was found that the mechanical dosing device (siphon) through historical modifications did not function consistently thus, there were irregular loadings (2–12 m^3/d) to the VFCW
- Distribution through the feeding pipes was not even, often leading to dry/dead zones on the surface of the VFCW
- Filter layer of media consisted of commercially available sand (0–2 mm) and not according to the design plans of 2–4 mm fine gravel
- Full nitrification was not achieved (only ~70 %) and thus the final effluent could not be discharged into the nearby water resource (Table 1)
- Grab sampling was insufficient for an accurate assessment of the VFCW performance; 24-hour sampling was necessary should discharge of the final effluent be required
- Mass balances or tracer tests could not be done due to the low head in the drainage manhole as the outflow could not measured
- VFCW was shut down in April 2017 due to ponding on the surface of the bed resulting from high flows in Train 1 of the ABR since February 2017. This caused the siphon to discharge more than 30 times per day compared to 7–9 times per day until which the float to the siphon was completely damaged leading to continuous flow onto the VFCW hence, ponding was observed on the surface of the bed (Figure 3)

Figure 3: Visible ponding on the surface of the VFCW (taken March 2017)

Table1: Influent and effluent quality of the VFCW

	Influent concentration	Effluent concentration	Removal efficiency	South African Discharge limit	n
	mg/l	mg/l	%	mg/l	
COD	257 (± 76.06)	68.5 (± 24.06)	73.35	75	14
NH_4-N	62 (± 13.12)	14 (± 12.55)	77.1	6	28
NO_3-N	0.6 (± 0.6)	25.5 (± 17.44)	N/A	15	28
TN	67.1 (± 16.68)	47.2 (± 14.91)	29.6		22
PO_4-P	14.9 (± 3.6)	6.1 (± 1.92)	59.1	10	28
TP	15.6 (± 5.64)	14.1 (± 7.15)	9.8		22
TSS	32 (± 16.27)	5 (± 4.72)	84.4	25	22

Repair and modifications

- Siphon was reinstalled after replacing the ballast weight to allow for drawdown
- Plants were removed and the media was compacted to prevent any preferential flow
- A 0.005 mm layer of fine sand (0.5–2 mm) layer was added to the surface of the bed to reduce the permeability thus, increasing the hydraulic retention time
- The distribution system was modified from d 50 mm to d 70 mm pipes with alternate perforations to improve the distribution of the wastewater on the surface (Figure 4)

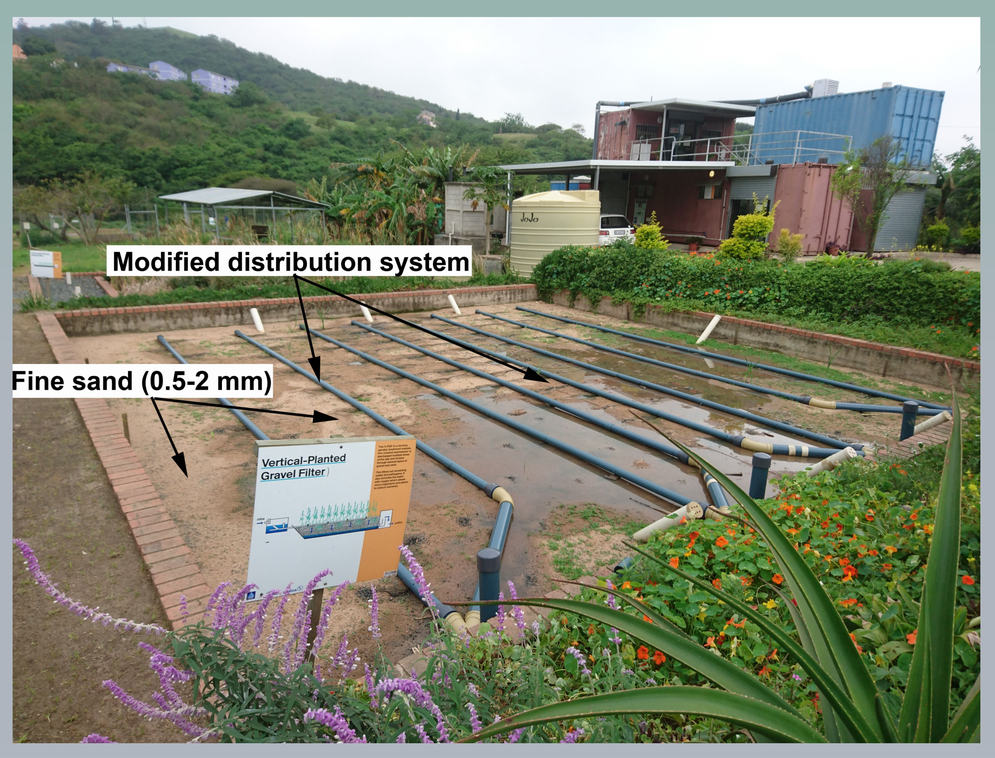

Figure 4: Modification to the distribution system (October 2017)

Future analyses and Construction

- A sampling sump will be constructed at the end of the VFCW for composite sampling
- An intensive sampling campaign will follow thereafter to assist EWS in providing performance data of the Nelwands Mashu DEWATS for the WULA

Acknowledgements

- eThekwini Water and Sanitation Unit for permitting UKZN to evaluate and conduct research activities at the Newlands Mashu DEWATS
- BORDA for providing expert advice and providing the funds for the construction of the pilot vertical flow constructed wetlands simulation
- WRC for providing the project funding to conduct all research and analyses
- The staff at PRG for providing all administrative and technical support