Performance of a DEWATS Plant Treating Domestic Wastewater: A South African Case Study

Sudhir Pillay*, Nicolas Reynaud**, Bjoern Pietruschka***, Kitty Foxon* and Chris Buckley*

* Pollution Research Group, University of KwaZulu-Natal, Durban, South Africa

**Technical University Dresden, Urban Water Management, Germany

*** International Institute Zittau (IHI Zittau), Technical University Dresden, Germany

Country level

1994: democracy and new constitution

- access to potable water - constitutional right
- sanitation policy and minimum standards
- backlog 12 million water; 19 million sanitation
- funding available for poor and indigent

City boundaries expanded since 2000

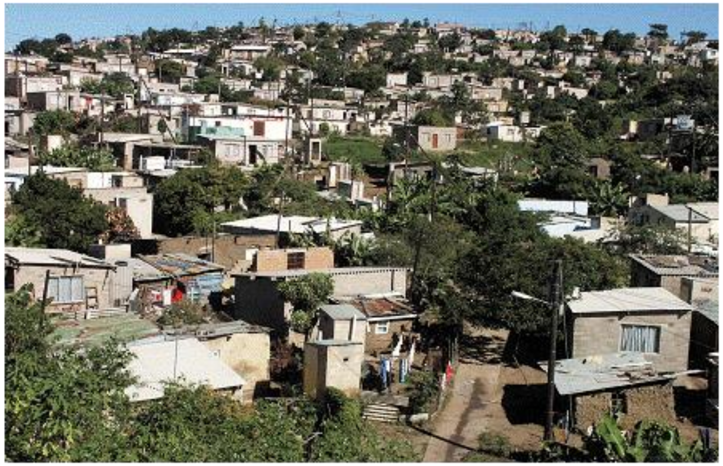
- area +68% to 2 297 km^2
- population +9% to 2.7 million
  - 63 000 rural households require water and sanitation
  - urban informal settlements
  - large inward migration

Water and sanitation servitudes provided by eThekwini Municipality

- Ethekwini Water and Sanitation (EWS) unit

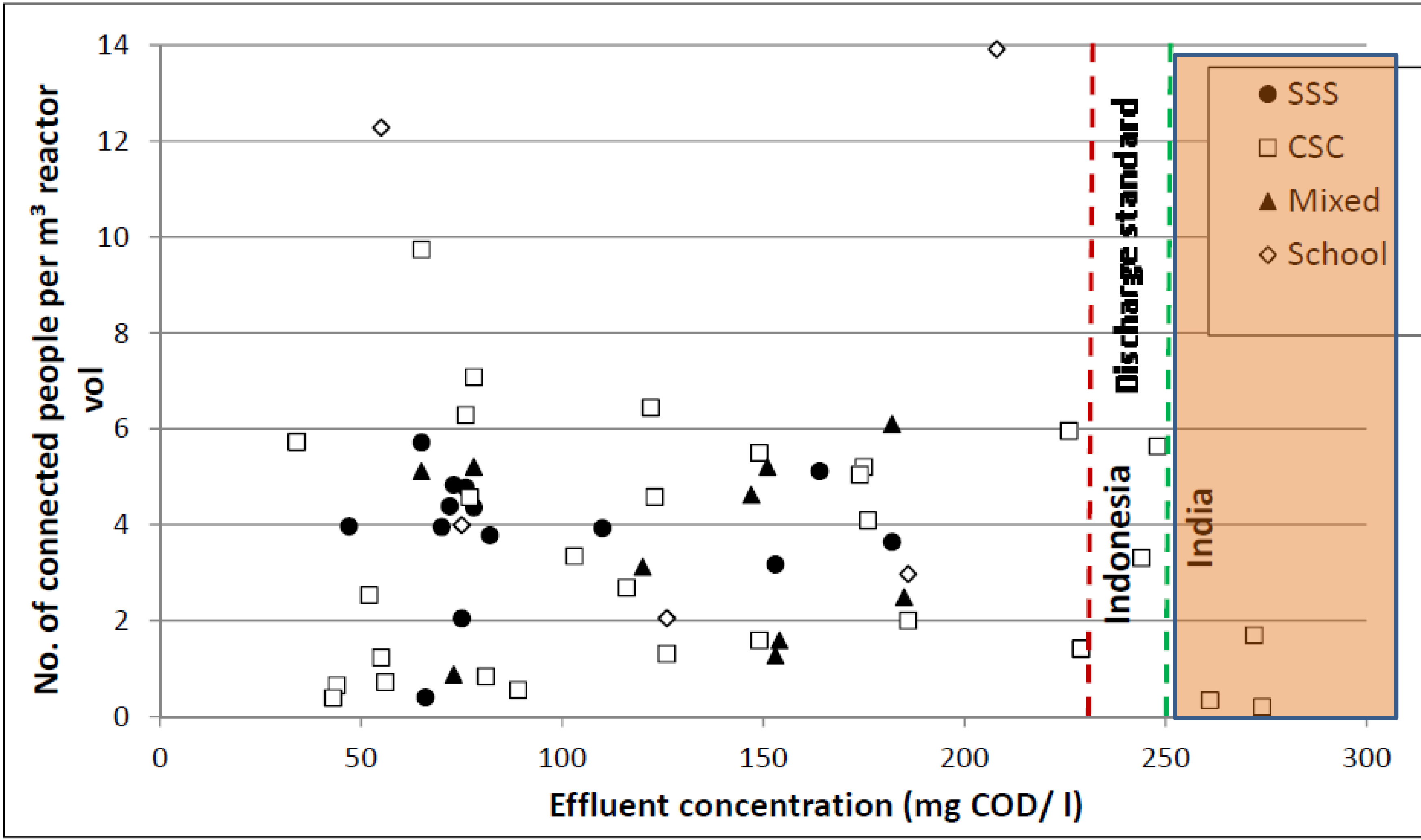
DEWATS: Application in South Africa

- Communities preferring waterborne sanitation
- High-density communities not connected to sewered network
  - Peri-urban areas serviced by CABs
  - Low cost housing not suitable for septic tanks or dry sanitation
    - Hilly terrain
    - Semi-pressurised roof tanks
    - Water available for flushing
    - Space limited for evapotranspiration areas




Biodigester
ABR


Wetland

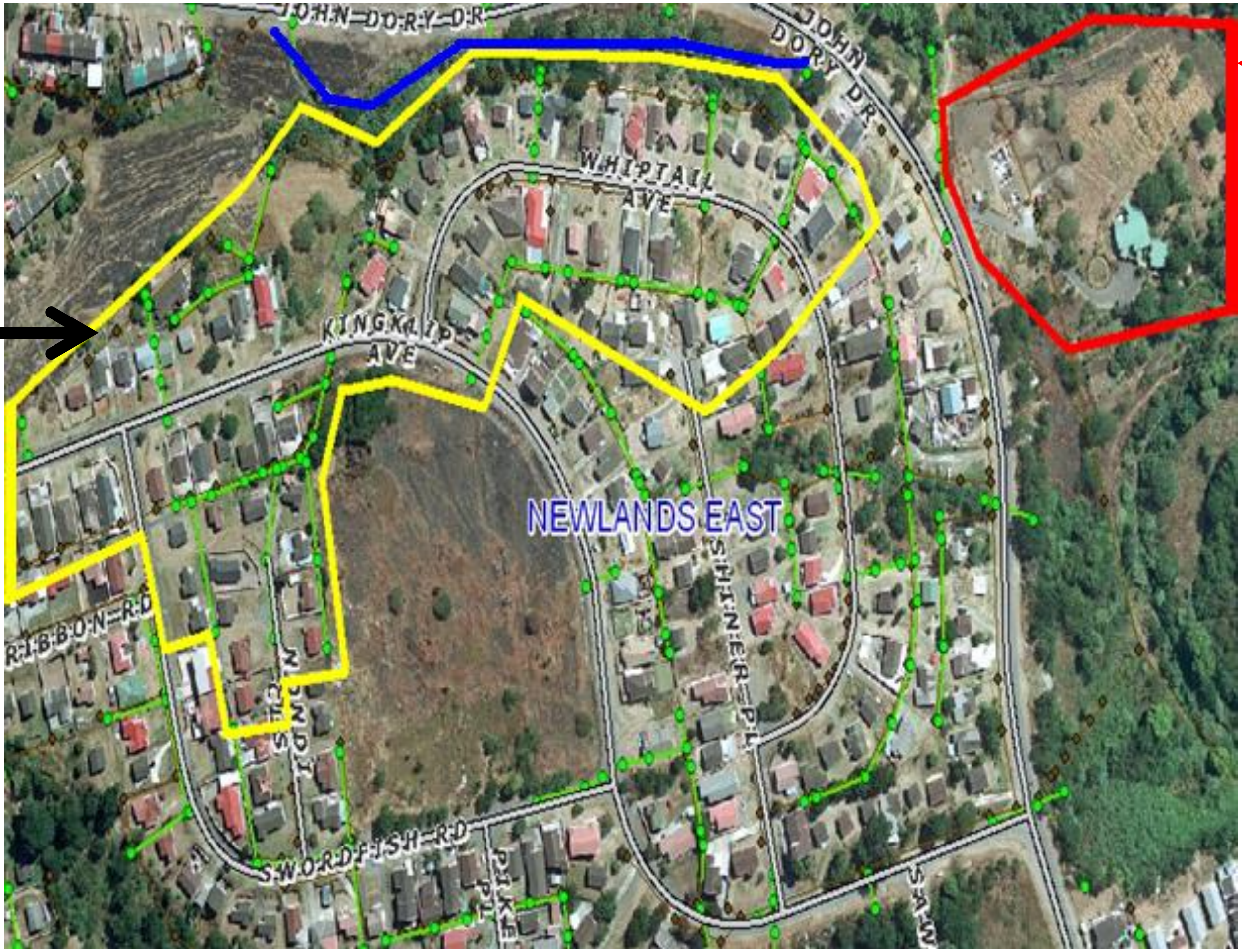

14
12
10
8
6
4
2
0
No. of connected people per m³ reactor vol
0
50
100
150
200
250
300
Effluent concentration (mg COD/ l)
Discharge standard
Indonesia
India
SSS
CSC
Mixed
School

Research Questions

- How tolerant is DEWATS treatment to external factors?
- What can we learn about the general relationship between loading and treatment of DEWATS?

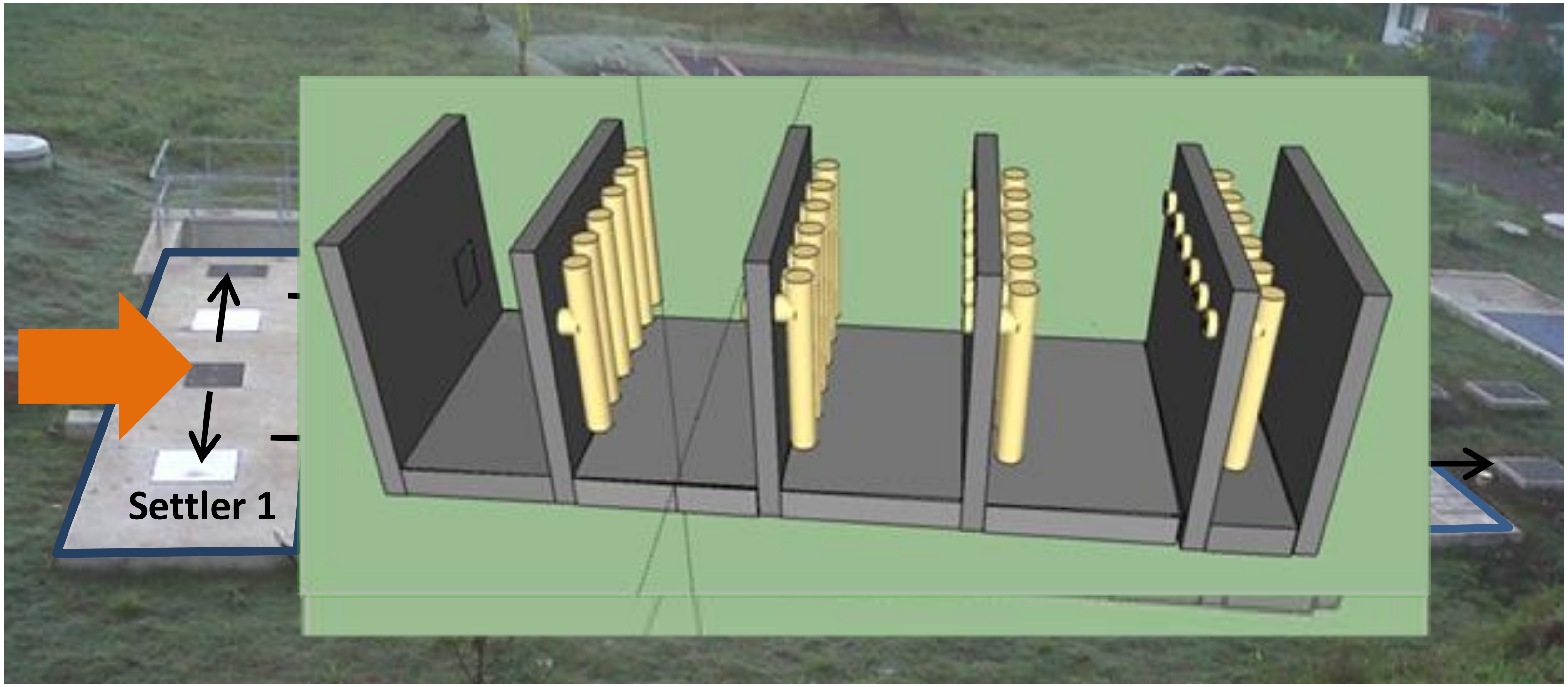
Low/Medium Income Houses

Catchment area



Site

Trunk sewer

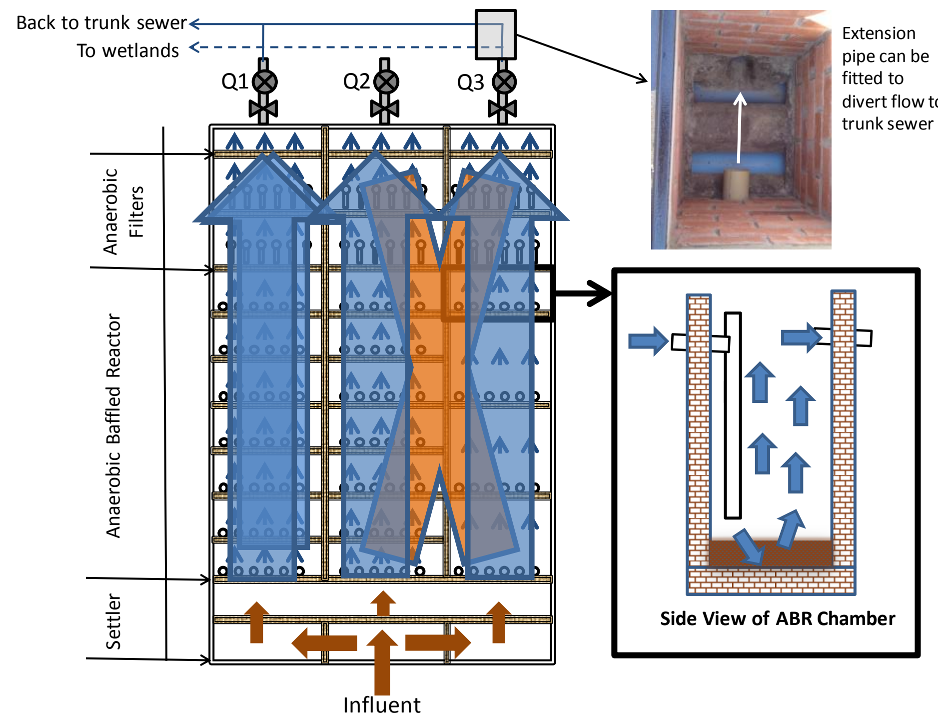


- Built according to BORDA design spreadsheet (Sasse, 1998)
- Designed to treat domestic wastewater from 86 households (41 m^3/ d domestic wastewater)
- Construction cost covered by eThekwini Water Services
- Reactor seeded in October 2010 and operated under varying conditions


July 7, 2013

Two Operations

- Research Phase 1
  - Feb to May 2012
  - Overloaded train
  - Design flow x 3
- Research Phase 2
  - June to October 2012
  - Trains operated at approx. design flow



Research Phase 1
All flow diverted through one train

Investigated treatment influencing factors

Design Details

- Module arrangement
- Loading vs Design

Feed Characteristics

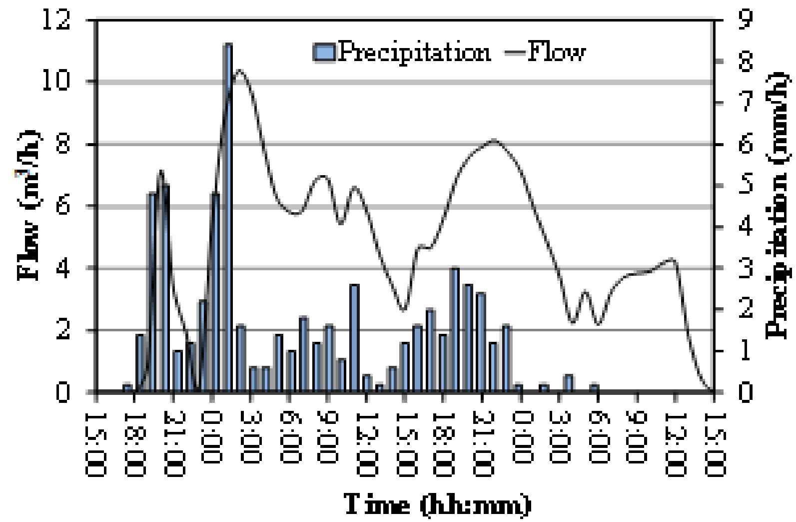
- Exposure to stormwater
- General properties

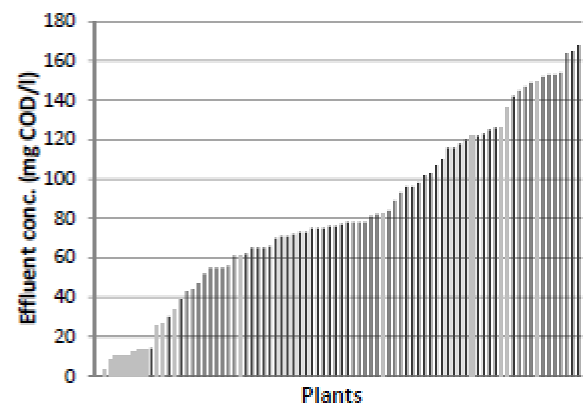
Design Details

- O & M
- Desludging
- Descumming

Q1: How tolerant is DEWATS treatment to external factors?

- Rain water intrusion influenced effluent concentration
  - Rainfall days removed from analysis (false positive results)
- Worldwide, all SSS plants and some CSC showed signs of stormwater intrusion



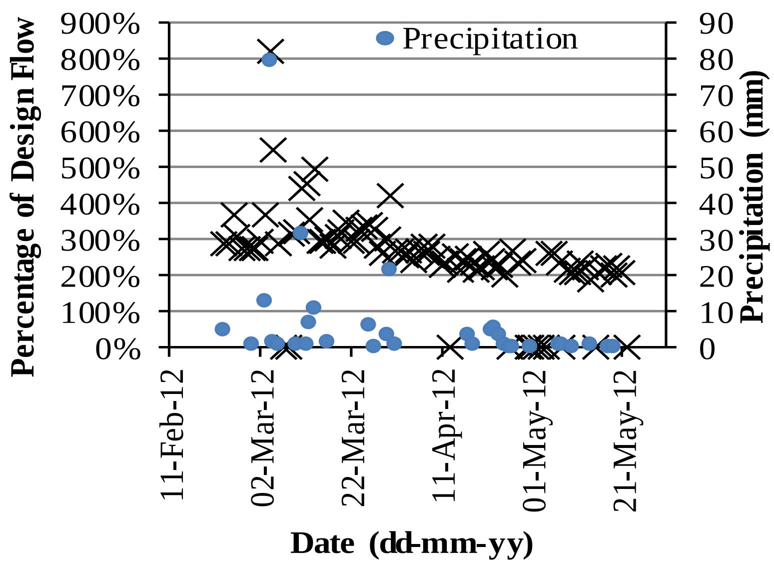


Reynaud et al. (2013)

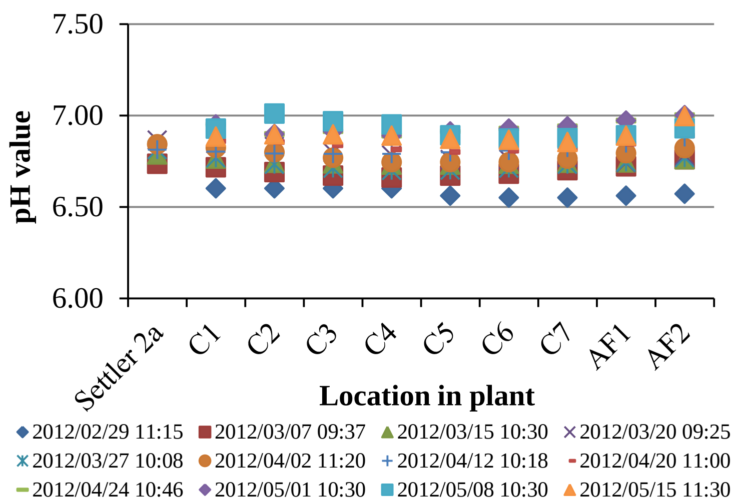
Q2: What can we learn about the general relationship between loading and treatment of DEWATS?

Research Phase 1: Loading Conditions

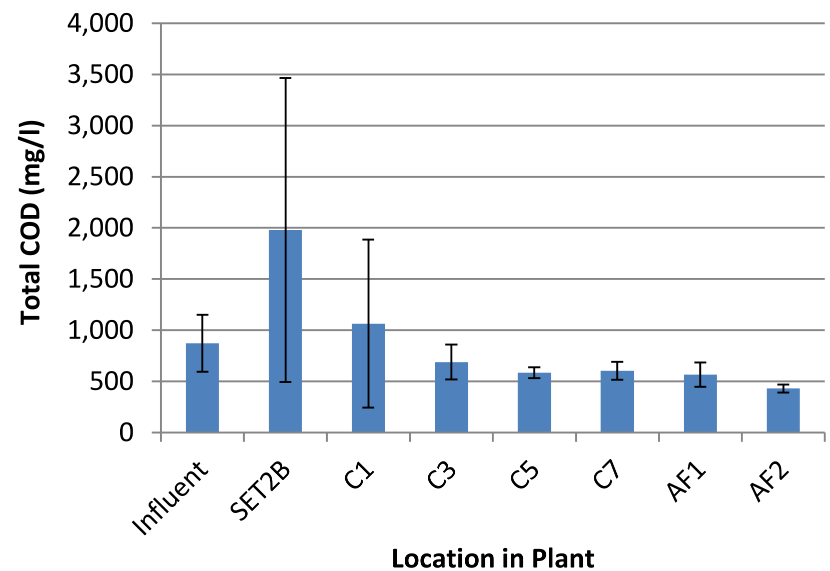
	Average Daily Flow	Percentage of Design Flow	Average HRT of ABR	Average HRT of AF
	m^3/d	%	d	d
Design (3 trains)	41.6	100	1.5	0.6
Design (1 train)	13.9	100	1.6	0.6
Research Phase I				
Train 1	37.8	**ca. 273**	0.6	0.2



Research Phase 1: Performance

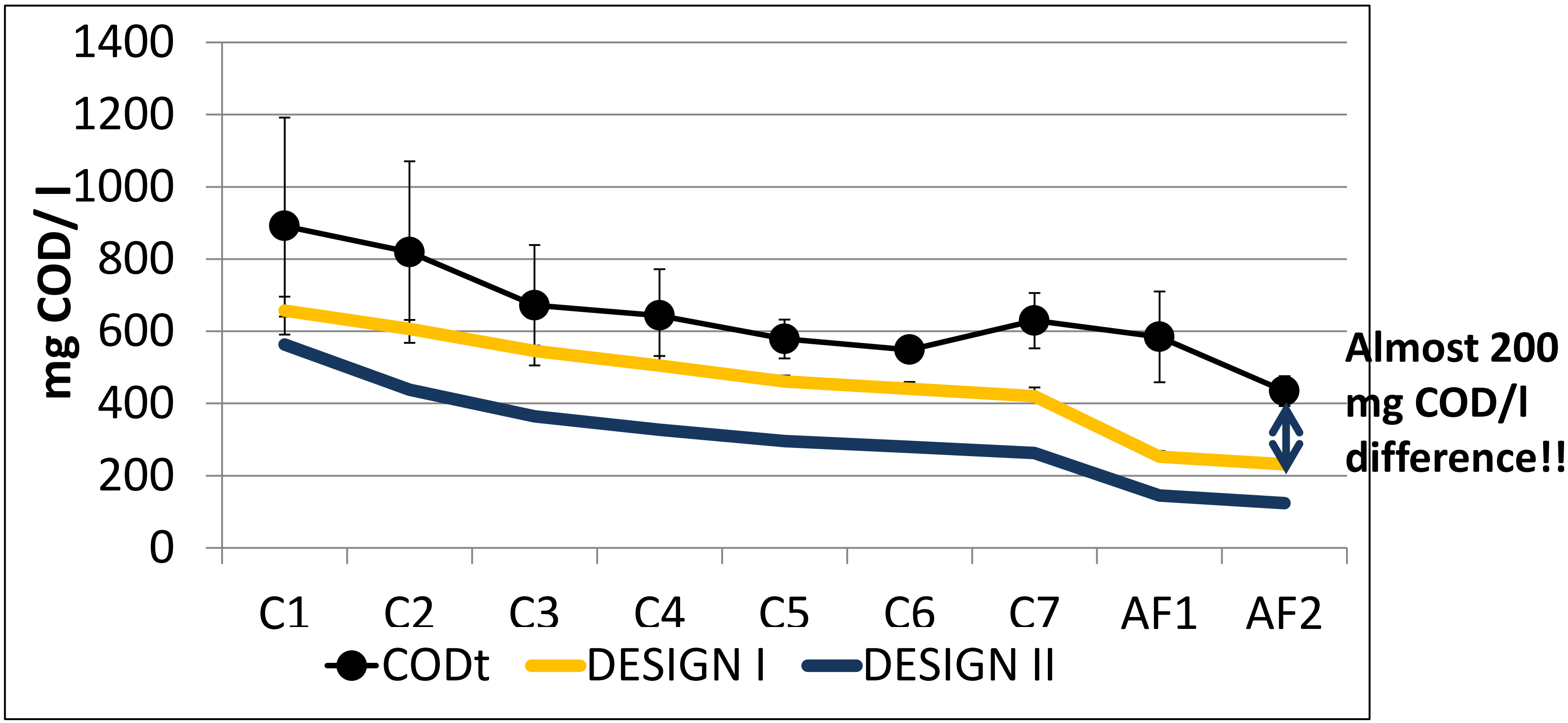


- The pH value low but not inhibitory → indicates hydrolysis is occurring through plant (pH influent value around 8.0)



- The settler and ABR module steps combined only remove 30% of the influent total COD
- The AF modules could only slightly increase the total COD removal to around 50%.
- Better total COD removal efficiencies have been reported in ABRs operated at similar or lower HRTs

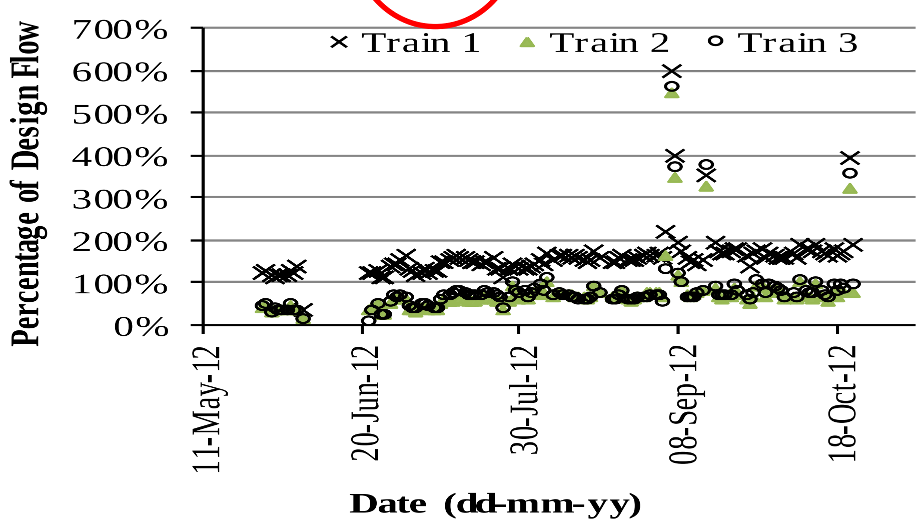
Research Phase 1: Design vs Actual



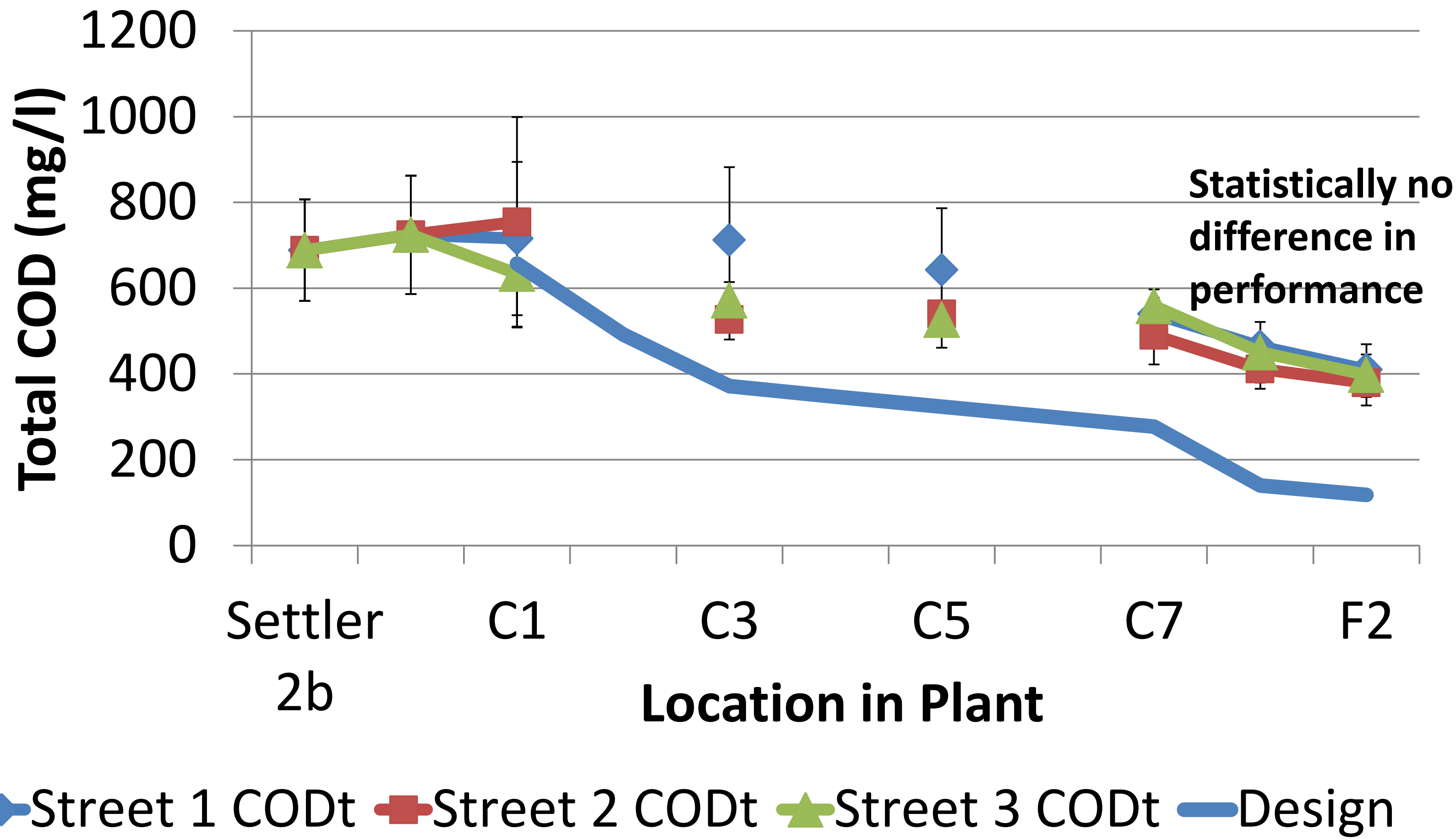
Research Phase 1: Wetland Performance

Research Phase 2: Loading Conditions

	Average Daily Flow	Percentage of Design Flow	Average HRT of ABR	Average HRT of AF
	m^3/d	%	d	d
Design (3 trains)	41.6	100	1.5	0.6
Design (1 train)	13.9	100	1.6	0.6
Research Phase I				
Train 1	37.8	273	0.6	0.2
Research Phase II				
Train 1	21.2	**153**	1.0	0.4
Train 2	9.5	**68**	2.3	0.9
Train 3	10.2	**73**	2.2	0.9



Research Phase 2: Performance



Research Phase 2: Performance

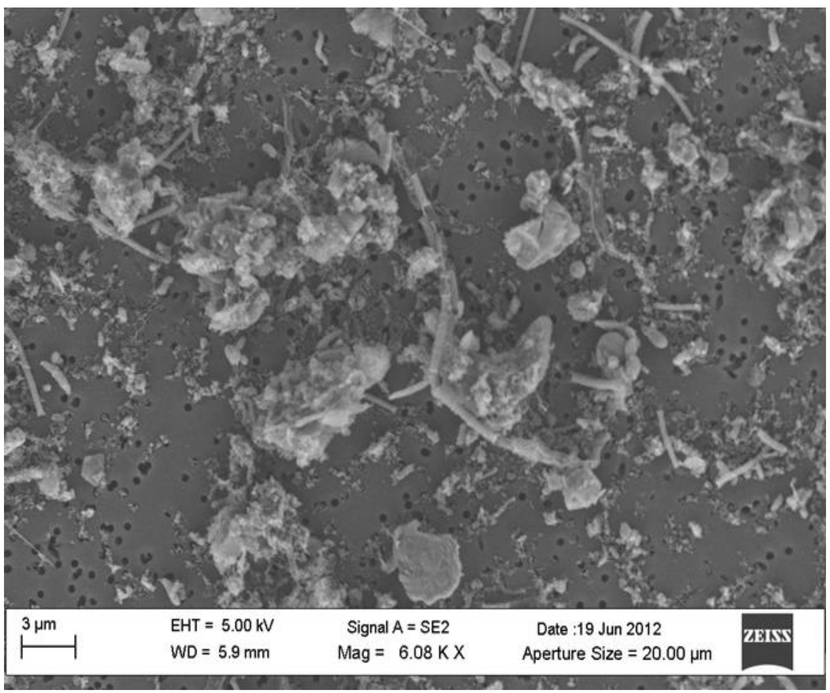
Train 2							
Operational Details: ABR = HRT 2.3 d, AF = HRT 0.9 d							
Parameter	unit	Influent	Settler 2a	Settler 2b	ABR 7th Chamber	AF 2nd Chamber	HFCW
pH		8.34	na	7.63	7.34	7.58	**8.04**
Total COD	mg/l	873	672	732	444	347	**190**
Soluble COD	mg/l	469	442	460	305	263	
NH_4-N	mg/l	39	64	64	61	63	**40**
PO_4-P	mg/l	6	8	9	8	7	**6**

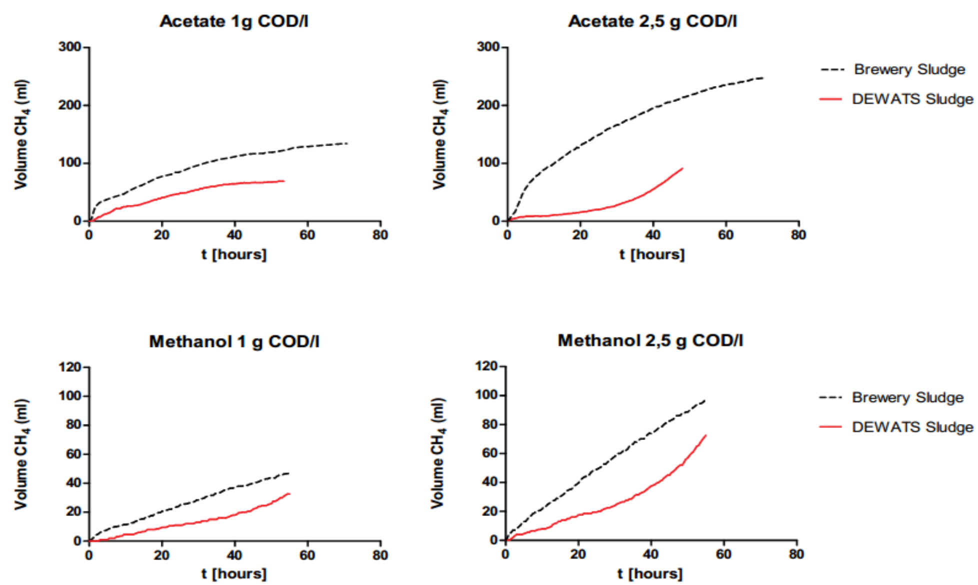
What does the Results tell us?

- No difference in performance between overloaded (200% design) vs underloaded systems (70% design)
- The total COD removals for the plant and for individual treatment modules are much less than those reported elsewhere and at similar loadings.
- The ABRs are not as effective as shown in previous studies → The results indicate that the digestion process is not efficient.
- Most BORDA DEWATS plants in Indonesia and India have lower effluent concentrations - 200 to 300 mg COD/L - using <u>only</u> anaerobic steps.
- NH_4-N still above discharge guideline.

Possible reasons for performance

- Combination of low sludge activity and extreme hydraulic conditions → need an overflow



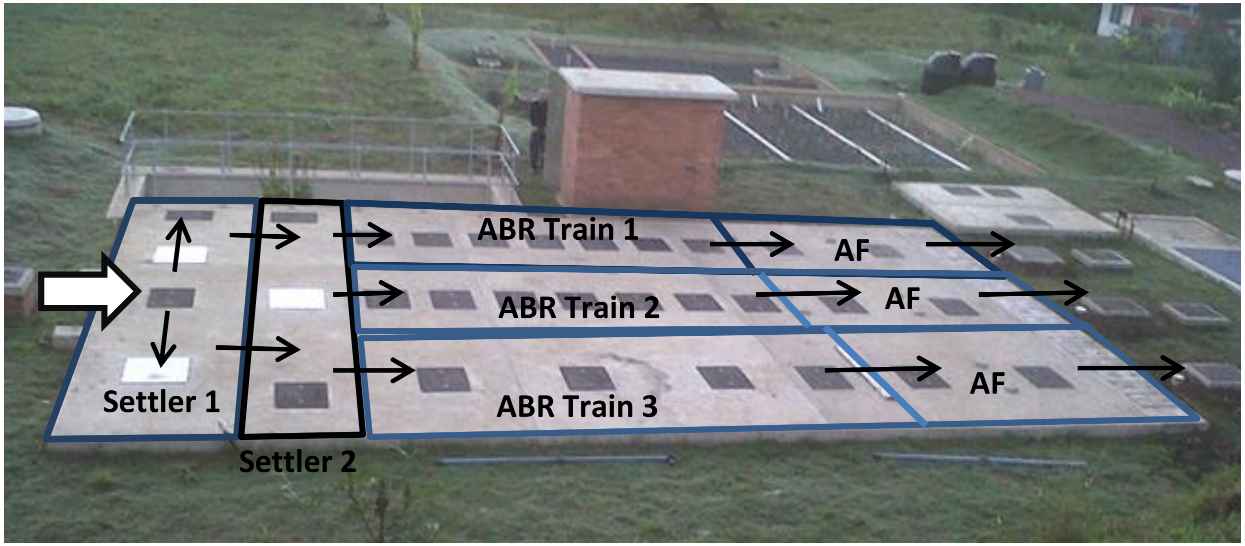


Operation & Maintenance

- Plant performance similar across all loadings tested but was generally unfavourable in comparison to other work.
- The ABR did not perform as expected with the AF modules removing the majority of COD through solids retention.
- It was hypothesized that the unfavourable performance was due to unstable operating conditions linked to stormwater intrusions and a biomass with low methanogenic activity.
- Need to incorporate technology upstream to limit trash dumping such as pour flush being tested by PiD & UKZN

Toilet design uses low flushes and limits trash dumping in bowel

Rainwater harvesting to limit stormwater intrusion – used as resource for flushing, gardening
Photo: www.wrc.org.za



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THANK YOU!