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LESSON
SERIES

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DEWATS PROCESS FOR DECENTRALISED WASTEWATER TREATMENT

Technical Lessons From eThekweni Municipality



NOTE

This lesson is compiled from **WRC Research Report No. K5/2002: *EVALUATION OF THE DEWATS PROCESS FOR DECENTRALISED WASTEWATER TREATMENT***, by Pollution Research Group.

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Hering South Africa

Project team from Research Project K5/2002.

1 INTRODUCTION

Decentralised wastewater treatment involves treatment and disposal of wastewater close to the source it was generated from. *Decentralised Wastewater Treatment System* (DEWATS) plants are envisaged in South Africa for high-density areas that are not located close to centralised sewer network. Despite the wide scale implementation of DEWATS plants around the world, there have been few studies that document compliance monitoring of DEWATS plants and / or assess the performance at different hydraulic loadings conditions. A technical evaluation plant designed by the not-for-profit organisation BORDA – Bremen Overseas Research and Development Association - was built by the Ethekekwini Municipality for this purpose with the research undertaken by the Pollution Research Group, University of KwaZulu-Natal.

EThekwini Municipality, in common with other municipalities in South Africa, are faced with the increasing challenge of providing housing and infrastructure to the population of the city. New housing developments are continuously being established within the urban and peri-urban areas in order to meet the housing backlog, many of which are not able to be connected to the main sewer line. The city therefore looked to the DEWATS approach as a possible sanitation solution for future housing developments.

The document looks at the technical lessons learnt from the evaluation of the BORDA DEWATS process under different operating conditions.

2 THE NEWLANDS MASHU DEWATS PROJECT

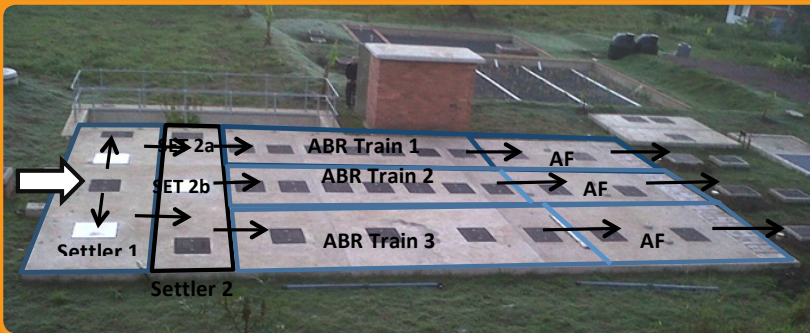
A technical evaluation DEWATS plant was built in Newlands Mashu, Durban and connected to a main trunk sewer conveying wastewater from around 80 low to medium income households. BORDA, which has implemented DEWATS plants mostly in Asia, provided the designs for the installation, the Ethekekwini Water and Sanitation unit provided the construction and auxiliary equipment costs, and the Pollution Research Group undertook the research activities for the plant through WRC funds. The purpose of the project was to evaluate the DEWATS process under range of operating conditions, and to have a clearer understanding of the skills and requirements to

implement, operate and maintain the system optimally.

The plant was designed according to BORDA guidelines to treat domestic wastewater from around 80 households. The modularised plant consisted of three treatment steps

- a settling chamber/biogas collector,
- 3 parallel ABR trains and 2 anaerobic filter (AF) modules. Two of the ABR trains (trains 1 and 2) had seven identical chambers whilst the last ABR train (Train 3) had 4 chambers with front three double the chamber size of the other ABR trains. The larger chambered

ABR train was designed according to recommendations from the pilot study conducted earlier. Polishing in either a vertical flow constructed wetland (VFCW) or horizontal flow constructed wetland (HFCW)



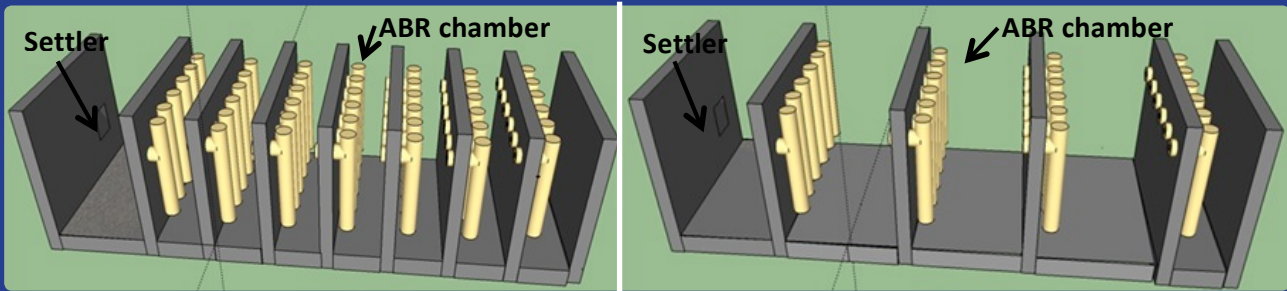
The settler-ABR-AF steps of the experimental BORDA DEWATS plant. Wastewater is screened in the settlers, passes through three parallel ABR trains followed by two AF chambers in series. (Abbreviations: ABR-Anaerobic Baffled Reactor; AF-Anaerobic Filter; SET-Settler).



The wetland modules of the Newlands Mashu DEWATS plant. The vertical flow constructed wetland (middle) is fed through a siphon filter. The horizontal flow constructed wetland is shown on the top (wetland was not planted when photograph was taken in February 2012). Both wetlands were planted with vetiver grass.

The technical evaluation DEWATS plant could be configured to divert flow through different combination of ABR trains or through all ABR trains. The effluent from only train 2 was polished in either constructed wetland as the step was designed to treat only a third of the total design flow (about 14 m³/d). As the plant would be eventually driven to failure over the course of the project (to establish the operational limits of the plant), a safety measure was implemented whereby all treated and untreated streams could be safely bypassed back into the trunk sewer.

The settlers were seeded with anaerobic sludge from the KwaMashu wastewater treatment facility to facilitate the startup of the plant. From the 2 November 2010 to 3 October 2012, the plant was operated in the continuous mode with the plant shutdown in periods in between to perform maintenance tasks mostly related to electrical components required for gathering flow data.



a) Schematic representation of the seven chambered ABR used in Trains 1 and 2

b) Schematic representation of the four chambered ABR used in Train 3

Two-dimensional sketch with a cut-away showing the internal design of the ABR chambers of the different treatment trains. Downcomer pipes were used instead of an internal hanging wall.

Plant Performance

Four operating *Research Phases* or operational periods were conducted on the technical evaluation Newlands Mashu DEWATS plant. Each of these had different objectives as follows:

Operation Phase	Objectives
Research Phase 1	<ul style="list-style-type: none"> To reach steady operation in the anaerobic steps of the Newlands Mashu DEWATS plant. The specific aims were to determine the strength of the incoming wastewater, evaluate treatment performance through the plant and compare design versus actual reduction in COD removal through the anaerobic steps.
Research Phase 2	<ul style="list-style-type: none"> To operate all trains at the same flow rate to determine if there was a significant difference in the removal of certain physico-chemical parameters between the two identical trains and the third train with larger ABR compartments.
Research Phase 3	<ul style="list-style-type: none"> To determine the performance of the ABR and VFCW train under high hydraulic loadings (relative to the design). A single treatment train containing the two settler steps, 7-compartment ABR and 2-AF chambers in series was operated at approximately three times the design flow. Polishing occurred through a VFCW. The performance of the system under this loading was determined by the removal of total and soluble COD through the plant.
Research Phase 4	<ul style="list-style-type: none"> To determine if there differences in performance between treatment trains and if so, determine the factors influencing performance. Compare the performance of trains to discharge limits Compare design versus actual performance in terms of COD removal.

During each of the research phases, different objectives were achieved with different modules of the Newlands Mashu DEWATS plant operated, as shown in the table below:

Operation	Settler	ABR Train 1	ABR Train 2	ABR Train 3	VFCW	HFCW
Research Phase 1	X	X	X	X	X	
Research Phase 2	X	X	X	X	X	
Research Phase 3	X	X	X		X	
Research Phase 4	X	X	X	X		X

Modules operated during the different Research Phases

This project revealed that plant performance was similar across all loadings tested (70 to 250% of the design flow) but was generally unfavourable in comparison to other work. The core treatment step, the ABR, did not perform as expected with anaerobic modules functioning primarily through solids retention. It was hypothesized that the unfavourable performance was due to unstable operating conditions linked to stormwater intrusions which led to hydraulic overloading of the system, chemical and trash dumping, and a biomass with low methanogenic activity. These events have been described in detail in Volume 3 of WRC Research Report K5/2002.



Stormwater overflow installed at head of Newlands Mashu DEWATS plant.

Photo by Bjoern Pietruschka (2014).



Weekly maintenance work performed by municipality workers.

Photoby Bjoern Pietruschka (2014).

When the plant was operated at close to its design loadings, it could achieve a final effluent concentration of between 100 to 200 mg COD/l, 20 to 40 NH₄-N mg/l and around 5 mg PO₄-P/l. This despite major operating and performance affecting challenges being experienced throughout the project. The plant did not initially meet all national compliance standards for agriculture or the more stringent water discharge. Upon closure of WRC Research Project K5/2002, the Ethekwini Municipality decided to continue with the research of the plant taking into account the findings from the research report. In 2013, a stormwater

overflow was installed at the head of the DEWATS plant, the ABRs were re-seeded with high methanogenic activity granular brewery sludge and routine maintenance performed by the municipality to remove trash and scum. The plant was also re-configured to run both wetland types simultaneously. Mr. Bjoern Pietruschka, who completed his MSc on the Newlands Mashu DEWATS plant as part of Research Project K5/2002, is continuing the R&D activities of the plant as part of his PhD which is funded through BORDA.

Improved performance was observed after the plant was re-configured (effluent: COD = 47 mg/l, NH₄-N = 4 mg/l, PO₄-P = 5 mg/l, SS = 3 mg/l, FC = 2600 CFU/100ml), and routine maintenance and operational tasks performed – the plant was previously operated without a screen and daily/weekly maintenance (grit, trash, scum removal). Agricultural trials with the treated wastewater indicated that the effluent was beneficial to selected crop growth but there were still issues around over application (in terms of P source) of the effluent and the presence of pathogen indicators on irrigated crops.



Photographs of samples taken through the Newlands Mashu DEWATS process. Abbreviations: ABR, anaerobic baffled reactor; AF, anaerobic filter; VGF, vertical flow wetland; HGF, horizontal flow wetland.
Photos by Bjoern Pietruschka (2014).

3 LESSONS LEARNT

Most of the challenges during the commissioning of the plant were related to the installation of auxiliary equipment associated with evaluating the treatment process. For example, flow meters would not necessarily be installed with plant in field-based systems and thus, electrical problems of this nature will not be expected.

The table below presents the lessons learnt from Research Report K5/2002. Besides the auxiliary equipment installation challenges, the plant did not have many technical problems related to measuring its performance. Fats, oils and grease (FOG) were a major performance-

limiting observation noticed. The scum layer was mostly solid and filled most of the volume of the two settling steps. This layer was sludge-like; it was viscous and difficult to remove by pumping. A pit emptying crew from EWS unit had to constantly churn the scum with water in order to pump it out. This task was made more difficult by the fact that trash consisted of a large portion of settled material in the settler. A variety of items were removed from the settlers including condoms, sanitary pads, refuse bags and sport balls. The emptying task took around 2 days to complete. Sludge levels were generally low in the settlers and were not a problem to remove using a desludging valve in the settler.

Lessons learnt during operation of the plant

Problem	Cause	Solution
Operation		
Stormwater intrusion	Illegal connections	Include greater safety factor into design or include stormwater overflow
Scum accumulation	Wastewater contains high concentration of fats, oils and grease (FOG)	Larger settler to remove FOG Grease traps at household level
Trash accumulation	Trash dumping at user interface	Education programmes to be included during implementation Manual screening of waste prior to DEWATS plant User interface technology which limits trash dumping

Scum migration and trash migration through the system often caused blockages to the downflow pipes especially at the front end of the ABR. The Project Team observed that once downflow pipes were cleaned, a *burping* of the system would occur resulting an influx of wastewater from the preceding chamber. Sanitary pads were also found to block downflow pipes as it moved from one chamber to the next. Not all the downflow pipes were accessible from manholes; the Project Team accepted that some channeling could occur through different chambers based on the clogging of downflow pipes.

4 CONCLUSIONS & RECOMMENDATIONS

An implementation guideline was developed from operational experience of the Newlands Mashu DEWATS plant. The guide focused on 5 aspects that should be taken into account during implementation of a DEWATS plant. They are:

1. Encouraging community participation during implementation stage.
2. Educating users on the use and benefits of the technology should also be incorporated.
3. Selecting appropriate conveyance, pre-treatment and module treatment steps.
4. Incorporating construction approval steps to ensure built quality.
5. Establishing the roles and responsibility for the upkeep of the plant based on literature and plant operation. This was particularly important as BORDA plants installed outside South Africa are implemented and maintained through (partial or whole) financing through the serviced community; and therefore less prone to trash dumping. In South Africa, it is likely that the municipality would have to be responsible for upkeep of the plant.

5 FUTURE OF DEWATS

Research activities are being conducted to monitor the new configuration over a longer period and to establish the influence of FOGs on the digestion process. The research activities will also be extended to community ablution blocks that are connected to ABRs in Frasers settlement, north of Durban.



*Photograph of community ablution blocks connected to ABRs in the Frasers settlement.
Photo by Bjoern Pietruschka (2014).*

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