Start-up and performance evaluation of DEWATS plants in Afghanistan

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Abstract

December 2011, BORDA (Bremen Overseas Research and Development Association) started its activities in Afghanistan. Since then, a total of 9 DEWATS plants have been constructed in Kabul and Mazar-e Sharif and Jalalabad. However, both cities are known to have long cold winters, which have an inhibitory effect on anaerobic digestion processes and thus on the DEWATS (Decentralized Wastewater Treatment Systems) treatment efficiency.

The following paper compares the treatment efficiency of DEWATS that have been built in Kabul and started up during the winter (February) and DEWATS that have been started up during spring. Furthermore, different construction designs were compared to their performance and applicability to the weather conditions in Afghanistan. The assessment was conducted by monitoring the wastewater temperature, COD and pH, measurements of the respective DEWATS effluents from the ABRs (Anaerobic Baffle Reactors) and AFs (Anaerobic Filters).

Keywords
DEWATS; start-up time; construction design; comparison

INTRODUCTION

Afghanistan's unique situation offers a highly promising opportunity for the installation of BORDA DEWATS plants. The general lack of sewage systems and treatment options leave a high demand for decentralized treatment of black and gray water. Existing infrastructures suffered largely during the wars and the lack of maintenance from the time of Soviet occupation until the end of the Taliban regime (Oxfam 2009).

Anaerobic Baffled Reactors (ABRs), initially developed in Stanford (McCarty 1981) has been shown to be an effective technology in treating wastewater in decentralized systems and are able to cope with organic shock loads (Stuckey and Nachaiyasit 1997). ABRs are constructed so that the wastewater flows in an over-under fashion from the influent to the effluent. Wastewater COD / BOD is reduced as anaerobic microorganisms convert carbon to methane. The ABRs are usually constructed after settlers or septic tanks and the effluent can lead into collection tanks for percolation or directly be discharge into open water bodies (Gutterer 2009).

However, the climate in some regions of Afghanistan is not optimal for small scale decentralized treatment due to high changes in temperature over the year. The temperature in Kabul for example, as shown in Fig. 1, can range from up to 33°C in summer, to -7°C in winter. With average winter temperatures at 0°C and less, a highly reduced microbial activity can be assumed (Nachaiyasit 1997).

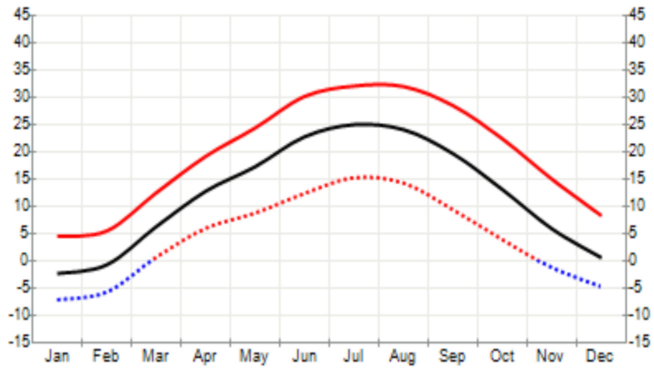

Figure 1: Kabul temperature as measured by the Kabul Airport weather station, showing high (red line), low (blue-red) and mean (black line) temperature for a 1 year period in 2011 (see also www.yr.no, 2013)

DESCRIPTION OF DEWATS PLANTS

The following study researches the performance of 3 DEWATS plants, implemented by BORDA in and around Kabul, Afghanistan. These plants have been monitored for 5 months from May to September 2013. Details of the plants are shown in Table 1.

Table 1: Overview of the 3 DEWATS plants in Kabul area

Plant	AUWSSC	ACT	Mosque
Start-up Date	25.02.2013	25.12.2012	20.02.2013
Septic Tank (2 compartments)		1	1
Settler (1 compartment)	2	-	1
ABR compartments	6	5	8 (on 2 levels)
AF compartments	2	2	-
Collection Tank	1	1	1
Percolation Bed	-	1	-
Design Material	CMU+RCC	RCC	CMU+RCC

AUWSSC DEWATS plant

The AUWSSC (Afghan Urban Water Supply and Sewage Corporation) DEWATS plant, shown in Figure 2, has been implemented to treat the wastewater for the office building of AUWSSC. The wastewater is generally domestic and comes from toilets, hand wash basins, and cleaning of toilets. The measured water consumption is about 8 m^3 per day and the design capacity is 20 m^3. Since beginning of July influent volume has been increased from 5 to 8 m^3 while the number of users hasn't changed, this might have influenced the results in last three months. No sludge layer has been formed yet.

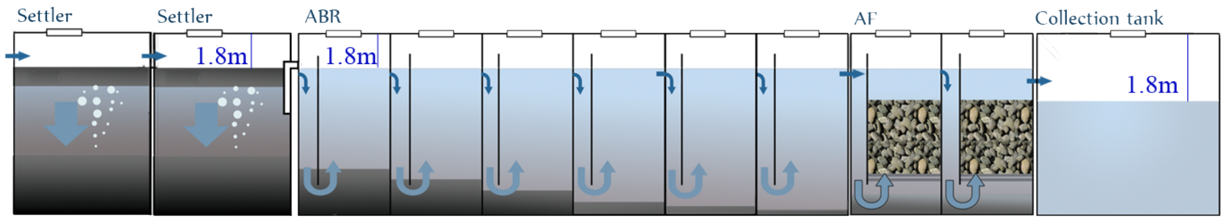

Figure 2: Schematic drawing of the AUWSSC DEWATS plant in Kabul[1]

ACT DEWATS plant

The ACT (Agency of Consulting for Training) DEWATS plant, shown in Figure 3, is designed for treating 10 m^3 per day of domestic wastewater. From August on a scum layer has begun to build-up in the septic tank. Recent indication has shown a noticeably lower hydraulic load than the original design has been made for. Estimations are in the range of about 1/6 of the designed load. The ABR and AF are covered by two concrete slabs which are supposed to have an insulating function.

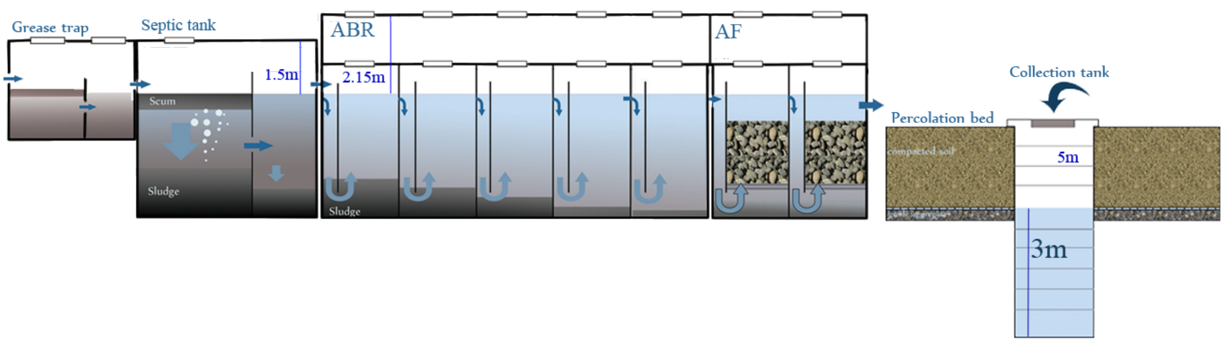

Figure 3: Schematic drawing of ACT DEWATS plant in Kabul

The Abdul Rahman Mosque DEWATS plant

This DEWATS plant was built on the premises of the Haji Abdul Rahman Mosque in Kabul. It is designed for a capacity of 34 m^3 wastewater per day. The DEWATS was designed to treat black water only. It has a 2-story ABR. Four ABR compartment s are located on the first story, with the water level 3 meter below the ground level. From the fourth compartment it is pumped to the fifth compartment in the upper second story. The next four compartments have the water level 0.5 meter below the ground surface. The schematic drawing of the DEWATS plant is shown in Figure 4.

[1] - The heights showed in figure are the water surface depth from the ground level.

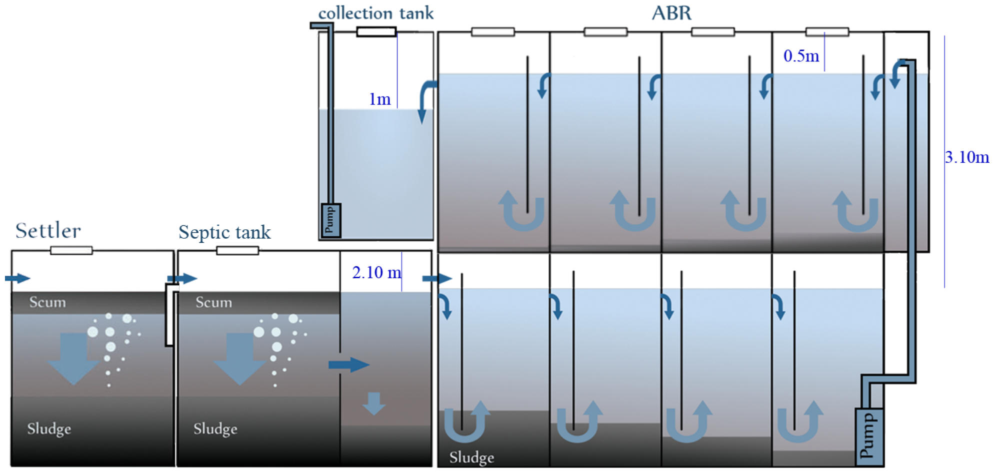

Figure 4: Schematic drawing of the Abdul Rahman Mosque DEWATS plant in Kabul

RESULTS

The temperature profile of the 3 sites, as shown in Figure 5, clearly shows a decrease of several degrees in the ACT plant beginning in the Septic tank at the front of the plant towards the collection tank (CT) at the end. The difference in temperature between May and June most likely is to be linked to the higher temperatures in summer months. The differences in temperature in the different compartments probably come from the mixing of warm influent into colder wastewater inside the compartments. As measurements have been done during the morning hours, the wastewater inside the plant is still colder than the inflowing wastewater due to more exposure to ambient temperature and sun. The first compartments of the DEWATS plants are logically the first ones to show a rise in temperature. This applies primarily to the ACT plant as the other plants show more stable temperatures over all compartments.

The AUWSSC plant shows a more stable temperature profile of the various DEWATS components for all months. The highest temperatures observed in July and August clearly relate to higher temperatures during the summer. The generally highest temperatures can be seen in the collection tank, where all effluent is stored.

The Mosque DEWATS plant shows the highest temperatures of all three plants with the highest temperature in ABR 8. This may be a result of the 2-story construction of the ABR, with the ambient temperature having a higher effect on the ABRs in the upper level.

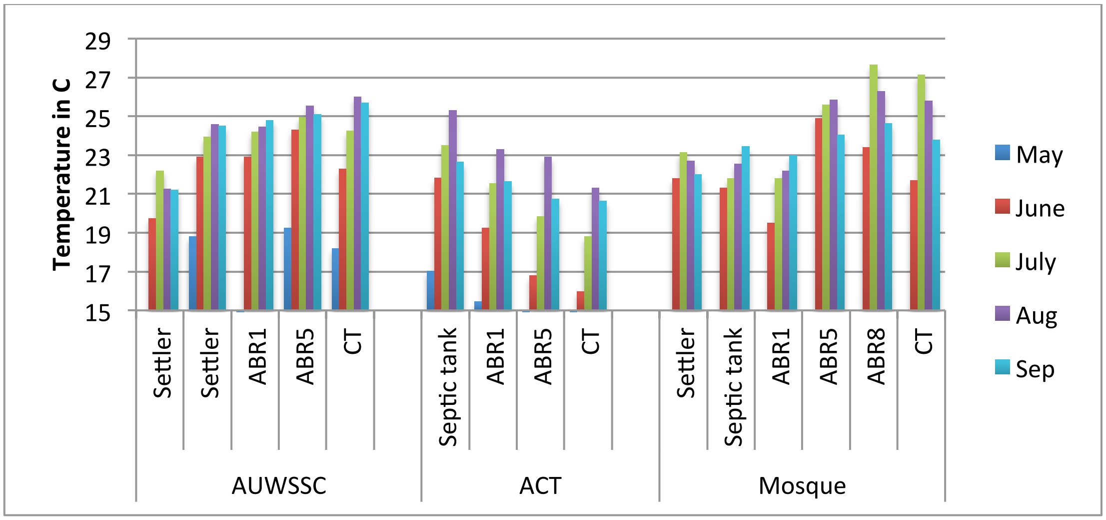

Figure 5: Temperature overview for AUWSSC, ACT and Mosque DEWATS plants

The pH for the AUWSSC DEWATS plant, as see in Figure 6, shows a general rise in pH from the first to the last compartment. The variation from May till September shows a slight reduction of the pH in all compartments over the time. The extremely high pH peak in the CT in May most probably relates to an emptying of the CT shortly before measurements were taken.

The ACT DEWATS plant shows a noticeably rise from first to the last DEWATS component of the plant. From May till September a clear reduction in pH can be observed in all compartments of the plant except for ABR 5 which only shows a reduction from May to June and then keeps a constant pH.

The Mosque DEWATS plant shows a slight decrease of the pH from Septic tank till ABR 1 and a higher value from ABR 5 till the CT. This might be due to a slower establishment of the microbial community in the higher compartments.

The pH shows to be generally high (above pH 8) at all times and places. This might be due to a not very efficient hydrolysis step or acidogenesis in the plant. This would reduce the amount acids being produced in the plants and thus leading to a slightly higher pH than neutral. As the hydrolysis being the slowest step in anaerobic digestion this is a plausible possibility. Additionally, as the plants have been started just recently a full grown microbiocenoesis might not have been established yet. This would explain the results in ACT and Mosque DEWATS plants as they show a reduction of the pH from beginning of the measurement in May/June till later months as a growing microbial population should have been established by then.

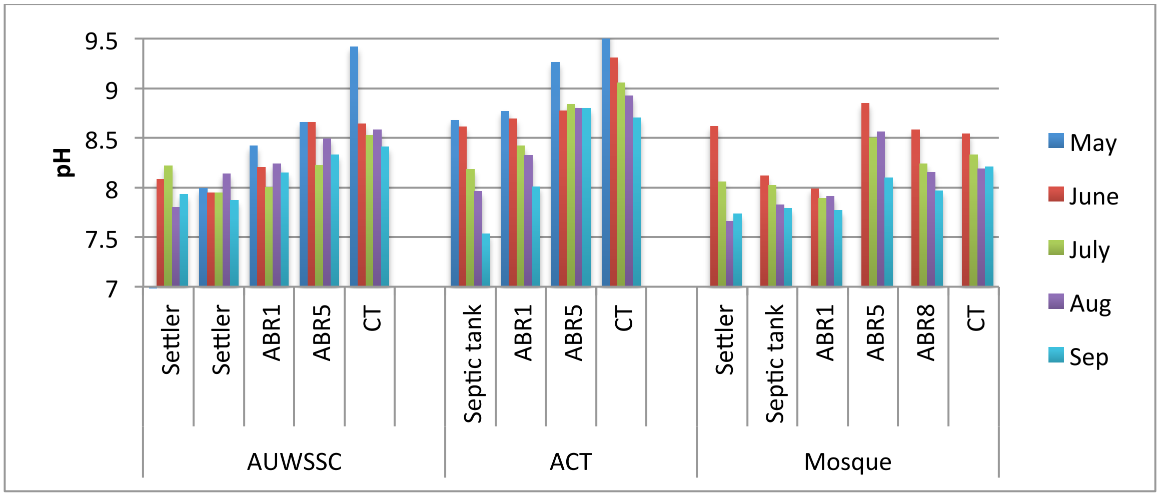

Figure 6: pH profile for AUWSSC, ACT and Mosque DEWATS plants

The total COD in the different components of all DEWATS plants are shown in Figure 7. The AUWSSC plant has similar influent COD to the ACT plant, but only minimal COD reduction was observed. The increase of the total COD in the ABRs compared to the settler might be due to biomass that has been flushed up into the sampling area of the ABR. This would cause the COD to be higher than it actually is as the biomass adds to it.

The ACT plant shows a constant reduction of the total COD from septic tank till CT from the beginning of the measurements. However, the extreme peak in the septic tank COD values in August and September can be explained by the build-up of a scum layer which affects the measurements strongly. The effect can be seen for September in all compartments of the plant.

The Mosque DEWATS plant shows very high inflow COD values with a strong COD reduction from 2800 mg/l to an average of 300 mg/l in the ABR_8. This plant shows extreme variations in the inflow which is due to a varying amount of visitors to the mosque, especially during religious holidays. It can be clearly seen that the treatment efficiency of the plant is rising from June to September. Additionally it shows the ability of DEWATS plants to cope with varying organic shock loads. During the first 6 months after the start-up the daily wastewater production ranged from 4 to 8 m³ (during Ramadan) compared to the designed 34 m³ per day. This is due to the fact that a flushing system for urinals has been installed. A discharge of around 2 liter per flush can be assumed during that time. However, the flushing system got replaced to a siphon flush system increasing the flush to 9 liters. After 6 months of system start up a daily wastewater production of 16 – 32 m³ (during Ramadan) can be assumed.

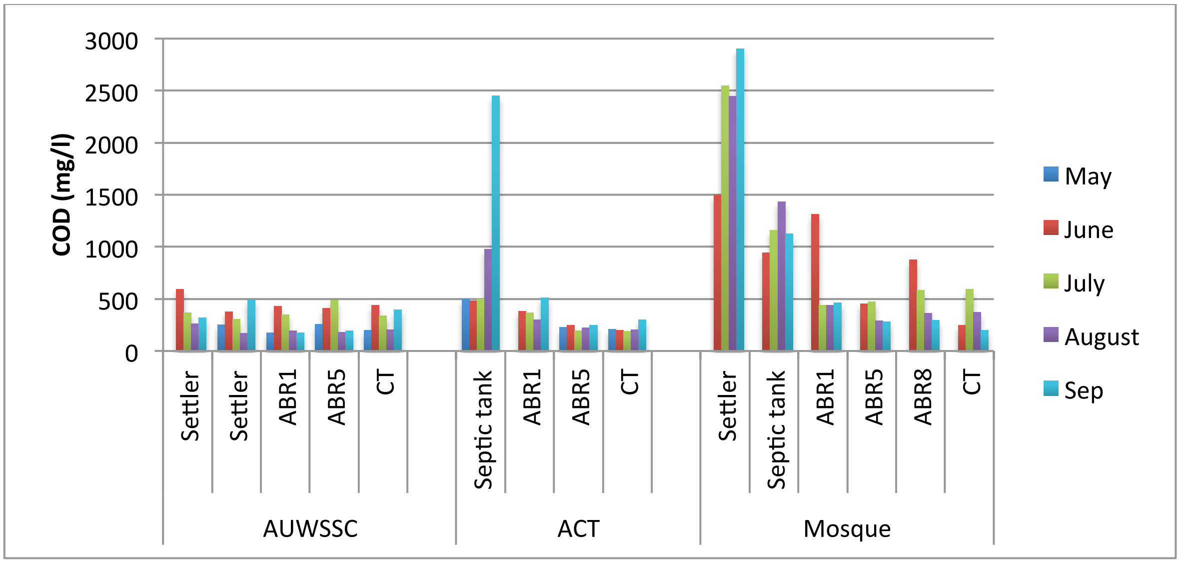

Figure 7: COD values for AUWSSC, ACT and Mosque project

The overall average treatment efficiency of the plants varies strongly, as shown in Figure 8. However, the final COD of all plants remains above 200 mg/l at all times. This can be explained by the recent start-up of the plants and should improve over time due to on-going growth of biomass in the ABRs. The ACT plant shows a clear rise in efficiency whereas the Mosque DEWATS plant seems to be at constant treatment efficiency at a comparatively high level of 80% and higher.

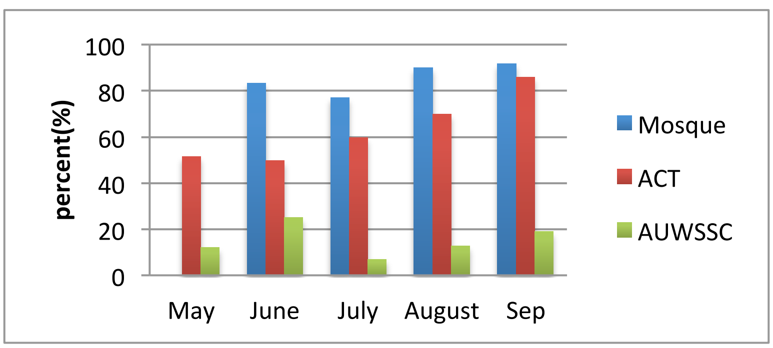

Figure 8: Comparison of plant efficiencies in total COD removal between settler and effluent in the collection tank.

CONCLUSIONS

The ACT plant, which was started in December 2012, shows a noticeably stronger COD reduction than the AUWSSC plant. This suggests that the AUWSSC plant is still in start-up phase, and may need a few more months to develop a sludge layer and an adequate amount of microorganisms.

It could be clearly shown that the DEWATS system seems to be working best for high COD inflow as could be seen at the Mosque plant. It also was noticed that there can be strong differences between the amount of wastewater the plant was designed for and the actual amount being produced and other design parameters like COD and HRT. This has led to starting a study about the actual wastewater productions of schools and other institutions for determining the actual amount for future designs. It is essential to find some standard calculations which are based on the number of users and particular water usages to find the wastewater production per capita and COD.

Further monitoring has to be conducted to clearly show the temperature effect on the treatment efficiency of the DEWATS plants. Additionally the change in treatment efficiency during the coming cold season will be monitored closely. Furthermore comparisons with DEWATS plants in countries with similar temperature profile will be undertaken. As few BORDA DEWATS plants have been installed in similar climate conditions only plants in Lesotho, Africa will be available for comparison. Both countries are similar in elevation and latitude thus providing ideal conditions for comparison.

Power black-outs and the partial difficulty of importing chemicals also make it difficult to take measurements as planned and provide high quality lab results.

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