A modified constructed wetland system for grey water treatment and reuse

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Abstract Light greywater (GW_L) is the fraction of domestic sewage originating from sinks, shower, bath and laundry activities. Natural systems can be used for GW treatment, for arrangements regarding both uni-residential as well as condominial systems. Green spaces in urban areas improve the local microclimate, benefiting public health and reducing energy consumption, and the use of gray water for developing such spaces, as well as for irrigating private areas, should be considered. For this purpose, a modified constructed wetland system is proposed, aimed at low operation and maintenance. This system, named "EvaTAC", is a combination of an evapotranspiration and treatment tank (CEvaT) with an inbuilt anaerobic chamber (AnC), followed by a horizontal subsurface flow constructed wetland (HSSF-CW). The anaerobic chamber was chosen for its capacity to digest organic matter and retain coarse material, as the intention was to eliminate the septic- or sedimentation tank for pre-treatment, in order to reduce or even avoid problems like clogging and odours. To better understand the capacity of the AnC to equalise daily variations of flow and organic load in the system, we performed two 24-hour and one 8-day monitoring profiles. The results show that the two units complement each other. The 8-day profile shows that, within the CEvaT, the AnC presents the highest removal efficiency of the studied parameters. The HSSF-CW operates as an efficient polishing unit, with the effluent average turbidity of 8 NTU. During the 3 years of operation, no sludge withdrawal was necessary and no maintenance in the distribution pipe (inlet) of the HSSF-CW was required. The implemented system at full scale was quite acceptable to the householders, not disturbing their routine, rendering a green site totally integrated into the garden, without the use of potable water for irrigation.

Keywords domestic sewage, resource oriented sanitation, source separation, water conservation

INTRODUCTION

Global concerns about water scarcity and increasing pressure on fresh water supplies have become an incentive for wastewater reuse. Greywater (GW) is a term which refers to domestic wastewater from all sources except toilets, and it has been estimated to account for about 60 – 80% of all domestic sewage (Eriksson *et al*., 2002). As greywater typically has a lower pathogen content and lower organic matter load than combined domestic sewage, it has been considered a potential source of water to meet current and future needs even though it is mostly considered for non-potable use (Benami *et al*., 2015; Ghunmi *et al*., 2011; Maimon *et al*., 2014; Teodoro *et al*., 2014). This holds true especially for the light grey water (GW_L) fraction, which apart from excluding the toilets also excludes the kitchen sink and dishwasher fractions, which are the greywater fractions that carry the highest COD loads and have the highest content of suspended solids (Abu Ghunmi *et al*., 2011; Paulo *et al*., 2009). Greywater can be highly variable in composition and volume generated per person, being heavily dependent on the dynamics and behaviour of individuals, sanitary standards, age, lifestyle, water use, eating habits, personal care and household products choice and water availability, among others. According to a review paper from Li *et al*. (Li *et al*., 2009), an analysis of grey water characteristics by different categories indicates that the kitchen and the laundry fractions contain higher concentrations of both organic and physical pollutants than the bathroom and the mixed grey water fractions. Additionally, they found that all greywater fractions show good biodegradability, even though COD:BOD ratios, according to Boyjoo *et al*. (2013), can be as high as 4:1. This can be explained by the high load of chemicals and surfactants, present in these greywater flows, due to personal care and cleaning products used in a household (Eriksson *et al*., 2002; Revitt *et al*., 2011).

Existing greywater treatment systems show a wide range of design principles and sophistication, from simple single-household soil filter systems to more elaborate community-scale multi-stage rotating biological contact (RBC) reactors, constructed wetlands and membrane bioreactors, amongst others - all based on chemical, physical and biological processes such as settling, filtration, adsorption, aeration, precipitation, aerobic/anaerobic digestion, and disinfection (Donner *et al*., 2010; Ghunmi *et al*., 2011). The choice of a grey water treatment system includes considering different treatment steps that may be applied, depending on the required quality of the effluent (Ghunmi *et al*., 2011). For the sustainability of household or small-scale decentralized treatment systems, several aspects have to be taken into account, like for instance: cost, operation and maintenance requirements, odour nuisance, and health risks. Natural systems are considered sustainable ecotechnologies for small scale treatment of domestic wastewater and its fractions (Mahmood *et al*., 2013; Paulo *et al*., 2013; Morel and Diener, 2006). In this view, filters (planted or unplanted) and several variations of constructed wetlands have been used for greywater treatment (Ramprasad and Philip, 2016; Ghunmi *et al*., 2011; Hoffmann *et al*., 2011; Li *et al*., 2009; Paulo *et al*., 2009; ; Gross *et al*., 2007). One advantage of these ecotechnologies is that they can be totally integrated into the gardens (if individual) or into the landscaping of available common areas, increasing the green sites in urban zones, and contributing to an improvement of the microclimate, where an improvement of thermal and environmental comfort is expected. Natural systems appear to be a feasible option to promote water reuse for ornamental gardens and urban landscaping as there is no direct contact with the grey water, thus promoting water conservation with reduced risks. However, care needs to be taken when designing greywater treatment systems. Based on i) our daily experience dealing with greywater, ii) unpublished reports from the internet and iii) literature, we can infer that the solids present in greywater may cause clogging in the inlet portion of filter media, both for combined greywater as for light GW, where hair, and the lint present in the laundry and shower fraction are the major solid constituents. Therefore, considering the importance to treat and reuse greywater, by means of a simplified system, we propose a hybrid system, called EvaTAC (Evapotranspiration and Treatment of Greywater), which is composed of an evapotranspiration and treatment tank (CEvaT) with a inbuilt anaerobic digestion chamber (AnC), followed by a horizontal subsurface flow constructed wetland (HSSF-CW). The CeVAT replaces the pre-treatment, usually done in a septic or sedimentation tank, and it was chosen for its capacity to digest organic matter and retain coarse material. The CEvaT is an adaptation of the TEvap (Paulo *et al*., 2013), used here not with the purpose of zero discharge. It is a soil and plants based system, consisting of an impermeable tank, filled with layers of different substrates. The greywater enters the system through the AnC, raises and percolates through its holes, permeating upwards, until reaching the top soil layer, from where capillary forces, wind and heat, as well as uptake by plants' roots cause partial elimination of the water by evapotranspiration. The pre-treated greywater will then drain to the HSSF-CW. With this configuration we expected to reduce maintenance and avoid problems with clogging and odours. Thus, the objective of this study was to assess the behaviour of a real scale EvaTAC system, installed in a 3-persons household, based on 24 hour and 8 day monitoring profiles, and to better understand the capacity of the AnC to equalise the daily variation of flow and organic load in the EvaTAC.

MATERIAL AND METHODS

The system was implemented in a 3 persons-household, located in Campo Grande-MS, Brazil (20°31' S e 54°39' W) and was in operation for 3 years on the occasion of this study. To design the system, the family was interviewed and during 21 days data were collected regarding the daily routine for each greywater generating point, including frequency of use, duration and time of the day. Based on these data, a physico-chemical and microbiological characterisation was performed, by simulating the family routine, using grab and composite samples. With the processed information, the system was dimensioned, based on the highest greywater flow generated (when using the washing machine), which was 126.7 L per inhabitant per day. Another factor taken into account was the available area. We wanted to build the system along the external wall, one meter wide, in the front garden, where the length available was 5.5 metres. To decide the length of each unit, we started by calculating the minimum volume required for the AnC (anaerobic chamber), following the NBR 7229 guidelines (ABNT, 1997) for the design of a septic tank, which suggests a minimum HRT of 1 day when flows are lower than 1500 L per day.

Experimental Setup

The AnC was made of a fiberglass pipe, with 0.5 m diameter and 2.0 m length, with a useful volume of 392.7 L. It was perforated along all its extension and top part of its circumference, with the lowest perforations at 40 cm from the bottom, as sludge was expected to settle in the bottom part. The diameter of the holes was 1 cm each, and the distance between holes was 10 cm. The EvaTAC (Figure 1) was built in masonry and lined with fiberglass. The dimensions (L x W x D) of the units were: CEvaT (Evapo transpiration and Treatment tank): 2.0 m × 1 m × 1.05 m. HSSF-CW (Horizontal Sub-Surface Flow Constructed Wetland): 2.0 m × 1 m × 0.60 m (0.7 $m^2.hab^{-1}$). The average water depth was approximately 0.74 m for the CEvaT and 0.50 m for the CW. For the CEvaT, the layers, starting from bottom to top were: gravel n$^{\underline{o}}$ 4 (porosity: 0.50; part. size: 32 to 150 mm; layer height: 0.6 m), gravel n$^{\underline{o}}$ 2 (porosity: 0.48; part. size: $d_{10=}$20mm, $d_{30=}$17mm $d_{60=}$12mm; layer height: 0.15 m) and (on top of a geotextile blanket): 0.30 m of soil. The HSSF-CW was filled with fine gravel (porosity: 0.44; part. size: $d_{10=}$13mm, $d_{30=}$11mm $d_{60=}$10mm; height: 0.60 m). The 0.2 m inlet and outlet portions were filled with gravel n$^{\underline{o}}$ 2. Both in CEvaT and HSSW-CW two piezometers were installed: one in the centre and one 20 cm before the outlet. The bottom slope of the EvaTAC was 1%.

For collecting grab and composite samples, as well as for positioning the level loggers and multiparameter sensors for continuous monitoring, flow cells were constructed; one at the inlet for monitoring raw greywater (sampling point P1), one at the exit of CEvaT (inlet of the HSSF-CW; sampling point P3) and one at the outlet of the HSSF-CW (sampling point P4). Sampling point P2 was in the second piezometer installed in the CEvaT, representing the contents in the AnC.

At the entrance part of the CEvaT 13 specimen of White Ginger (*Hedychium coronarium*) were planted, followed by 11 Parrot's beak (*Heliconia psittacorum*) plant cuttings, and in the final part of the system 10 cuttings of Caladium (*Caladium hortulanum*) were planted, all with a 20 cm distance between plants. In the HSSF-CW 10 cuttings of Beri (*Canna x generalis*) were planted, with a 30 cm space between them. A schematic view of the complete system is shown in Figure 1.

Monitoring profiles

There are two typical conditions of flow and loading for the EvaTAC system: receiving inflow originating mainly of bathroom/shower effluents, or receiving inflow from the effluent of the washing machine, probably combined with the greywater produced in the bathrooms. Based on these data, two 24-hour and one 8-day qualitative and quantitative monitoring profiles were performed, simulating three routines: (A): only showers, (B): showers and washing machine and (C): same as B, during 8 days. Profiles A and B were considered preliminary and served to better understand the behaviour of the treatment system, considering hydraulic, hydrologic and water quality parameters, and were used later on to delineate the continuous monitoring procedure used during the 8-day monitoring period (Profile C).

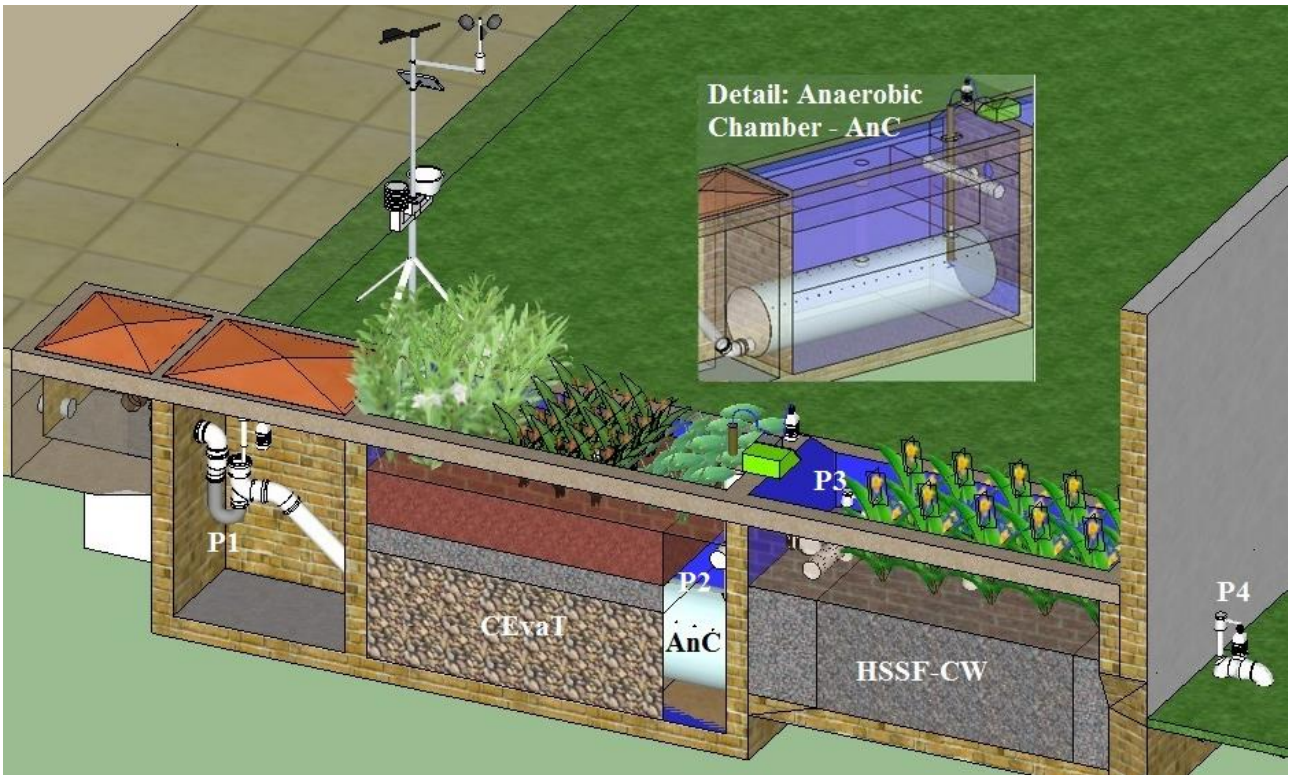

Figure 1: schematic view of the EvaTAC system as described above, including sampling points.

Quantitative and qualitative characterisation

To quantify the greywater generated at point P1, individual eletromagnectic flow meters were installed. Besides, a questionnaire was to be filled in during the days that monitoring was carried out, to know exactly the type and location of water use, and the user. This methodology is comparable to that used by Antonopoulou *et al*. (Antonopoulou *et al*., 2013) except that, in our case, the frequency, duration and volumes generated were also monitored by the flow meters. An ultrasonic flow meter (PT878, GE, USA) was used to quantify the flow at the exit of the system (P4). Leveloggers (Solinst, 3001, Canada), placed in the piezometers located closest to the exits of both units, were used to monitor the water level inside the units. Multiparameter sensors (Hanna Instruments, HI 9829, USA) were installed at the sampling points P1, P3 e P4 to continuously measure temperature, conductivity and redox potential while carrying out the 3 monitoring profiles. Sample collection and preservation was performed according to "*Standard Methods for the Examination of Water and Wastewater"* (APHA, 2012). A meteorological station (Squitter, S1220, Brazil) monitored the hydrological conditions on-site such as relative humidity, reference evapotranspiration, temperature and precipitation. All sensors were synchronized and sampling was performed according to the routine of the greywater generation.

The experimental planning for Profiles A and B was designed so that we could assess the influence of different flows and uses before and after each activity generating greywater. Samples were taken at the entrance of the system (flow cell P1) sampling use from bathroom sinks (grab samples), showers and washing machine (both composite samples). At piezometer P2 samples were always collected in intervals between flows (grab samples) to assess whether flow patterns affected internal mixing in the anaerobic digestion chamber. At sampling points P3 and P4 the effect of inflow on the outflow of the CEvaT and HSSF-CW respectively was quantified, immediately after any significant flow (grab samples). Based on the results, it was possible to draw an experimental planning for the long term (8 days) Profile C. Grab samples were taken from all sampling points (1 to 4) to determine total and dissolved chemical oxygen demand (COD_{total} and $COD_{soluble}$) and turbidity, amongst others, but in this paper only the COD and turbidity will be discussed.

RESULTS AND DISCUSSION

The quantitative analysis performed here permitted the characterisation of water use and greywater production in the household. The results from this work reinforce literature data (Antonopoulou *et al*., 2013) on the variation of greywater characteristics, demonstrating once more the difficulty in comparing literature data. In this study three profiles were analysed: profile A, where bathing corresponds to 93% of influent volume of the system, profile B, where the washing machine is responsible for 58% of the greywater volume, and profile C, representing the greywater production during 8 consecutive days, being a combination of profiles A and B. Table 1 shows some of the operating parameters for these profiles, taking into account the effects of evapotranspiration.

Table 1: Operating parameters of the residential EvaTAC system.

Operating parameters	Profile A		Profile B		Profile C	
	CEvaT	HSSF-CW	CEvaT	HSSF-CW	CEvaT	HSSF-CW
Influent flow ($m^3.d^{-1}$)	0.107	0.093	0.213	0.202	0.160 ± 83.91$^{(8)}$	0.151 ± 87.34$^{(8)}$
Hydraulic Loading Rate (surface) ($m^3.m^{-2}.d^{-1}$)	0.05	0.05	0.11	0.10	0.08 ± 0.04$^{(8)}$	0.08 ± 0.04$^{(8)}$
Hydraulic Retention Time (d)	6.0	4.0	2.9	1.8	4.7 ± 1.8$^{(8)}$	3.1 ± 1.3$^{(8)}$
Organic Loading Rate (surface) ($gCOD.m^{-2}.d^{-1}$)	16.4	5.9	30.9	5.5	31.3 ± 36.1$^{(8)}$	9.3 ± 6.6$^{(8)}$
Volumetric Organic Loading Rate ($gCOD.m^{-3}.d^{-1}$)	54.73	32.17	103.26	30.07	104.5 ± 120.6$^{(8)}$	50.5 ± 35.4$^{(8)}$

Numbers between brackets represent the number of samples.

Every day, influent flows of the same order of magnitude are applied to both treatment units. As both units have the same surface area, both CEvaT and HSSF-CW are subject to approximately the same hydraulic loading rates (HLR) that may vary between 50 and 120 $mm.d^{-1}$. The maximum HLR however may be as high as 500 - 600 $mm.d^{-1}$, depending on the family routine. Some authors recommend that for greywater the HLR applied to HSSF-CW should be around 60 to 80 $mm.d^{-1}$ (Ridderstolpe, 2004; Morel and Diener, 2006), and that the superficial organic loading rate should not exceed 16 $gCOD.m^{-2}.d^{-1}$, in cold climate regions (Hoffmann *et al*., 2011; Morel and Diener, 2006a). In the present study, superficial organic loading rates of between 5 and 20 $gCOD.m^{-2}.d^{-1}$ were applied to the HSSF-CW. In warm climates good results were obtained with superficial organic loading rates of 60 - 70 $gCOD.m^{-2}.d^{-1}$ and hydraulic loading rates above 200 $mm.d^{-1}$, which shows that the HSSF-CW is operating in agreement with established recommendations. For the CEvaT it is still early for making such comparisons once we still do not know which configuration would be more similar. If the distribution of the flow leaving the AnC is even through the holes from the bottom to the top, it could be considered an upflow vertical filter.

Figure 2 shows influent and effluent flows of the EvaTAC system, for light greywater production, in Profile B. There is a great regularity in the average flow of greywater from bathing and the washing machine, entering the system every day. The flow and average duration of showers are 5 $L.min^{-1}$ and 5 minutes, respectively. The washing machine produces an outflow of 8.5 $L.min^{-1}$ on average, and with duration of 10 minutes. In profile B it can be verified that the two first showers taken every day cause a rise in the level of both systems, causing an overflow of the CEvaT into the HSSF-CW, and this one, in its turn, producing an outflow of treated greywater. The same happens when the washing machine is draining. In the afternoon and night, little greywater enters the system at P1, and this flow is insufficient to cause any flow of greywater between the compartments or out of the system, causing a reduction of the water level in both compartments in the afternoon, as a result of evapotranspiration. The effect is that in the night the inflow of greywater from the shower into P1 only elevates the level in the CEvaT and HSSF-CW, not having any outflow of treated greywater from the HSSF-CW.

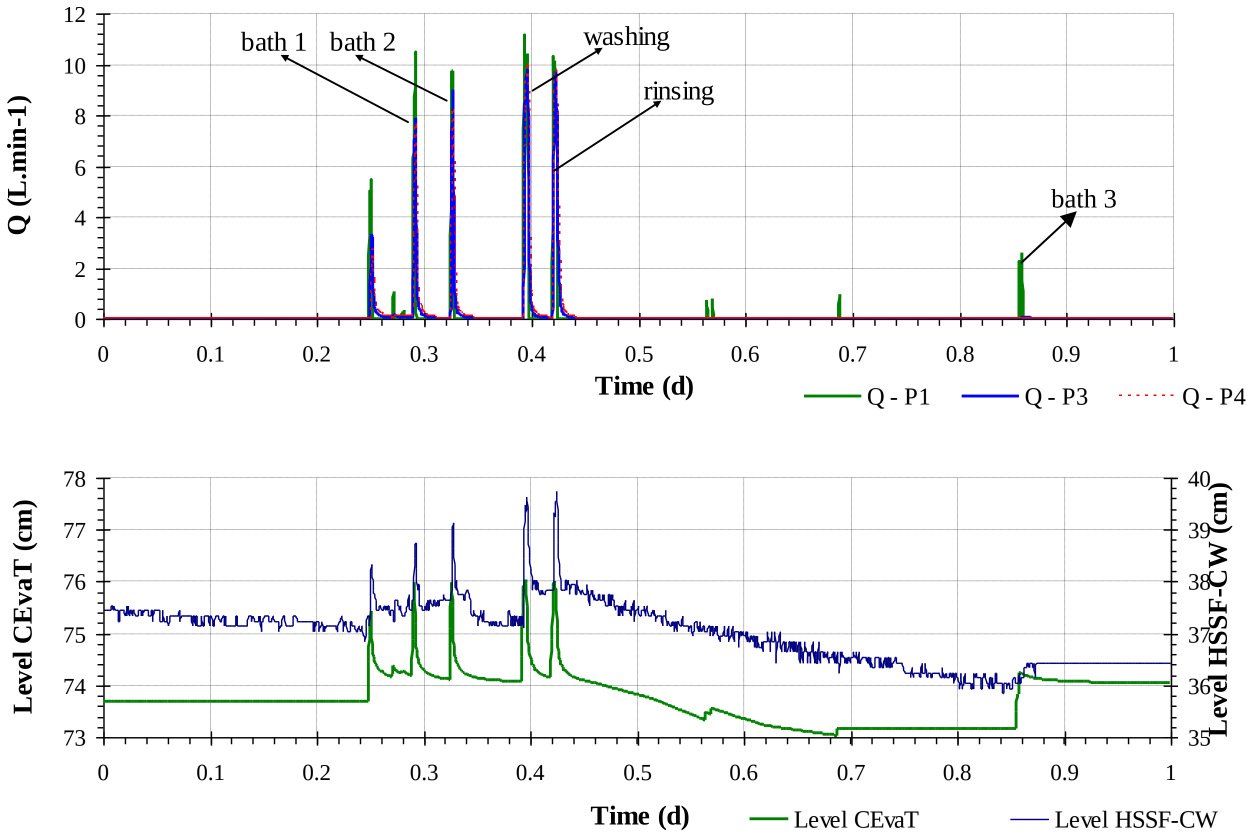

Figure 2: Flow (Q) at sampling points P1, P3 and P4 and water levels inside the CEvaT and HSSF-CW units for greywater production on profile B. The overflow of CEvaT is at 74 cm and the overflow of the HSSF-CW is at 37.5 cm.

For a qualitative characterisation of the greywater, synchronised sampling was performed, in such a way that samples of inflows were collected at P1 and P2, before and after greywater producing events, and of the effluent of the CEvaT (P3) and of the HSSF-CW (P4) as well. This planning of synchronised sampling permitted evaluating the effect of greywater flow along the sampling points, and verification of the effect of flow rate on the quality of the water treated in the different compartments of the system, as a function of this flow rate. Table 2 summarises the results of COD_{total} and turbidity monitoring at sampling points P1 - P4, for the greywater production profiles A, B and C. For profile A, where the average greywater flow was 5.1 $L.min^{-1}$, it could be observed that in this 24 h period, the organic and hydraulic loading did not cause any alteration of the composition of the water inside the AnC (comparing P2 and P3). On the other hand, we can notice that, for profiles B and C that also received the contribution of the washing machine, the COD and turbidity results are more unstable. Still, observing the results on P4 one can note that even this high flow does not reflect on the final effluent quality. It is clear that the greywater entering the system at P1 is different from the flow leaving the system at P4, considering the HRT of the system. For this reason we do not discuss the removal efficiency of the studied parameters. However, considering influent and effluent data we can conclude that the system copes with flow and load variations. The system is operating over 3 years already dealing with the regular family routine and, proper interactions developed between the filter media, soil and roots. When looking closer at the results for profile C, for instance, that had an average HRT of 7.8 days, and received COD_{total} as high as 900 $mg.L^{-1}$ (grab sample) from washing machine discharges, the effluent quality remained stable, considering one complete HRT has passed by the last day of the experiment. The HSSF-CW seems to be operating as an efficient polishing unit, with average COD_{total} for P4 of 63 $mg.L^{-1}$ and an average turbidity of 8 NTU. Another important observation is that along all the operating time never an increased concentration of solids was observed at P3, something that would be expected if excess sludge would be accumulating in the AnC. When carrying out the profiles, we measured the height of the sludge layer in the anaerobic chamber, which was less than 2 cm. Permaculture practitioners do not recommend this system for domestic sewage or greywater, believing that the chemicals present would cause accumulation of non-biodegradable sludge in the AnC, recommending it only for the black water fraction. However the results obtained so far encourage us to continue development of this system as it seems to combine simplicity and high efficiency with low maintenance. No sludge withdraw was necessary during the whole period. Also, no maintenance in the distribution pipe (inlet) of the HSSF-CW was required.

Table 2: Results of monitoring of COD_{total} and turbidity at sampling points P1-P4 and average flow at sampling point P1, for the profiles A, B and C in the CEvaT and HSSF-CW units.

	Profile A Q_{P1} **= 5.1 L.min^{-1}**				**Profile B** Q_{P1} **= 8.3 L.min^{-1}**				**Profile C** Q_{P1} **= 6.6 ± 2.2$^{(36)}$ L.min^{-1}**			
sampling point	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**	**P1**	**P2**	**P3**	**P4**
COD_{total} (mg.L^{-1})	304.8	128.7	127.2	75.8	289.9	113.2	54.8	41.0	307.2 ± 190.2$^{(8)}$	147.3 ± 67.0$^{(8)}$	118.4 ± 21.2$^{(8)}$	73.1 ± 15.7$^{(8)}$
Turbidity (NTU)	101.0	51.1	50.0	4.2	60.4	34.8	39.8	9.3	56.3 ± 17.2$^{(8)}$	44.8 ± 17.3$^{(8)}$	43.0 ± 12.3$^{(8)}$	9.50 ± 1.5$^{(8)}$

Numbers between brackets represent the average flow measured during the 8-day Profile.

Figure 3 shows concentrations of COD_{total} and $COD_{dissolved}$ in samples withdrawn along the day at the 4 sampling points for profile B, which had an average flow of 8.3 L.min^{-1}. Three different events were sampled at P1 (P1-1...P1-3) and at points P2 - P4 the effect of these events was studied withdrawing a sample before and after such an event (hence more samples were taken for P2 - P4). It can be seen that after entry of the flow originating from a washing machine discharge, both $COD_{dissolved}$ and COD_{total} increase, although only slightly, in the effluent of the AnC, showing that this chamber functions, at least partially, as a mixed flow reactor. It can also be observed that the largest part of COD is present as dissolved rather than as suspended matter.

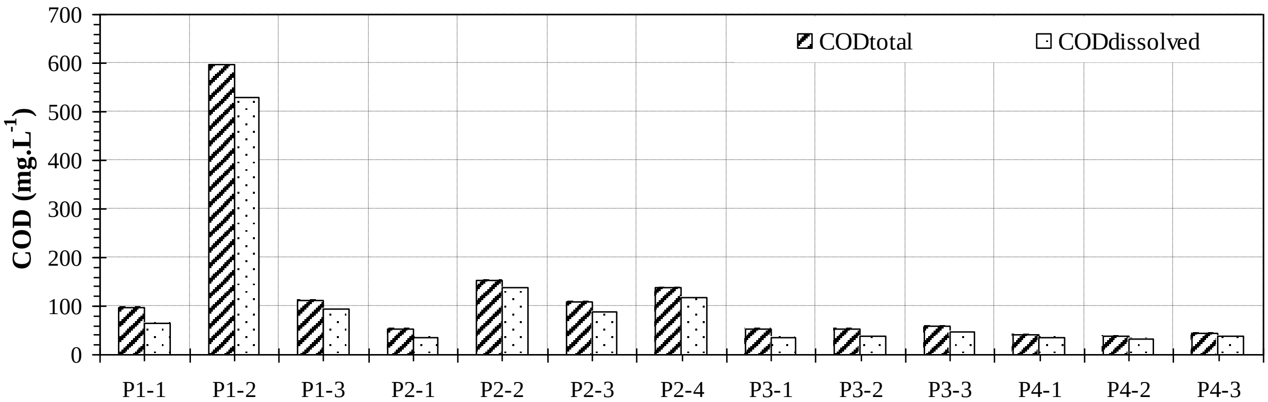

Figure 3: Variation of COD (dissolved and total) at sampling points P1 - P4 for profile B of greywater entering the system.

Depending on the profile studied, the HRT in the CEvaT varies between 3 and 6 days, while the HRT in the HSSF-CW varies between 1.8 and 4 days. Figures 3 and 4 and Table 2 show that the AnC promotes stability in the system as seen in the results for P3 and P4, acting as the main compartment of the system. Figure 4 shows the result of the continuous monitoring of profile C, during the 8 days duration of this experiment, and it can be seen that at sampling point P1, the variation of the conductivity, which might be seen as a proxy for the concentration of dissolved components, is much bigger than the variation of the conductivity as observed at sampling points P3 and P4, although the conductivity at these points is higher than at P1 (mineralization of organic matter tends to convert dissolved organic compounds, that do not contribute much to conductivity, into dissolved inorganic compounds, elevating the conductivity). In the intervals between influent flow, the conductivity, especially at P1, rises as a result of drying out of the flow cell as a result of evapotranspiration, with rapid variations as a result of small flows (hands washing and short rain events. Rain accounted for 6% of the inflow in the period of monitoring profile C).

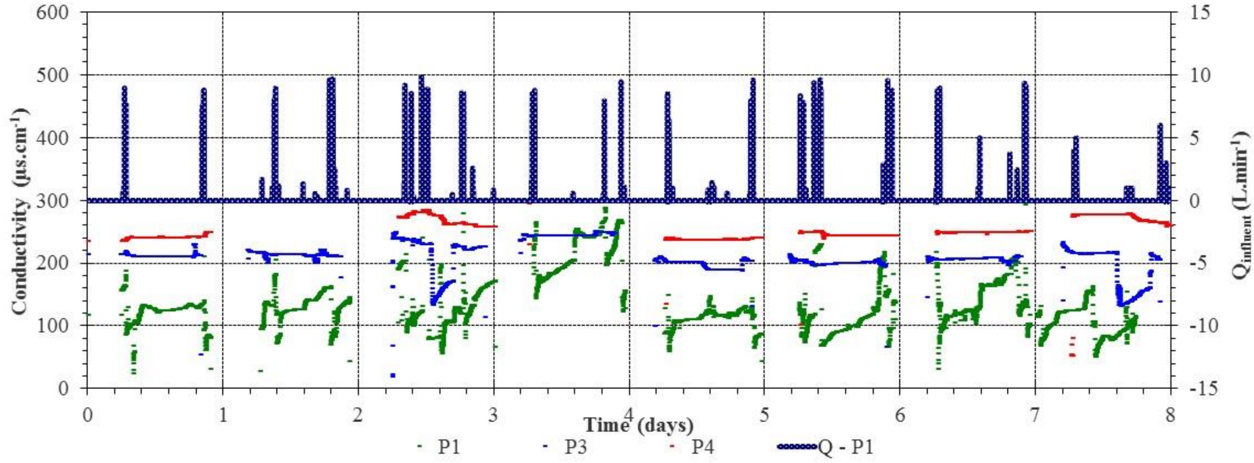

Figure 4: Continuous monitoring of influent flow (at P1) and conductivity (at sampling points P1, P3 and P4) for profile C. Conductivity at P1: green, P3: blue, P4: red, and inflow (Q): dark blue.

Profile C showed, during its 8 days of duration, characteristics very similar to those of profile B. The results at sampling points P3 and P4 are very similar, indicating that most of the treatment occurs in the CEvaT, and within CEvaT mainly in the AnC. In the HSSF-CW a small additional removal of organic compounds (mineralization) occurs, and a small amount of evapotranspiration, thus causing a slightly higher conductivity of its effluent compared to the effluent of the CEvaT. Evapotranspiration from the system occurs mainly from CEvaT though (Figure 5), probably as a result of more dense vegetation (surface area of both units is the same: 2 m^2).

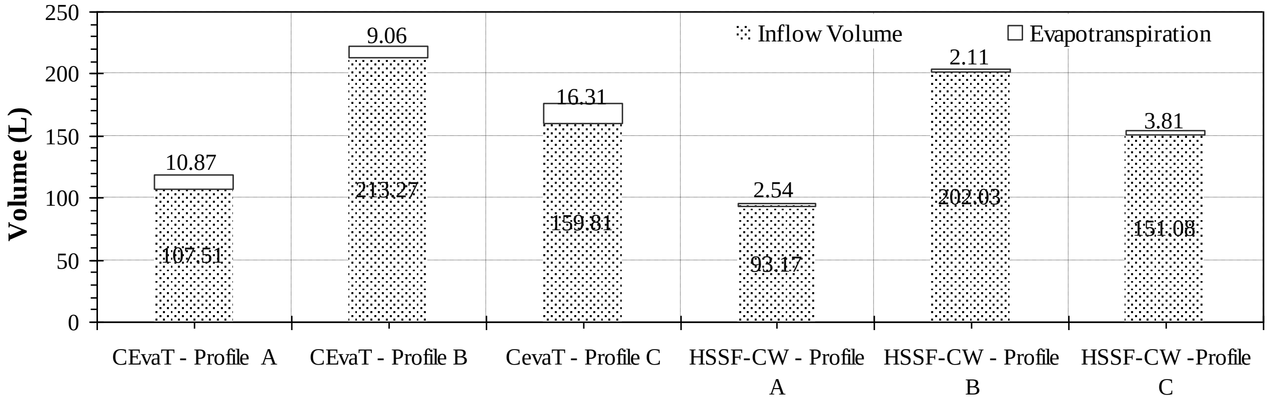

Figure 5: Daily volume of greywater fed into the each unit of the system (at P1 for CEvaT and at P3 for HSSF-CW) and evapotranspiration from each unit, as determined for profiles A, B and C.

The importance of evapotranspiration and how this affects wetland performance has been studied before (Herbst and Kappen, 1999; Chazarenc *et al.*, 2003). Quantification of the volumes of water (greywater and rain) entering and leaving the system, as shown in Figure 5, permit calculation of the amount of water lost by evapotranspiration. For the CEvaT unit, evapotranspiration varies between 5 and 8 $mm.d^{-1}$, while the HSSF-CW showed evapotranspiration of between 1 and 2 $mm.d^{-1}$. The effect of evapotranspiration, a loss of at most 10% of influent volume, can thus be clearly observed, but is not big enough to change the HRT in a very significant way: for dimensioning the system it will not be necessary to take losses of flow into account explicitly. Evapotranspiration losses also will not affect effluent salinity in such a way that this should be taken into account, for instance in the choice of plants to be used in the system. The CEvaT can however, if desired, be dimensioned to achieve high or total evapotranspiration, in order to allow for a zero discharge system when there is no need for water reuse or when there is no possibility to discharge or infiltrate. The number of CEvaTs and/or HSSF-CW to be used will thus depend on the household's choice.

CONCLUSIONS

In this work, we proposed to use an anaerobic digestion chamber (AnC) built inside an evapotranspiration-treatment based system, combining it with a subsurface horizontal flow constructed wetland. Hypothesis was that the AnC would replace a pre-treatment unit, with a double function: i) retaining solids and ii) equalising the inflows, avoiding clogging and also improving the stability of the system, considering the high variation of the greywater inflow to which the system is subjected. To better understand the behaviour of the system, we performed two 24-hour and one 8-day monitoring profiles that showed to be appropriate to the goal of the study: coupling information on the hydraulic and organic loads with their effects on effluent quality. Results show that, on a typical day (only contribution from showers and bathroom sinks), neither mixing is observed in the AnC, nor any alteration is observed in the effluent quality. When the washing machine is discharged, the AnC attenuates the peak load and stabilises the system, even when receiving COD_{total} as high as 900 $mg.L^{-1}$. It is clear from the obtained results that the two units complement each other. The 8-day profile shows that, within the CEvaT, the AnC presents the highest removal efficiency of the studied parameters. The HSSF-CW seems to be operating as an efficient polishing unit, with effluent average COD_{total} and turbidity of 63 $mg.L^{-1}$ and 8 NTU, respectively. During the 3 years of operation, no sludge withdrawal was necessary and no maintenance in the distribution pipe (inlet) of the HSSF-CW was required. The implemented system in full scale was quite acceptable to the householders, not disturbing their routine, rendering a green site totally integrated into the garden, without the use of potable water for irrigation.

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