LONG TERM OPERATION OF ONSITE VOLUME REDUCTION SYSTEM TO EVALUATE WATER EVAPORATION EFFICIENCY OF THE GAUZE SHEET

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Introduction:

An onsite wastewater differentiable treatment System (OWDTS) was proposed for treatment of various fractions of domestic wastewater separately (Lopez et al, 2002). In this system, wastewater streams are separated at source into various fractions such as black water (urine and faeces); higher load graywater (kitchen sink and washing machine) and lower load graywater (bath tub), which are then treated properly at household level, thus saving cost of sewerage pipelines. Urine diverting toilets are used for separate urine collection at source. One of the advantages of urine separation is saving energy cost in composting of faeces in composting toilets. As urine contains high concentration of nutrients (N, P, K) but is in small quantity (1% of wastewater flow), therefore, it can be used as natural fertilizer. However, use of urine as fertilizer is problematic with regard to management, storage and transportation (B.B Lind et al 2001), because its large quantity is to be transported to fields to meet per hectare crop requirement. We proposed an onsite volume reduction system, OVRS to address transportation issue in our previous study (Pahore et al, 2010). The current study was carried to evaluate performance of the OVRS for a long term operation of 60 days to assess whether the same cloth sheet can be used for a long time without any replacement.

Material and Method:

The experimental set up of a laboratory-scale onsite volume reduction unit is illustrated in Figure 1 (Pahore et al, 2010). The experiments were performed for conditions similar to dry climate as specified in Table 1. The tank weight was measured periodically to evaluate evaporation rate, ER of synthetic urine (Wilsenach, 2007) in a tank through a vertical gauze sheet. The water level in the sheet, H was measured periodically during evaporation. For every new experiment, virgin vertical gauze sheet was used. The mass transfer coefficient, kmol cm^{-2} h was estimated from following equation (Pahore et al, 2010).

$$Sh = 0.08.Re^{0.266} \qquad (1)$$

Xi of sample is calculated from following equation:

$$ER = M_{air}\ Ky\ (Xi - X) \qquad (2)$$

where ER is the water evaporation rate (g h^{-1}), Ky is the mass transfer coefficient (kmol cm^{-2} h^{-1}). M_{air} is molecular weight of air (k/ kmol), Xi is the saturated air humidity (g-water/g-dry air), X is the humidity of supplied air (g-water/g-dry air). A is effective evaporation area, cm^2, which is design parameter for OVRS.

A will be calculated from the water level in sheet, *H* and the sheet width.

Table 1: Experimental conditions for long term experiments

Air conditions			Duration	Parameters			
WV (m/s)	*T* (°C)	*Hum.* (%)	(days)	(g h^{-1}) (cm)	(mg cm^{-2})	(g-water/g-dry air)	
2	60	25	60	*ER*	Salt conc.	*Xi*	*H*

W.V=wind velocity, *T*=air temperature, *Hum.*=air humidity, *ER*=water evaporation rate

Xi=Saturated interface air humidity, *H*= water level in the sheet

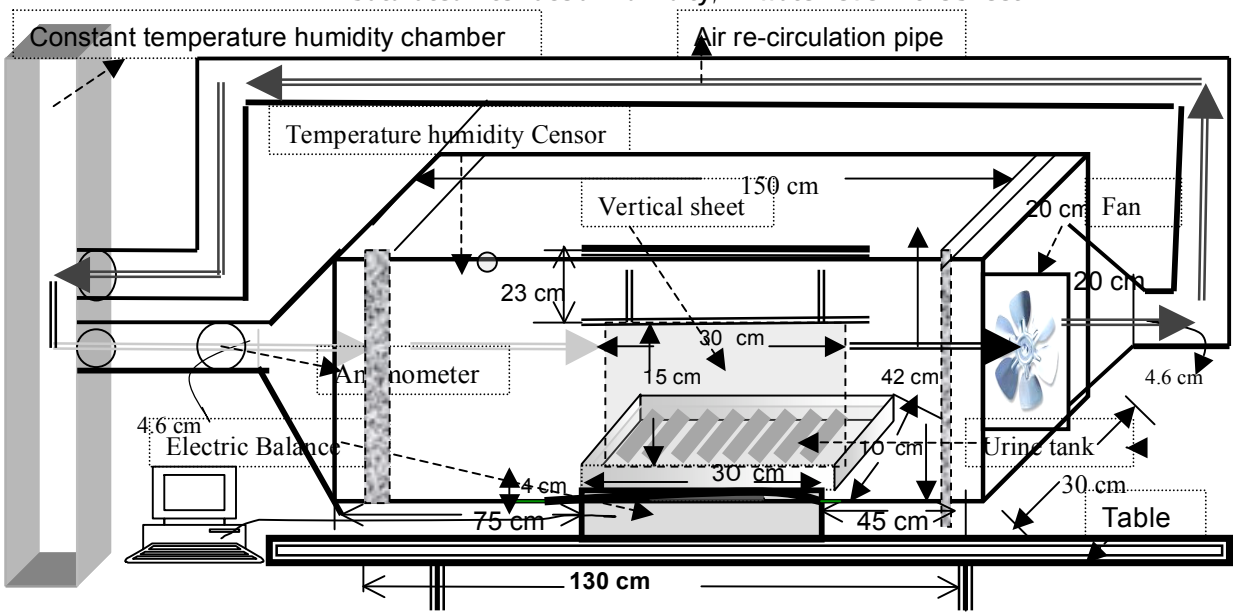

Figure 1 Laboratory-scale onsite volume reduction unit.

Results and Discussion:

Figure 2 revealed that steady-state water evaporation was observed during experiment period without any decrease or inhibition. Thus, a single and same gauze sheet has efficiency to evaporate water from urine without any change during 60 days period.

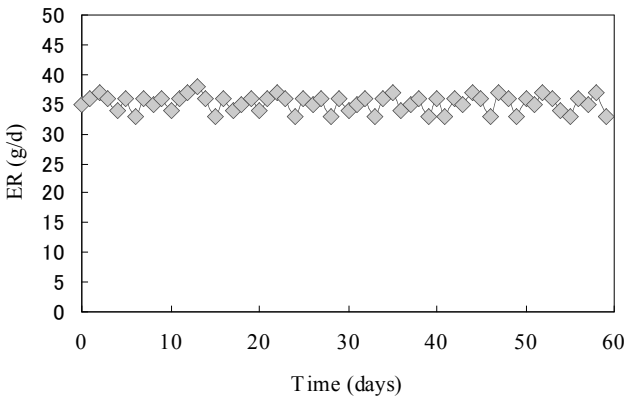

Fig. 2 Time-course of evaporation rate.

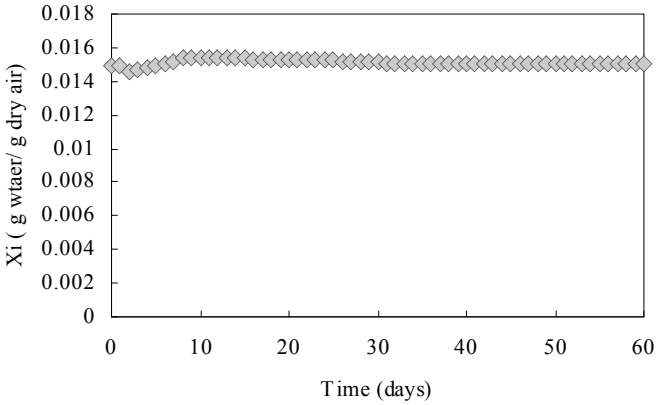

Fig.3 Time-course of saturated interface air humidity.

Figure 3 shows *Xi* was constant over experiment period which illustrates that salt accumulation in the

gauze sheet does not inhibit evaporation. The emergence of steady state operation supports continuous use of the same gauze sheet for 60 days or more.

Figure 4 shows that the water level in initial stage was found high owing to empty sheet, which soon settled to steady-state without any further change. This indicates that salt does not continue to accumulate in the effective evaporation zone suggesting regular salt falling from the sheet back to the tank under influence of turbulence and capillary pressure exerted into the sheet due to water penetration.

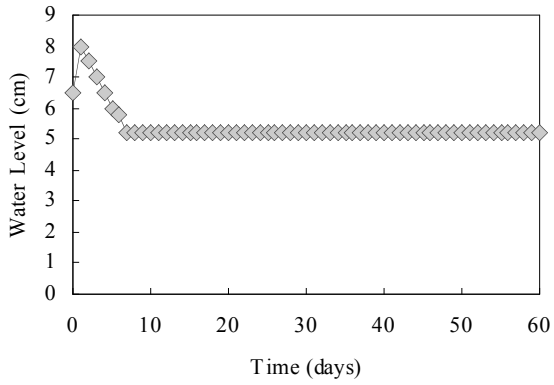

Fig. 4 Time-course of water level in the sheet.

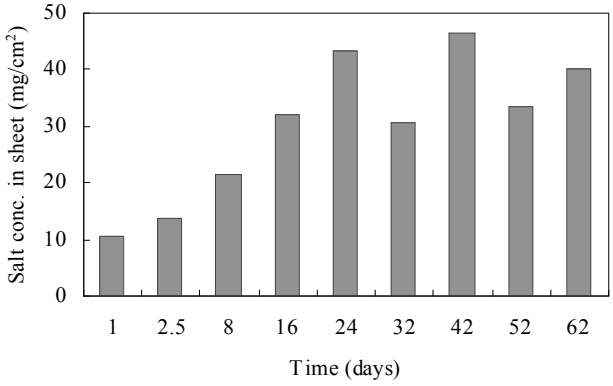

Fig. 5 Time-course of salt conc. in the sheet.

Figure 5 shows salt concentration in the sheet during initial period continued to accumulate which however, reached to a steady state in which the accumulation was followed by salt falling. During the steady-state period salt does not accumulate which means that salt concentration did not inhibit the evaporation process.

Conclusion:

The long term experiment of 60 days was performed to evaluate evaporation efficiency of the single and the same gauze sheet using an onsite volume reduction system. We measured water evaporation rate, the Xi, salt concentration and the water level in sheet. The important findings are summarized as under:

- Steady-state evaporation was observed over the experiment period without any inhibition.
- The Xi, salt concentration and the water level in the gauze sheet were also found constant during steady- state condition. Therefore, same gauze sheet can be used for 2-3 months or more without any replacement.

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