

VERTICAL FLOW CONSTRUCTED WETLAND TREATING HIGH STRENGTH WASTEWATER FROM SWINE MANURE COMPOSTING



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Introduction and Objectives

Intensive swine farms generate high volumes of manures that not always have near surfaces of culture and sufficient extension for their direct reutilization to the soil. An integral solution looking for the recovery of the fertilizer elements is the joint composting of diverse solid wastes generated in the installation or in the near rural area (solid manure, crop waste and forest and agro-industrial wastes), where the composting material was watered with liquid manure.

In this system (Figure 1a), a high percentage of the water contained in the liquid manure is evaporated while nutrients are retained in the compost produced. In this way, about 80% of liquid manure may be removed in the compost system, while the remaining volume generated as leachate from the compost piles was treated in a pilot vertical flow constructed wetland (VFCW) (Figure 1b).



Figure 1. Composting plant (1a, left) and VFCW system (1b, right) used to treat swine manure

Materials and Methods

The pilot VFCW system (Figure 1b and Figure 2) was a 2×3×1.2 m (length×width×height) basin built *in situ* and lined with rubber membrane. A drainage bed, 20 cm thick, made of 10-20 mm granitic gravel was placed at the bottom of the VFCW and equipped with drainage pipes 70 mm in diameter. Above the drainage bed was a filter layer, 80 cm thick, made of 0-6 mm granitic gravel. The influent distribution pipes were placed over the filter. The system was planted with *Phragmites australis* but only a few small plants were present during the operation period.

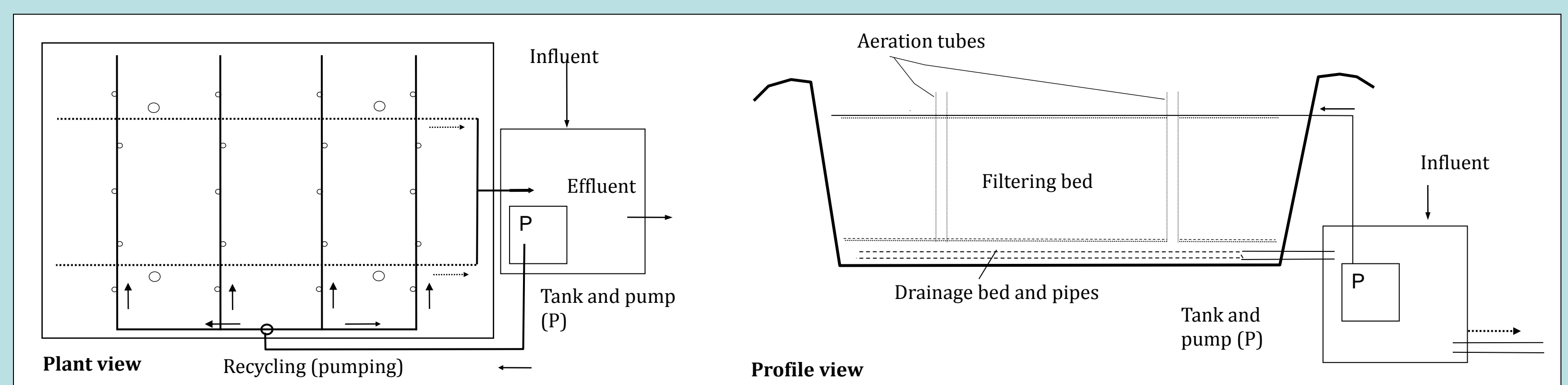


Figure 2. Plant and profile views of the VFCW system used to treat swine manure

The constructed wetland was operated for more than 200 days. During this time, a total of 24 influent and effluent samples were collected and analysed for conductivity, total and volatile suspended solids (TSS, VSS), total and soluble chemical oxygen demand (TCOD, SCOD), biological oxygen demand (BOD₅), ammonium nitrogen and total Kjeldhal nitrogen. Determinations *in situ* were carried out for pH, temperature (T), dissolved oxygen (DO) and oxidation-reduction potential (ORP). Analyses were carried out following the Standard Methods (APHA, 1995).

Results and Discussion

Table 1 shows the characteristics of influent and effluent VFCW streams. The wastewater treated has a high load in terms of TSS and TCOD. Although the average values for BOD₅ and ammonium or NTK at the influent were lower than expected, in general these concentrations were higher than municipal wastewater concentrations by a factor of about 10 to 20. Actual influent concentration to the VFCW were reduced after the dilution of the influent in the recycling tank by a factor of about 2 to 6 times (3.5 times in average)

Table 1. Influent and effluent characteristics for the overall operational period

	pH	Conductivity	T	OD	ORP	TSS	VSS	TCOD	SCOD	BOD ₅	NH ₃ -N	TKN
Influent												
Average	7.80	7066	nd	nd	nd	2549	2108	10640	6878	1382	212	599
Est. Dev.	0.49	2193	nd	nd	nd	1896	1544	6536	4847	1012	233	379
Maximum	8.60	10030	nd	nd	nd	6980	5360	24400	14933	3780	754	1182
Minimum	6.50	2200	nd	nd	nd	203	150	1034	295	123	14	67
Effluent												
Average	5.36	1673	17.6	6.2	162	116	95	626	522	13	6.29	35.8
Est. Dev.	1.18	1212	4.7	1.4	91	126	105	408	330	13	8.63	26.5
Maximum	8.30	4260	23.6	8.3	346	388	323	1413	1300	51	24.29	84.9
Minimum	4.10	306	8.5	3.4	16	7	8	10	30	0	0.10	3.0

Concentration in mg/L, Conductivity in microS/cm, ORP in mV, T in °C. Data number: 24

Table 2. Surface loading rate and removal efficiency for different operational periods

Period (days)	SLR (g/m ² -d)				
	TSS	TCOD	BOD ₅	NH ₃ -N	TKN
I (0-74)	14.7	70.3	6.3	0.8	3.4
II (75-156)	4.0	19.5	3.2	0.3	1.7
III (157-205)	9.2	17.9	4.8	1.1	1.6
Overall	8.8	36.2	4.6	0.6	2.1

Period (days)	Removal efficiency (%)				
	TSS	TCOD	BOD ₅	NH ₃ -N	TKN
I (0-74)	99.1	97.8	99.1	97.1	98.7
II (75-156)	74.6	78.2	98.6	99.3	90.6
III (157-205)	98.6	93.2	99.2	96.6	92.0
Overall	95.5	94.1	99.0	97.0	94.0

Hydraulic loading rate (HLR) ranged from 2 to 7 mm/d (data not shown), although the overall HLR (including recirculation) resulted in about 240 mm/d. TSS SLR (Table 2) ranged from 4 to 15 g TSS/m²-d and was high in comparison to usually values proposed for subsurface CW. In these conditions, the VFCW removed in general more than 90% of influent load. Only TSS and TCOD removals significantly decreased during period II, which was in part due to a suddenly decrease in influent concentration.

Figure 3-left shows a typical effluent flow profile (obtained at day 29 of operation) for the main operational conditions applied (dosing of about 360 L during a short time of about 15 minutes and a cycle time of 6 hours).

Figure 3-right shows the evolution of the maximum "after dosing" effluent flow through the operation time. After day 138 (period II), the infiltration capability of the gravel bed progressively decreased as indicated by the reduction of the maximum effluent flow. When a resting period of 2 weeks was applied, the infiltration capability was partially recovered and the system maintained the high treatment efficiency.

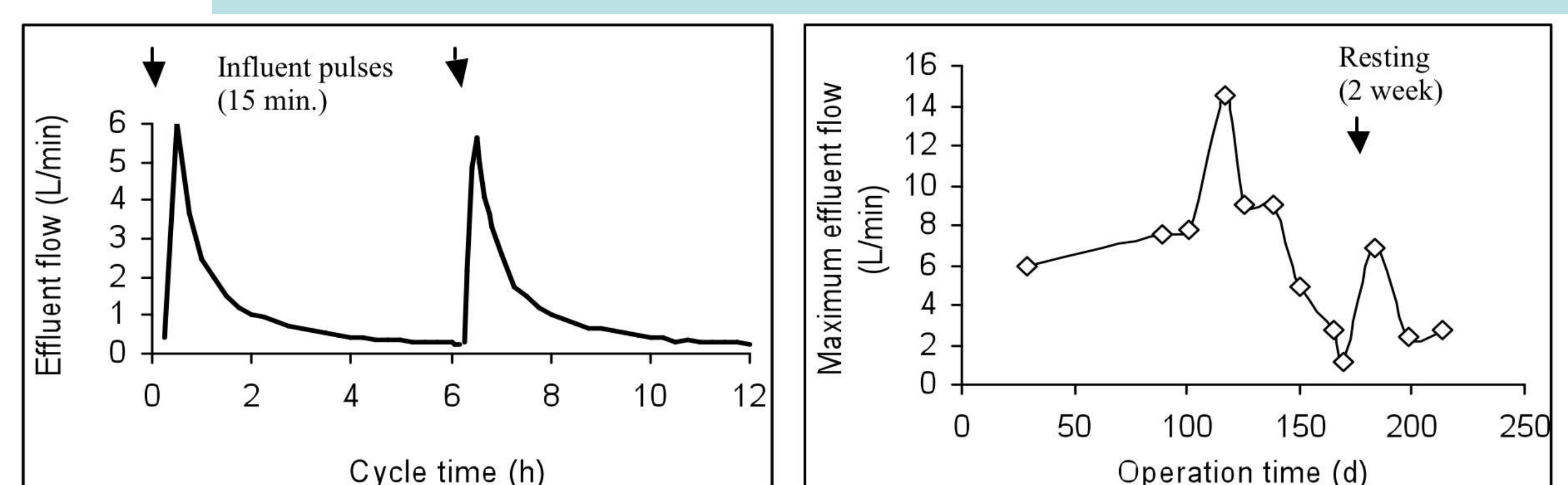


Figure 3. Typical effluent flow profile (left) and maximum effluent flow after dosing (right).

Conclusions

A vertical flow CW provided with effluent recycling allowed a high percent contaminant removal from high strength swine wastewater and a high quality effluent. However, applying high surface hydraulic organic and nitrogen loading rates without clogging will require previous TSS removal or the intermittent operation with treatment and resting alternating periods.