May 2016, Santa Fe - Argentina.

UNIVERSIDADE FEDERAL DE SANTA CATARINA

GESAD
ENS - UFSC
GRUPO DE ESTUDOS EM SANEAMENTO DESCENTRALIZADO

PERFORMANCE OF A HYBRID CONSTRUCTED WETLAND EMPLOYED AS SANITARY WASTEWATER TREATMENT SOLUTION DURING ITS OPERATIONAL STARTING PERIOD

Benny Zuse Rousso

Catiane Pelissari

Giovanna Sanchez

Mayara Oliveira

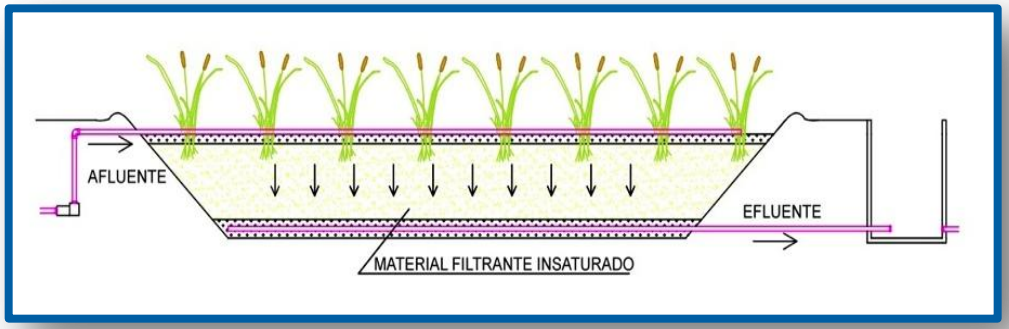
Pablo Heleno Sezerino

Wetlands Brasil

1. Introduction

HYBRID CONSTRUCTED WETLANDS (HCW)

- Combination of different CW in series
- Main goal is to achieve higher removal efficiencies of OM, SS and N
- Most common variation is VFCW→ HFCW (VYMAZAL, 2013).

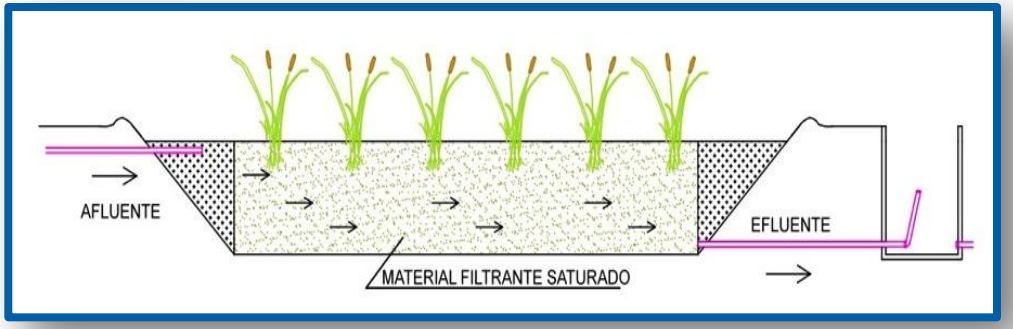


VFCW

- Downward flow
- Non saturated environment / aerobic
- Oxidative processes (e.g. nitrification)

HFCW

- Horizontal flow
- Saturated environment/ anaeroic and anoxic
- Reducing processes (*e.g. denitrification*)



1. Introduction

STUDY OBJECTIVES

EVALUATE THE PERFORMANCE OF A REAL SCALE HCW APPLIED IN SANITARY WASTEWATER TREATMENT IN SOUTHERN REGION OF BRAZIL

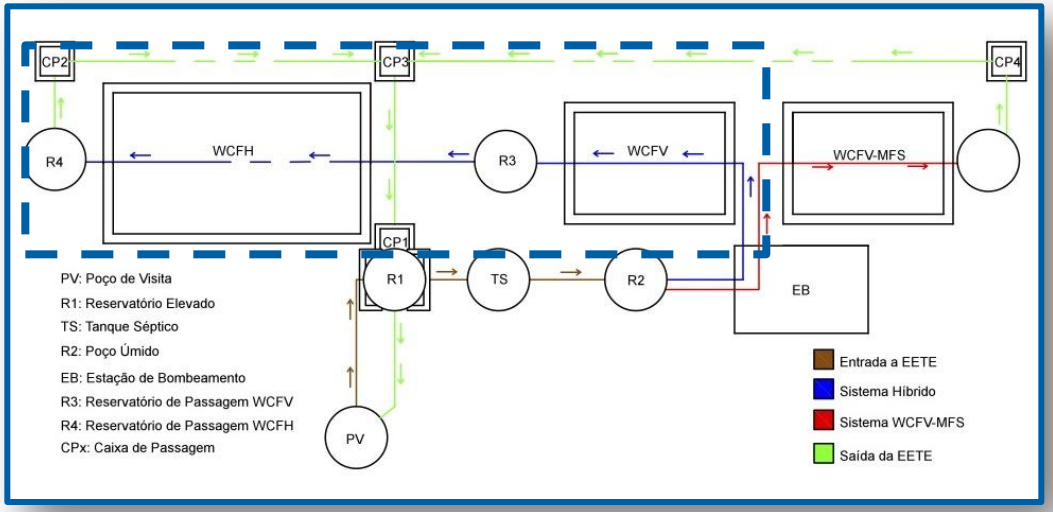
- Measure the performance of each unit and of the system as a whole

- Measure the VFCW evapotranspiration and estimate this unit's removal efficiencies in terms of applied loading rates

2. Methodology

STUDY SITE

UFSC pilot scale wastewater treatment plant using CW



Daily treated volume ~ 600L/d;
Applied loading rate ~ 41gCOD/m^2.d (SEZERINO, 2006)
Intermittent feeding (PLATZER, 1999)
Cycling of operational periods (SANTOS, 2015)

2. Methodology

VFCW

Superficial area: 7.6 m^2

Bed media: gravel and coarse sand (d_{10} = 0.21mm, U = 5.10)

Layers: 0.05 m of gravel, 0.60 m of coarse sand, and 0.05 m of gravel.

Macrophyte: *Typha dominigensis*

HFCW

Superficial area: 16 m^2

Bed media: gravel and coarse sand (d_{10} = 0.21mm, U = 5.10)

Layers: 0.50 m of gravel, 4.20 m of coarse sand, and 0.60 m of gravel.

Macrophyte: *Typha dominigensis*

2. Methodology

MONITORING

First 215 days of operation (June/2015 – January/2016)

Physical Chemical efficiency

Analysis every week (except rainy periods)

Parameters: pH, alkalinity, SS, COD, BOD_5, NH_4^+-N, NO_2^--N, NO_3^--N, TN, PO_4^{3-}-P (APHA, 2005; VOGEL, 1981)

Water balance in VFCW

Control taken within a daily period ($Q_{outlet} \approx 0$)

Volumetric device before and after VFCW

UFSC weather station (precipitation data)

3. Results and discussion

POLLUTANT REMOVAL EFFICIENCIES

Table 1 – Average concentrations for influent and effluent for each treatment unit and global removal efficiency.

		pH n = 19	Alkalinity n = 19	COD (mg/L) n = 19	SS (mg/L) n = 18	NH_4^+-N (mg/L) n = 19	TN (mg/L) n = 9	PO_4^{3-}-P (mg/L) n = 19
Influent to HCW	Average	7.2	293	586	43	67	79	30
	SD	0.1	37	168	16	15	15	5
Post-VFCW	Average	6.7	101	92	2	31	57	8
	SD	0.3	58	64	4	10	17	5
Post-HFCW	Average	6.9	86	17	1	12	21	1
	SD	0.3	28	21	3	10	13	1
Global Efficiency	(%)	-	-	**97 ± 3%**	**99 ± 4%**	**82 ± 15%**	**73 ± 15%**	**95 ± 7%**

- Excellent global removal rates for COD, SS and PO_4^{3-}-P
- High removal of PO_4^{3-}-P may be related to starting periods (high adsorption capacity)
- VFCW was responsible for major removal of organic matter and SS
- Good ammonia removal efficiency, reaching higher values after 4th operation month.
- Higher TN removal from HFCW (67%) than VFCW (27%)

3. Results and discussion

VFCW WATER BALANCE

Table 2 – Average evapotranspiration results and conditions of sampling

Operational and weather conditions					Results	
Date	P (mm/d)	HLR (mm/d)	Humidity (%)	$Temp_{air}$ (°C)	Evapotrans. (mm/d)	Evapotrans. (%HLR)
22/09/15	0	76.09	80.70	22.37	4.5	5.9
23/09/15	0	75.61	78.13	23.23	4.0	5.3
09/10/15	4.17	75.00	90.07	18.35	4.4	5.9
28/09 – 5/10/16*	4.34	68.50	77.47	18.92	4.7	6.8
				Average	**4.6**	**6.5**

- 10 samples were taken during first 215 days monitoring period
- Samples were taken during dry or low rain days ($Q_{outlet} \approx 0$)
- Average evapotranspiration of 4.6 mm/d or 6.5% of the Hydraulic Loading Rate (HLR)

3. Results and discussion

VFCW PERFORMANCE IN TERMS OF APPLIED LOAD REMOVAL

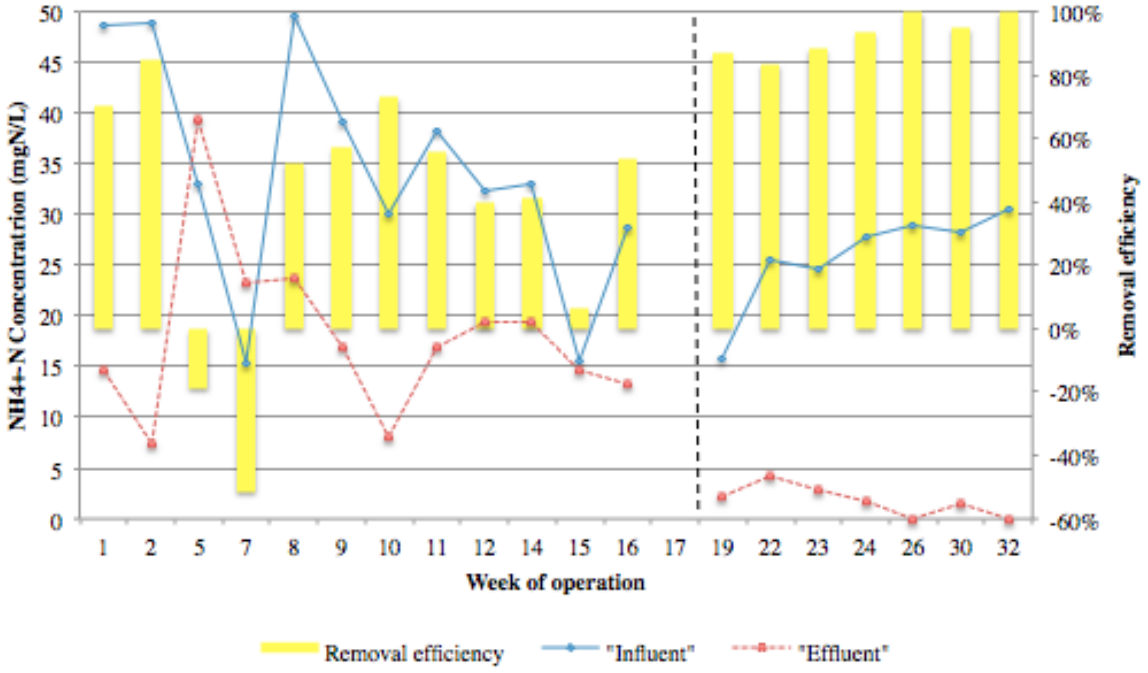
Table 3 – Average performance of VFCW in terms of applied loading rates

		COD ($g/m^2.d$) n = 14	BOD_5 ($g/m^2.d$) n = 14	SS ($g/m^2.d$) n = 14	NH_4^+-N ($g/m^2.d$) n = 14	TN ($g/m^2.d$) n = 5	PO_4^{3-}-P ($g/m^2.d$) n = 14
Applied load in VFCW	Average	38.5	18.5	2.5	4.5	5.3	2.1
	SD	11.7	4.3	0.9	1.2	0.9	0.4
Influent load of VFCW	Average	3.88	2.3	0.03	1.8	3.4	0.5
	SD	2.3	0.6	0.1	0.5	0.8	0.1
Global Efficiency	(%)	**90 ± 5%**	**87 ± 3%**	**99 ± 1%**	**57 ± 13%**	**34 ± 12%**	**77 ± 4%**

- Excellent removal rates for organic matter, suspended solids and phosphorus
- Low removal rates for total nitrogen → transformation x removal of nitrogen compounds

3. Results and discussion

NH_4^+-N REMOVAL IN HFCW



- Increase and stabilisation of performance after 4th month of operation
- Ammonia concentrations close to 0 after the 4th month of operation
- However, nitrate concentration in effluent is still high (average of 17 ± 9 $mgNO_3^-$-N/L

4. Conclusions

- The hybrid system showed good performance in terms of organic matter, suspended solids and phosphorus removal;
- Ammonia removal reached excellent removal rates after the 4th month of operation, with an effluent with concentrations near to zero;
- Nitrogen removal is still limited, with a considerable amount of nitrate on the final effluent.

Acknowledgments

GESAD
ENS - UFSC
GRUPO DE ESTUDOS EM SANEAMENTO DESCENTRALIZADO

UNIVERSIDADE FEDERAL DE SANTA CATARINA

FUNASA
Ministério da Saúde
Fundação Nacional de Saúde

CNPq

CAPES

Wetlands Brasil

Come to join us...

GESAD
ENS - UFSC
GRUPO DE ESTUDOS EM SANEAMENTO DESCENTRALIZADO

Wetlands Brasil

wetlandsbrasil@gmail.com

www.gesad.ufsc.br

3º Simpósio Brasileiro sobre

Wetlands Construídos

Maio 2017 – Campo Grande – MS