

Article

Viability of a Single-Stage Unsaturated-Saturated Granular Activated Carbon Biofilter for Greywater Treatment

Ahmed Sharaf ¹, Bing Guo ¹, David C. Shoults ², Nicholas J. Ashbolt ^{2,3} and Yang Liu ^{1,*}

¹ Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB T6G 1H9, Canada; aadel@ualberta.ca (A.S.); bg@ualberta.ca (B.G.)

² School of Public Health, University of Alberta, Edmonton, AB T6G 2G7, Canada; dshoults@ualberta.ca (D.C.S.); ashbolt@ualberta.ca or nick.ashbolt@scu.edu.au (N.A.)

³ School of Environment, Science & Engineering, Southern Cross University, Lismore NSW 2480, Australia

* Correspondence: yang.liu@ualberta.ca; Tel.: +1-780-492-5115

Table S1: Synthetic greywater formulation adapted from the NSF/ANSI Standard 350 [1] for combined bathing and laundry waters.

Component	Amount per 100 L	Brand
Body wash with moisturizer	15.90	Olay®
Toothpaste	1.59	Crest®
Deodorant	1.06	Gillette®
Shampoo and conditioner	21.20	Dove®
Lactic acid	1.59	ACROS Organics™
Bath cleaner	5.30	Lysol®
Liquid hand soap	12.19	Softsoap®
Liquid laundry detergent (2X)	18.80	Tide®
Liquid laundry fabric softener	9.87	Downy®
Na ₂ SO ₄	1.88	Fisher Chemical™
NaHCO ₃	0.94	Fisher Chemical™
Na ₂ PO ₄	1.88	Fisher Chemical™
Secondary effluent ¹	1.88	Fisher Chemical™

¹ Obtained from a municipal wastewater treatment plant in Edmonton, AB.

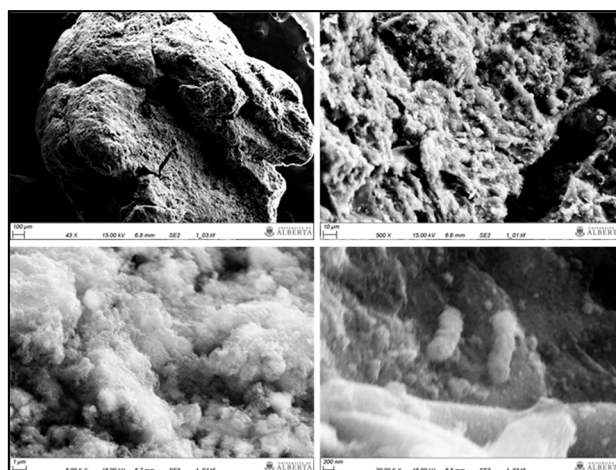


Figure S1: Scanning electron microscopy images of the GAC media collected from the GAC biofilter treating greywater.

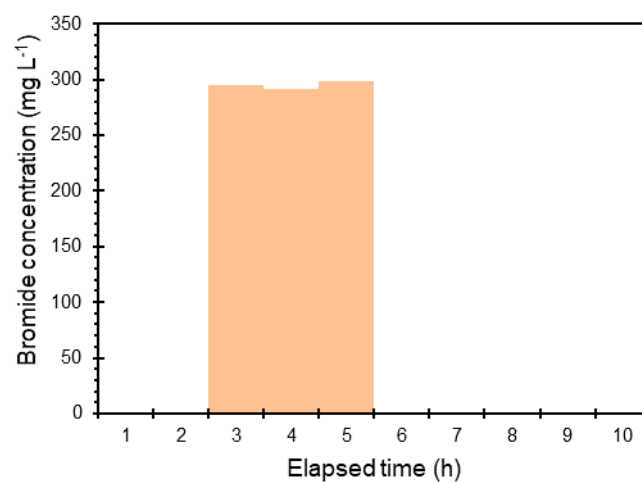


Figure S2: Bromide tracer test breakthrough curve.

Cost-Benefit Analysis

Savings

Water Savings

Consumption charge per m ³	\$	2.129	(0-10.0 m ³)
	\$	2.326	(10.1-35.0 m ³)
Average household pays	\$	38.16	
Monthly water consumption		16.41	L
Water savings due to reuse		40%	(30-50%)
Monthly savings	\$	17.20	
Monthly charge	\$	20.96	
Savings over 5 years	\$	1,032	
	\$	3,097	For 3 households

	Water savings	30%	40%	50%
Per household	Savings/month	\$ 13.71	\$ 17.20	\$ 20.70
	Savings/year	\$ 164.52	\$ 206.44	\$ 248.35
	Savings/5 years	\$ 823	\$ 1,032	\$ 1,242
3 households	Savings/month	\$ 41.13	\$ 51.61	\$ 62.09
	Savings/year	\$ 493.57	\$ 619.31	\$ 745.06
	Savings/5 years	\$ 2,468	\$ 3,097	\$ 3,725

Expenditures

CAPEX

Tank	\$	250	(\$250 /m ³)	Lifetime: 15 years (assumed)
GAC	Volume	600	L	
	Weight	240	kg	
	Price/Ton	400-525	\$/Ton	
		462.5	(Assume)	
	\$	111		
Pump	\$	350		Lifetime: 15 years (assumed)
Fixtures	\$	200		
Total	\$	511	(per 5 years)	

OPEX

Power/5 yr	\$	220	(EPCOR rates)
GAC replacement	\$	1,800	(twice a year)
Total	\$	2,020	

Total Cost **\$ 2,531** (For 5 years)

GAC Media Lifetime Calculation

To be conservative, it is assumed that the GAC media used in this study is to be replaced at the end of stage VIII. Table S2 shows the total mass of COD treated by the GAC biofilter throughout the entire experiment period (253 days) until the end of stage VIII.

Table S2. Operation stages and system capacity.

Stage	Time (d)			HLR		OLR	Treated COD
	Start	End	Duration	(L m ⁻² d ⁻¹)	(cm d ⁻¹)	(g COD m ⁻² d ⁻¹)	(g COD m ⁻²)
I	0	30	30	71	7	22	678
II ¹	31	57	26	71	7	24	736
III	58	93	35	100	10	35	1354
IV	94	138	44	150	15	54	2220
V	139	155	16	250	25	78	1374
VI	156	180	24	600	60	189	4957
VII	181	195	14	900	90	333	3977
VIII	196	253	57	1200	120	454	20120
Total							35416

Calculations hereafter are based on a GAC biofilter with a surface area of 1 m².

It is very common and recommended to have a holding/septic tank upstream of the GAC biofilter, as suggested in the manuscript. It was reported that COD can be reduced by 25-50% through those pre-treatment units.

Assuming an average COD reduction of 37.5%:

- Maximum COD mass to be treated = 56665 g

It was revealed in our previous mechanistic study that biodegradation can contribute 26% to the COD removal in biologically active GAC media:

- Maximum COD mass to be treated = 76575 g

Given an average COD concentration in the used greywater formulation of 347 g m⁻³:

- Maximum greywater volume to be treated = 221 m³

Assuming an average greywater generation rate of 100 Lpd (0.1 m³ p⁻¹ d⁻¹):

- Maximum number of days = 2207 days

Given the highest achieved HLR of 1200 L m⁻² d⁻¹, and assuming an average greywater generation rate of 100 Lpd (0.1 m³ p⁻¹ d⁻¹):

- Maximum number of persons: 12 persons
- Maximum number of days of operation = 2207 days (for one person)
- Maximum number of days of operation = 184 days (for 12 persons) = 6 months

Conclusion: a GAC biofilter with a surface area of 1 m² is sufficient to treat greywater generated from 12 persons for six months (i.e. media are to be replaces twice per year).

References

1. NSF International NSF/ANSI 350: On-site residential and commercial water reuse treatment systems; NSF International, 2012.

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