

Supplementary Information

Removal of PFAS from biosolids by a semi-pilot scale pyrolysis reactor and the application of biosolids derived biochar for the removal of PFAS from contaminated water

Sazal Kundu¹, Savankumar Patel¹, Pobitra Halder¹, Tejas Patel¹, Mojtaba Hedayati Marzbali¹, Biplob Kumar Pramanik², Jorge Paz-Ferreiro¹, Cícero Célio de Figueiredo³, David Bergmann⁴, Aravind Surapaneni^{4,5}, Mallavarapu Megharaj^{6,7}, Kalpit Shah^{1,5*}

¹Chemical & Environmental Engineering, School of Engineering, RMIT University, Melbourne, Victoria 3000, Australia.

²Civil and Infrastructure Engineering, School of Engineering, RMIT University, Melbourne, Victoria 3000, Australia.

³Faculty of Agronomy and Veterinary Medicine, University of Brasília, 70910-970 Brasília, DF, Brazil

⁴South East Water, Frankston, Victoria 3199, Australia.

⁵ARC Training Centre for Transformation of Australia's Biosolids Resource, RMIT University, Bundoora, Victoria 3083, Australia.

⁶Global Centre for Environmental Remediation, Faculty of Science, University of Newcastle, Callaghan, NSW 2308, Australia

⁷Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE), Callaghan, NSW 2308, Australia

*Corresponding author Email: kalpit.shah@rmit.edu.au; Telephone: +613 9925 1109; Fax: +61 3 9925 7110



Pin-mill



Vibrating screen

Figure S1: Pin-mill and vibrating screen employed in crushing and segregating biosolids sample.

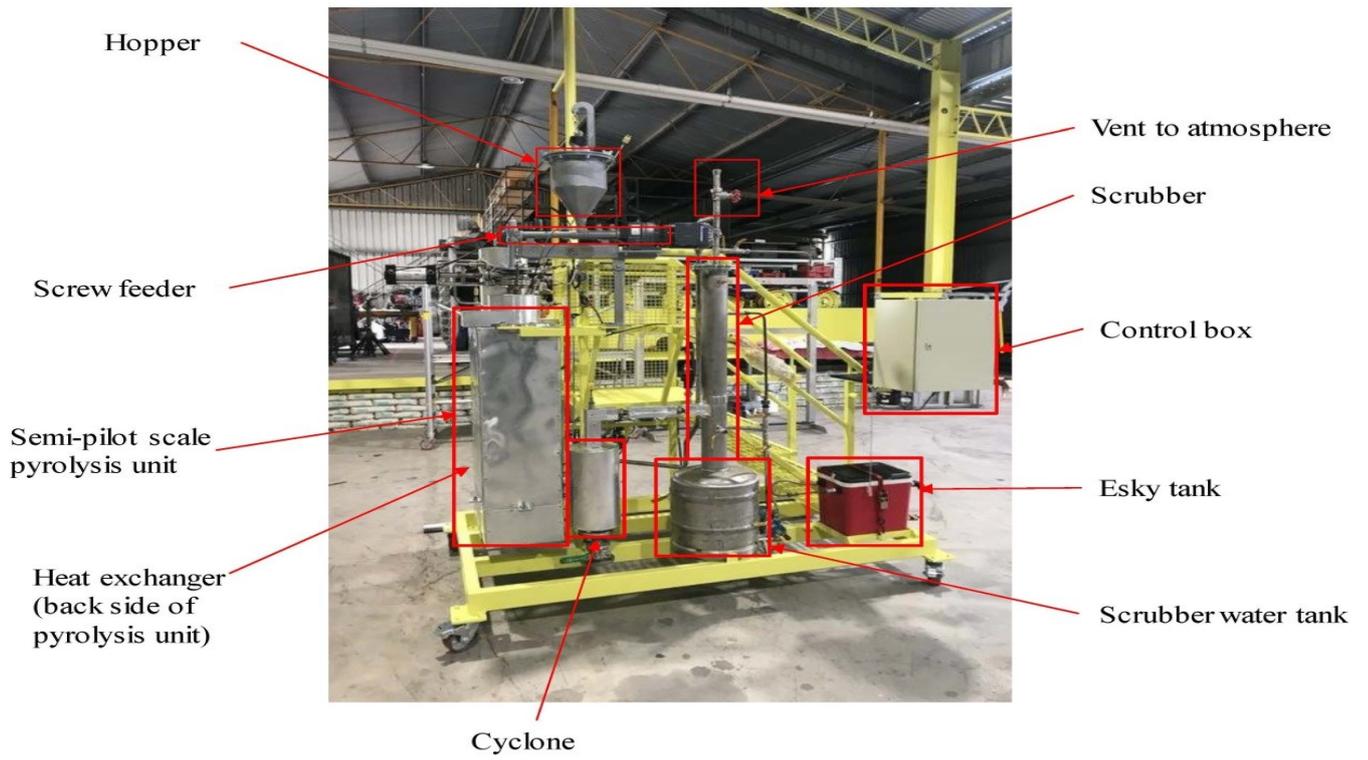


Figure S2: Semi-pilot plant for biosolids' pyrolysis trials.

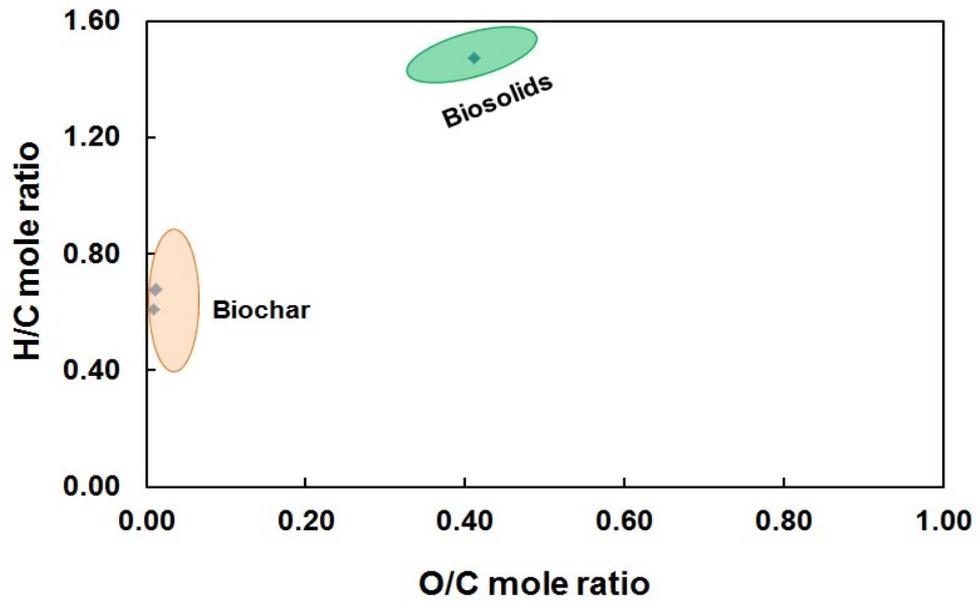


Figure S3: Van Krevelen Diagram for this study.

Table S1: PFAS analyses data for biosolids, biochar and scrubber water

Species	Chemical Formula	Biosolids	Biochar [†]	Scrubber water [‡]
		mg/kg	mg/kg	µg/L
Perfluorobutane sulfonic acid (PFBS)	F(CF ₂) ₄ SO ₃ H	0.0022	<0.0002	<0.02
Perfluorohexane sulfonic acid (PFHxS)	F(CF ₂) ₆ SO ₃ H	0.0006	<0.0002	<0.02
Perfluorooctane sulfonic acid (PFOS)	F(CF ₂) ₈ SO ₃ H	0.0148	<0.0002	<0.01
Perfluorobutanoic acid (PFBA)	F(CF ₂) ₃ COOH	0.0020	<0.001	<0.1
Perfluoropentanoic acid (PFPeA)	F(CF ₂) ₄ COOH	0.0023	<0.0002	<0.02
Perfluorohexanoic acid (PFHxA)	F(CF ₂) ₅ COOH	0.0037	<0.0002	<0.02
Perfluoroheptanoic acid (PFHpA)	F(CF ₂) ₆ COOH	0.0013	<0.0002	<0.02
Perfluorooctanoic acid (PFOA)	F(CF ₂) ₇ COOH	0.0086	<0.0002	<0.01
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	F(CF ₂) ₄ (CH ₂ CH ₂)SO ₃ H	<0.0005	<0.0005	<0.05
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	F(CF ₂) ₆ (CH ₂ CH ₂)SO ₃ H	<0.0005	<0.0005	<0.05
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	F(CF ₂) ₈ (CH ₂ CH ₂)SO ₃ H	<0.0005	<0.0005	<0.05
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	F(CF ₂) ₁₀ (CH ₂ CH ₂)SO ₃ H	0.0013	<0.0005	<0.05

[†]Applicable for BSBC-500, BSBC-550 and BSBC-600.
[‡]Applicable for scrubber water generated in 500, 550 and 600 °C trials.

Table S2: Mass balance and determination of PFASs destruction¹.

Species	Chemical Formula	Biosolids	Biochar [†]	Scrubber water [‡]	Destruction
		µg	µg	µg	%
Perfluorobutane sulfonic acid (PFBS)	F(CF ₂) ₄ SO ₃ H	2.20	0.07	0.50	74
Perfluorohexane sulfonic acid (PFHxS)	F(CF ₂) ₆ SO ₃ H	0.58	0.07	0.50	1
Perfluorooctane sulfonic acid (PFOS)	F(CF ₂) ₈ SO ₃ H	14.78	0.07	0.25	98
Perfluorobutanoic acid (PFBA)	F(CF ₂) ₃ COOH	2.00	0.35	2.50	-43
Perfluoropentanoic acid (PFPeA)	F(CF ₂) ₄ COOH	2.30	0.07	0.50	75
Perfluorohexanoic acid (PFHxA)	F(CF ₂) ₅ COOH	3.65	0.07	0.50	84
Perfluoroheptanoic acid (PFHpA)	F(CF ₂) ₆ COOH	1.25	0.07	0.50	54
Perfluorooctanoic acid (PFOA)	F(CF ₂) ₇ COOH	8.63	0.07	0.25	96
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	F(CF ₂) ₄ (CH ₂ CH ₂)SO ₃ H	0.50	0.18	1.25	-185
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	F(CF ₂) ₆ (CH ₂ CH ₂)SO ₃ H	0.50	0.18	1.25	-185
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	F(CF ₂) ₈ (CH ₂ CH ₂)SO ₃ H	0.50	0.18	1.25	-185
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	F(CF ₂) ₁₀ (CH ₂ CH ₂)SO ₃ H	1.33	0.18	1.25	-7

[†]Applicable for BSBC-500, BSBC-550 and BSBC-600.
[‡]Applicable for scrubber water generated in 500, 550 and 600 °C trials.

¹For species with indefinite PFAS concentration values, as detailed in Table S1, the limit values were considered to be PFAS concentration values.