

Excellence in excrements: Upcycling of herbivore manure into nanocellulose and biogas

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Supplementary Tables

Table S1 Degradation yield of hemicellulose, cellulose and lignin content (wt.%) of the biogas digestate after 5 to 40 days of anaerobic digestion and elephant manure collected at different month (April (0-1), June (0-2), January (0-3))

Days of anaerobic digestion	Cellulose [wt.%]	Hemicellulose [wt.%]	Lignin [wt.%]
0-1	30.7	27.7	15.2
0-2	57.1	5.9	19.1
0-3	39.6	9.3	28.6
5	23.7	24.0	13.0
10	15.0	12.4	12.8
20	11.5	9.2	10.0
30	9.5	8.1	9.5
40	9.8	9.0	9.8

Table S2 Elemental composition (C, H, N, O in wt.%) of elephant manure collected in April (0-1), June (0-2) and January (0-3) and fermentation residue after 0 to 40 days of anaerobic digestion.

Days of Anaerobic digestion	C [wt.%]	H [wt.%]	N [wt.%]	O [wt.%]
0-1	46.0	6.0	1.0	43.4
0-2	44.4	5.8	0.7	43.7
0-3	40.1	5.5	1.5	43.8
5	43.8	5.7	0.8	41.4
10	45.6	5.8	0.8	39.5
20	44.3	5.8	1.0	39.9
30	45.6	5.9	1.0	39.0
40	44.4	5.8	1.0	38.4

Table S3 Elemental composition (C, H, N, O in wt.%), cellulose and hemicellulose content (wt.%) and molecular weight (M_w , kg mol⁻¹) of extracted fibrous material after NaOH and NaOCl treatment from fermentation residue after 0 to 40 days of anaerobic digestion.

Days of Anaerobic digestion	C [wt.%]	H [wt.%]	N [wt.%]	O [wt.%]	Cellulose [wt.%]	Hemicellulose [wt.%]	M_w [kg mol⁻¹]
0-1	41.58	6.24	0.05	46.55	72.2 ± 2.0	16.3 ± 2.0	312
5	43.01	6.39	<0.05	44.90	69.6 ± 0.1	15.6 ± 1.0	319
10	42.38	6.15	<0.05	46.32	71.5 ± 1.0	8.8 ± 0.9	319
20	43.11	6.16	<0.05	45.03	68.1 ± 0.7	4.5 ± 1.1	302
30	43.67	6.41	0.05	44.30	66.4 ± 0.7	9.0 ± 1.9	371
40	43.46	6.02	0.08	43.91	67.3 ± 2.2	5.2 ± 1.8	341

Table S4 Elemental composition (C, H, N, O in wt.%) of the neutralised and dried residue after alkaline treatment of elephant manure (April (0-1)) and fermentation residue after 5 to 40 days of anaerobic digestion.

Days of Anaerobic digestion	C [wt.%]	H [wt.%]	N [wt.%]	O [wt.%]
0-1	21.72	2.73	0.72	24.47
5	26.76	3.31	1.04	24.97
10	24.80	3.13	0.92	25.14
20	28.61	3.45	1.21	24.97
30	19.51	2.41	1.05	20.37
40	20.50	2.49	1.11	21.33

Table S5 Tensile strength (σ , MPa), elastic modulus (E, GPa), strain to failure (ϵ , %), fibre diameter (μm , nm) of the produced paper of cellulose extracted from elephant manure of elephant manure collected in April (0-1), June (0-2) and reference material from kraft pulp (KP).

Days of AD	Cycles	σ [MPa]	E [GPa]	ϵ [%]	Fibre diameter	Energy
						Consumption [kWh/kg]
0-2	1	56 ± 4	7.5 ± 1.3	1.39 ± 0.25	81 ± 29 nm	0.3 ± 0.1
					10 ± 4 μm	
0-2	2	79 ± 6	10.2 ± 1.0	1.39 ± 0.15	46 ± 9 nm	0.5 ± 0.1
					9 ± 4 μm	
0-2	5	102 ± 3	9.7 ± 0.8	2.62 ± 0.23	47 ± 12 nm	1.8 ± 0.6
0-2	7	118 ± 3	11.6 ± 0.9	1.78 ± 0.15	35 ± 11 nm	2.9 ± 1.0
0-2	10	130 ± 8	13.2 ± 1.7	1.71 ± 0.27	40 ± 16 nm	5.2 ± 2.1
0-3	10	96 ± 5	10.9 ± 1.4	2.84 ± 0.38	44 ± 21 nm	
KP	1	16 ± 2	2.8 ± 0.4	1.39 ± 0.24	19 ± 5 μm	0.1 ± 0.1
KP	2	30 ± 2	5.0 ± 0.9	1.86 ± 0.52	15 ± 5 μm	0.3 ± 0.1
KP	5	57 ± 7	9.1 ± 2.4	2.16 ± 0.54	56 ± 19	1.1 ± 0.3
KP	7	61 ± 2	8.1 ± 0.5	2.95 ± 0.45	47 ± 10	2.5 ± 1.3
KP	10	102 ± 6	11.4 ± 0.4	3.65 ± 0.48	43 ± 13	4.2 ± 2.0

Supplementary Graphs

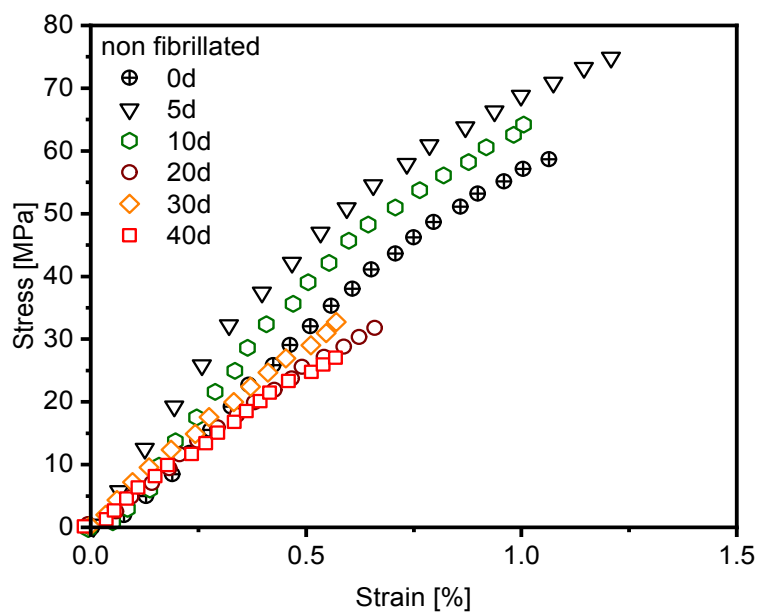


Fig S1 Representative stress-strain curves of papers produced using microfibrillated (non fibrillated) lignocellulosic fibres extracted from elephant manure (crossed dot) and fermentation residue after 5 (black triangle), 10 (green pentagon), 20 (brown circle), 30 (orange diamond) or 40 (red square) days of AD.