

Appendix A

Mechanical properties of composites

A.1 Mechanical properties of raw lime sludge filled HDPE composites

A.1.1 Tensile strength

Table A.1: Tensile strength results in MPa for raw lime sludge filled HDPE composites

Sample Designation	Tensile Strength						Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V			
Pure HDPE	15.59	17.72	16.90	17.32	16.86	16.88	0.79	
5 LS HDPE	11.58	11.94	12.22	11.85	11.96	11.91	0.23	
10 LS HDPE	12.77	14.57	13.54	13.86	13.62	13.67	0.64	
15 LS HDPE	11.08	12.84	11.96	12.18	11.74	11.96	0.64	
20 LS HDPE	11.18	11.96	10.83	11.41	11.23	11.32	0.41	
25 LS HDPE	10.95	10.77	12.05	11.42	11.02	11.24	0.51	
30 LS HDPE	10.91	11.43	10.96	11.13	11.06	11.09	0.20	

A.1.2 Tensile modulus

Table A.2: Tensile modulus results in MPa for raw lime sludge filled HDPE composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	142.0	139.0	136.0	140.0	139.0	139.20	2.16
5 LS HDPE	140.5	134.7	135.6	143.6	147.3	140.34	5.32
10 LS HDPE	160.5	157.1	145.6	148.3	152.6	152.82	6.12
15 LS HDPE	156.3	172.1	169.2	164.8	158.6	164.20	6.73
20 LS HDPE	179.7	178.6	165.3	159.9	170.8	170.86	8.50
25 LS HDPE	178.4	183.7	197.9	191.2	189.1	188.06	7.41
30 LS HDPE	202.0	226.4	209.5	216.8	221.4	215.22	9.65

A.1.3 Elongation at break

Table A.3: Elongation at break results in % for raw lime sludge filled HDPE composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	717.0	773.0	801.0	906.0	834.0	806.2	70.38
5 LS HDPE	781.0	590.0	701.0	641.0	688.0	680.2	71.28
10 LS HDPE	572.0	686.0	623.0	655.0	610.0	629.2	43.50
15 LS HDPE	75.70	66.50	74.20	67.50	72.70	71.32	4.09
20 LS HDPE	41.73	21.08	38.54	32.21	37.03	34.12	8.05
25 LS HDPE	40.80	28.15	33.28	31.45	33.67	33.47	4.64
30 LS HDPE	30.18	35.43	32.70	31.45	34.28	32.81	2.11

A.1.4 Flexural strength

Table A.4: Flexural strength results in MPa for raw lime sludge filled HDPE composites

Sample Designation	Flexural Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	6.37	6.54	5.51	6.51	6.23	6.23	0.42
5 LS HDPE	8.05	9.02	8.59	8.28	8.48	8.48	0.36
10 LS HDPE	9.54	8.81	8.58	8.23	9.08	8.84	0.49
15 LS HDPE	10.59	9.36	9.78	9.95	10.48	10.03	0.50
20 LS HDPE	10.96	10.15	10.33	10.7	10.53	10.53	0.31
25 LS HDPE	10.35	10.95	10.72	10.89	10.64	10.71	0.23
30 LS HDPE	13.21	11.50	11.65	12.18	12.41	12.19	0.68

A.1.5 Flexural modulus

Table A.5: Flexural modulus results in MPa for raw lime sludge filled HDPE composites

Sample Designation	Flexural Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	245.5	255.6	225.2	258.6	242.7	245.5	13.16
5 LS HDPE	461.7	449.5	451.6	454.2	458.6	455.1	5.01
10 LS HDPE	502.0	498.0	483.0	479.0	491.0	490.6	9.71
15 LS HDPE	540.0	514.0	521.0	527.0	535.0	527.4	10.45
20 LS HDPE	596.0	581.0	593.0	585.0	591.0	589.2	6.09
25 LS HDPE	605.0	599.0	602.0	590.0	600.0	599.2	5.63
30 LS HDPE	633.0	621.0	647.0	639.0	635.0	635.0	9.48

A.1.6 Impact strength

Table A.6: Impact strength results in J/m for raw lime sludge filled HDPE composites

Sample Designation	Impact Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	30.75	29.16	30.26	30.24	30.61	30.20	0.62
5 LS HDPE	9.16	8.79	8.63	9.12	8.92	8.92	0.22
10 LS HDPE	8.38	7.50	8.02	7.67	8.13	7.94	0.35
15 LS HDPE	7.88	7.70	7.75	7.83	7.80	7.79	0.07
20 LS HDPE	7.50	7.94	7.64	7.75	7.85	7.74	0.17
25 LS HDPE	7.87	7.16	7.54	7.38	7.72	7.53	0.27
30 LS HDPE	7.74	6.85	6.93	7.38	7.85	7.35	0.45

A.2 Mechanical properties of stearic acid coated lime sludge filled HDPE composites

A.2.1 Tensile strength

Table A.7: Tensile strength results in MPa for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Tensile Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
5 LSSC	15.24	12.28	14.76	13.95	14.64	14.18	1.15
10 LSSC	14.86	13.56	13.31	13.69	14.17	13.92	0.61
15 LSSC	13.41	14.96	13.57	13.74	13.92	13.92	0.61
20 LSSC	15.90	13.76	13.41	16.66	14.91	14.93	1.37
25 LSSC	15.83	14.33	14.13	16.05	15.06	15.08	0.86
30 LSSC	13.66	12.51	12.90	13.46	13.14	13.13	0.45

A.2.2 Tensile modulus

Table A.8: Tensile modulus results in MPa for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
5 LSSC	160	139	135	130	135	139.8	11.73
10 LSSC	145	135	139	142	144	141.0	4.06
15 LSSC	148	142	138	154	158	148.0	8.24
20 LSSC	175	160	170	160	160	165.0	7.07
25 LSSC	180	180	190	180	183	182.6	4.33
30 LSSC	180	200	200	195	194	193.8	8.19

A.2.3 Elongation at break

Table A.9: Elongation at break results in % for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
5 LSSC	680	702	710	690	695	695.4	11.43
10 LSSC	648	640	631	663.6	630	642.52	13.87
15 LSSC	298	269	288	288.7	296	287.94	11.46
20 LSSC	161.5	145.8	149.5	155	160	154.36	6.70
25 LSSC	58.6	73.2	48.9	77.5	42.9	60.22	14.98
30 LSSC	60.9	52.8	66.2	53.7	58.3	58.38	5.48

A.2.4 Flexural strength

Table A.10: Flexural strength results in MPa for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Flexural Strength						Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V			
5 LSSC	9.22	9.42	9.50	9.43	9.49	9.41	0.11	
10 LSSC	10.25	9.91	11.04	9.50	10.66	10.27	0.60	
15 LSSC	10.83	10.70	10.78	10.76	10.83	10.78	0.05	
20 LSSC	11.11	11.44	12.31	10.07	11.75	11.34	0.83	
25 LSSC	11.02	11.84	11.41	11.62	11.22	11.42	0.32	
30 LSSC	12.05	12.87	12.32	12.76	12.50	12.50	0.33	

A.2.5 Flexural modulus

Table A.11: Flexural modulus results in MPa for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Flexural Strength						Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V			
5 LSSC	455	403	421	432	444	431	20.18	
10 LSSC	517	465	486	457	505	486	25.51	
15 LSSC	519	505	509	512	515	512	5.38	
20 LSSC	574	553	601	595	552	575	22.85	
25 LSSC	583	559	616	601	566	585	23.75	
30 LSSC	619	581	589	610	601	600	15.36	

A.2.6 Impact strength

Table A.12: Impact strength results in J/m for stearic acid coated lime sludge filled HDPE composites

Sample Designation	Impact Strength						Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V			
5 LSSC	28.06	27.36	27.84	27.96	27.95	27.83	0.27	
10 LSSC	24.44	23.56	23.76	23.99	24.25	24.00	0.35	
15 LSSC	22.92	22.73	22.84	22.78	22.89	22.83	0.07	
20 LSSC	22.01	21.58	21.76	21.84	21.96	21.83	0.17	
25 LSSC	20.53	19.87	20.09	20.19	20.34	20.20	0.24	
30 LSSC	19.22	18.13	18.74	18.94	19.14	18.83	0.43	

A.3 Mechanical properties of lime sludge filled HDPE-PP composites

A.3.1 Tensile strength

Table A.13: Tensile strength results in MPa for lime sludge filled HDPE-PP blends

Sample Designation	Tensile Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure PP	31.11	31.34	31.72	31.54	31.62	31.47	0.24
5L -85H-10P	7.31	7.48	7.59	7.71	7.79	7.58	0.19
10L-80H-10P	9.38	9.46	9.56	9.68	9.77	9.57	0.16
15L-15H-70P	9.69	9.76	9.86	9.92	9.99	9.84	0.12
20L-10H-70P	12.45	12.67	12.78	12.87	12.97	12.75	0.20

A.3.2 Tensile modulus

Table A.14: Tensile modulus results in MPa for lime sludge filled HDPE-PP blends

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure PP	376	387	393	398	405	391.8	11.03
5L -85H-10P	149	157	163	172	178	163.8	11.56
10L-80H-10P	179	186	196	203	210	194.8	12.51
15L-15H-70P	260	269	277	281	292	275.8	12.11
20L-10H-70P	282	289	291	296	303	292.2	7.85

A.3.3 Elongation at break

Table A.15: Elongation at break results in % for lime sludge filled HDPE-PP blends

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure PP	17	16	19	23	21	19.2	2.86
5L -85H-10P	157	149	164	171	184	165	13.40
10L-80H-10P	134	142	149	156	160	148.2	10.50
15L-15H-70P	8	9	10	11	13	10.2	1.92
20L-10H-70P	7	9	11	11	12	10	2.00

A.3.4 Shore D hardness

Table A.16: Shore D hardness results for lime sludge filled HDPE-PP blends

Sample Designation	Shore D hardness						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure PP	68.4	68.6	70	71	72	70	0.62
5L -85H-10P	62.1	60.4	63	64.5	65	63	1.86
10L-80H-10P	63.8	64.6	65.5	66	67.6	65.5	1.45
15L-15H-70P	65.3	65.8	66	66.8	67	66.18	0.71
20L-10H-70P	70.5	71.2	71	70.5	72	71.04	0.62

A.4 Shore D hardness of raw lime sludge filled HDPE composites

Table A.17: Shore D hardness results for raw lime sludge filled HDPE composites

Sample Designation	Shore D hardness						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure HDPE	60.5	61	61.5	62	62.5	61.5	0.79
5 LS HDPE	61.5	62	62.5	61.5	62.5	62	0.50
10 LS HDPE	63	63.5	64	64.5	65	64	0.79
15 LS HDPE	66	66.5	66.5	66.5	67	66.5	0.35
20 LS HDPE	68.5	66.5	67	67.5	68	67.5	0.79
25 LS HDPE	67	67.5	68	68.5	69	68	0.79
30 LS HDPE	68	68.5	69	69.5	70	69	0.79

A.5 Mechanical properties of lime sludge filled HDPE-MAPE composites

A.5.1 Tensile strength

Table A.18: Tensile strength results in MPa for lime sludge filled HDPE-MAPE composites

Sample Designation	Tensile Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/LS/MAPE (89/10/1)	16.01	16.22	16.48	16.40	16.12	16.24	0.19
HDPE/LS/MAPE (79/20/1)	17.18	16.98	16.81	16.89	17.12	16.99	0.15
HDPE/LS/MAPE (69/30/1)	16.78	16.52	16.24	16.39	16.81	16.54	0.25
HDPE/LS/MAPE (87/10/3)	16.25	16.76	16.55	16.46	16.88	16.58	0.25
HDPE/LS/MAPE (77/20/3)	17.46	17.69	17.86	17.86	17.70	17.71	0.16
HDPE/LS/MAPE (67/30/3)	16.46	17.28	16.94	16.84	17.02	16.91	0.30
HDPE/LS/MAPE (85/10/5)	17.68	17.94	18.21	17.71	18.05	17.92	0.23
HDPE/LS/MAPE (75/20/5)	18.24	18.61	18.78	18.88	18.43	18.59	0.26
HDPE/LS/MAPE (65/30/5)	18.23	18.06	17.84	17.91	18.16	18.04	0.16

A.5.2 Tensile modulus

Table A.19: Tensile modulus results in MPa for lime sludge filled HDPE-MAPE composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/LS/MAPE (89/10/1)	181.3	207.6	195.6	189.4	208.2	196.2	11.64
HDPE/LS/MAPE (79/20/1)	203.6	210.6	198.4	223.7	215.9	210.5	9.97
HDPE/LS/MAPE (69/30/1)	229.6	218.9	208.7	226.4	212.5	219.2	8.88
HDPE/LS/MAPE (87/10/3)	187.8	208.4	199.1	204.8	192.3	198.5	8.53
HDPE/LS/MAPE (77/20/3)	211.2	221.8	234.5	214.6	224.3	221.3	9.09
HDPE/LS/MAPE (67/30/3)	248.3	261.2	254.7	256.8	280.5	260.3	12.21
HDPE/LS/MAPE (85/10/5)	212.8	226.4	233.1	240.2	248.3	232.2	13.55
HDPE/LS/MAPE (75/20/5)	242.3	250.4	255.9	263.6	271.8	256.8	11.44
HDPE/LS/MAPE (65/30/5)	259.8	275.8	286.5	290.7	264.8	275.5	13.35

A.5.3 Elongation at break

Table A.20: Elongation at break results in % for lime sludge filled HDPE-MAPE composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/LS/MAPE (89/10/1)	229	251	275	236	267	252	19.62
HDPE/LS/MAPE (79/20/1)	27	32	39	49	53	40	11.00
HDPE/LS/MAPE (69/30/1)	22	28	29	36	25	28	5.24
HDPE/LS/MAPE (87/10/3)	191	221	216	208	216	210	11.80
HDPE/LS/MAPE (77/20/3)	22	28	27	31	37	29	5.52
HDPE/LS/MAPE (67/30/3)	24	27	35	23	26	27	4.74
HDPE/LS/MAPE (67/30/3)	166	142	149	159	139	151	11.38
HDPE/LS/MAPE (75/20/5)	17	19	24	28	27	23	4.85
HDPE/LS/MAPE (65/30/5)	15	27	21	17	25	21	5.10

A.5.4 Flexural strength

Table A.21: Flexural strength results in MPa for lime sludge filled HDPE-MAPE composites

Sample Designation	Flexural Strength					Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V		
HDPE/LS/MAPE (89/10/1)	13.31	13.48	13.63	13.87	13.91	13.64	0.25
HDPE/LS/MAPE (79/20/1)	14.21	14.36	14.45	14.64	14.70	14.47	0.20
HDPE/LS/MAPE (69/30/1)	14.75	14.84	14.93	14.69	14.96	14.83	0.11
HDPE/LS/MAPE (87/10/3)	13.86	13.96	14.10	14.24	14.29	14.09	0.18
HDPE/LS/MAPE (77/20/3)	14.64	15.06	14.84	14.96	14.77	14.85	0.16
HDPE/LS/MAPE (67/30/3)	15.68	15.72	15.90	16.12	16.05	15.89	0.19
HDPE/LS/MAPE (85/10/5)	14.81	14.94	15.01	15.12	15.17	15.01	0.14
HDPE/LS/MAPE (75/20/5)	15.01	15.09	15.15	15.21	15.26	15.14	0.09
HDPE/LS/MAPE (65/30/5)	16.07	16.14	16.25	16.32	16.42	16.24	0.14

A.5.5 Flexural modulus

Table A.22: Flexural modulus results in MPa for lime sludge filled HDPE-MAPE composites

Sample Designation	Flexural Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/LS/MAPE (89/10/1)	524	518	514	508	499	512.6	9.58
HDPE/LS/MAPE (79/20/1)	579	591	596	600	609	595.0	11.11
HDPE/LS/MAPE (69/30/1)	629	638	646	656	659	645.6	12.5
HDPE/LS/MAPE (87/10/3)	501	515	522	537	529	520.8	13.75
HDPE/LS/MAPE (77/20/3)	593	608	612	619	628	612.0	13.06
HDPE/LS/MAPE (67/30/3)	678	682	688	676	693	683.4	7.10
HDPE/LS/MAPE (85/10/5)	582	591	597	608	612	598.0	12.30
HDPE/LS/MAPE (75/20/5)	634	645	653	659	668	651.8	13.03
HDPE/LS/MAPE (65/30/5)	687	692	699	689	696	692.6	4.93

A.5.6 Impact strength

Table A.23: Impact strength results in J/m for lime sludge filled HDPE-MAPE composites

Sample Designation	Impact Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/LS/MAPE (89/10/1)	29.32	29.85	31.84	32.95	34.98	31.79	2.31
HDPE/LS/MAPE (79/20/1)	42.14	40.28	40.78	38.29	39.79	40.26	1.41
HDPE/LS/MAPE (69/30/1)	40.67	41.02	41.26	41.49	41.74	41.24	0.41
HDPE/LS/MAPE (87/10/3)	38.12	38.92	39.12	39.38	40.15	39.14	0.74
HDPE/LS/MAPE (77/20/3)	41.39	41.86	42.16	42.94	42.55	42.18	0.60
HDPE/LS/MAPE (67/30/3)	43.84	44.21	44.34	44.51	44.89	44.36	0.39
HDPE/LS/MAPE (85/10/5)	43.28	43.44	43.76	43.92	44.54	43.79	0.49
HDPE/LS/MAPE (75/20/5)	44.21	44.17	44.36	44.56	44.39	44.34	0.20
HDPE/LS/MAPE (65/30/5)	46.42	46.57	46.85	46.96	47.41	46.84	0.38

A.6 Mechanical properties of lime sludge filled coir fibre reinforced HDPE-MAPE composites

A.6.1 Tensile strength

Table A.24: Tensile strength results in MPa for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Tensile Strength						Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V			
HDPE/CF (90/10)	15.18	16.19	14.12	14.46	15.61	15.11	0.84	
HDPE/CF (80/20)	18.65	17.99	19.18	19.53	18.92	18.85	0.58	
HDPE/CF (70/30)	15.95	15.26	16.62	15.74	16.23	15.96	0.51	
HDPE/CF/MAPE (85/10/5)	22.73	22.09	23.19	22.68	22.65	22.67	0.39	
HDPE/CF/MAPE (75/20/5)	30.31	29.59	29.14	29.86	29.27	29.63	0.47	
HDPE/CF/MAPE (65/30/5)	22.59	21.98	22.94	22.65	22.15	22.46	0.39	
HDPE/LS/CF/MAPE (65/10/20/5)	24.19	23.84	24.69	24.25	23.82	24.16	0.36	
HDPE/LS/CF/MAPE (60/15/20/5)	34.52	33.96	34.92	34.78	34.26	34.49	0.39	
HDPE/LS/CF/MAPE (55/20/20/5)	25.43	25.13	25.97	24.76	25.67	25.39	0.47	

A.6.2 Tensile modulus

Table A.25: Tensile modulus results in MPa for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/CF (90/10)	236.6	213.6	264.6	221.5	246.3	236.52	20.22
HDPE/CF (80/20)	259.3	269.2	287.5	242.1	233.2	258.26	21.6
HDPE/CF (70/30)	271.3	276.3	283.2	249.8	298.2	275.76	17.70
HDPE/CF/MAPE (85/10/5)	331.6	310.4	300.7	287.3	326.0	311.20	18.15
HDPE/CF/MAPE (75/20/5)	337.9	358.2	349.3	314.5	324.4	336.86	17.79
HDPE/CF/MAPE (65/30/5)	365.8	382.2	346.2	332.5	394.2	364.18	25.28
HDPE/LS/CF/MAPE (65/10/20/5)	302.2	318.2	322.1	321.2	343.8	321.50	14.84
HDPE/LS/CF/MAPE (60/15/20/5)	344.2	370.2	323.2	336.8	351.3	345.14	17.45
HDPE/LS/CF/MAPE (55/20/20/5)	379.5	359.2	396.1	368.8	389.2	378.56	14.93

A.6.3 Elongation at break

Table A.26: Elongation at break results in % for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/CF (90/10)	45.3	62.8	72.3	82.2	53.2	63.16	14.70
HDPE/CF (80/20)	28.3	17.8	22.54	29.5	15.3	22.68	6.25
HDPE/CF (70/30)	8.95	10.72	12.56	13.2	8.82	10.85	2.01
HDPE/CF/MAPE (85/10/5)	79.2	71.2	88.9	64.3	87.1	78.15	10.45
HDPE/CF/MAPE (75/20/5)	56.2	41.32	47.1	54.3	44.9	48.76	6.31
HDPE/CF/MAPE (65/30/5)	40.1	34.2	29.3	38.2	30.1	34.38	4.78
HDPE/LS/CF/MAPE (65/10/20/5)	52.8	43.8	60.7	48.5	56.4	52.44	6.60
HDPE/LS/CF/MAPE (60/15/20/5)	29.3	42.1	35.6	31.9	39.2	35.62	5.21
HDPE/LS/CF/MAPE (55/20/20/5)	20.7	15.1	8.9	11.2	18.6	14.90	4.93

A.6.4 Flexural strength

Table A.27: Flexural strength results in MPa for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Flexural Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/CF (90/10)	11.48	11.98	11.29	11.24	11.75	11.55	0.31
HDPE/CF (80/20)	12.02	12.71	12.19	12.48	11.97	12.27	0.31
HDPE/CF (70/30)	12.98	13.31	12.74	12.19	12.34	12.71	0.46
HDPE/CF/MAPE (85/10/5)	11.76	12.36	12.16	11.98	12.39	12.13	0.26
HDPE/CF/MAPE (75/20/5)	13.36	12.81	12.24	12.64	12.91	12.79	0.41
HDPE/CF/MAPE (65/30/5)	15.02	14.11	14.51	14.31	14.75	14.54	0.36
HDPE/LS/CF/MAPE (65/10/20/5)	16.96	17.59	17.96	17.41	17.86	17.56	0.40
HDPE/LS/CF/MAPE (60/15/20/5)	19.78	19.06	19.43	19.21	19.62	19.42	0.29
HDPE/LS/CF/MAPE (55/20/20/5)	20.94	21.53	21.98	21.34	21.96	21.55	0.44

A.6.5 Flexural modulus

Table A.28: Flexural modulus results in MPa for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Flexural Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/CF (90/10)	296.6	325.8	312.1	299.3	322.5	311.26	13.19
HDPE/CF (80/20)	365.2	374.6	389.2	355.2	392.3	375.30	15.72
HDPE/CF (70/30)	383.2	413.2	398.3	383.9	379.3	391.58	14.08
HDPE/CF/MAPE (85/10/5)	293.6	324.8	317.1	304.3	316.5	311.26	12.30
HDPE/CF/MAPE (75/20/5)	339.6	329.8	346.6	355.2	321.5	338.54	13.33
HDPE/CF/MAPE (65/30/5)	420.1	392.5	404.9	398.6	410.5	405.32	10.66
HDPE/LS/CF/MAPE (65/10/20/5)	424.5	449.3	436.8	446.8	429.4	437.36	10.73
HDPE/LS/CF/MAPE (60/15/20/5)	454.8	436.7	476.2	458.2	442.6	453.70	15.33
HDPE/LS/CF/MAPE (55/20/20/5)	494.3	457.8	474.6	469.2	482.9	475.76	13.80

A.6.6 Impact strength

Table A.29: Impact strength results in J/m for lime sludge filled coir fibre reinforced HDPE-MAPE composites

Sample Designation	Impact Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
HDPE/CF (90/10)	18.54	22.32	20.55	19.24	22.18	20.57	1.70
HDPE/CF (80/20)	17.14	19.95	18.08	17.56	17.56	18.06	1.11
HDPE/CF (70/30)	17.96	17.01	17.55	17.26	17.89	17.53	0.41
HDPE/CF/MAPE (85/10/5)	22.77	23.75	21.75	22.98	23.62	22.97	0.80
HDPE/CF/MAPE (75/20/5)	19.93	21.69	20.95	20.59	21.75	20.98	0.77
HDPE/CF/MAPE (65/30/5)	18.54	20.02	19.36	19.65	19.09	19.33	0.56
HDPE/LS/CF/MAPE (65/10/20/5)	19.84	20.72	21.52	20.36	20.96	20.68	0.63
HDPE/LS/CF/MAPE (60/15/20/5)	19.05	19.95	19.54	19.29	19.69	19.50	0.35
HDPE/LS/CF/MAPE (55/20/20/5)	17.59	18.65	18.17	18.36	17.91	18.14	0.41

A.7 Mechanical properties of lime sludge filled epoxy composites

A.7.1 Tensile strength

Table A.30: Tensile strength results in MPa for lime sludge filled epoxy composites

Sample Designation	Tensile Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure Epoxy	3.46	3.64	3.72	3.84	3.92	3.72	0.18
3LS-97 Epoxy	4.49	4.74	4.86	4.96	5.11	4.83	0.23
6LS-94 Epoxy	8.24	8.38	8.44	8.54	8.65	8.45	0.16
9LS-91 Epoxy	6.24	6.29	6.36	6.43	6.53	6.37	0.11
12LS-88 Epoxy	3.49	3.59	3.67	3.78	3.86	3.68	0.15

A.7.2 Tensile modulus

Table A.31: Tensile modulus results in MPa for lime sludge filled epoxy composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure Epoxy	358	365	373	384	389	373.8	12.87
3LS-97 Epoxy	388	394	399	408	411	400.0	9.57
6LS-94 Epoxy	415	418	422	440	434	425.8	10.73
9LS-91 Epoxy	441	449	455	464	470	455.8	11.56
12LS-88 Epoxy	479	486	492	501	508	493.2	11.56

A.7.3 Elongation at break

Table A.32: Elongation at break results in % for lime sludge filled epoxy composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
Pure Epoxy	4.83	4.92	5.03	5.14	5.19	5.02	0.15
3LS-97 Epoxy	4.59	4.72	4.82	4.92	4.96	4.80	0.15
6LS-94 Epoxy	4.42	4.56	4.63	4.68	4.79	4.62	0.14
9LS-91 Epoxy	3.01	3.15	3.21	3.28	3.36	3.20	0.13
12LS-88 Epoxy	1.91	1.98	2.07	2.14	2.21	2.06	0.12

A.8 Mechanical properties of lime sludge filled coir fibre reinforced epoxy composites

A.8.1 Tensile strength

Table A.33: Tensile strength results in MPa for lime sludge filled coir-epoxy composites

Sample Designation	Tensile Strength						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
30 Coir - Epoxy	16.19	16.26	16.38	16.40	16.12	16.27	0.12
3LS -30 Coir - Epoxy	12.19	12.26	12.34	12.39	12.48	12.33	0.11
6LS - 30 Coir - Epoxy	15.96	16.09	16.18	16.39	16.31	16.19	0.17
9LS - 30 Coir - Epoxy	13.49	13.75	13.56	13.86	14.14	13.76	0.26
12LS -30 Coir - Epoxy	12.81	12.72	12.92	13.02	13.08	12.91	0.15
30 Coir - Epoxy (long)	27.96	28.45	28.89	29.42	29.85	28.91	0.75
3LS -30 Coir - Epoxy (long)	20.14	19.85	20.39	20.75	20.91	20.41	0.43
6LS - 30 Coir - Epoxy (long)	24.85	25.31	25.40	25.64	25.89	25.42	0.39
9LS - 30 Coir - Epoxy (long)	21.98	22.45	22.92	23.53	23.86	22.95	0.77
12LS -30 Coir - Epoxy (long)	19.41	19.59	19.74	19.89	19.97	19.72	0.23

A.8.2 Tensile modulus

Table A.34: Tensile modulus results in MPa for lime sludge filled coir-epoxy composites

Sample Designation	Tensile Modulus						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
30 Coir - Epoxy	421	411	431	402	392	411.4	15.34
3LS -30 Coir - Epoxy	432	446	453	459	468	451.6	13.61
6LS - 30 Coir - Epoxy	476	489	495	512	508	496.0	14.58
9LS - 30 Coir - Epoxy	501	518	522	531	533	521.0	12.79
12LS -30 Coir - Epoxy	528	536	544	551	558	543.4	11.87
30 Coir - Epoxy (long)	481	495	502	511	519	501.6	14.66
3LS -30 Coir - Epoxy (long)	499	513	525	536	547	524.0	18.84
6LS - 30 Coir - Epoxy (long)	539	546	555	564	559	552.6	10.06
9LS - 30 Coir - Epoxy (long)	562	579	588	596	612	587.4	18.68
12LS -30 Coir - Epoxy (long)	598	605	614	621	628	613.2	12.03

A.8.3 Elongation at break

Table A.35: Elongation at break results in % for lime sludge filled coir-epoxy composites

Sample Designation	Elongation at break						
	Test I	Test II	Test III	Test IV	Test V	Mean	Std. dev.
30 Coir - Epoxy	9.91	10.17	10.27	10.25	10.12	10.14	0.14
3LS -30 Coir - Epoxy	8.99	9.09	9.16	9.28	9.39	9.18	0.16
6LS - 30 Coir - Epoxy	8.27	8.37	8.52	8.68	8.89	8.55	0.25
9LS - 30 Coir - Epoxy	6.44	6.64	6.76	6.87	6.97	6.74	0.21
12LS -30 Coir - Epoxy	6.03	5.98	6.16	6.27	6.43	6.17	0.18
30 Coir - Epoxy (long)	20.94	21.18	21.25	21.36	21.56	21.26	0.23
3LS -30 Coir - Epoxy (long)	18.57	18.62	18.75	18.89	18.99	18.76	0.18
6LS - 30 Coir - Epoxy (long)	12.52	12.68	12.86	13.11	13.21	12.88	0.29
9LS - 30 Coir - Epoxy (long)	10.01	9.94	10.09	10.18	10.31	10.11	0.15
12LS -30 Coir - Epoxy (long)	7.05	7.35	7.54	7.85	7.99	7.56	0.38

A.8.4 Flexural strength

Table A.36: Flexural strength results in MPa for lime sludge filled coir-epoxy composites

Sample Designation	Flexural Strength					Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V		
30 Coir - Epoxy	30.28	30.54	30.68	30.84	30.96	30.66	0.27
3LS -30 Coir - Epoxy	31.93	32.18	32.28	32.37	32.58	32.27	0.24
6LS - 30 Coir - Epoxy	36.01	36.16	36.27	36.38	36.59	36.28	0.22
9LS - 30 Coir - Epoxy	38.32	38.48	38.58	38.63	38.83	38.57	0.19
12LS -30 Coir - Epoxy	45.73	45.46	45.85	46.12	46.23	45.88	0.31
30 Coir - Epoxy (long)	42.44	42.56	42.67	42.78	42.96	42.68	0.20
3LS -30 Coir - Epoxy (long)	44.27	44.36	44.43	44.58	44.64	44.46	0.15
6LS - 30 Coir - Epoxy (long)	51.41	51.54	51.70	51.82	51.97	51.69	0.22
9LS - 30 Coir - Epoxy (long)	57.29	57.43	57.55	57.66	57.78	57.54	0.19
12LS -30 Coir - Epoxy (long)	60.12	60.34	60.43	60.52	60.68	60.42	0.21

A.8.5 Flexural modulus

Table A.37: Flexural modulus results in MPa for lime sludge filled coir-epoxy composites

Sample Designation	Flexural Modulus					Mean	Std. dev.
	Test I	Test II	Test III	Test IV	Test V		
30 Coir - Epoxy	295	311	315	319	321	312.2	10.35
3LS -30 Coir - Epoxy	339	347	354	359	368	353.4	11.10
6LS - 30 Coir - Epoxy	380	372	364	388	395	379.8	12.34
9LS - 30 Coir - Epoxy	423	429	435	439	445	434.2	8.56
12LS -30 Coir - Epoxy	454	460	446	469	473	460.4	10.97
30 Coir - Epoxy (long)	468	475	485	495	497	484.0	12.53
3LS -30 Coir - Epoxy (long)	492	498	508	516	525	507.8	13.31
6LS - 30 Coir - Epoxy (long)	520	527	513	534	548	528.4	13.46
9LS - 30 Coir - Epoxy (long)	560	568	574	578	582	572.4	8.65
12LS -30 Coir - Epoxy (long)	565	574	584	590	594	581.4	11.87

Appendix B

List of Publications

B.1 Journal Publications:

- (i) Kashyap, S. and Datta, D. Evaluation of stearic acid modified industrial lime sludge waste as filler in high density polyethylene composites. *Journal of Polymer Engineering*, 38(4):333-341, 2018.
- (ii) Kashyap, S. and Datta, D. Industrial lime sludge waste - HDPE composites - a study of their mechanical, thermal and morphological properties. *Journal of Thermoplastic Composite Materials*, 2017.
doi: <https://doi.org/10.1177/0892705717738289>.
- (iii) Kashyap, S., Islam, J. and Datta, D. A study of industrial lime sludge waste as filler in hybrid polymeric composites. *IOP Conference Series: Materials Science and Engineering*, 377:1-7, 2018.
- (iv) Kashyap, S. and Datta, D. Reusing industrial lime sludge waste as a filler in polymeric composites. *Materials Today: Proceedings*, 4(2) Part A:2946-2955, 2017.
- (v) Kashyap, S. and Datta, D. Process parameter optimization of plastic injection molding: a review. *International Journal of Plastics Technology*, 19(1):1-18, 2015.

B.2 Book Chapter:

- (i) Kashyap, S. and Datta, D. Development of industrial lime sludge waste filled hybrid polymeric composites for environmental sustainability. In *Futuristic Composites - Behavior, Characterization, and Manufacturing*, Springer, Germany (accepted for publication).

