Struvite Production from Dairy Processing Waste

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Table S1. Experimental matrix and quantitative PO_4^{3-} reduction from AD wastewater following struvite precipitation.

TEMP (oC)	pH	MgCl2 dose	Phosphate % reduction	TEMP (oC)	pH	MgCl2 dose	Phosphate % reduction
10	7	0	8.50	20	7	0	-5.41
10	7	0	14.25	20	7	0	19.35
10	8	0	-2.23	20	8	0	2.31
10	8	0	7.68	20	8	0	11.03
10	9	0	10.54	20	9	0	22.10
10	9	0	13.51	20	9	0	22.19
10	10	0	34.35	20	10	0	31.30
10	10	0	35.31	20	10	0	27.87
10	7	0.5:1	-6.48	20	7	0.5:1	7.50
10	7	0.5:1	-21.12	20	7	0.5:1	-2.68
10	8	0.5:1	12.09	20	8	0.5:1	18.91
10	8	0.5:1	8.59	20	8	0.5:1	11.21
10	9	0.5:1	12.21	20	9	0.5:1	46.95
10	9	0.5:1	13.57	20	9	0.5:1	47.94
10	10	0.5:1	60.36	20	10	0.5:1	63.94
10	10	0.5:1	64.01	20	10	0.5:1	67.71
10	7	1.1	-12.30	20	7	1.1	7.08
10	7	1.1	-5.05	20	7	1.1	13.93
10	8	1.1	4.71	20	8	1.1	14.47
10	8	1.1	-4.41	20	8	1.1	27.57
10	9	1.1	61.39	20	9	1.1	69.58
10	9	1.1	73.75	20	9	1.1	70.89
10	10	1.1	89.67	20	10	1.1	76.11
10	10	1.1	88.75	20	10	1.1	76.02
10	7	1.5:1	-7.12	20	7	1.5:1	7.05
10	7	1.5:1	-0.62	20	7	1.5:1	8.10
10	8	1.5:1	7.43	20	8	1.5:1	27,36

10	8	1.5:1	18.05	20	8	1.5:1	31.70
10	9	1.5:1	78.65	20	9	1.5:1	72.15
10	9	1.5:1	78.28	20	9	1.5:1	63.43
10	10	1.5:1	89.05	20	10	1.5:1	81.82
10	10	1.5:1	83.39	20	10	1.5:1	79.23
10	7	2:1	-14.74	20	7	2:1	-3.83
10	7	2:1	-2.83	20	7	2:1	11.78
10	8	2:1	17.85	20	8	2:1	35.85
10	8	2:1	26.67	20	8	2:1	34.29
10	9	2:1	90.77	20	9	2:1	74.39
10	9	2:1	88.71	20	9	2:1	77.42
10	10	2:1	90.27	20	10	2:1	90.28
10	10	2:1	89.54	20	10	2:1	92.59
10	7	10:1	3.30	20	7	10:1	-0.78
10	7	10:1	4.18	20	7	10:1	10.81
10	8	10:1	47.59	20	8	10:1	54.92
10	8	10:1	46.48	20	8	10:1	64.63
10	9	10:1	87.25	20	9	10:1	68.96
10	9	10:1	87.90	20	9	10:1	64.58
10	10	10:1	88.67	20	10	10:1	86.27
10	10	10:1	86.59	20	10	10:1	89.38
10	7	20:1	-5.42	20	7	20:1	3.36
10	7	20:1	-0.95	20	7	20:1	16.22
10	8	20:1	30.45	20	8	20:1	55.11
10	8	20:1	44.05	20	8	20:1	68.22
10	9	20:1	88.18	20	9	20:1	69.68
10	9	20:1	90.43	20	9	20:1	68.94
10	10	20:1	91.59	20	10	20:1	82.46
10	10	20:1	91.44	20	10	20:1	78.15
10	7	30:1	-11.71	20	7	30:1	3.48
10	7	30:1	-0.91	20	7	30:1	0.48
10	8	30:1	63.77	20	8	30:1	57.50
10	8	30:1	63.54	20	8	30:1	67.12
10	9	30:1	87.23	20	9	30:1	83.38
10	9	30:1	84.54	20	9	30:1	84.08
10	10	30:1	91.31	20	10	30:1	91.64
10	10	30:1	81.68	20	10	30:1	91.60
10	7	40:1	6.04	20	7	40:1	-0.29
10	7	40:1	4.19	20	7	40:1	16.50
10	8	40:1	44.82	20	8	40:1	62.31
10	8	40:1	47.74	20	8	40:1	60.08
10	9	40:1	84.63	20	9	40:1	82.02
10	9	40:1	85.82	20	9	40:1	85.94
10	10	40:1	87.57	20	10	40:1	78.89
10	10	40:1	80.25	20	10	40:1	84.16

TEMP (oC)	pH	MgCl2 dose	Phosphate % reduction	TEMP (oC)	pH	MgCl2 dose	Phosphate % reduction
30	7	0	5.24	40	7	0	19.77
30	7	0	-1.38	40	7	0	22.19
30	8	0	9.38	40	8	0	16.18
30	8	0	7.85	40	8	0	25.34
30	9	0	33.06	40	9	0	49.15
30	9	0	27.61	40	9	0	43.92
30	10	0	36.11	40	10	0	42.77
30	10	0	40.34	40	10	0	55.57
30	7	0.5:1	1.74	40	7	0.5:1	14.22
30	7	0.5:1	-0.21	40	7	0.5:1	13.62
30	8	0.5:1	10.25	40	8	0.5:1	30.69
30	8	0.5:1	3.04	40	8	0.5:1	28.22
30	9	0.5:1	65.41	40	9	0.5:1	49.95
30	9	0.5:1	51.16	40	9	0.5:1	47.95
30	10	0.5:1	81.44	40	10	0.5:1	65.83
30	10	0.5:1	76.04	40	10	0.5:1	54.96
30	7	1.1	-1.45	40	7	1.1	18.99
30	7	1.1	-4.43	40	7	1.1	15.17
30	8	1.1	13.03	40	8	1.1	27.29
30	8	1.1	32.02	40	8	1.1	33.87
30	9	1.1	53.15	40	9	1.1	51.34
30	9	1.1	55.12	40	9	1.1	61.12
30	10	1.1	76.64	40	10	1.1	75.16
30	10	1.1	74.54	40	10	1.1	74.96
30	7	1.5:1	-7.59	40	7	1.5:1	18.93
30	7	1.5:1	-2.62	40	7	1.5:1	12.96
30	8	1.5:1	35.20	40	8	1.5:1	26.67
30	8	1.5:1	30.58	40	8	1.5:1	31.93
30	9	1.5:1	66.31	40	9	1.5:1	58.27
30	9	1.5:1	75.04	40	9	1.5:1	59.62
30	10	1.5:1	81.25	40	10	1.5:1	77.85
30	10	1.5:1	88.65	40	10	1.5:1	78.54
30	7	2:1	-10.22	40	7	2:1	31.93
30	7	2:1	10.58	40	7	2:1	22.19
30	8	2:1	46.99	40	8	2:1	27.31
30	8	2:1	42.43	40	8	2:1	32.73
30	9	2:1	73.23	40	9	2:1	51.43
30	9	2:1	68.50	40	9	2:1	62.46
30	10	2:1	89.80	40	10	2:1	78.87
30	10	2:1	73.48	40	10	2:1	83.29
30	7	10:1	3.39	40	7	10:1	24.54
30	7	10:1	6.70	40	7	10:1	23.23
30	8	10:1	45.64	40	8	10:1	44.14
30	8	10:1	41.26	40	8	10:1	31.53

30	9	10:1	85.26	40	9	10:1	56.92
30	9	10:1	71.37	40	9	10:1	75.49
30	10	10:1	86.69	40	10	10:1	78.34
30	10	10:1	78.42	40	10	10:1	86.25
30	7	20:1	1.33	40	7	20:1	15.31
30	7	20:1	1.70	40	7	20:1	10.50
30	8	20:1	50.92	40	8	20:1	33.38
30	8	20:1	60.88	40	8	20:1	41.53
30	9	20:1	85.90	40	9	20:1	68.71
30	9	20:1	77.74	40	9	20:1	61.69
30	10	20:1	78.73	40	10	20:1	85.10
30	10	20:1	87.10	40	10	20:1	92.85
30	7	30:1	-3.96	40	7	30:1	18.62
30	7	30:1	0.04	40	7	30:1	32.64
30	8	30:1	51.62	40	8	30:1	34.16
30	8	30:1	60.20	40	8	30:1	33.61
30	9	30:1	73.58	40	9	30:1	60.73
30	9	30:1	63.44	40	9	30:1	59.52
30	10	30:1	81.14	40	10	30:1	86.28
30	10	30:1	90.53	40	10	30:1	96.14
30	7	40:1	2.96	40	7	40:1	28.22
30	7	40:1	7.18	40	7	40:1	19.27
30	8	40:1	61.94	40	8	40:1	53.91
30	8	40:1	66.36	40	8	40:1	53.10
30	9	40:1	69.39	40	9	40:1	73.42
30	9	40:1	80.24	40	9	40:1	80.05
30	10	40:1	78.69	40	10	40:1	88.18
30	10	40:1	93.07	40	10	40:1	95.88

Table S2. Final concentration (µmol/L) of PO_4^{3-} and NH_4^+ for blended feedstocks as calculated from raw compositions.

Feedstock blends	AD (mL)	HL (mL)	AT (mL)	PO_4^{3-} (µmol/L)	NH_4^+ (µmol/L)	Ca^{2+} (µmol/L)	Final pH
AD+HL	29	121		2053.1	2053.1	274.8	4.26
AD+AT	28		163	1404.1	1404.1	743.9	6.57
AD+HL+AT	29	70	70	1737.9	1737.9	1888.1	4.88

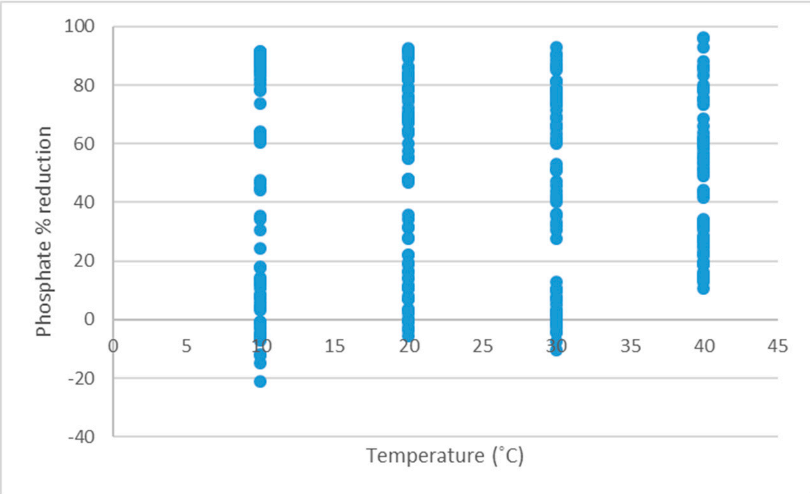

Figure S1. Raw data for temperature and PO_4^{3-} reduction indicating a small potential relationship.

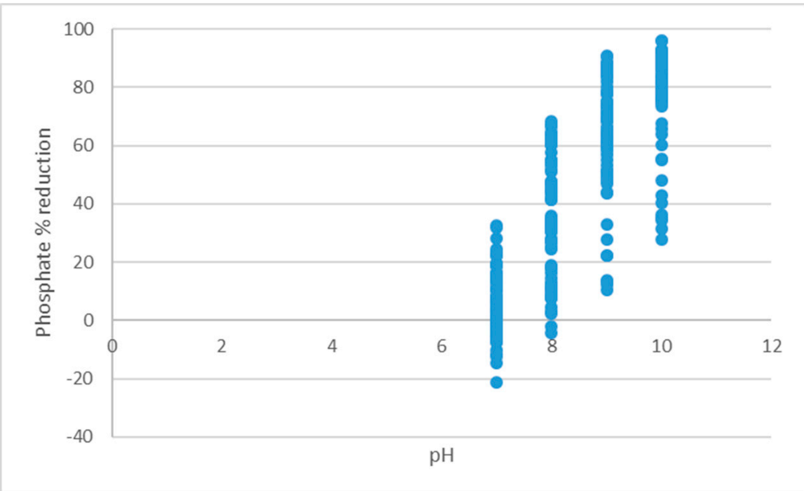

Figure S2. Raw data for pH and PO_4^{3-} reduction indicating a likely relationship.

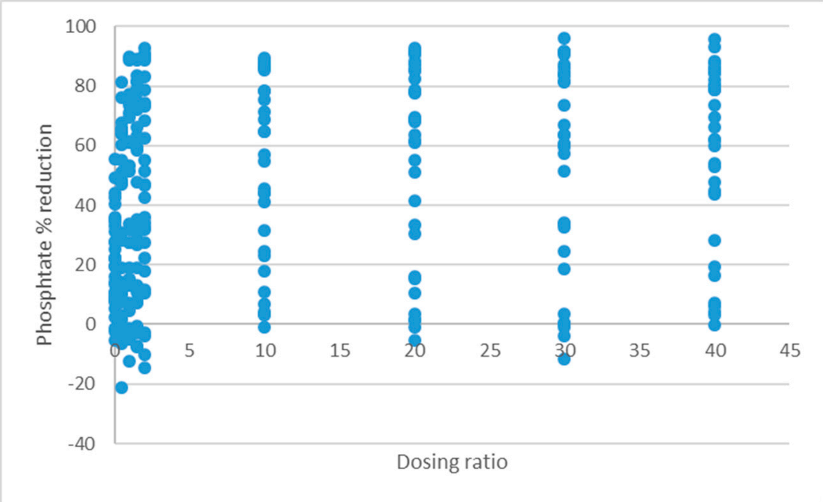

Figure S3. Raw data for dosing ratio and PO_4^{3-} reduction indicating an unlikely potential relationship.

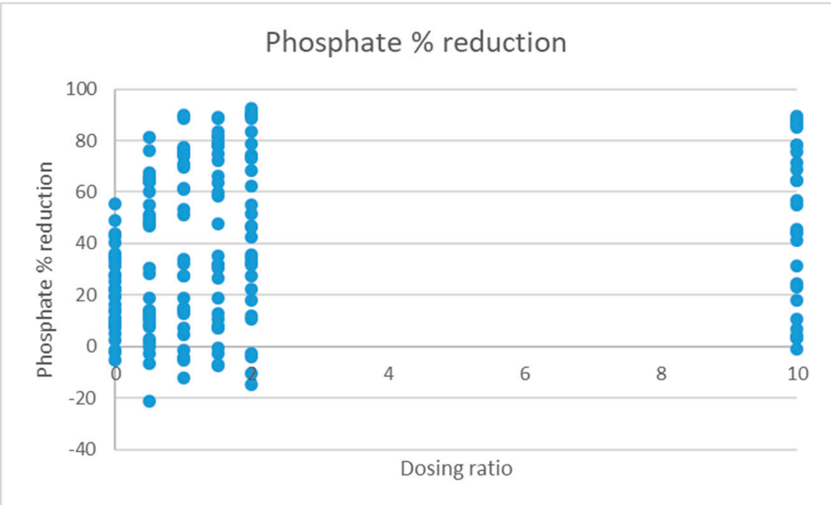

Figure S4. Raw data for dosing ratio and PO_4^{3-} reduction on a smaller x-axis range indicating an unlikely potential relationship

Table S3. P-values for sequential regressions identifying important factors to the linear model.

Parameter	β_o	β_1	β_2	β_3	β_4	β_5	β_6	β_7	Overall p-value for model
1. removed xR	4.3E-19	0.0048	3.8E-24	0.91	0.011	0.69	0.60	0.84	1.3E-86
2. removed xTxpHxR	1.6E-28	0.00072	2.3E-35		0.0024	0.47	1.6E-06	0.82	1E-87
3. removed xTxR	1.3E-28	0.00049	1.8E-35		0.0017	0.099	4.2E-07		7E-89
4. removed xTxpHxR	1.7E-28	0.00087	3.9E-36		0.0017		4.3E-16		1.7E-89

Table S4. Fitting parameters and goodness of fit for a non-linear model.

	Coefficient values			
Mg Dosing ratio	0	2	10	30
Intercept (α_0)	142.0257	-550.087	-642.9707	-776.6539
Temperature (α_1)	-0.5767	4.3274	2.5417	2.5307
pH (α_2)	-39.3614	101.9245	132.2098	162.754
Temperature and pH (α_3)	0.1394	-0.5155	-0.3018	-0.3063
pH^2 (α_4)	2.7044	-3.6122	-5.8118	-7.4916
R^2 Coefficient of Determination	0.7701	0.9097	0.9117	0.8947

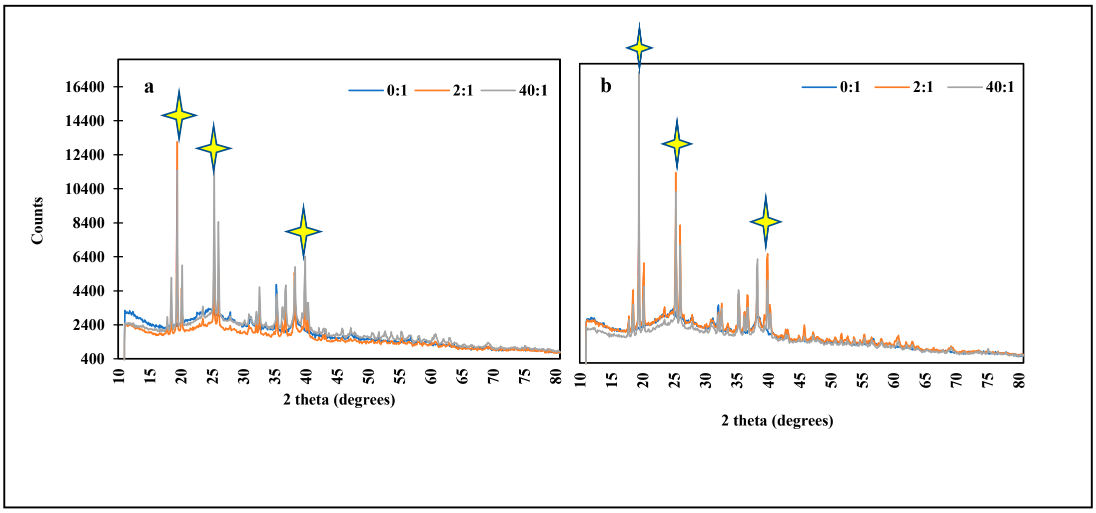

Figure S5. Example of XRD diffractograms showing the main struvite peaks in precipitates generated at 20ºC at pH 9 (a) and 10 (b) using various Mg:PO_4^{3-} ratios.

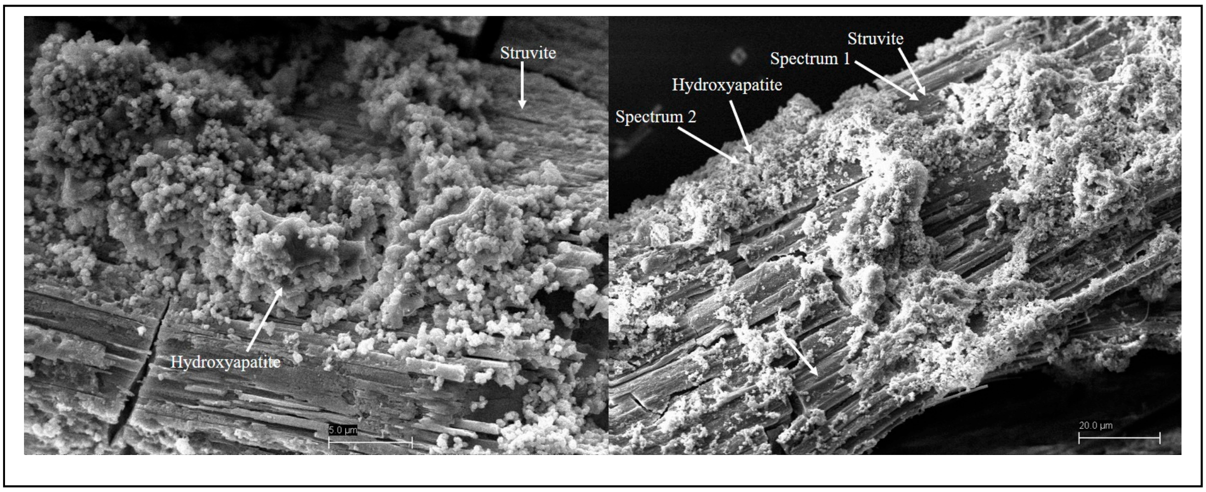

Figure S6. SEM micrographs of precipitates generated from AD wastewaters at 20°C and pH 10, showing the presence of both struvite and hydroxyapatite crystals. EDS spectrums of points 1 and 2 are shown in Figure S7.

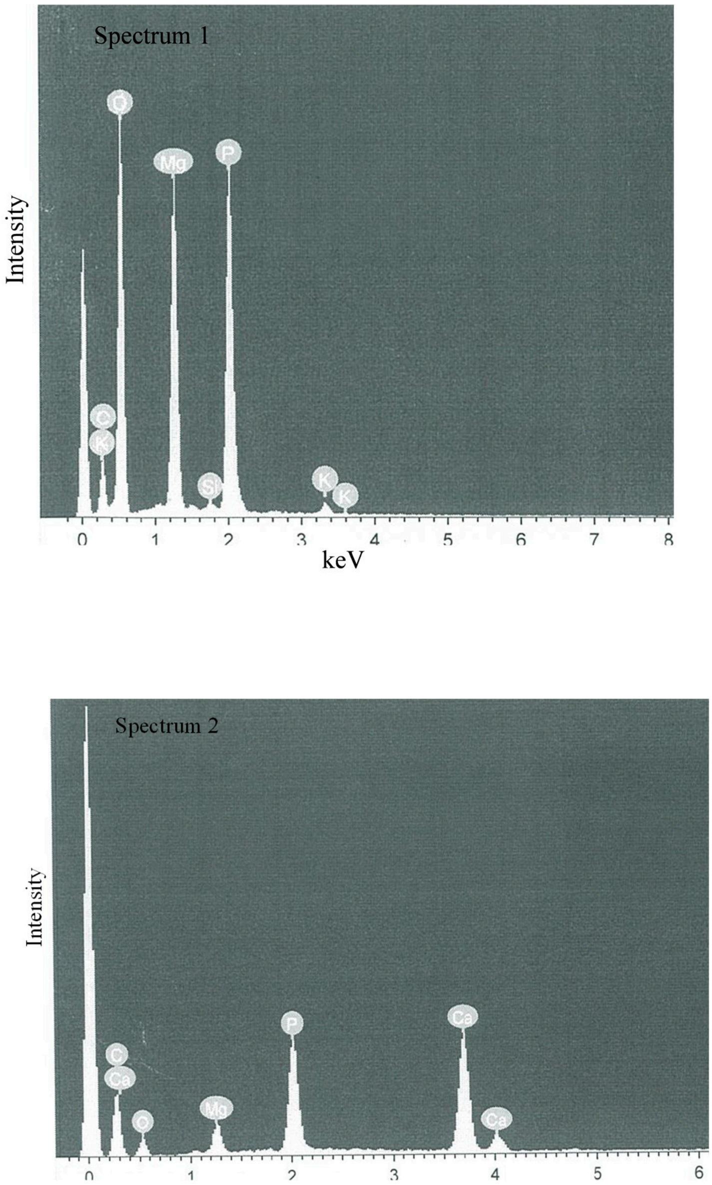

Figure S7. Energy Dispersive X-Ray Spectroscopy (EDS) elemental identification of struvite (Spectrum 1) and hydroxyapatite (Spectrum 2) in precipitates recovered from AD wastewater. Location points for spectrums are shown in Figure S6.