

# Sequestration of Sulfate Anions from Groundwater by Biopolymer-Metal Composite Materials

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## Supporting Information

**Table S1.** Chemical analysis report of Well-1 sample.

<b>Analysis</b>	<b>Result</b>	<b>Unit</b>	<b>Sask Guideline</b>
Health and Toxicity Panel			
Boron	0.1	mg/L	< 5.0
Aluminum (ICPMS)	<6.96	µg/L	No Guideline
Arsenic (ICPMS)	0.60	µg/L	< 10
Barium (ICPMS)	18.8	µg/L	< 1000
Cadmium (ICPMS)	<0.15	µg/L	< 5
Chromium (ICPMS)	<0.19	µg/L	< 50
Copper (ICPMS)	<8.29	µg/L	< 1000
Lead (ICPMS)	0.10	µg/L	< 10
Selenium (ICPMS)	5.8	µg/L	< 10
Uranium (ICPMS)	34.4	µg/L	< 20
Zinc (ICPMS)	7.2	µg/L	< 5000
Antimony (ICPMS)	<0.16	µg/L	No Guideline
Silver (ICPMS)	<0.20	µg/L	No Guideline
General Chemistry/Water Quality Panel			
Conductivity	3711	µS/cm	< 2300
pH	7.7	pH Units	6.5 - 9.0
Total Alkalinity	346	mg/L CaCO <sub>3</sub>	< 500
Phenol Alkalinity	0.00	mg/L CaCO <sub>3</sub>	No Guideline
Bicarbonate	422	mg/L	No Guideline
Carbonate	0	mg/L	No Guideline
Hydroxide	0	mg/L	No Guideline
Chloride Dissolved	98.3	mg/L	< 250
Fluoride Dissolved	0.24	mg/L	< 1.5
Nitrate Dissolved	6.9	mg/L	< 45
Sulfate Dissolved	2062.6	mg/L	< 500
Total Hardness (Calculated)	1912	mg/L CaCO <sub>3</sub>	< 800
Total Dissolved Solids	3552	mg/L	< 1500
Iron	<0.1	mg/L	< 0.3
Manganese	<0.01	mg/L	< 0.05
Calcium	388	mg/L	No Guideline
Magnesium	229	mg/L	< 200
Potassium	6	mg/L	No Guideline
Sodium	339	mg/L	< 300

## Supporting Information

**Table S2.** Chemical analysis report of Well-2 sample.

Analysis	Result	Unit	Sask Guideline
Health and Toxicity Panel			
Boron	0.3	mg/L	< 5.0
Aluminum (ICPMS)	36.6	µg/L	No Guideline
Arsenic (ICPMS)	0.90	µg/L	< 10
Barium (ICPMS)	14.7	µg/L	< 1000
Cadmium (ICPMS)	<0.15	µg/L	< 5
Chromium (ICPMS)	0.30	µg/L	< 50
Copper (ICPMS)	<8.29	µg/L	< 1000
Lead (ICPMS)	0.40	µg/L	< 10
Selenium (ICPMS)	3.3	µg/L	< 10
Uranium (ICPMS)	94.4	µg/L	< 20
Zinc (ICPMS)	18.6	µg/L	< 5000
Antimony (ICPMS)	<0.16	µg/L	No Guideline
Silver (ICPMS)	<0.20	µg/L	No Guideline
General Chemistry/Water Quality Panel			
Conductivity	4978	µS/cm	< 2300
pH	7.8	pH Units	6.5 - 9.0
Total Alkalinity	486	mg/L CaCO <sub>3</sub>	< 500
Phenol Alkalinity	0.00	mg/L CaCO <sub>3</sub>	No Guideline
Bicarbonate	593	mg/L	No Guideline
Carbonate	0	mg/L	No Guideline
Hydroxide	0	mg/L	No Guideline
Chloride Dissolved	146.8	mg/L	< 250
Fluoride Dissolved	0.29	mg/L	< 1.5
Nitrate Dissolved	27.6	mg/L	< 45
Sulfate Dissolved	2653.7	mg/L	< 500
Total Hardness (Calculated)	2198	mg/L CaCO <sub>3</sub>	< 800
Total Dissolved Solids	4711	mg/L	< 1500
Iron	<0.1	mg/L	< 0.3
Manganese	<0.01	mg/L	< 0.05
Calcium	331	mg/L	No Guideline
Magnesium	333	mg/L	< 200
Potassium	8	mg/L	No Guideline
Sodium	618	mg/L	< 300

## Supporting Information

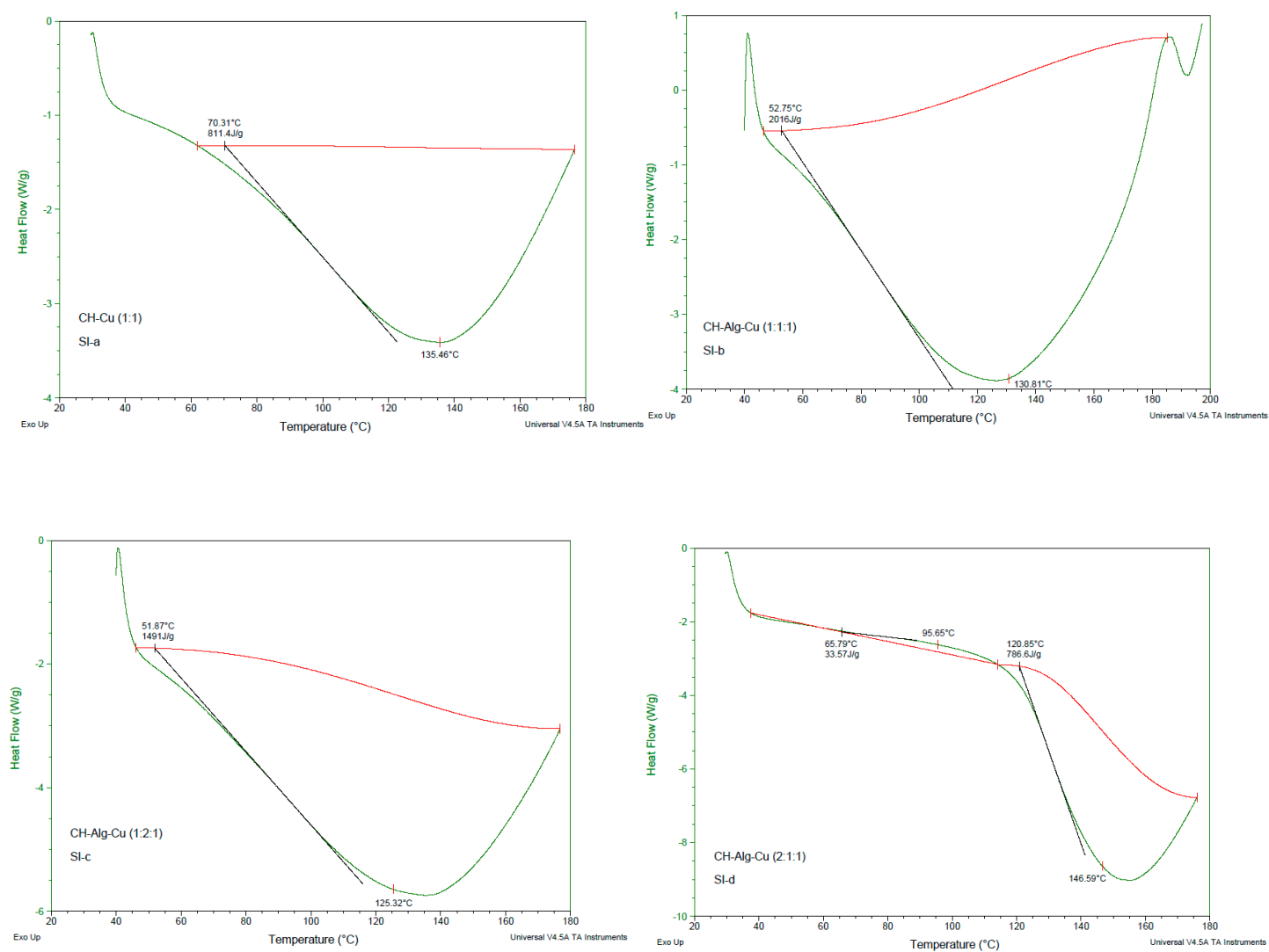
**Table S3.** Chemical analysis report of Well-3 sample.

<b>Analysis</b>	<b>Result</b>	<b>Unit</b>	<b>Sask Guideline</b>
Health and Toxicity Panel			
Boron	0.1	mg/L	< 5.0
Aluminum (ICPMS)	<6.96	µg/L	No Guideline
Arsenic (ICPMS)	2.8	µg/L	< 10
Barium (ICPMS)	19.2	µg/L	< 1000
Cadmium (ICPMS)	0.80	µg/L	< 5
Chromium (ICPMS)	0.20	µg/L	< 50
Copper (ICPMS)	<8.29	µg/L	< 1000
Lead (ICPMS)	0.10	µg/L	< 10
Selenium (ICPMS)	3.5	µg/L	< 10
Uranium (ICPMS)	48.4	µg/L	< 20
Zinc (ICPMS)	<4.00	µg/L	< 5000
Antimony (ICPMS)	<0.16	µg/L	No Guideline
Silver (ICPMS)	<0.20	µg/L	No Guideline
General Chemistry/Water Quality Panel			
Conductivity	9515	µS/cm	< 2300
pH	7.5	pH Units	6.5 - 9.0
Total Alkalinity	592	mg/L CaCO <sub>3</sub>	< 500
Phenol Alkalinity	0.00	mg/L CaCO <sub>3</sub>	No Guideline
Bicarbonate	722	mg/L	No Guideline
Carbonate	0	mg/L	No Guideline
Hydroxide	0	mg/L	No Guideline
Chloride Dissolved	328.1	mg/L	< 250
Fluoride Dissolved	0.13	mg/L	< 1.5
Nitrate Dissolved	1.6	mg/L	< 45
Sulfate Dissolved	6030.0	mg/L	< 500
Total Hardness (Calculated)	4194	mg/L CaCO <sub>3</sub>	< 800
Total Dissolved Solids	9896	mg/L	< 1500
Iron	<0.1	mg/L	< 0.3
Manganese	3.69	mg/L	< 0.05
Calcium	593	mg/L	No Guideline
Magnesium	659	mg/L	< 200
Potassium	49	mg/L	No Guideline
Sodium	1513	mg/L	< 300

## Supporting Information

**Table S4.** Sips isotherm adsorption parameters for sulfate dianion species at 298 K and pH 6.8 in aqueous solution.

Sorbent	$Q_m$ (mg/g)	$K_s$	$n_s$	$R^2$
Chitosan	288.1	0.0006	1.5831	0.98
CACu1	371.4	0.0012	2.4599	0.99



**Figure S1.** DSC thermograms of composite materials (a) CCu, (b) CACu1, (c) CACu2 and (d) CACu3.

## Supporting Information

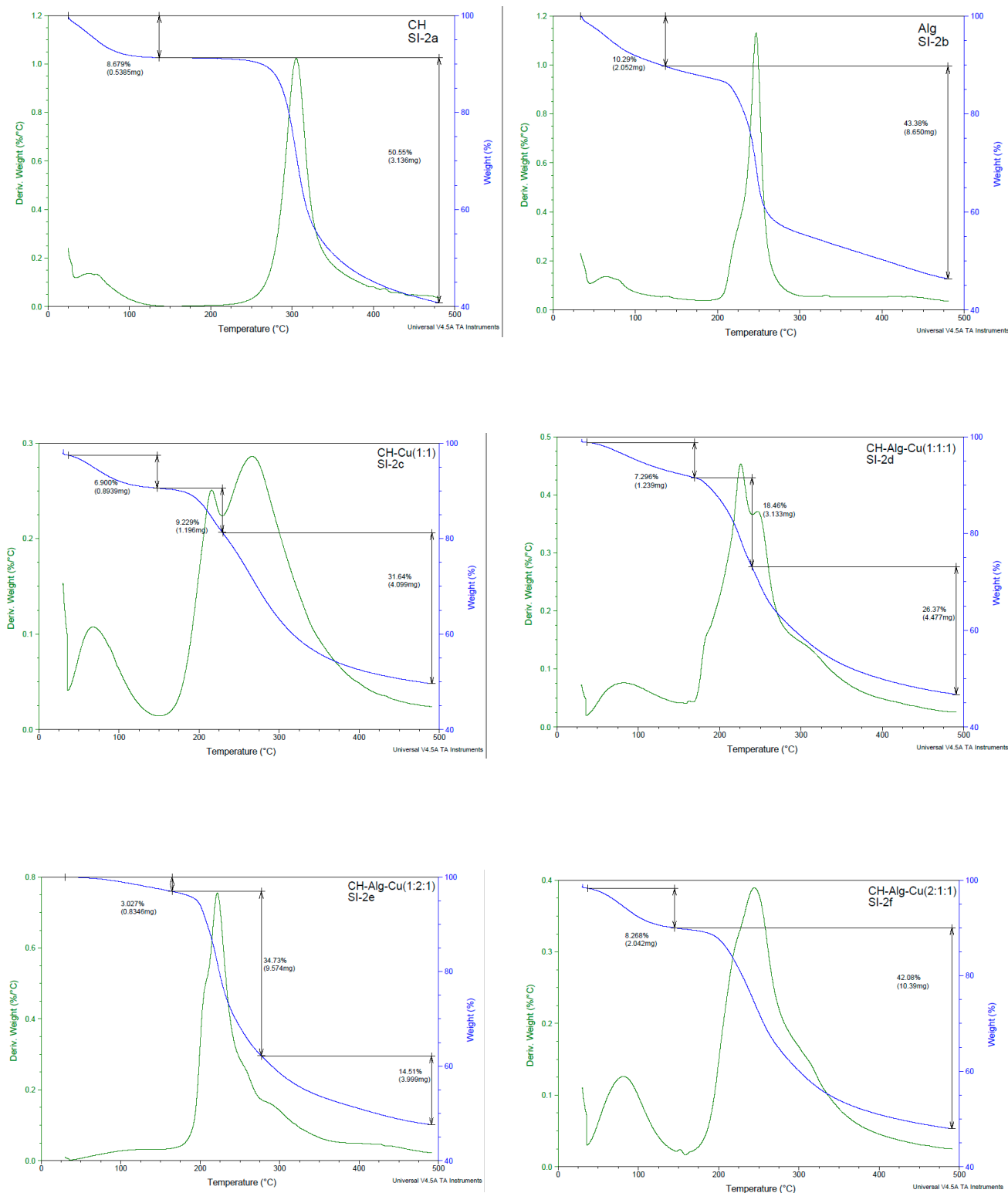


Figure S2. (a-f) Derivative plot from TGA for C, A, CCu, CACu1, CACu2, and CACu3.

Supporting Information

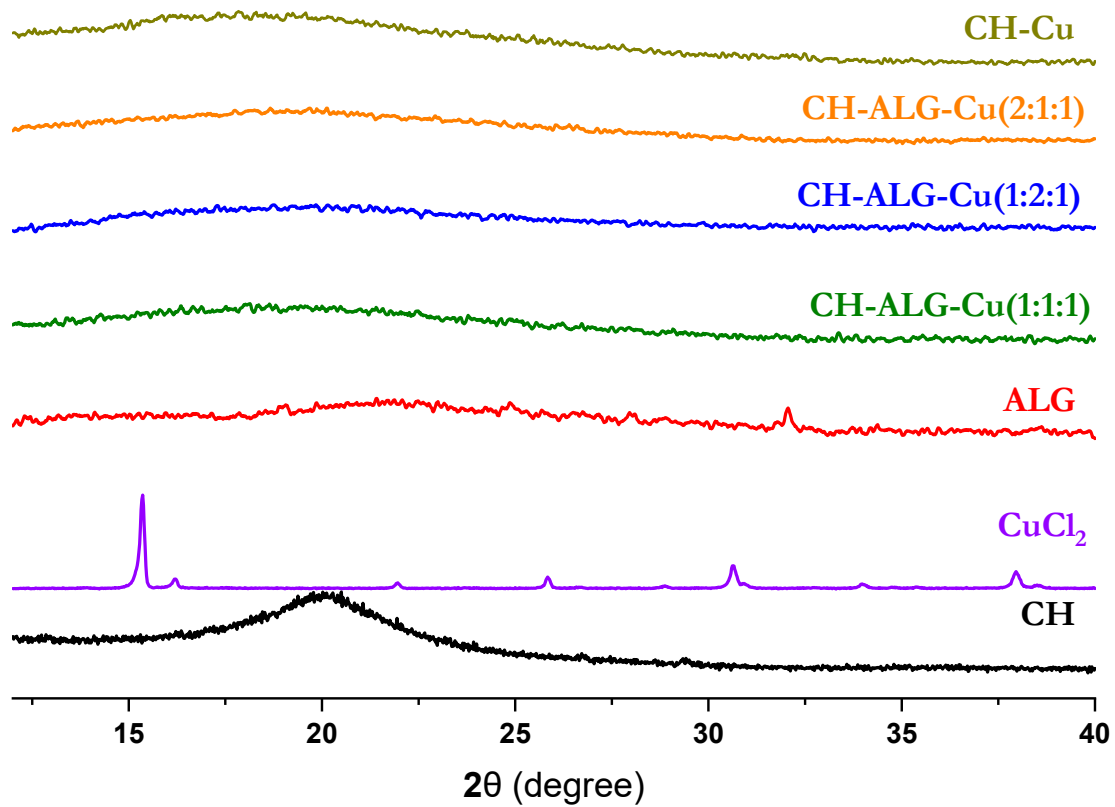


Figure S3. XRD patterns of C, A, CACu1, CACU2, CACu3 and CCu.

## Supporting Information

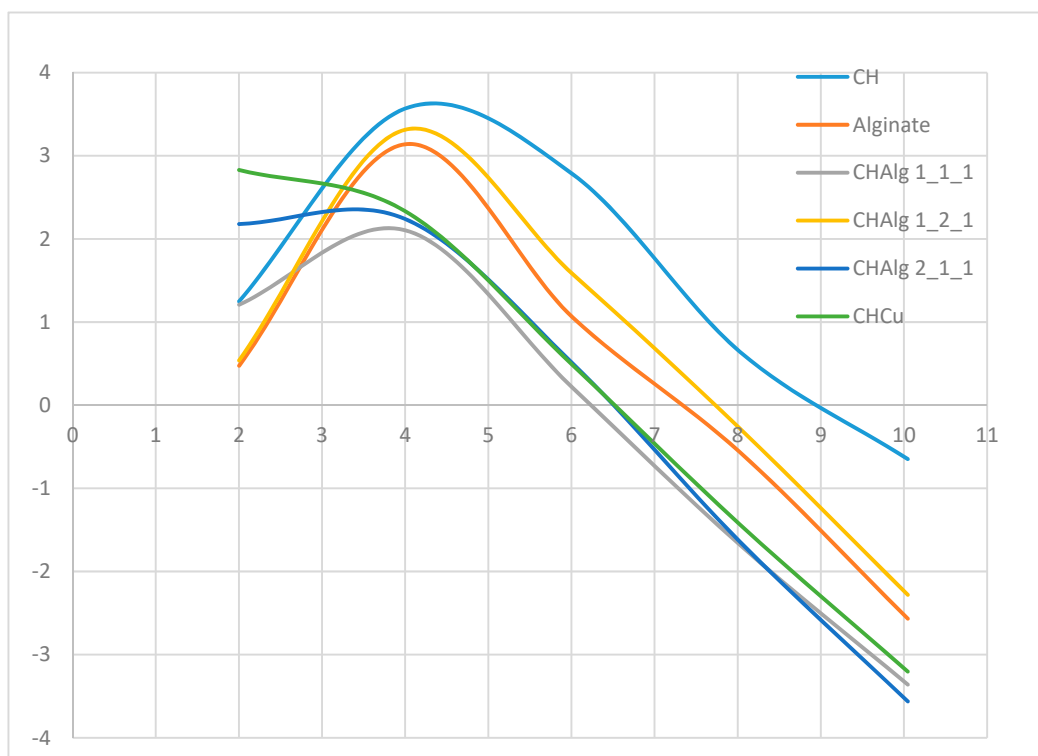


Figure S4. PZC graph for C, A, CCu and CACu1-3 materials.

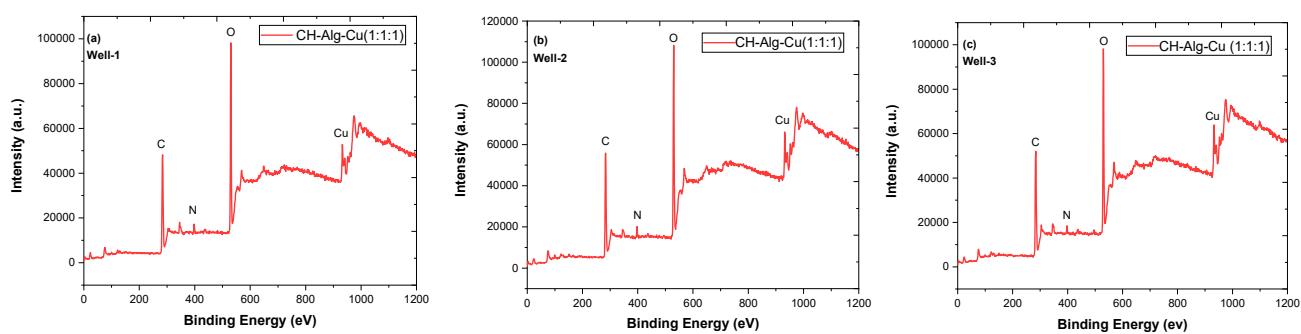


Figure S5. XPS wide scan spectra of CACu1 after the adsorption process.



## Supporting Information

**Table S5.** Measured (ICP-OES) copper concentration in well water samples and various composite materials (chitosan powder (C), chitosan pellet (CP), CAA1 (chitosan-alginate-aluminum) and two CPCu (chitosan pellet; copper) as well as two CACu (chitosan, alginate, copper) materials) to assess potential health hazards from copper leaching of the polyelectrolyte composite materials and comparison to CBMS, where copper was replaced with aluminum to compare it with the copper containing materials concerning leaching.

Source water	[Cu(II)] (cps)	RSD (%)	Reported ( $\mu\text{g/L}$ )
Well-1	44	24.2	<8.29
Well-2	32	9.9	<8.29
Well-3	46	12.4	<8.29
C	12	31.0	<8.29
CP	13	55.9	<8.29
CAA1	207	45.2	<8.29
CPCU7	3677	8.9	<1000
CPCU4	7228	0.9	<1000
CACu4	6565	2.5	<1000
CACu	7268	4.7	<1000