

CENE 476 PROPOSAL

CORN COB BIOSORBENT RESEARCH (CORN CORPS.)

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Project Purpose

- Biosorbent: biological material that is used to remove contaminants from aqueous solution
- Identify if ground corn cob can remove heavy metals from drinking water
 - *Cadmium (Cd)*
 - *Lead (Pb)*
- Health Effects
 - *Cadmium: nausea/vomiting, muscle cramps, sensory disturbances, kidney failure [1]*
 - *Lead: nausea/vomiting, abdominal pain, memory loss, nervous system damage [2]*

Client and Background

- Client: Dr. Fethiye Ozis
- NASA Space Grant research (2017-18)
 - *HACH 8017*
 - Test 10µg/L , 25 µg/L, 80 µg/L
 - Triplicates conducted
 - *Inconclusive Isotherm adsorption model*
 - Limited concentrations
 - Linear rate

Table 1: Test results initial and final concentrations [3]

Test Results			
	Test 1	Test 2	Test 3
C_i (ug/L)	C_f (ug/L)	C_f (ug/L)	C_f (ug/L)
10	11.08*	7.13	14.41*
25	14.67	33.41*	14.41
80	42.95	28.84	45.52

Table 2: Removal Efficiencies [3]

Removal Efficiencies	
Initial concentrations	Average % removal
10 (ug/L)	9
25 (ug/L)	42
80 (ug/L)	51

Research Plan – Major Tasks

Task 1.0 – Experimental Methods

Task 2.0 – Isotherm Development

Task 3.0 – Prototype Development

Task 4.0 – Pilot Testing and Scale-up

Task 5.0 – Cost-Benefit Analysis

Task 6.0 – Team Management



Task 1.0 – Experimental Methods

Task 1.1 – Corn Biosorbent Preparation

- Dry, pulverize, sieve
- Treatment with 1N nitric acid and sodium hydroxide



Figure 1: Dried corn cob prior to pulverization



Figure 2: Sieving of pulverized corn cob

Task 1.0 – Experimental Methods

Task 1.2 – Cadmium Testing

- 90-minute batch reaction time
- Total 5 concentrations with triplicates
- HACH 8017 Dithizone method (10 µg/L - 80µg/L)

Table 3: Cadmium experimental matrix

Cadmium Experimental Matrix			
Experiment	Initial Concentration, Ci (µg/L)	Treated	Number of Tests
Cd-1	10	No	3
Cd-2	20	No	3
Cd-3	35	No	3
Cd-4	50	No	3
Cd-5	75	No	3
Cd-6	10	Yes	3
Cd-7	20	Yes	3
Cd-8	35	Yes	3
Cd-9	50	Yes	3
Cd-10	75	Yes	3

Task 1.0 – Experimental Methods



Figure 3: Liquid-liquid separation

Table 3: Cadmium experimental matrix

Cadmium Experimental Matrix			
Experiment	Initial Concentration, C_i ($\mu\text{g/L}$)	Treated	Number of Tests
Cd-1	10	No	3
Cd-2	20	No	3
Cd-3	35	No	3
Cd-4	50	No	3
Cd-5	75	No	3
Cd-6	10	Yes	3
Cd-7	20	Yes	3
Cd-8	35	Yes	3
Cd-9	50	Yes	3
Cd-10	75	Yes	3

Task 1.0 – Experimental Methods

Table 3: Lead experimental matrix

Lead Experimental Matrix			
Experiment	Initial Concentration, Ci (µg/L)	Treated	Number of tests
Pb-1	10	No	3
Pb-2	50	No	3
Pb-3	100	No	3
Pb-4	175	No	3
Pb-5	225	No	3
Pb-6	300	No	3
Pb-7	10	Yes	3
Pb-8	50	Yes	3
Pb-9	100	Yes	3
Pb-10	175	Yes	3
Pb-11	225	Yes	3
Pb-12	300	Yes	3

Task 1.3 – Lead Testing

- 90-minute batch reaction time
- Total 6 concentrations with triplicates
- HACH 8033 Dithizone method (3 µg/L - 300µg/L)

Task 2.0 – Isotherm Development

Example:

- Freundlich Isotherm

$$q = K C_e^{1/n}$$

- q = mass of metal per unit mass of corn ($\mu\text{g/g}$)
- K = Freundlich isotherm partition coefficient (L/g)
- C_e = equilibrium aqueous metal concentration ($\mu\text{g/L}$)
- $\frac{1}{n}$ = Freundlich isotherm intensity parameter (unit-less)

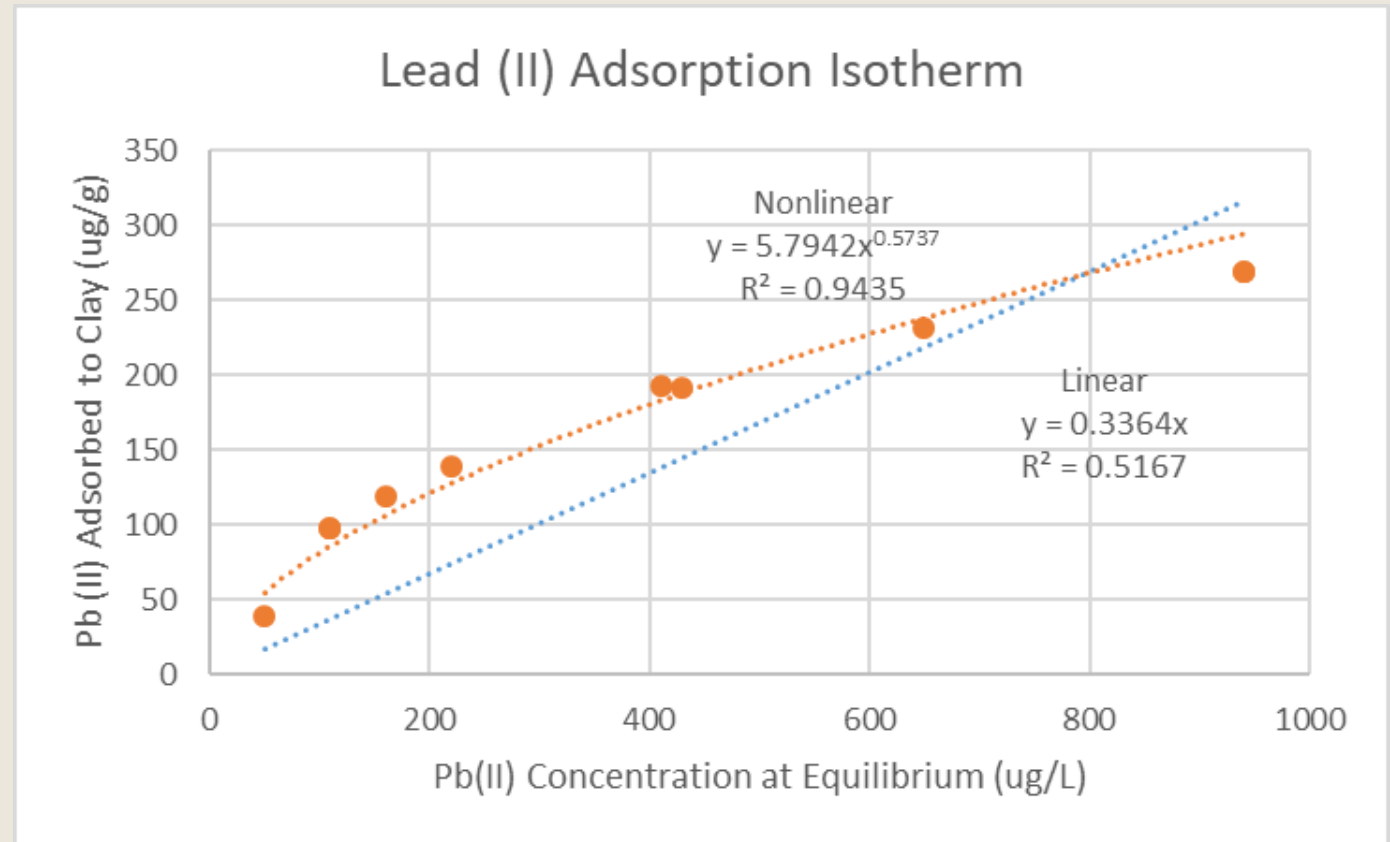


Figure 3: Example data set showing a non-linear isotherm model [4]

Task 3.0 – Prototype Development

■ Task 3.1 Design Calculations

- Based on the ideal ratio of mass of metal adsorbed per unit mass of corn cob (determined from the isotherm)
- Based on desired contact time designated by the client
- Prototype dimensions will be completed

■ Task 3.2 Prototype Construction

- Construction plan for tower will be developed using SolidWorks
- Acrylic plexiglass tower will be manufactured by NAU Machine Lab

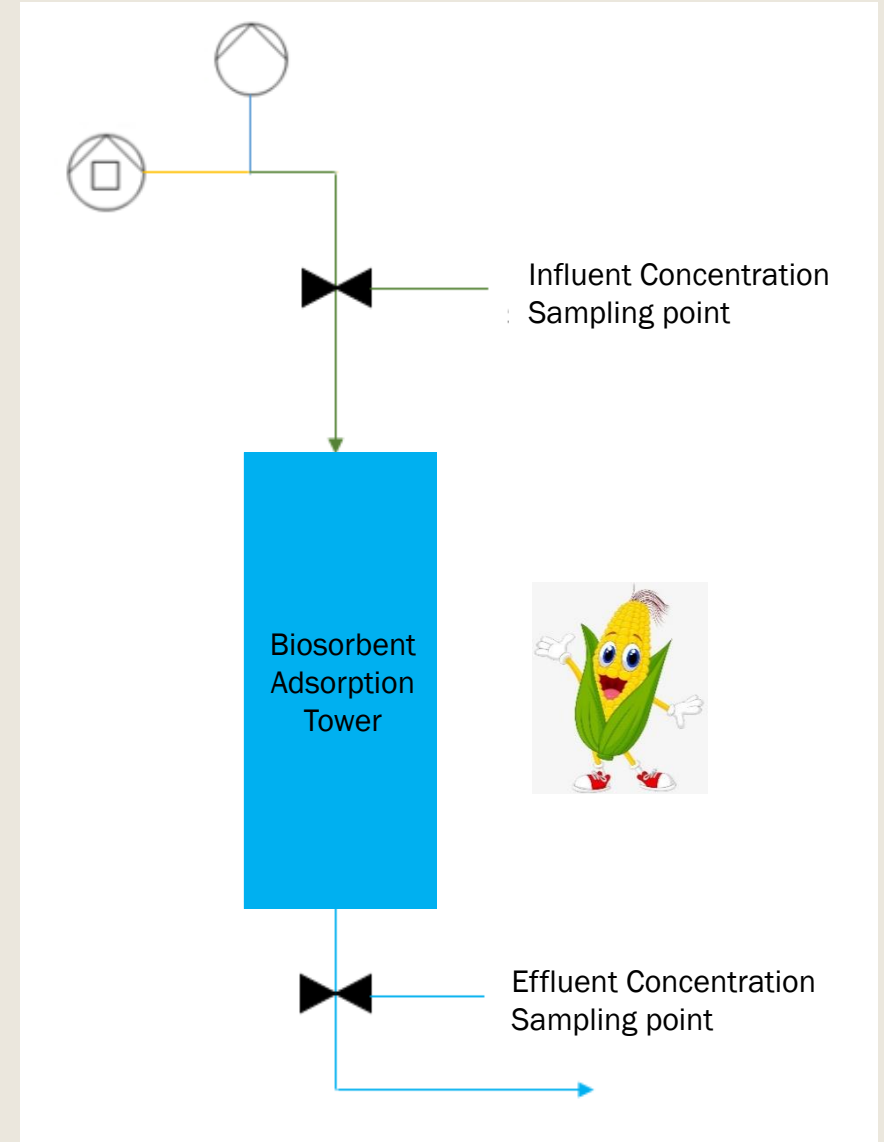


Figure 4: Adsorption Tower Schematic

Task 4.0 – Pilot Testing and Scale-up

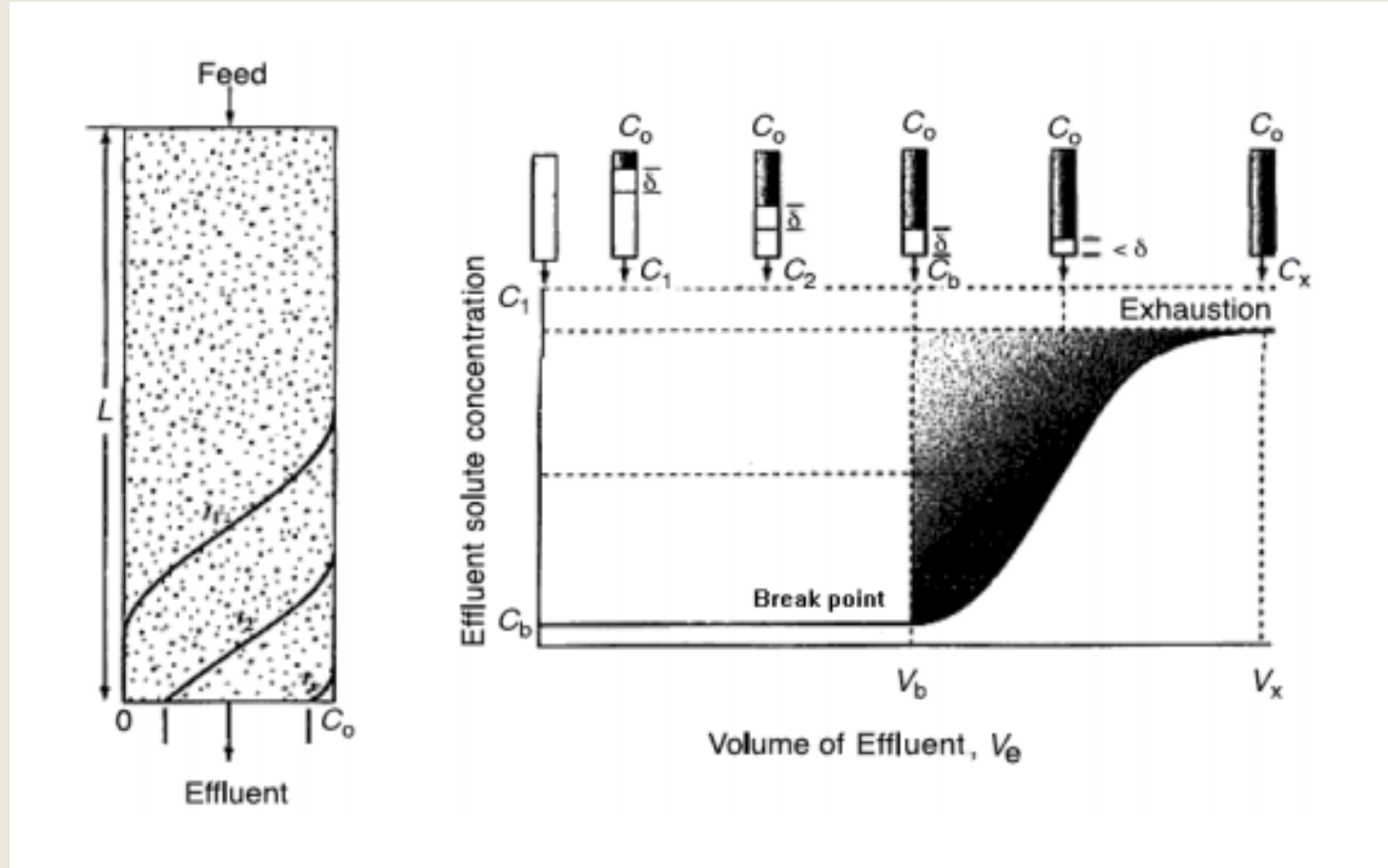


Figure 5: Pilot Test and Breakthrough Curve Example [5]

- Cadmium and lead pilot testing of bench-scale prototype
 - *determines time before biosorbent needs replacement*
- Results will be plotted to create a breakthrough curve
 - *Curve will be used to scale up the prototype to model a full-scale design*

Task 5.0 – Cost Benefit Analysis

- Task 5.1 – Feasibility Assessment
 - *Corn cob vs. comparable technology*
 1. *Effectiveness*
 2. *Cost*
- Task 5.2 – Assessment of Potential Impacts
 - *Environmental benefits*
 - *Cultural benefits*
 - *Economic benefits*



Figure 6: Ground corn vs granular activated carbon [6]

Task 6.0 – Project Management

■ Task 6.1 – Professional/Team Interactions

- *Team meetings (min. weekly)*
 - Schedule check-in
- *Client/TA (biweekly)*
- *GI (as needed)*
- *Additional professional meetings (as needed)*
- *Agenda/Meeting Minutes*

■ Task 6.2 – Project Deliverables

- *Task 6.2.1 30% Report*
- *Task 6.2.2 60% Report*
- *Task 6.2.3 Final Report*
- *Website*
- *Final Presentation*

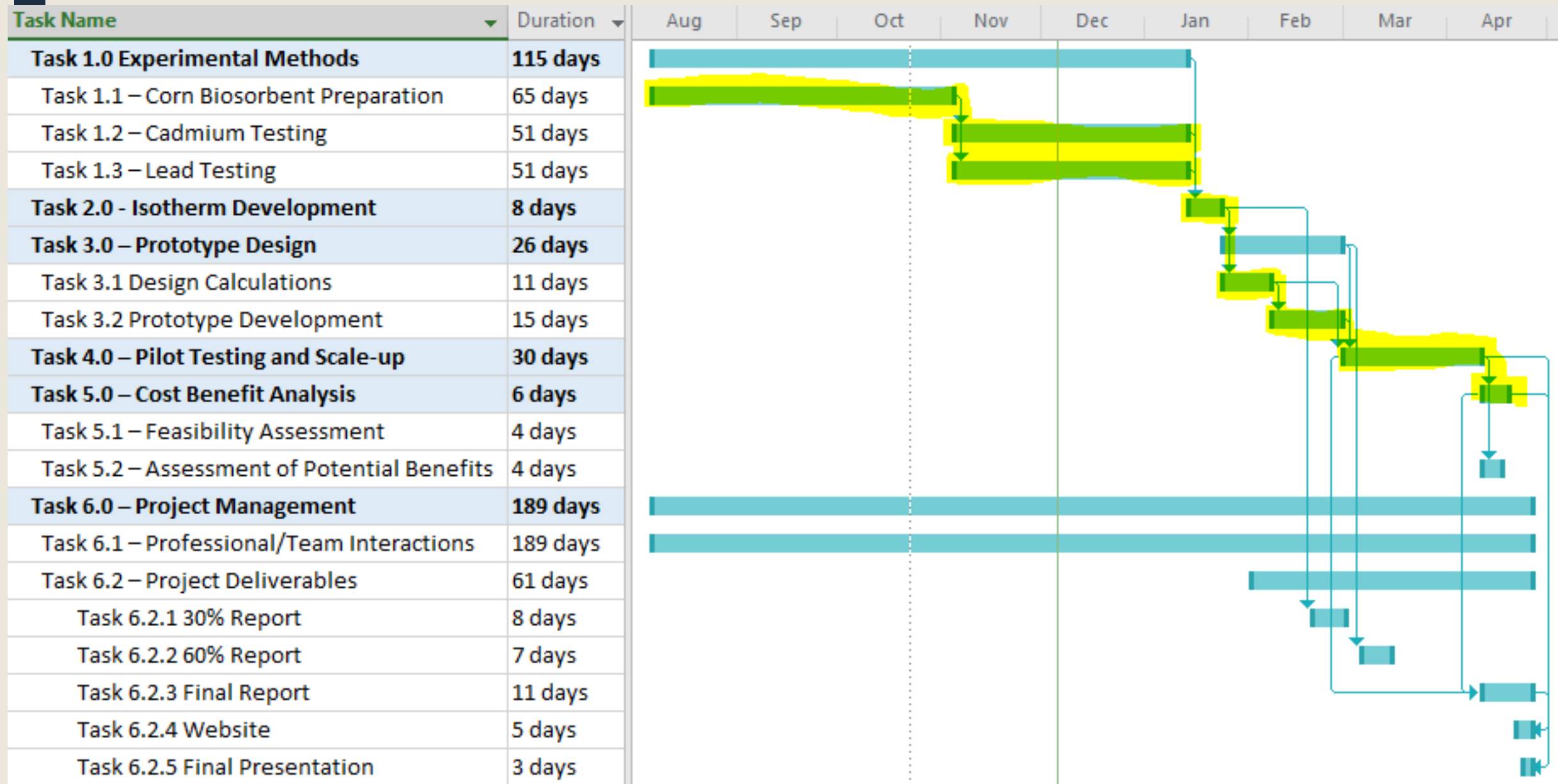


Figure 7: Gantt chart

Staffing Plan

Table 4: Task Matrix

Legend

Classification	Code
Senior Engineer	SENG
Engineer	ENG
Lab Technician	LAB

Task	SENG Hours	ENG Hours	LAB Hours	Total
Task 1.0 Experimental Methods	0	0	190	190
Task 1.0 Experimental Methods				0
Task 1.1 Corn Biosorbent Preparation			36	36
Task 1.2 Cadmium Testing			71	71
Task 1.3 Lead Testing			83	83
Task 2.0 Isotherm Development	1	11	0	12
Task 3.0 Prototype Design	8	14	0	22
Task 3.1 Design Calculations	1	9		10
Task 3.2 Construction Drawings	1	5		6
Task 3.3 Construction	6			6
Task 4.0 Pilot Testing and Scale-up	2	12	109	123
Task 5.0 Cost Benefit Analysis	1	11	0	12
Task 5.1 Feasibility Assessment	0.5	5.5		6
Task 5.2 Assessment of Benefits	0.5	5.5		6
Task 6.0 – Project Management	113	153	0	266
Task 6.1 Professional/Team Interactions	108			108
Task 6.2 Project Deliverables		79		79
Task 6.2.1 30% Report		16		16
Task 6.2.2 60% Report		20		20
Task 6.2.3 Final Report	5	10		15
Task 6.2.4 Website		20		20
Task 6.2.5 Final Presentation		8		8
TOTAL	125	201	299	625

Cost of Engineering Services

Table 5: Total Projected Project Cost

1.0 Personnel			
Classification	Hours	Rate, \$/hr	Cost
SENG	125	120	\$15,000
ENG	201	90	\$18,090
LAB	299	55	\$16,445
Total			\$49,535
2.0 Supplies			
Item	Quantity	Cost Each	Cost Total
Syringe Pump	1	300	\$300
Cadmium Reagents	56	6.80	\$381
Lead Reagents	63	7.52	\$474
Acrylic Plexiglass (2'x6')	1	14	\$14
Corn Cobs	60	1	\$60
Ninja Food Processor	1	20	\$20
PPE	4	90	\$360
Lab Rental Fee	45 days	286/day	\$12,870
Total			\$14,479
3.0 Subcontracting			
Subcontractor	Cost		
Engineering Fabrication Shop	\$50		
Total	\$50		
Project Total			
			\$64,064

References

- [1] Agency for Toxic Substances and Disease Registry, Cadmium Toxicity: What Diseases Are Associated with Chronic Exposure to Cadmium? 12 May 2008. [Online]. Available: <https://www.atsdr.cdc.gov/csem/csem.asp?csem=6&po=12>. [Accessed 21 October 2018].
- [2] Mayo Clinic, Lead Poisoning; 6 December 2016. [Online]. Available: <https://www.mayoclinic.org/diseases-conditions/lead-poisoning/symptoms-causes/syc-20354717>. [Accessed 21 October 2018].
- [3] M. Jacquez, "Cadmium Removal from an Aqueous Solution by Corn Cob Biosorbent," Northern Arizona University, 2018.
- [4] J. Gilbert, "CENE 282L Adsorption Analytics Lab 2," Northern Arizona University, 2018.
- [5] "Chapter 6 Column Studies," http://shodhganga.inflibnet.ac.in/bitstream/10603/3037/12/12_chapter%206.pdf, p. 187
- [6] Alibaba, "Coal-based mining granular activated carbon," 2018. [Online]. Available: https://www.alibaba.com/product-detail/Coal-based-mining-granular-activated-carbon_50018921744.html.