Sargassum hydrochar for the removal of cadmium and lead in aqueous solutions: A new perspective for environmental remediation

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CONAHCYT

INTRODUCTION

Environmental contamination with heavy metals poses a significant threat to ecosystems and human health. This study explores a novel approach to remediate cadmium and lead contaminated water using hydrochar derived from brown algae Sargassum. Sargassum is an abundant biomass resource in coastal regions and presents a sustainable solution for heavy metal removal. The main objective of this research is to evaluate the adsorption potential of Sargassum-derived hydrochar for the removal of Cd and Pb from aqueous solutions. The influence of pH on the adsorption efficiency is investigated and information on the underlying mechanisms is provided. Experiments were performed using static adsorbers to evaluate single and multicomponent adsorption systems. This approach allows us to examine the competitive adsorption behavior of Cd and Pb when present together in water, providing valuable insights into real-world scenarios. Our findings reveal that Sargassum-derived hydrochar exhibits remarkable adsorption capacity for both Cd and Pb (141 and 333 mg g-1, respectively). The Radke-Prausnitz isotherm model fits the experimental data well, suggesting both monolayer and multilayer adsorption. It was observed that the presence of lead is antagonistic to cadmium removal, reducing its adsorption efficiency. However, this antagonistic effect is not observed in the reverse scenario, as previously reported for unmodified Sargassum. Sargassum-derived hydrochar demonstrates great potential as an effective adsorbent for the removal of Cd and Pb from polluted waters. This sustainable and readily available material offers a promising solution for environmental remediation.

STAGE 1

SARGASSUM HARVESTING

STAGE 2

WASHING, GRINDING, SIEVING AND PRESERVATION

STAGE 3

HYDROCARBONIZATION

STAGE 4

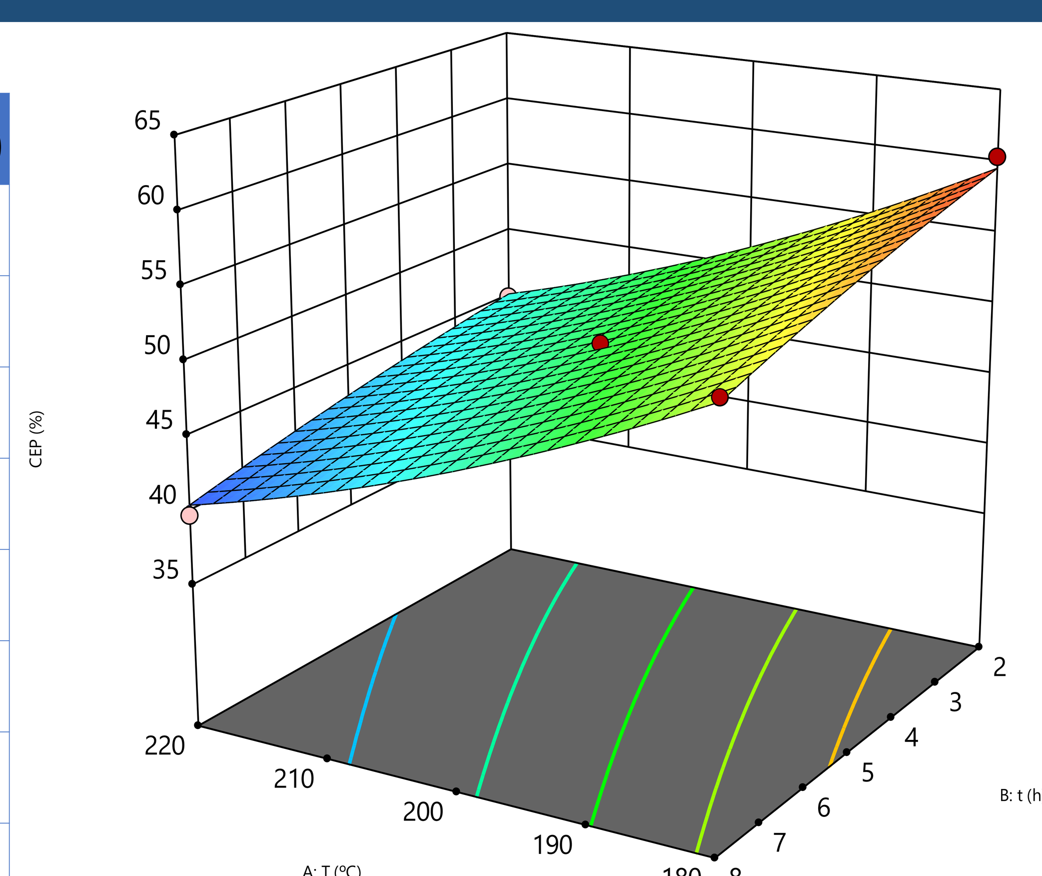
CHARACTERIZATION AND ADSORPTION EXPERIMENTS

DESIGN OF EXPERIMENTS

RESULTS

HYDROCHAR SYNTHESIS

Exp.	T (°C)	t (h)	r (mL g^{-1})	CEP (%)	S (m^2 g^{-1})	PZC	q_{Cd} (mg g^{-1})	q_{Pb} (mg g^{-1})
HCS-1	200	2.0	5.0	50.14	120.2	6.13	63.97	175.23
HCS-2	200	8.0	5.0	46.84	81.7	6.28	45.55	164.34
HCS-3	180	2.0	7.5	60.35	126.7	6.00	64.82	184.84
HCS-4	200	2.0	10	51.55	99.4	6.16	62.72	172.48
HCS-5	220	8.0	7.5	39.73	52.5	6.81	37.07	165.63
HCS-6	200	5.0	7.5	49.32	101.5	6.25	50.93	158.97
HCS-7	180	8.0	7.5	54.06	86.2	6.14	45.06	138.71
HCS-8	220	5.0	5.0	43.79	62.1	6.63	40.85	159.51
HCS-9	200	5.0	7.5	49.32	75.4	6.24	47.99	155.97
HCS-10	220	5.0	10	43.21	77.5	6.65	41.85	158.57
HCS-11	200	8.0	10	45.26	74.1	6.43	41.53	145.34
HCS-12	220	2.0	7.5	45.02	92.7	6.47	53.98	163.30
HCS-13	200	5.0	7.5	48.32	84.8	6.23	50.57	153.08
HCS-14	180	5.0	5.0	56.12	114.7	6.09	46.75	141.34
HCS-15	180	5.0	10	56.54	105.1	6.09	46.92	144.56

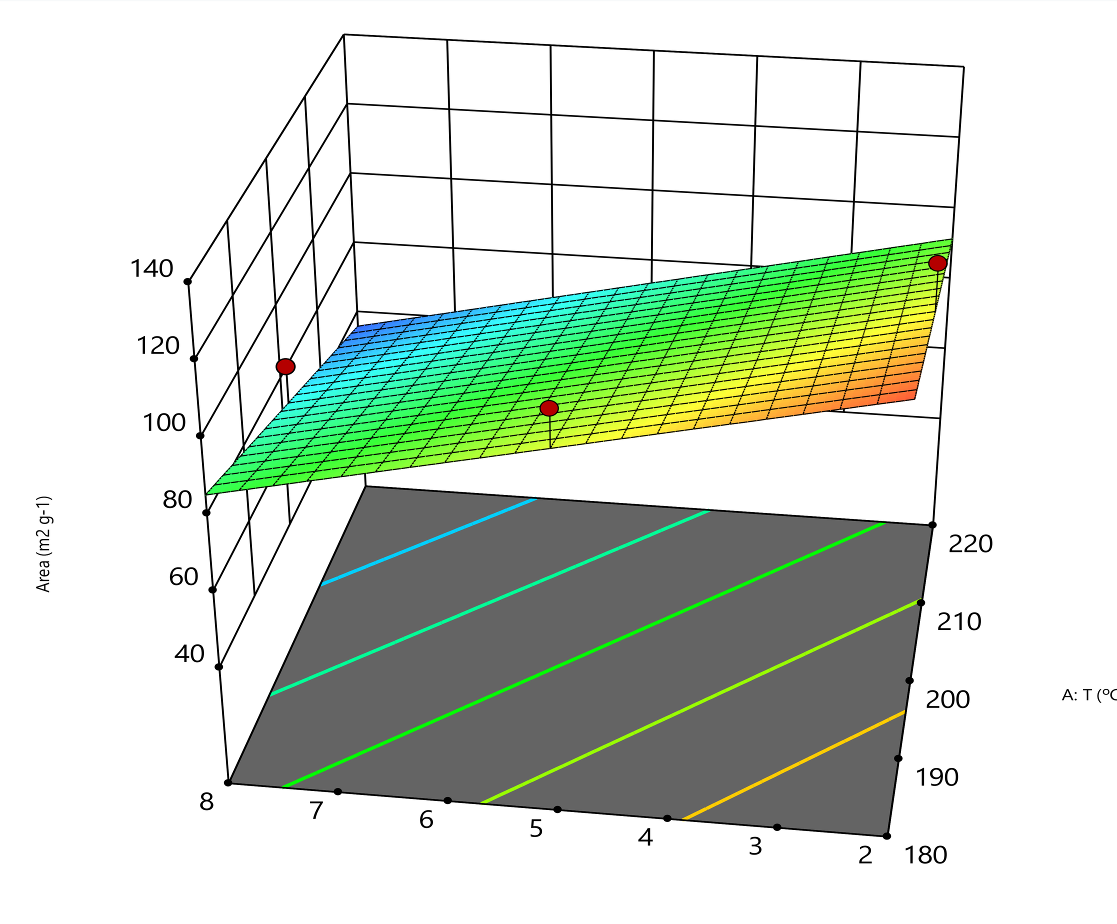


Estimated parameter	Value
T (ºC)	180
t (h)	2
CEP Max. (%)	57.35

Max. CEP (%) = 60.35

% Dev = 1.3 %

$$CEP\,(\%) = 246.1 - 1.9T - 3.2t + 7.3r$$

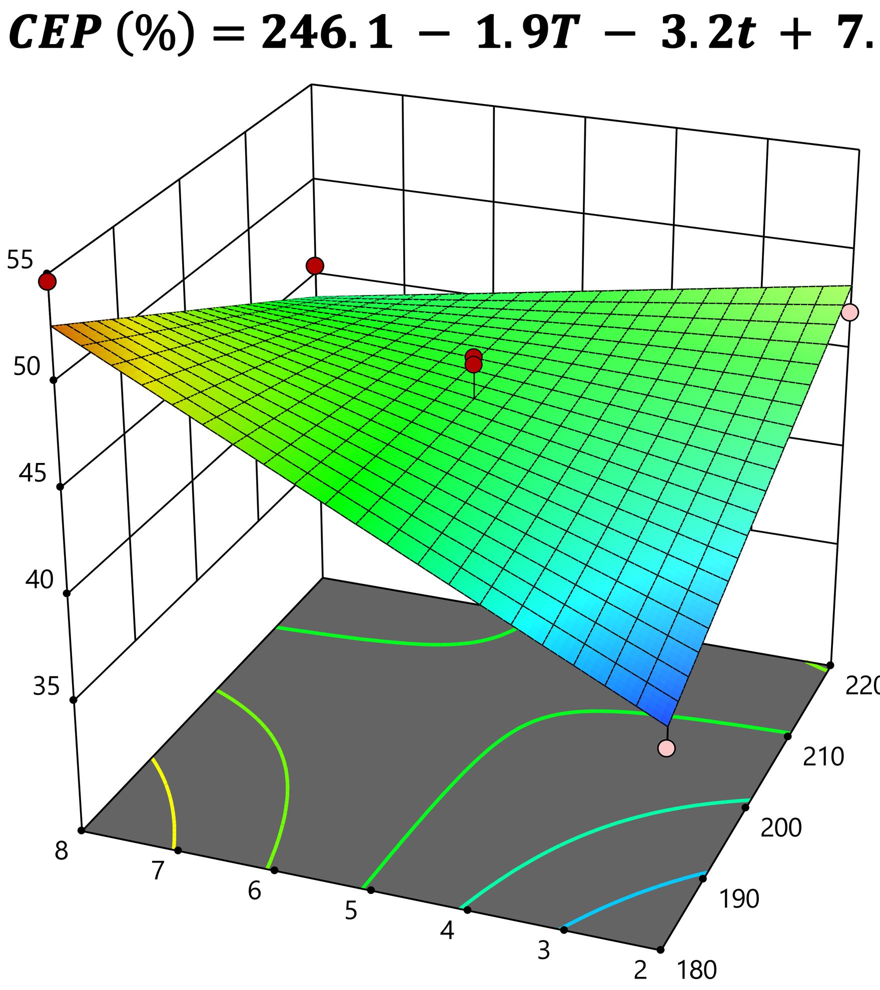


Estimated parameter	Value
T (ºC)	180
t (h)	2
Max Surface (m^2/g)	121.4

Max S (m^2/g) = 126.7

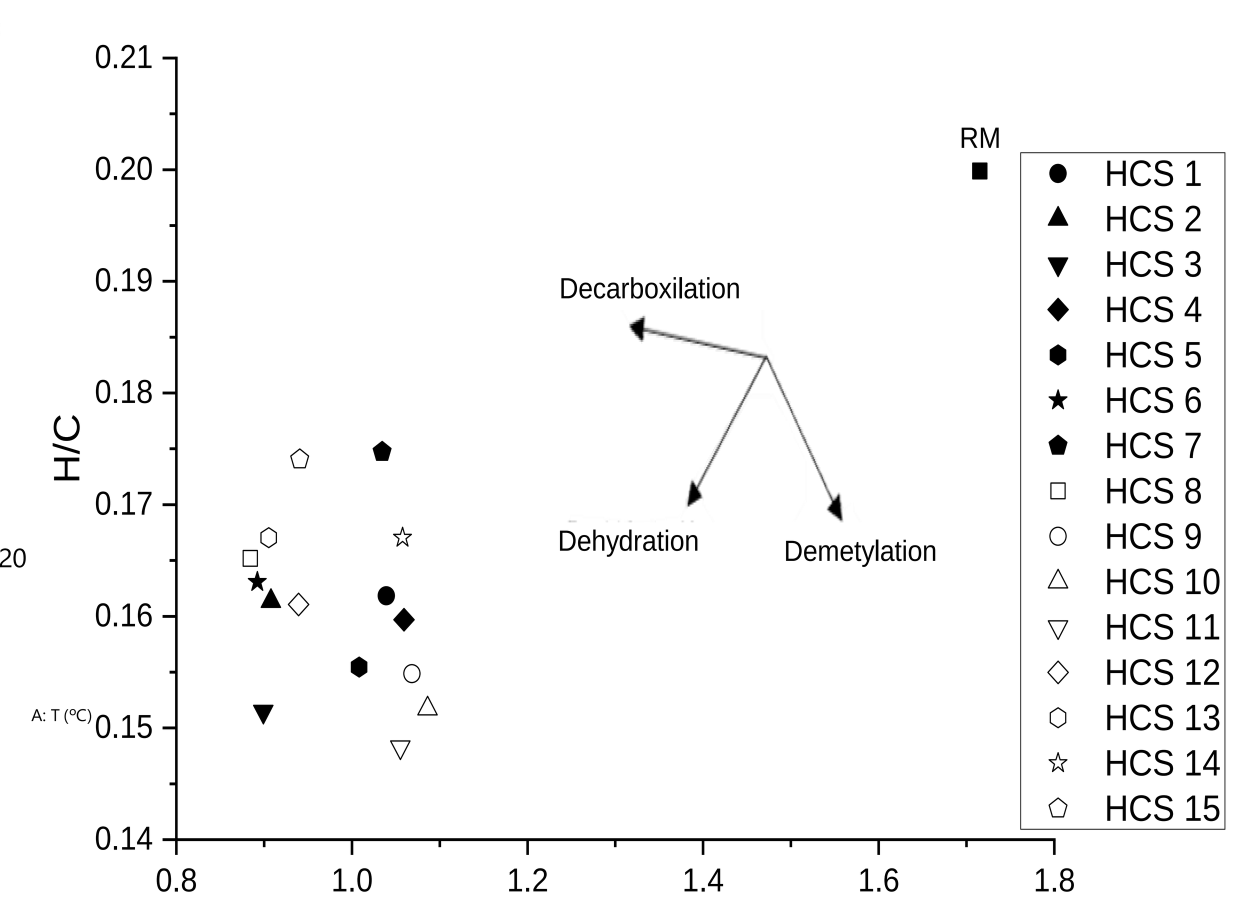
% Dev = 4.1 %

$$S = 269.18 - 0.75T - 6.02t$$

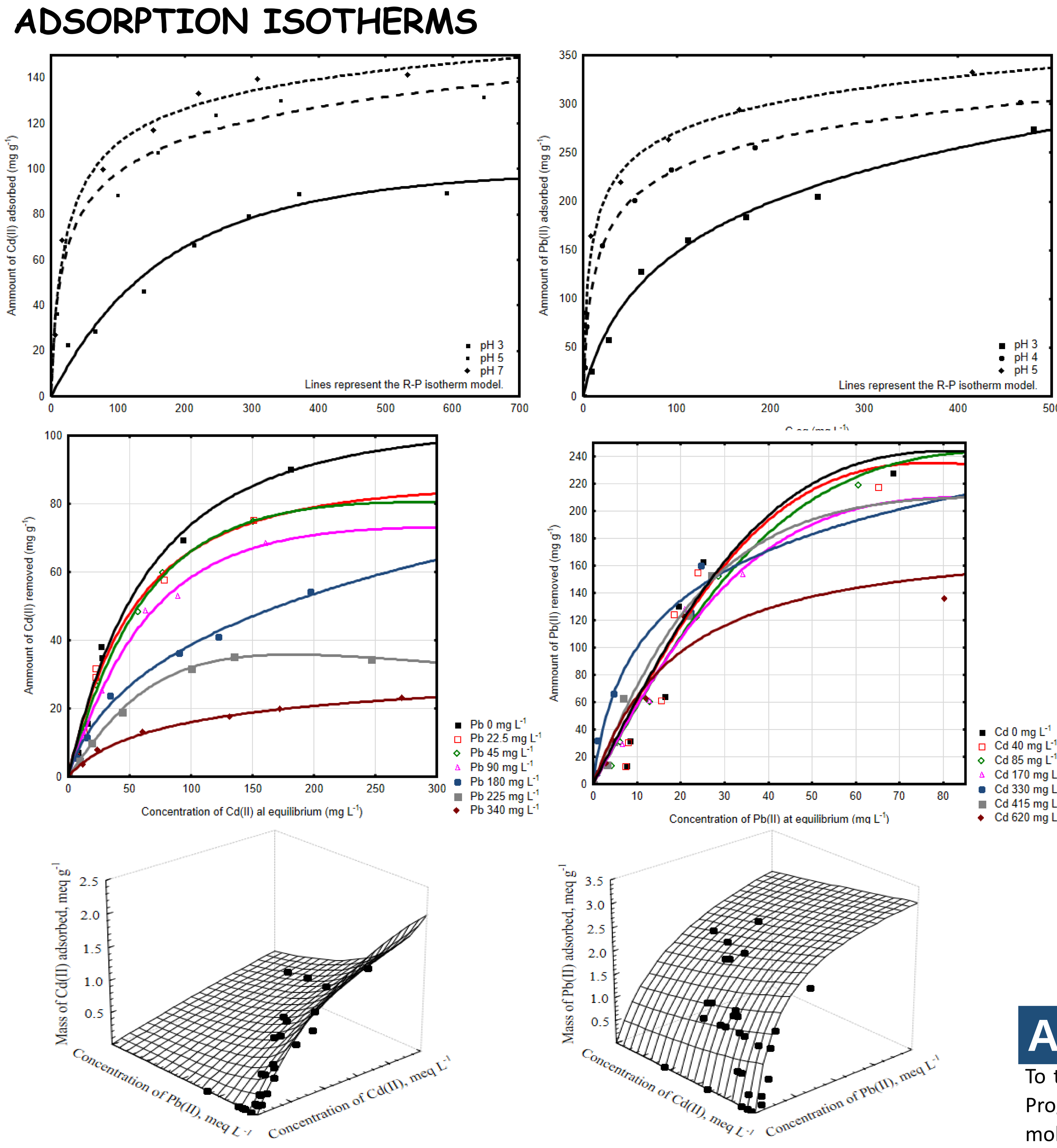


$$\%C = -82.79 + 16.36t - 0.07T \cdot t$$

$55 > \%C > 35.0$



ADSORPTION ISOTHERMS



CONCLUSIONS

The physicochemical analysis of hydrocarbons derived from Sargassum biomass from the Mexican Caribbean coast shows that their morphology and chemical composition favor the incorporation of metal ions such as Cd(II) and Pb(II). Among the materials synthesized, the one produced at 180°C for 2 hours (HCS-3) had the highest yield, specific area, carbon content, and cadmium and lead removal capacity. The adsorption equilibrium study revealed efficient adsorption mechanisms, with capacities above 140 mg/g for cadmium and 340 mg/g for lead. HCS-3 shows higher affinity for lead, and its use could mitigate the economic and environmental impact of Sargassum.

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