KINETIC, THERMODYNAMIC AND EQUILIBRIUM STUDIES OF THE REMOVAL OF Cd^{2+} FROM AQUEOUS SOLUTION BY HYDROXYAPATITE

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INTRODUCTION

The release of heavy metals into the ecosystem not only endangers the human and animal health but also affects the general physiology of plants, because of their toxicity, mutagenicity, and non-biodegradability [1].

Many conventional methods such as coagulation, oxidations, electrochemical, membrane separation, ion-exchange have been discussed for the removal of pollutants in effluents and wastewater [2].

Some of these methods however do not eliminate the contaminant completely; sometimes they are very expensive and usually cause other waste pollutants as secondary products [2-3].

Therefore, the purification of wastewater discharges remains a problem for many industries and it is necessary to develop new technologies to treat these wastewaters.

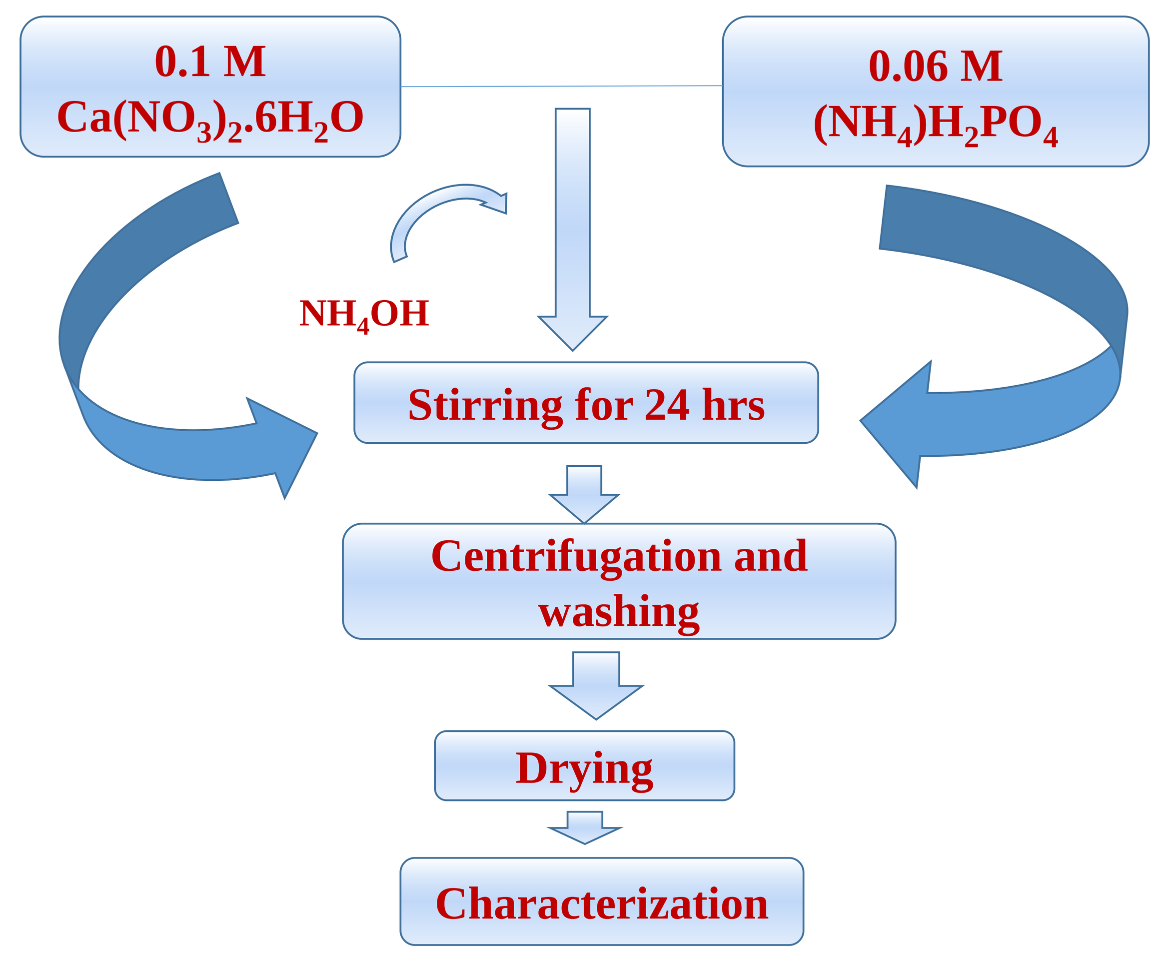
Hydroxyapatite (HAp) is one of the apatite minerals with a major inorganic constituent with about 60-70 % of the inorganic portion of the bone matrix and possesses the high ability of ion-exchange against various cations which make it highly biocompatible, bioactive and as an adsorbent for removal of organic pollutants and other divalent metal cations [3-5].

OBJECTIVES

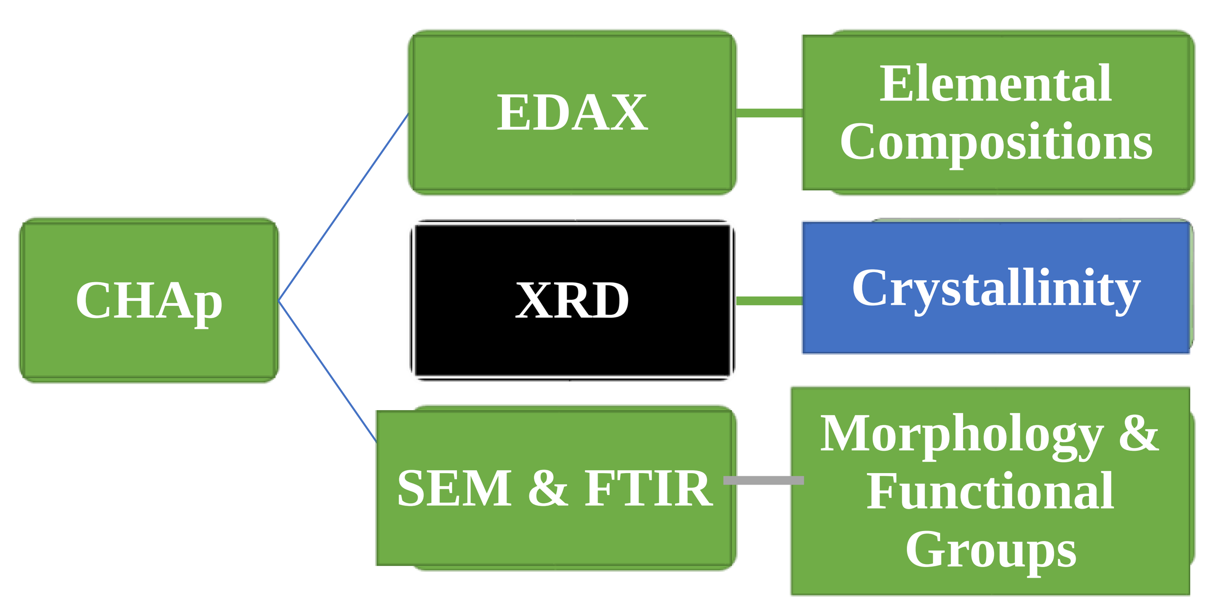
In this study, hydroxyapatite adsorbent was chemically synthesized for the adsorption of cadmium ion from aqueous solution and then characterized using XRD, FT-IR, SEM, EDAX, and TEM. The effects of initial concentration of adsorbates, contact time, pH, and adsorbent dosage were investigated. Kinetics, equilibrium, and thermodynamics of the adsorption process were also evaluated.

METHODS

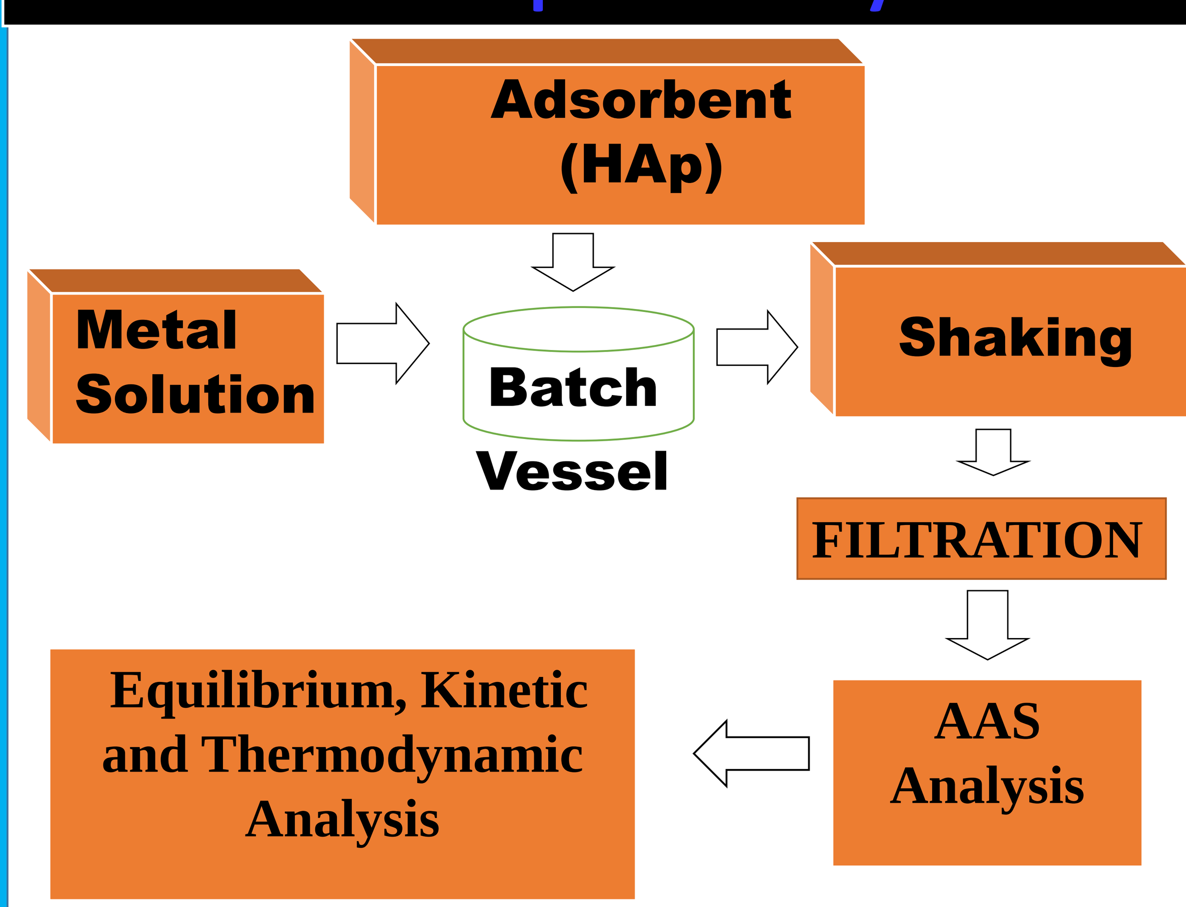
Synthesis of Hydroxyapatite



Characterization of hydroxyapatite



Adsorption Study



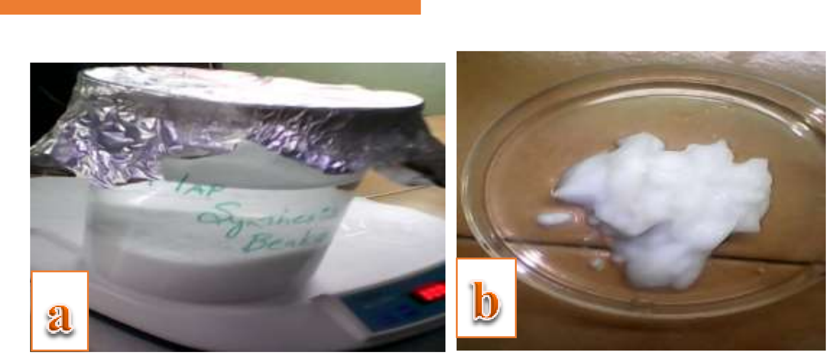


Fig.1: (a) Preparation of HAp (b) Prepared HAp cake

RESULTS

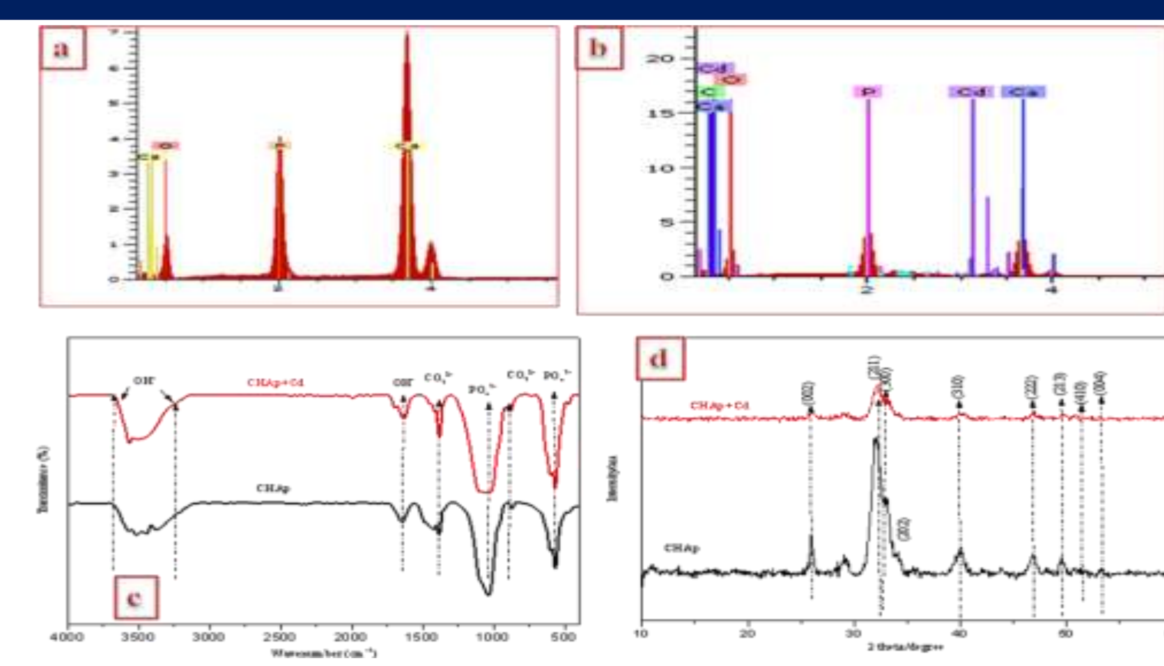


Fig.2: (a&b) EDAX, (c) FT-IR and (d) XRD analysis of CHAp powder

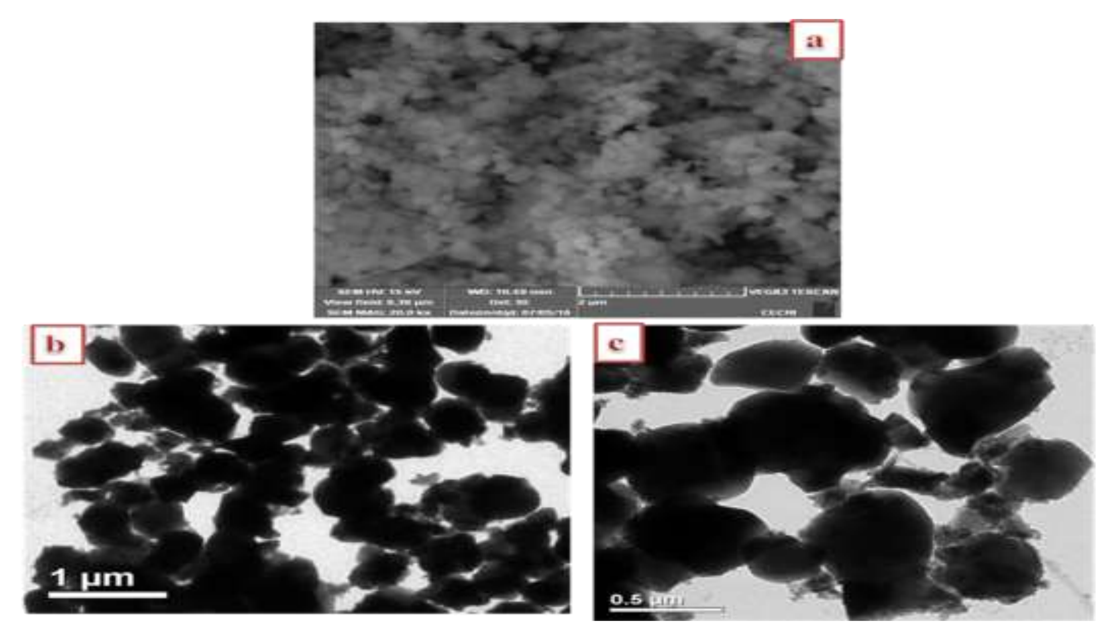


Fig. 3: (a) SEM and (b&c) TEM analysis of CHAp

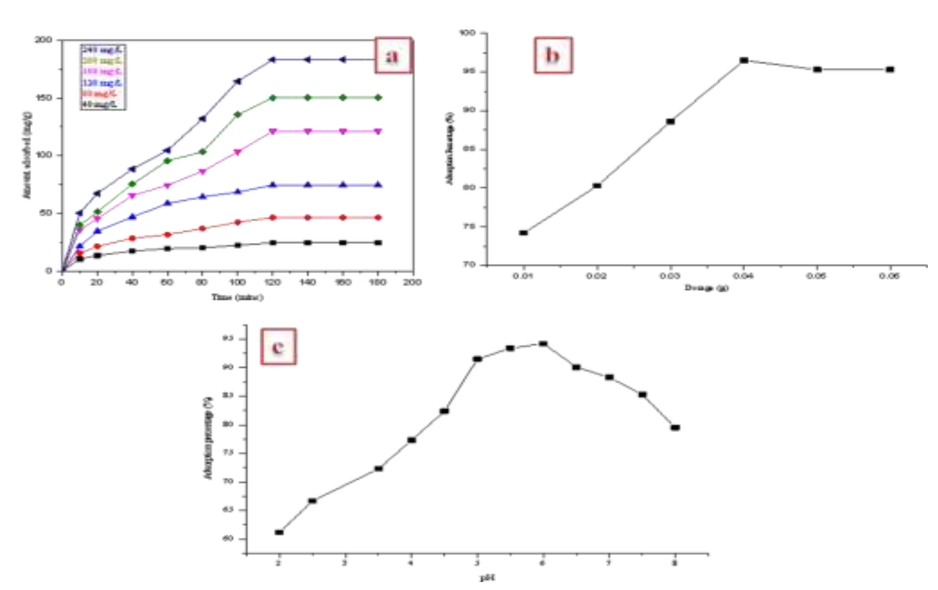


Fig.4: Effects of different parameters

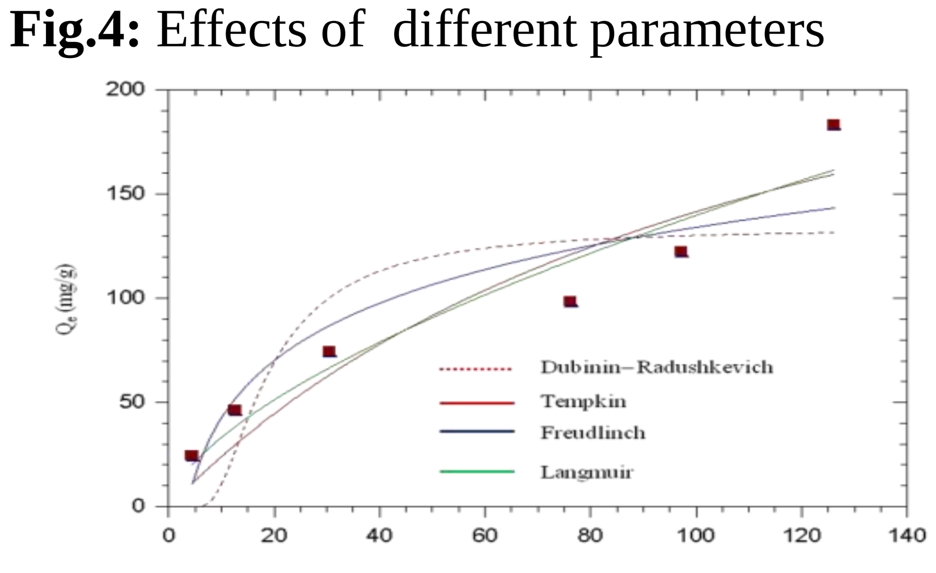


Fig.5: Isotherms fit

Thermodynamic Parameters

T (K)	K_D	ΔG (kJ/mol)	ΔH (kJ/mol)	ΔS (kJ/mol)	R^2
298	1.0028	-6.9372			
303	1.0035	-8.8170	175.5917	0.6100	0.968
308	1.0044	-11.2671			

Equilibrium Parameters

	Q_{max}(mg/g)	195.711
	R_L	0.008
	b (mg/L)	0.517
Langmuir	R^2	0.998
	K_F (mg/g)(mg/L)$^{-1/2}$	6.703
	1/n	0.624
Freudlinch	R^2	0.981
	α_T(L/g)	0.292
	b_T (J/mol)	62.378
Tempkin	R^2	0.959
	Q (mg/g)	98.924
	E (kJmol^{-1})	0.106
	ε (mol/J)^2	15.550
Dubinin– Radushkevich	R^2	0.921

Kinetic Parameters

	C_o(mg/L)	40	80	120	160	200	240
	Q_e(exp) (mg/g)	24.500	46.300	74.500	98.400	122.300	183.400
	Q_e(cal) (mg/g)	23.621	46.669	75.086	98.002	124.046	201.942
	k_1 (mins^{-1})	0.017	0.024	0.027	0.029	0.036	0.036
First order	R^2	0.994	0.995	0.999	0.997	0.998	0.993
	% SSE	0.011	0.002	0.002	0.001	0.004	0.030
	Q_e(cal) (mg/g)	32.987	56.705	91.366	116.896	151.544	267.324
	k_2 x 10^4 (g/mg/min)	6.802	4.824	3.200	2.904	1.831	5.323
Second order	R^2	0.991	0.997	0.999	0.999	0.999	0.994
	% SSE	0.104	0.068	0.068	0.057	0.072	0.138
	α(mg/g/mins)	2.868	2.527	4.284	7.087	6.758	4.891
	β(g/mg)	0.179	0.073	0.045	0.037	0.027	0.013
Elovich	R^2	0.999	0.998	0.998	0.999	0.998	0.994
	K_p(mg/g/mins$^{1/2}$)	1.752	3.547	5.798	7.433	9.533	14.891
Intra particle	C (mg/g)	3.971	3.941	6.631	11.428	10.511	0.742
diffusion	R^2	0.990	0.995	0.992	0.992	0.992	0.994

CONCLUSION

The adsorption of Cd(II) ions from aqueous solutions by CHAp powder was investigated under different experimental conditions. The uptake of Cd^{2+} was best described with first-order kinetic model, while Langmuir isotherm fitted well with the adsorption behaviour. Thus, HAp powder can serve as an excellent adsorbent for the removal of cadmium ions from contaminated wastewater

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