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COPPER (II) IONS REMOVAL FROM SIMULATED WASTEWATER USING A CHITOSAN COMPOSITE ADSORBENT-STUDY OF PROCESS EQUILIBRIUM, KINETICS AND THERMODYNAMICS

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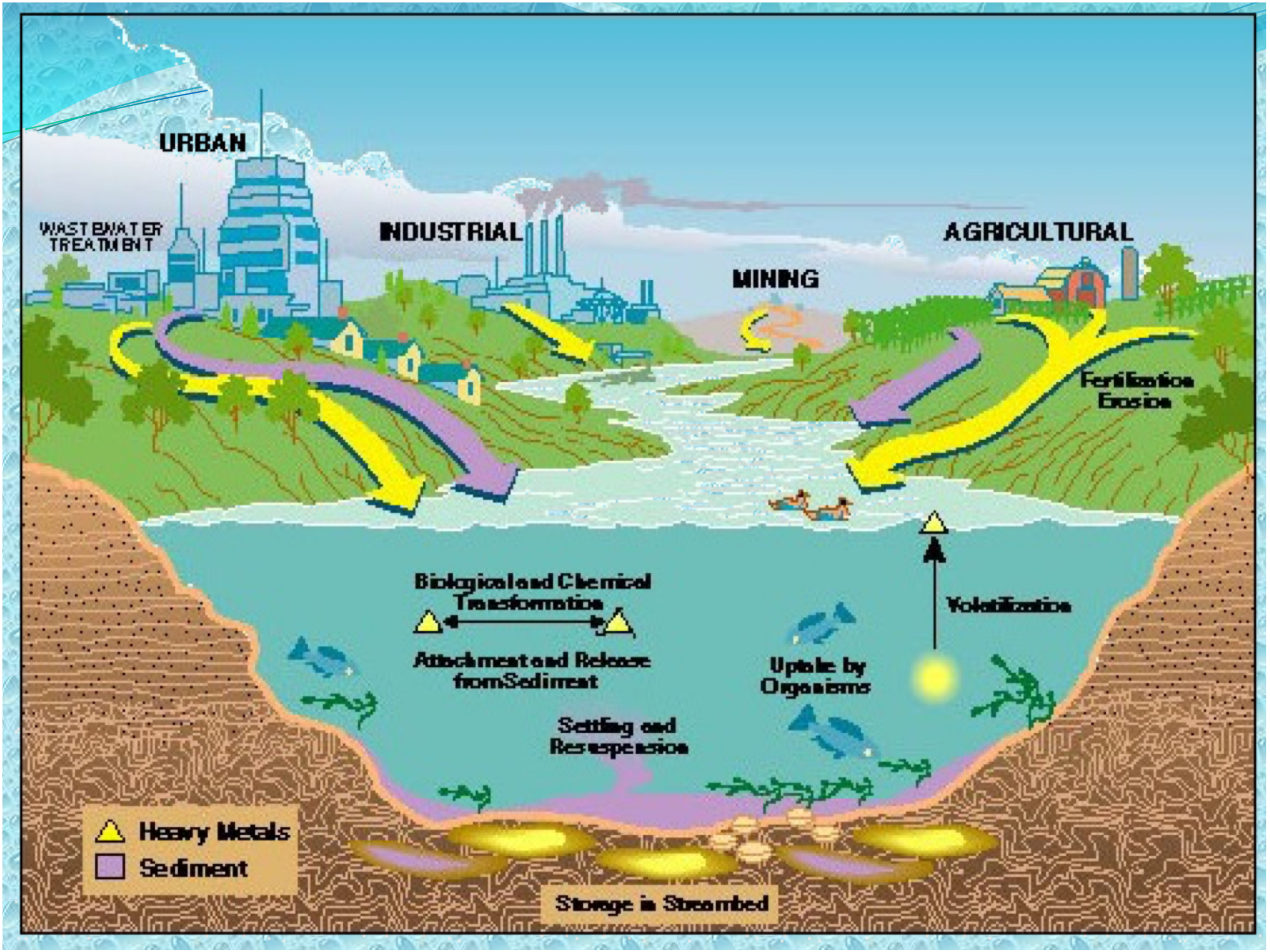
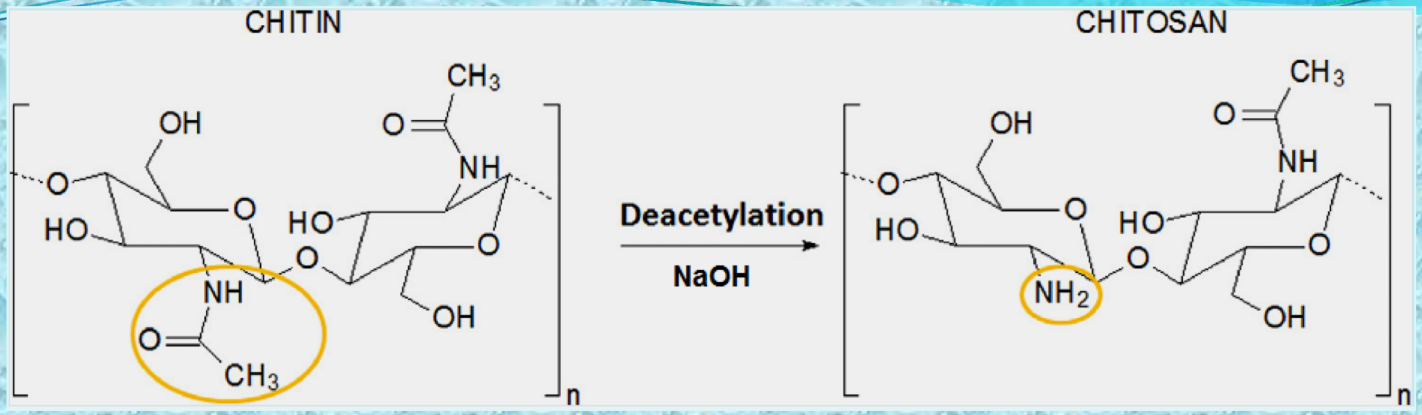
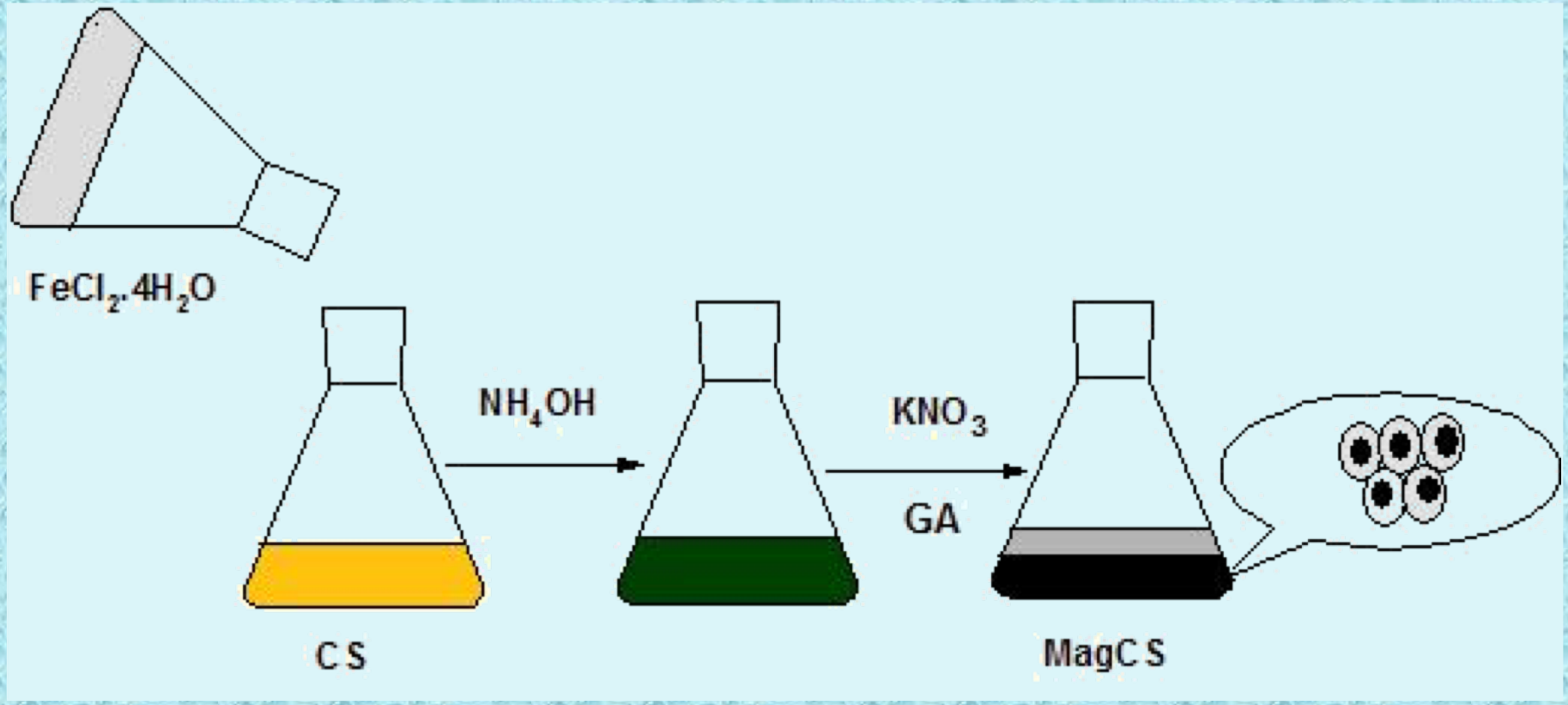

URBAN
WASTEWATER TREATMENT
INDUSTRIAL
MINING
AGRICULTURAL
Fertilization
Erosion
Biological and Chemical Transformation
Attachment and Release from Sediment
Uptake by Organisms
Volatilization
Settling and Resuspension
Heavy Metals
Sediment
Storage in Streambed

Materials and methods

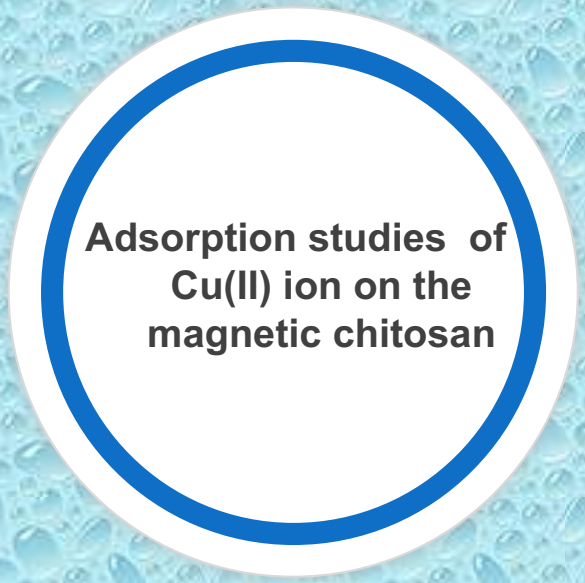


1. Sustainable raw material
2. Environmentaly friendly
3. Low cost
4. Abundant functional grups
5. Sorption characteristics

Preparation of magnetic chitosan adsorbent



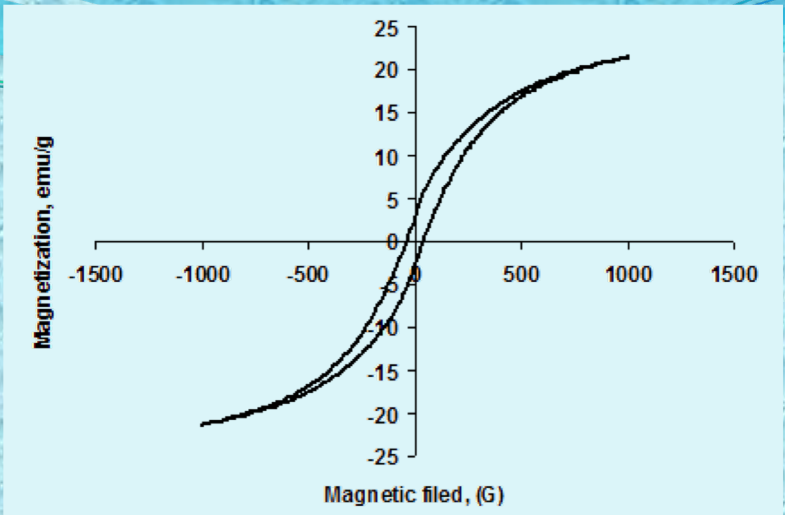
Results and discussions:



- effect of pH
- effect of initial metal ion concentration
- effect of contact time
- effect of temperature

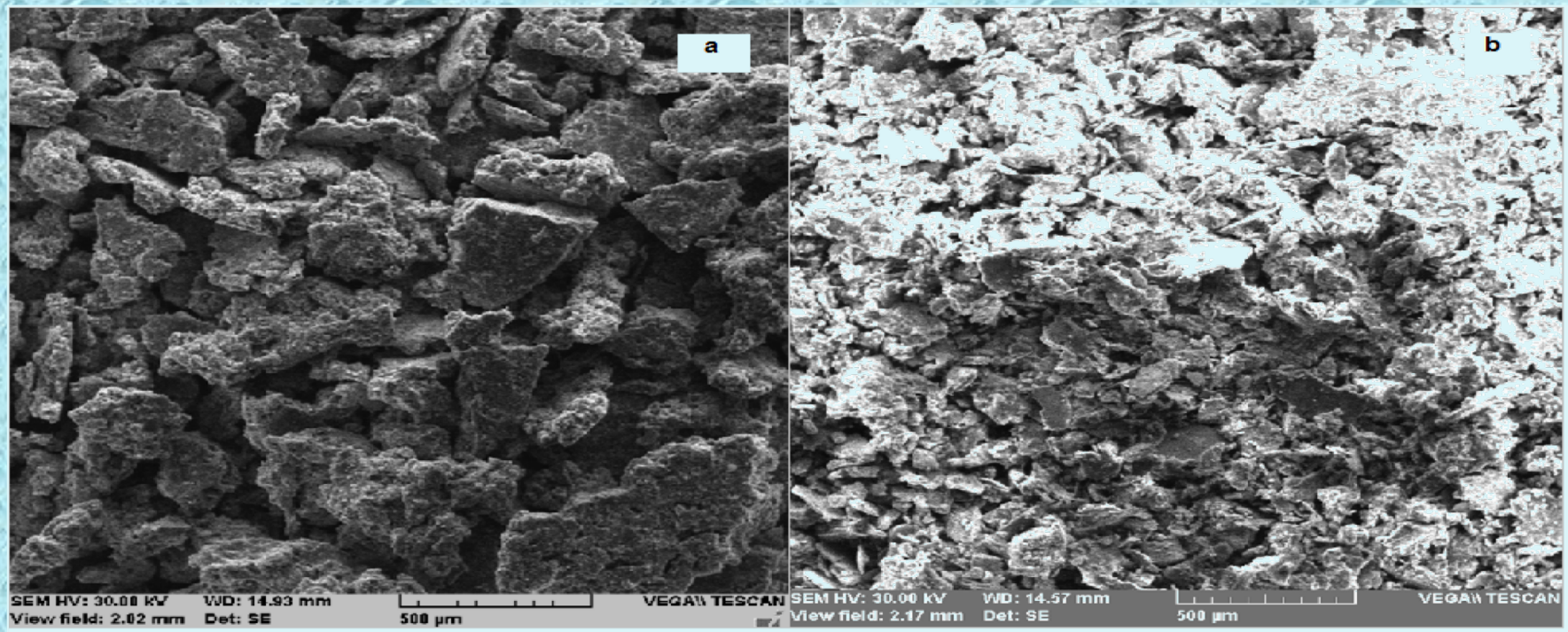
Magnetic chitosan characterization

- scanning electron microscopy (SEM)
- magnetization measurements
- particle size distribution
- energy dispersive X-ray spectrometry (EDX)



Hysteresis loop of magnetic chitosan

SEM analysis



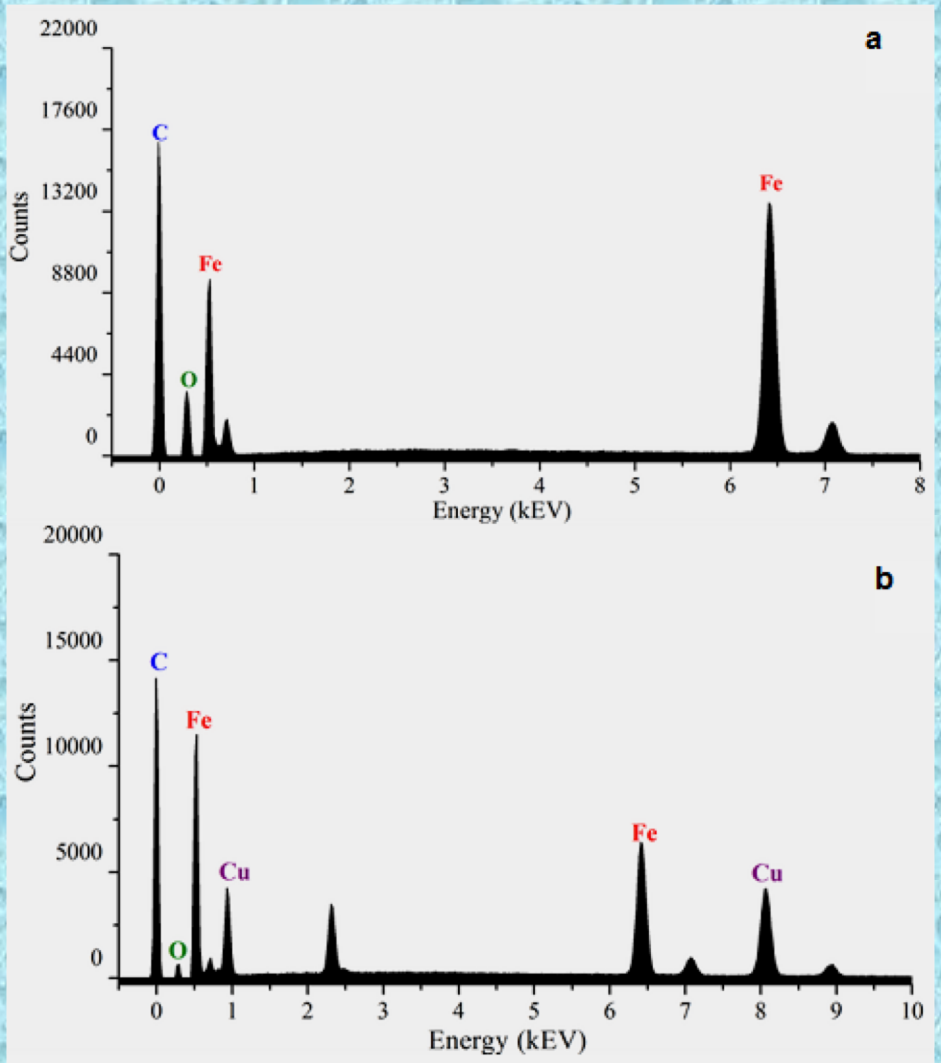
Comparative images of magnetic chitosan before copper adsorption (a) and after copper adsorption (b)

The average size and the saturation magnetization of the composite particles

Particle size distribution, μm		Magnetization, emu/g
Dn	Dv	
181.45	272.33	21.34

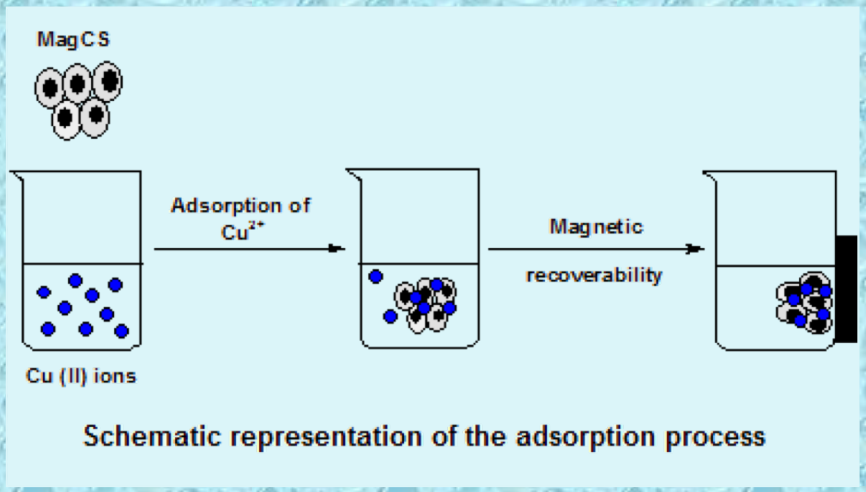
EDX analysis results

Material	MagCS		MagCS-Cu (II)	
Element	At. %	Wt. %	At. %	Wt. %
Oxygen	61.1564	39.1084	70.1262	40.9846
Iron	24.0162	53.6078	12.6327	25.7711
Carbon	14.8172	7.2780	3.5997	1.5794
Nitrogen	0.0102	0.0057	0.0002	0.0001
Copper	-	-	13.6411	31.6648

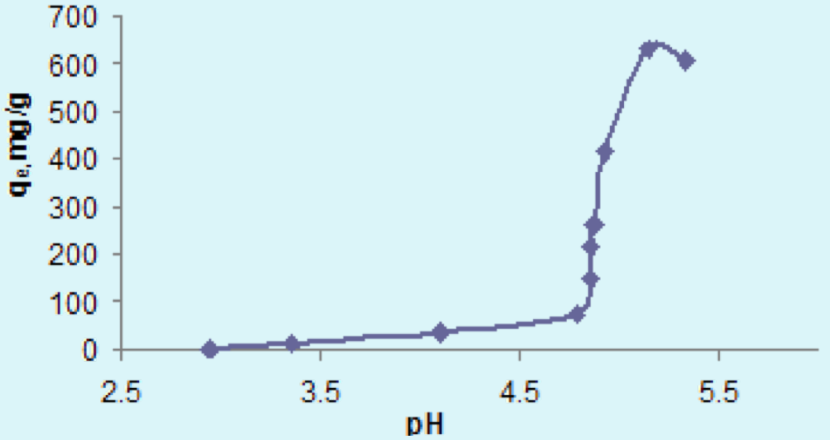


Energy disperse X-ray spectra of the composite material before (a) and after copper adsorption

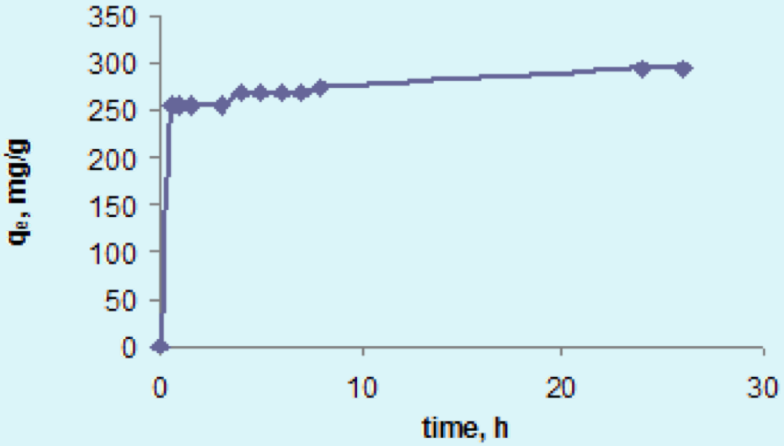
Adsorption studies



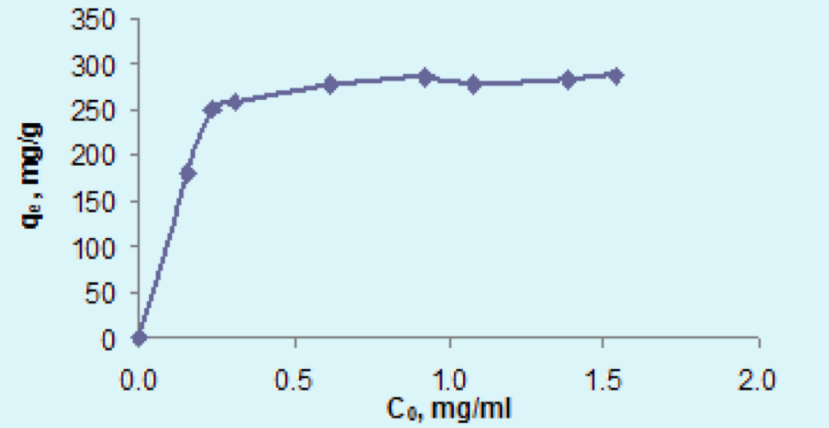
Schematic representation of the adsorption process



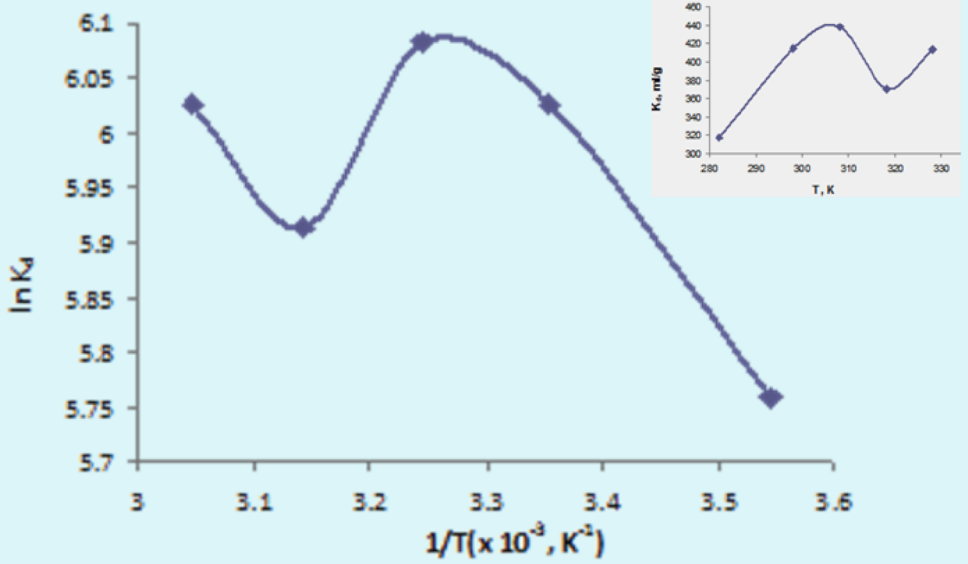
Effect of pH on sorption capacity of Cu (II) on MagCS (33 mg adsorbent, 40 ml solution, T=25^{0}C, initial metal concentration 0.7 mg/ml)

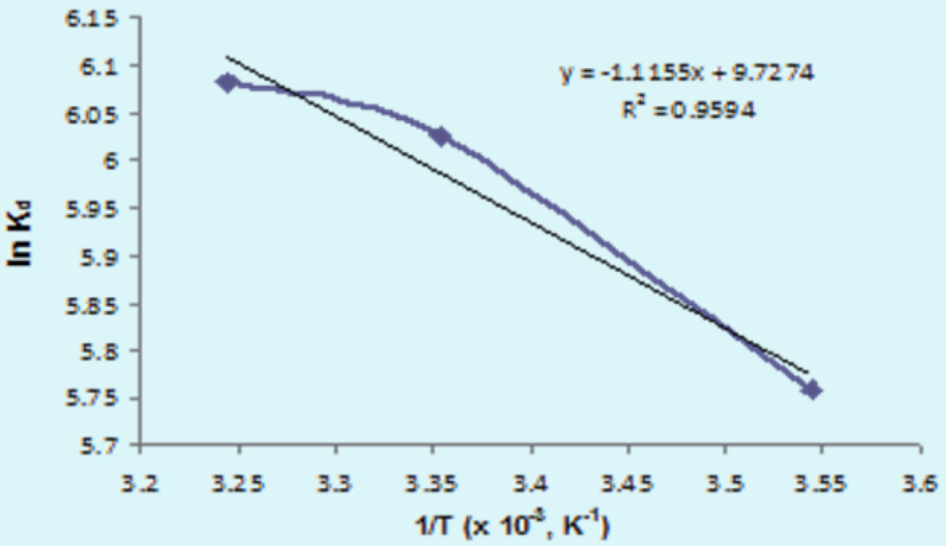


Effect of contact time on sorption capacity of Cu (II) on MagCS (330 mg adsorbent, 400 ml solution, T=25^{0}C, initial metal concentration 0.9 mg/ml)



Effect of initial metal concentration on sorption capacity of Cu (II) on MagCS (33 mg adsorbent, 40 ml solution, T=25^{0}C, pH=4.5-5, agitation time 24h)





Effect of temperature on the adsorption of Cu (II) on MagCS (33 mg adsorbent, 40 ml solution, initial concentration of metal ions of 0.9 mg/ml, pH=4.5-5, agitation time 24h)

$$\ln k_d = \frac{\Delta S}{R} - \frac{\Delta H}{RT}$$

Thermodynamic parameters for the adsorption of Cu(II) by the MagCS adsorbent

C_o, mg ml^{-1}	ΔH, J mol^{-1}	ΔS, J $K^{-1}mol^{-1}$	ΔG, J mol^{-1}
0.9	9274.26	80.87	-14838.2 0

Adsorption and kinetic studies

Langmuir model

$$\frac{C_e}{q_e} = \frac{1}{K_L \times q_m} + \frac{C_e}{q_m}$$

Freundlich model

$$\log q_e = \log K_F + \frac{1}{n}\log C_e$$

Dubinin-Radushkevich model

$$\ln q_e = \ln q_s - K_{ad}\,\varepsilon^2$$

Pseudo first order model

$$\ln(q_e - q_t) = \ln q_e - k_1 t$$

Second order model

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t$$

Intraparticle diffusion model

$$q_t = k_{id} t^{0.5} + c_i$$

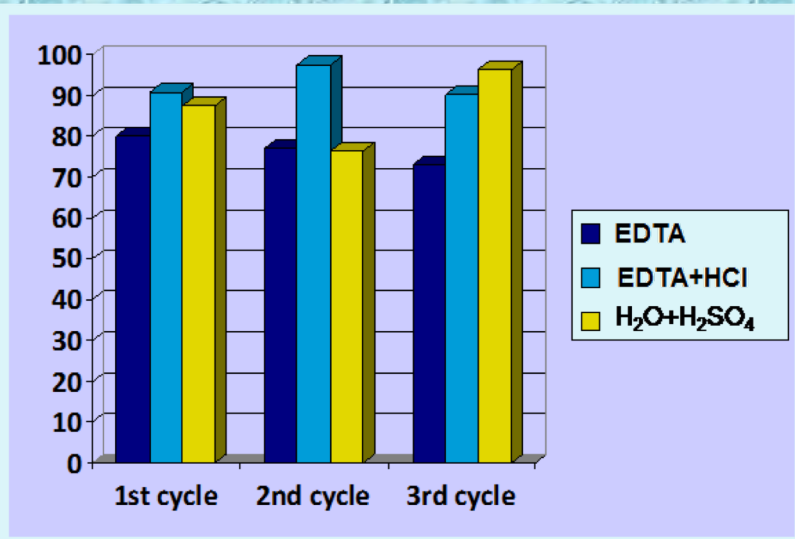
Isotherm constants for the adsorption of Cu(II) by MagCS

Langmuir constants			Freundlich constants			Dubinin–Radushkevich constants			
R^2	q_m (mg g^{-1})	K_L (ml mg^{-1})	R^2	K_F (mg g^{-1})	1/n	q_s, (mg g^{-1})	K_{ad}, (mol^2 kJ^{-2})	E, (KJ mol^{-1})	R^2
0.99	285.71	70.00	0.80	287.07	0.07	157.29	-0.01	6.90	0.57

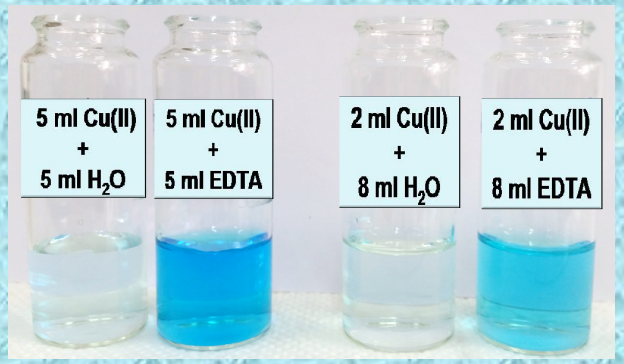
Kinetics parameters q_e, k_i and correlation coefficient R^2 for the adsorption of Cu(II) on MagCS

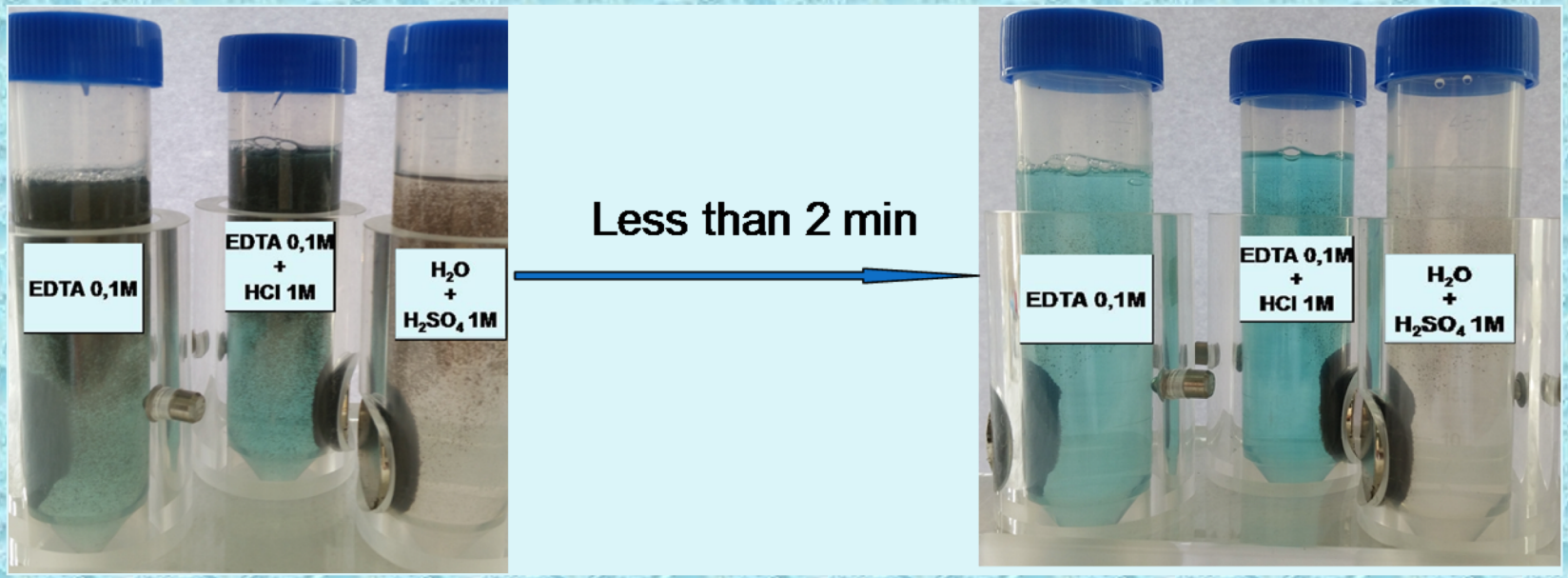
$q_{e,exp}$ (mg/g)	Pseudo-first-order model			Pseudo-second-order model			Intra-particle diffusion model constants	
	$q_{e,calc}$ (mg g^{-1})	k_1 (h^{-1})	R^2	$q_{e,calc}$ (mg g^{-1})	k_2 (g mg^{-1} h^{-1})	R^2	k_{id} (mg g^{-1} h$^{-0.5}$)	R^2
293.791	45.381	0.096	0.819	294.117	0.008	0.999	10.275	0.927

Desorption and re-usability studies



Desorption study for the chitosan composite





Maximum adsorption capacity (mg g^{-1}) of different adsorbents based chitosan for Cu(II) removal

Adsorbant	Initial concentration of Cu(II), mg/ml	Solution volume, ml	Adsorbant dosage, g	Adsorption mg Cu(II)/g	pH	Referinces
Chitosan coated $MnFe_2O_4$	0.001	300	0.008	22.6	6	Xiao et all.
Magnetic nanoparticles	0.01	50	0.005	25.77	6	Mei et all.
Magnetic chitosan	0.2	25	0.025	138.12	4	Fan et all.
Magnetic chitosan composite	0.1	500	0.05	216.6	5.5	Li et all.
Chitosan-modified magnetic Mn ferrite nanoparticles	0.1	30	0.1	65.1	6.5	Meng et all.
Chitosan	0.05	40	0.2	79.94	6	Benavente et all.
Magnetic chitosan nanoparticles	0.1	15	0.02	35.5	5	Yuwei et all.
Chitosan bound Fe_3O_4 magnetic nanoparticles	1.1	5	0.105	21.5	5	Chang et all.
Chitosan composite	0.9	400	30	293.79	5	**This study**

Conclusions

- The optimum parameters for adsorption of copper ions were determined:
  - **pH=5**
  - **T = 25^{0}C**
  - **Ci = 0.9 mg/ml**
- The equilibrium was reached within **one hour**
- The best fit for the data was the Langmuir isotherm model, with maximum monolayer adsorption capacity of **285.71** mg g^{-1}
- Kinetical data fitted the pseudo-second order model.
- Thermodynamic parameters evidence a **spontaneous** and **endothermic** process
- The results prove the chitosan composite as an **efficient** adsorbent, with high potential in practical applications.

ACKNOWLEDGEMENT

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Project title:

‘’GREEN” MAGNETIC ADSORBENT FOR WASTEWATER TREATMENT: MODE OF SYNTHESIS AND USE (GreenMagAds)

THANK YOU FOR YOUR ATTENTION!