Yeast residues activated carbon: nanomodification with magnetite for adsorption of pesticides

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Introduction

Pesticides are chemical compounds widely used to control pests and plant diseases. The use of pesticides in commercial agriculture has led to an increase in agricultural productivity. Pesticides are indispensable in modern agricultural practices, however, even in low concentrations, due to their high toxicity, carcinogenic nature and high persistence in ecosystems, they are considered a great threat to the environment and health, classified as emerging pollutants, presenting low biodegradability, which hinders its elimination in wastewater treatment plants and leads to its frequent presence in treated effluents. Who this, adsorption arises, which has the advantages of high efficiency, low cost, availability, controllability and is being expanded as an efficient alternative to conventional methods of removing pollutants. Due to its large surface area and high adsorption capacity, activated carbon is one of the most effective adsorbents that can be produced from abundant, low-cost products precursors, whose nanomodification allows to obtain nanoscale biomass particles in order to improve sorption properties.

Goals

Evaluate the potential of a biosorbent produced with residues from the sugar and alcohol industry, yeasts, nanomodified with magnetite (Fe_3O_4) for its use in the removal of the thiamethoxam pesticide from contaminated waters.

Material and Methods

Preparation of nanoparticles (NP) and yeast activated carbon magnetic nanocomposite (YAC-NP)

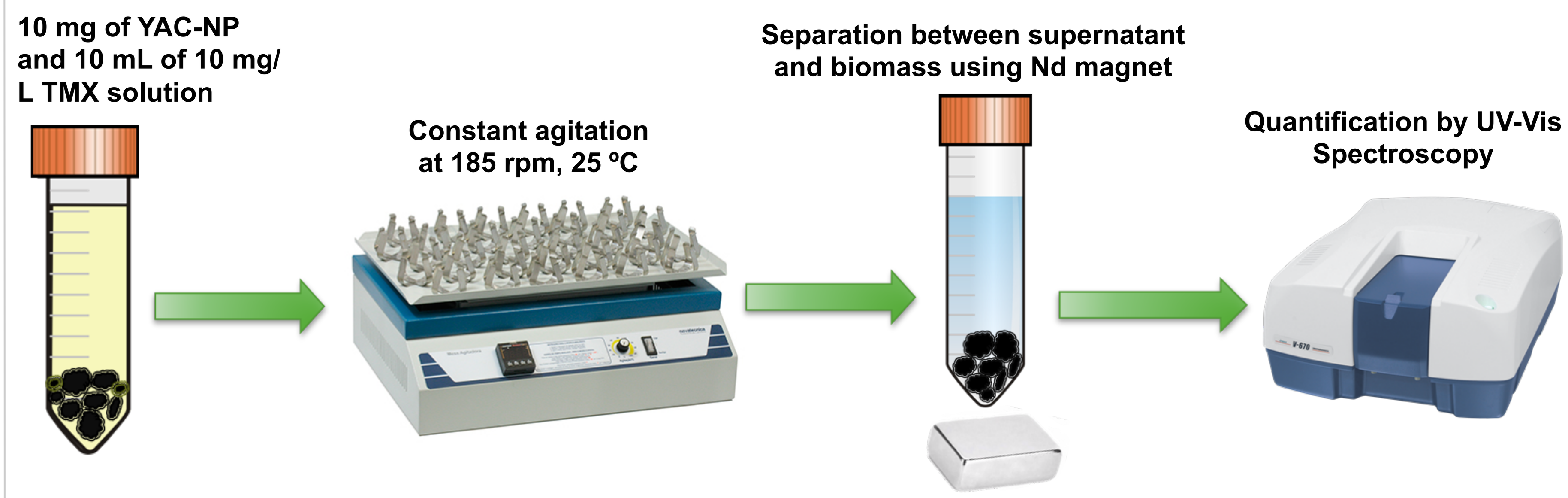
30 min

$$Fe^{2+}_{(aq)} + 2Fe^{3+}_{(aq)} + 8OH^{-}_{(aq)} \rightarrow Fe_3O_{4(s)} + 4H_2O_{(l)}$$

30 min; 80 °C

$$Fe_3O_{4(s)} + YB_{(s)} \rightarrow YAC\text{-}Fe_3O_{4(s)}$$

Biosorbent sorption capacity assessment

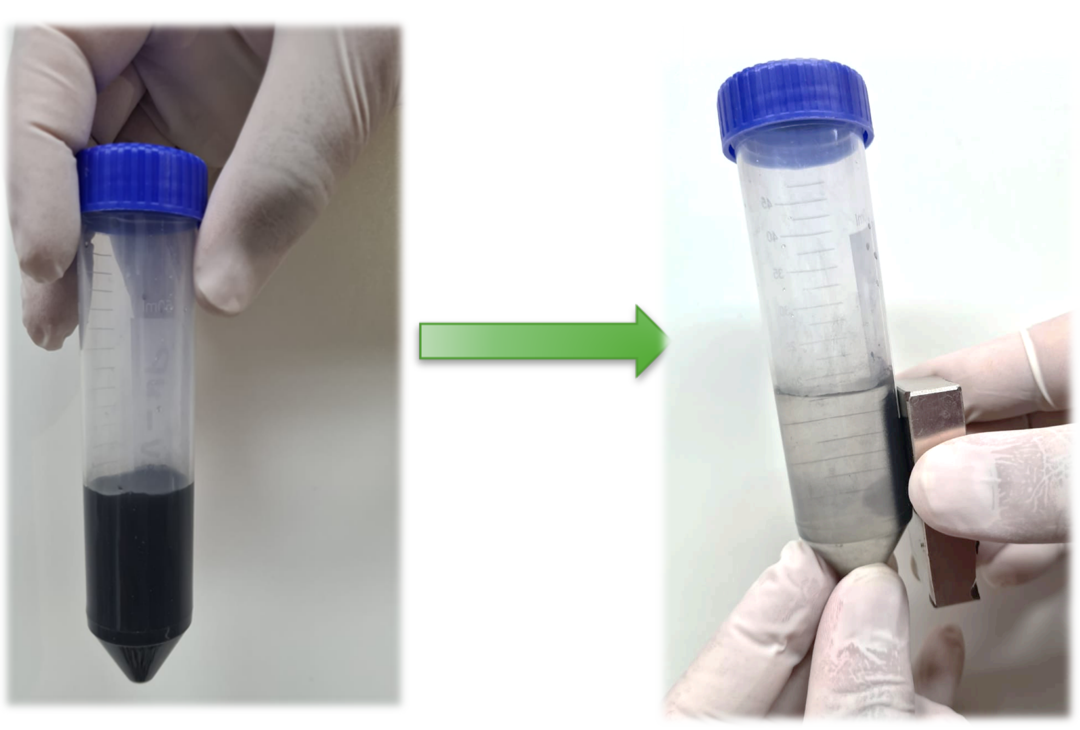


Batch procedure used to assess the sorption capacity of TMX by YAC-NP

Results and Discussion

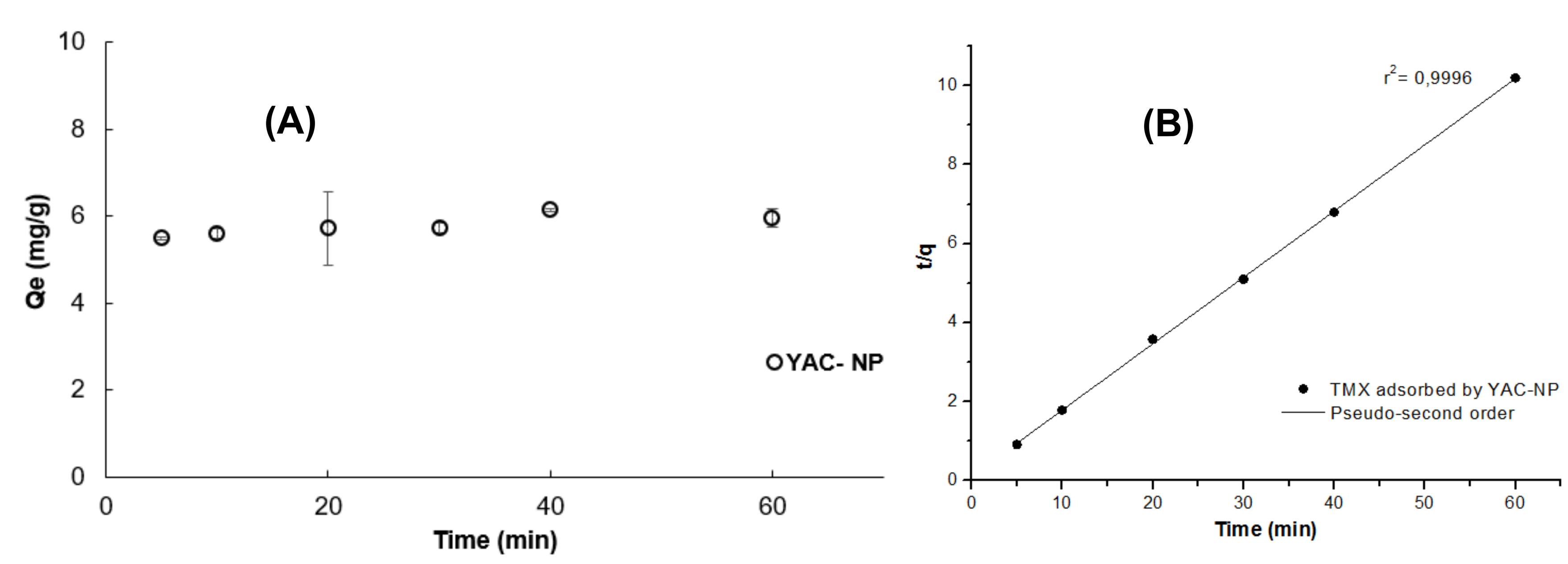
Magnetization effect

Yeast activated carbon magnetic nanocomposite (YAC-NP)



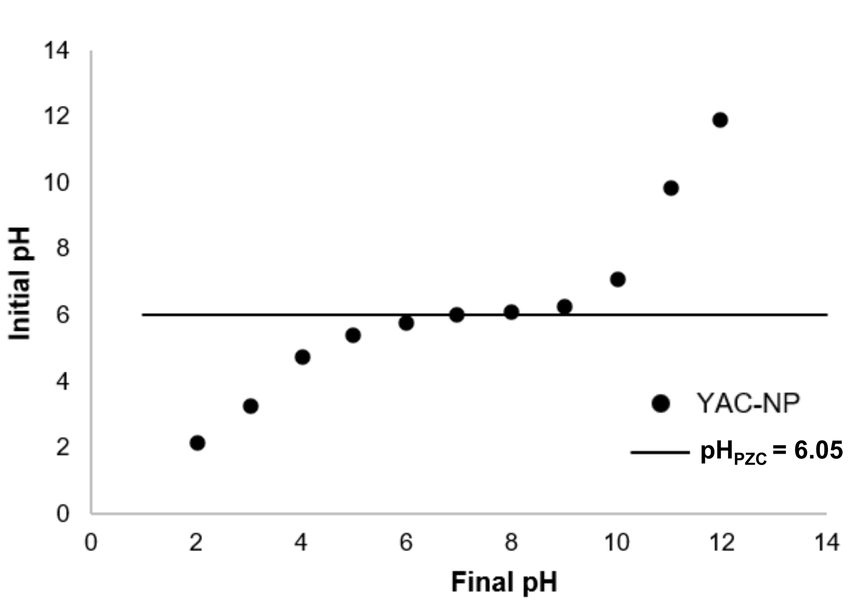
Effect of magnetization of activated carbon bionanocomposite from yeast residues and magnetite in TMX solution.

Sorption kinetics



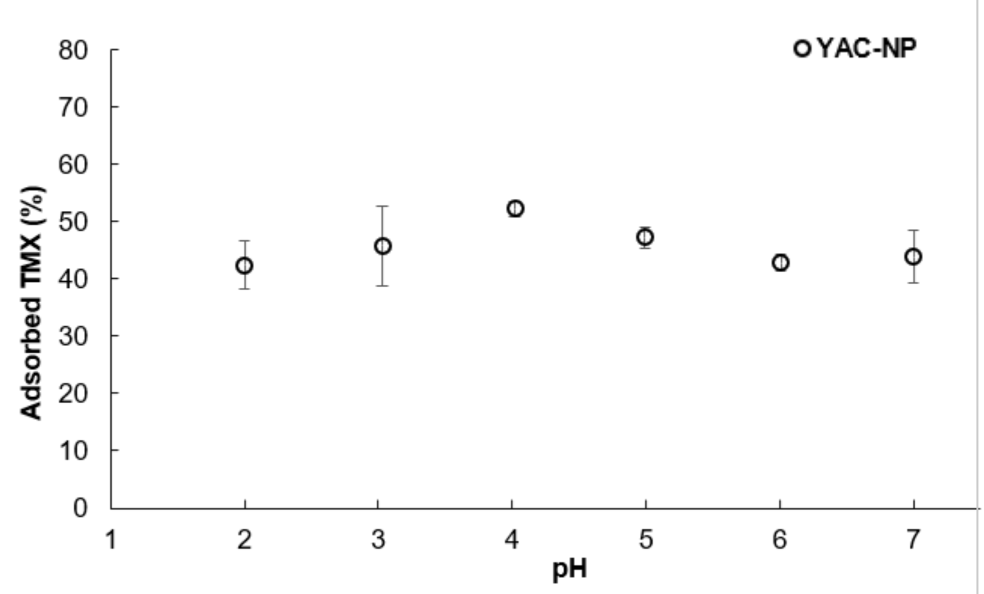
(A) TMX kinetics studies and (B) adjusts using the pseudo-second order model by YAC-NP, using 10 mg of biosorbent suspended in 10 mL of 10 mg/L TMX solution. n= 2

Point of zero charge (pH_{PZC})



The pH at point of zero charge (pH_{PZC}) of YAC-NP, using 1 g/L dosage of the nanocomposite with 0.1 mol/L NaCl solution at 2-12 pH range. n= 2

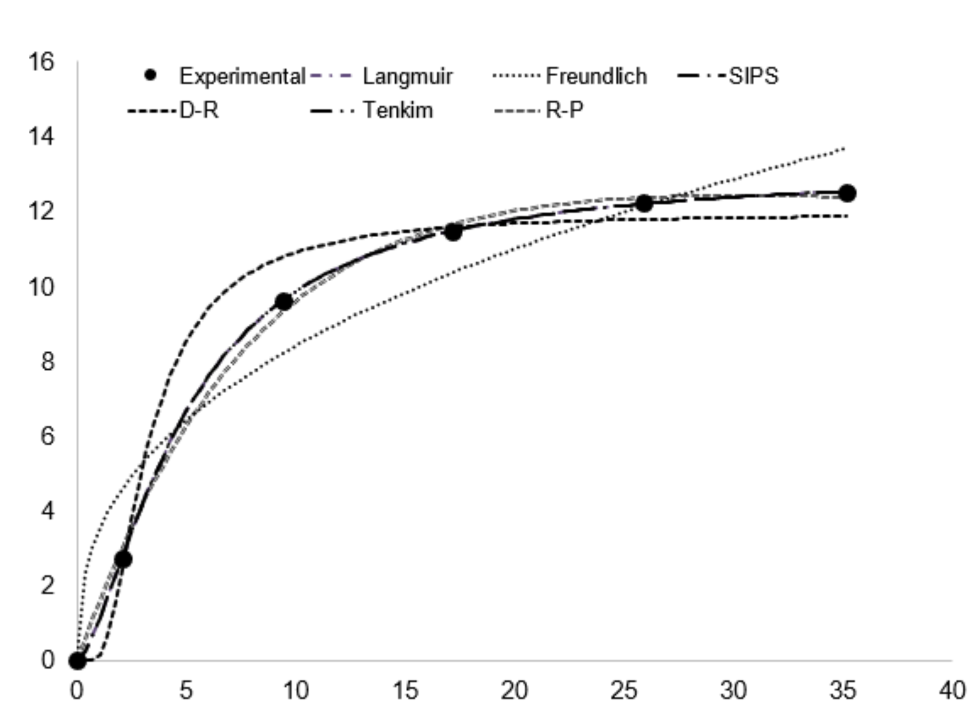
pH assessment



Effect of pH on the sorption of TMX. 10 mg of YAC-NP was mixed with 10 mL of 10 mg/L TMX solution. n = 2

Adsorption Isotherms

Experimental curve and Langmuir, Freundlich, Sips, Dubinin-Radushkevich (D-R), Temkin and Redlich-Peterson (R-P) isotherm models for TMX sorption by YAC-NP. n = 3.



Experimental sorption capacity (q_{exp}) values and parameters of isotherm models for TMX sorption by YAC-NP.

	YAC-NP
q_{exp} (mg/g)	12.50 ± 0.42 (SD)
	Langmuir
q_{max} (mg/g)	15.49678 ± 0.99 (SE)
b (L/g)	0.14715 ± 0.03337 (SE)
r^2	0.98678
X^2	0.38306
	Freundlich
K_f (L/mg)	3.44966 ± 1.03604 (SE)
n_f	2.58451 ± 0.64919 (SE)
r^2	0.93098
X^2	2.00046
	D-R
q_{DR} (mg/g)	11.95992 ± 0.39229 (SE)
B_{DR} (mol²/kJ)	$1.66 \times 10^{-6} \pm 3.13 \times 10^{-7}$ (SE)
E (kJ/mol)	0.11 ± 0.25
r^2	0.98202
X^2	0.52112
	Sips
q_{max} (mg/g)	13.13644 ± 0.04995 (SE)
K_s (L/mg)	0.20382 ± 0.00213 (SE)
n	1.5458 ± 0.01772 (SE)
r^2	0.99995
X^2	0.00131
	Temkin
b_T (J/mol)	$2.57 \times 10^4 \pm 2.47 \times 10^4$ (SE)
K (L/mg)	1.2253 ± 0.04 (SE)
r^2	0.97968
X^2	0.58901
	R-P
a_{RP} (L/mg)	1.5536 ± 0.15571 (SE)
k_{RP} (mg/g)	0.02692 ± 0.01343 (SE)
b	1.36046 ± 0.11048 (SE)
r^2	0.99754
X^2	0.07134

Conclusions

The results showed that the synthesized nanocomposite is an efficient and low-cost material that has characteristics suitable for the rapid removal of contaminants in an aqueous medium, and can easily be removed from the medium by a magnet. Thus, YAC-NP is a promising biosorbent for adsorption of the pesticide thiamethoxam and, therefore, its efficiency for the removal of some other anionic pesticides and herbicides can be investigated.

Acknowledgments

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