The potential of *in natura* and magnetic nanomodified hydroponic lettuce roots for Cr(VI) removal in aqueous medium

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Introduction

The increase in industrialization is an aggravating factor for environmental degradation, mainly due to the disposal of improperly contaminated effluents (Dhankhar and Hooda 2011). Among the most harmful contaminants are potentially toxic metals, which can pose severe risks due to their bioaccumulation and persistence in the environment. Several anthropogenic sources introduce Cr(VI), a toxic, carcinogenic metal, into effluents (Jobby et al., 2018). Among the methods for removing these contaminants from the environment, biosorption has been an attractive alternative. It is a process that uses biomasses, such as lettuce roots, which have low added value, for the adsorption of pollutants. Some modifications can be used to biomass to improve and facilitate the biosorption process, such as magnetic nanoparticles (Abilio et al., 2021; José et al., 2019).

Goals

Evaluate the potential of a biosorbent produced with hydroponic lettuce roots *in natura* and nanomodified with magnetite (Fe_3O_4), for removal of Cr(VI) species in an aqueous medium, aiming at the remediation of water and effluents.

Material and Methods

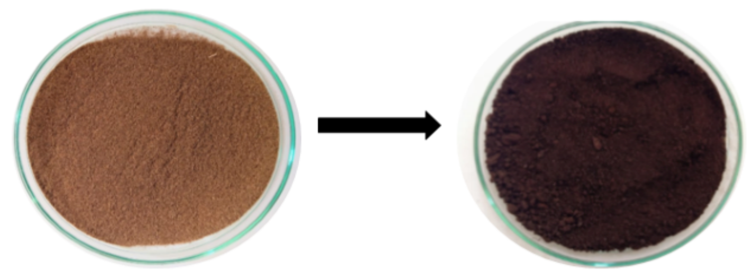
Preparation of magnetite nanoparticles (NP)

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

The magnetic nanocomposite (LR-NP)

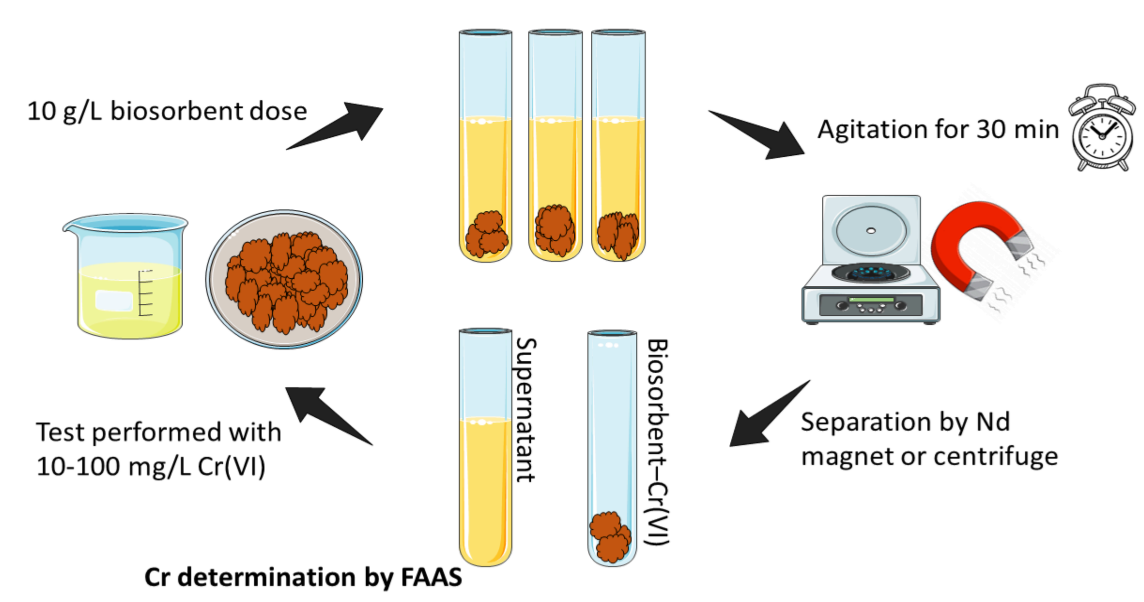
$$Fe_3O_{4\,(s)} + LR \rightarrow LR - Fe_3O_{4\,(s)}$$

Nanomodification (Fe_3O_4) of LR



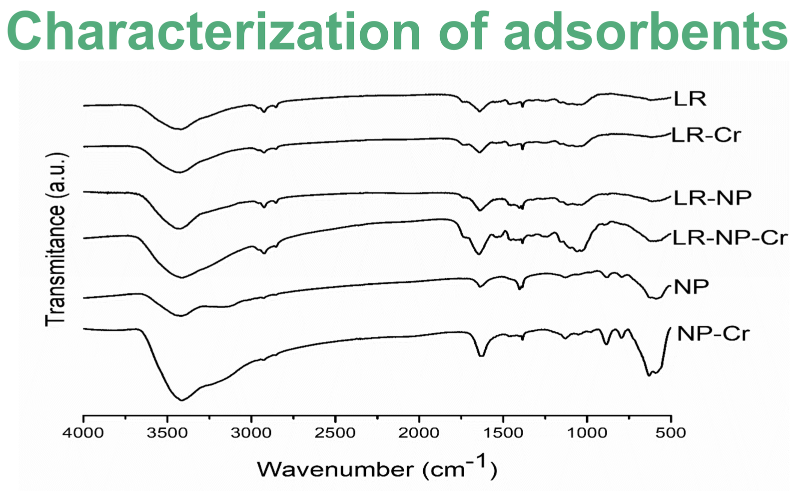
in natura LR → Magnetic Nanomodified LR

Sorption capacity assessment

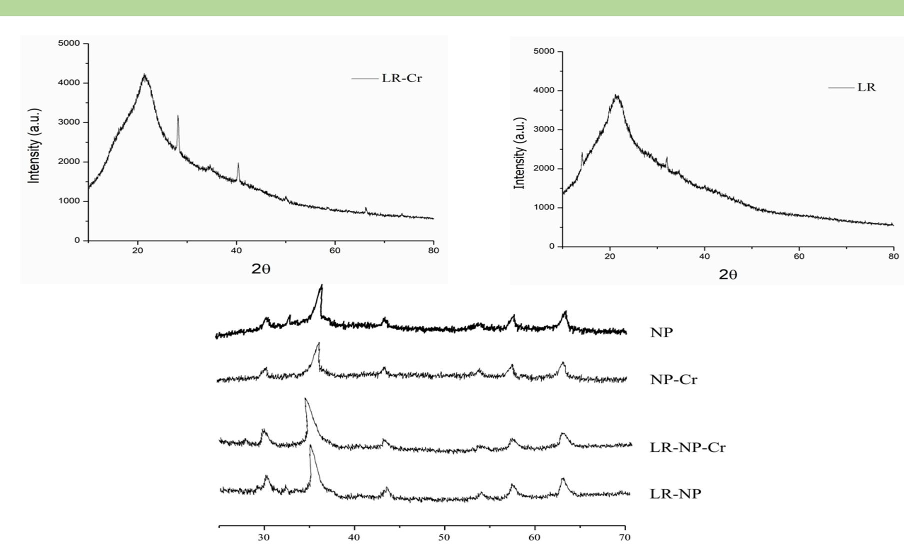


Results and Discussion

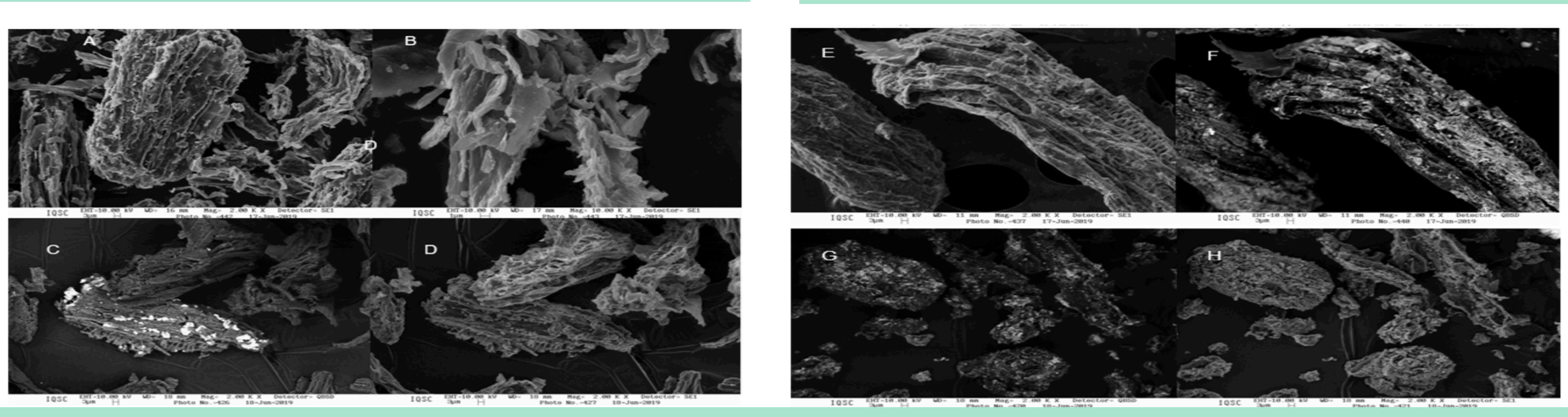
Characterization of adsorbents



FTIR spectra of the biomass, nanocomposites and magnetite in study: lettuce roots biomass (LR) prior and (LR-Cr) after chromium sorption; nanomodified lettuce roots biomass (LR-NP) prior and after (LR-NP-Cr) chromium sorption; magnetite nanoparticles (NP) prior and after (NP-Cr) chromium sorption.

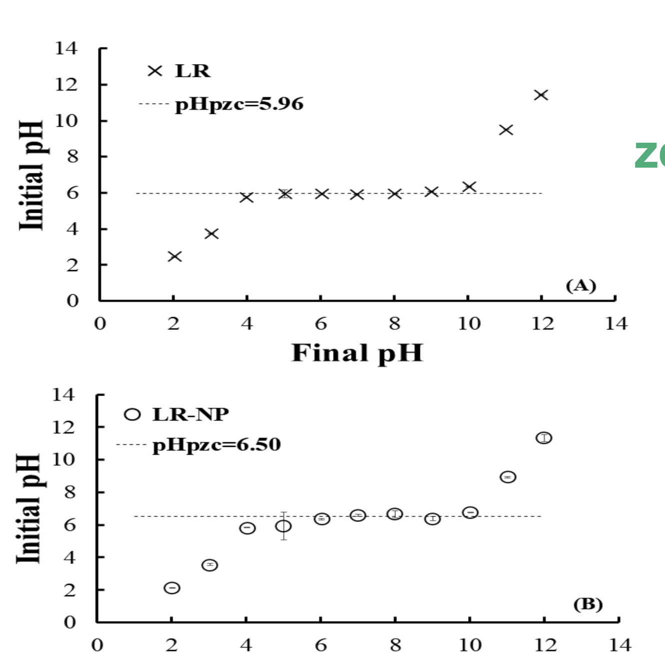


X-ray diffractograms by *in natura* lettuce roots (LR), nanomodified lettuce roots (LR-NP) and magnetic nanoparticle (NP) prior and after Cr(VI) sorption.



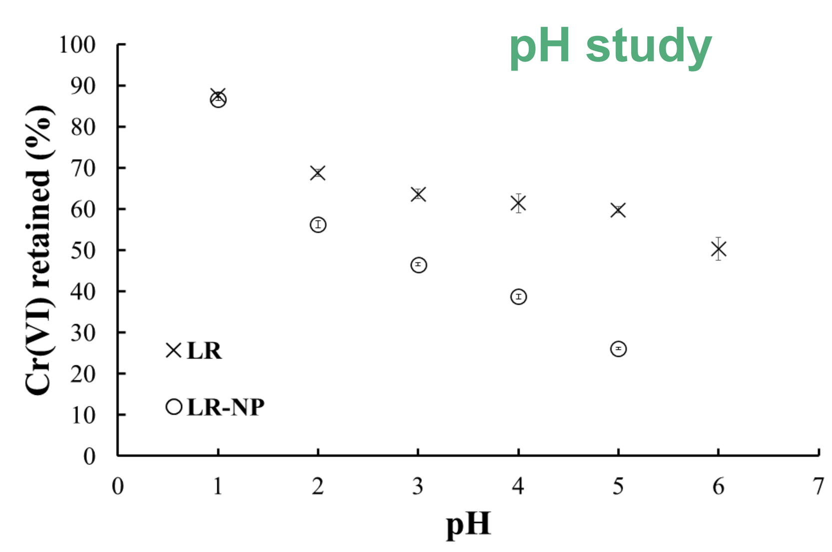
Scanning electron microscopy (SEM) images of raw materials *in natura* lettuce roots (LR) (A and B) and after sorption (LR-Cr) (C and D), nanomodified lettuce roots (LR-NP) (E and F) prior and after Cr(VI) sorption (G and H).

Point of zero charge (pH_{PZC})



Point of zero charge (pH_{PZC}) using 1.0 g/L dosage of the (A) in natura (LR) and (B) nanomodified lettuce roots (LR-NP), with 0.1 mol/L NaCl solution at 2-12 pH range.

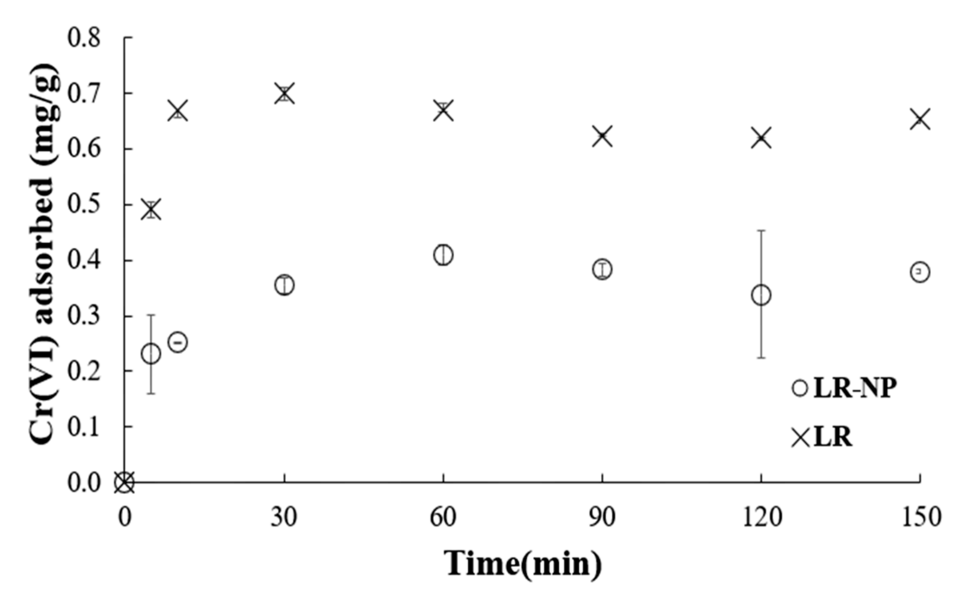
pH study



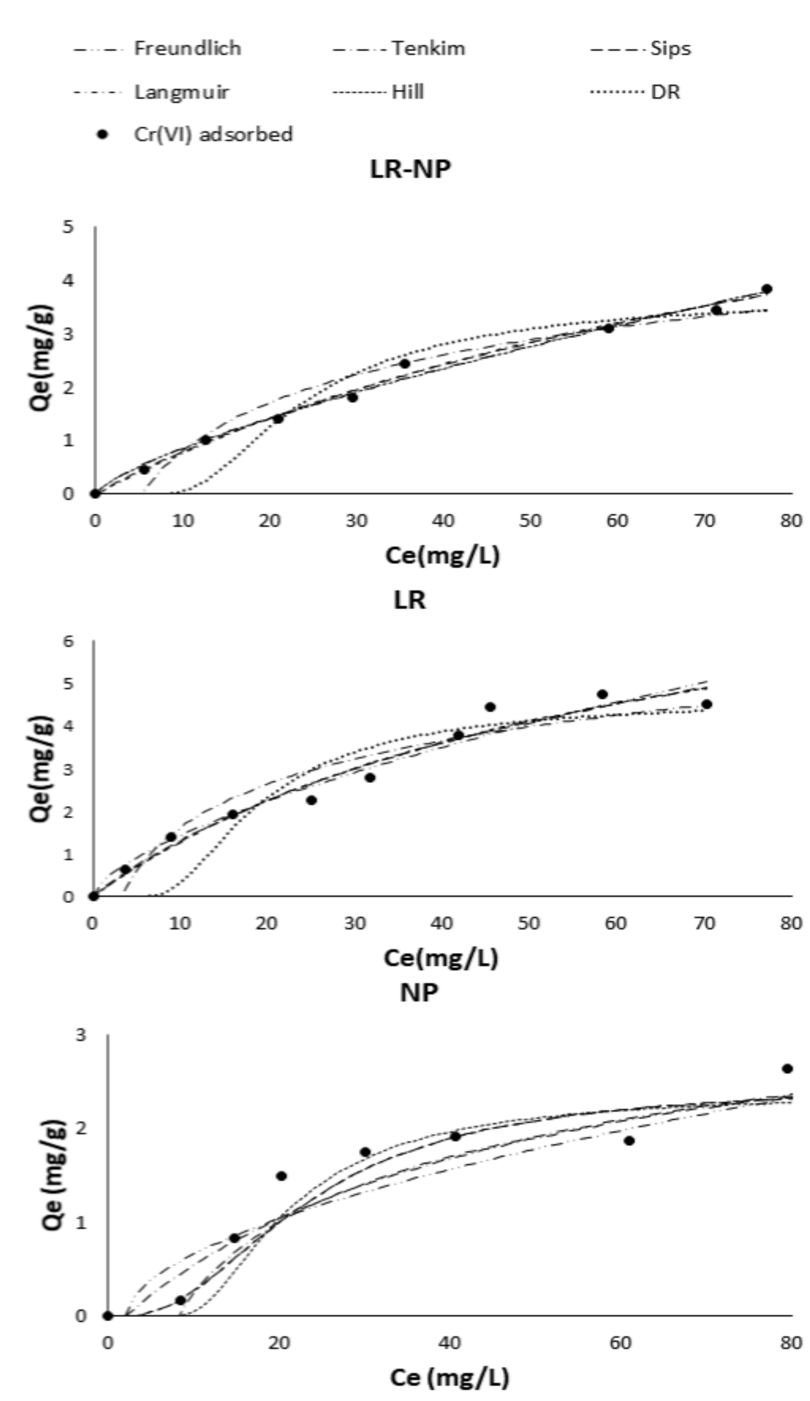
pH Study on the removal capacity of Cr(VI) by *in natura* (LR) and nanomodified lettuce roots (LR-NP), using 10 g/L dosage of LR or LR-NP with 10 mg/L Cr(VI) solution.

Kinetics studies

Kinetics studies of Cr(VI) sorption by *in natura* biomass (LR) and the nanocomposite (LR-NP) with 10 g/L dosage, 10 mg/L Cr(VI) solution at pH 1.0.



Sorption isotherms



Data of experimental sorption capacity (Q_{exp}), isotherms parameters and χ^2 error evaluation for Cr(VI) sorption by NP (magnetic nanoparticles).

LR (*in natura* lettuce roots biomass) and LR-NP (nanomodified lettuce roots biomass). SD = Standard Deviation; SE = Standard Error provided by fitting the model to the experimental data. n = 3.

Conclusions

This study of Cr(VI) sorption by LR and LR-NP proved to be more efficient at pH 1. Among the isotherm models applied to experimental data, Freundlich was the model that best described the sorption process of the LR, LR-NP, and NP. Therefore, these materials are an efficient and low-cost alternative for removing Cr(VI) from contaminated water.

Acknowledgments

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References

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