Kinetic studies of adsorption of Cu (II) from aqueous solution by coriander seeds (Coriandrum Sativum)

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Abstract. The adsorption of copper ions Cu2+ by Coriandrum Sativum seeds (CSS) from aqueous solution was studied in order to highlight the importance of coriander seeds as a potential tool in the treatment of wastewaters containing heavy metals. The kinetic studies of adsorption of Cu (II) were discussed using the spectroscopic technique "Inducting Coupled Plasma" (ICP). The effects of initial copper ion concentration and contact time were determined. All results show that coriander seeds have, over their culinary and medicinal benefits, a significant adsorbent power of copper ions.
Keywords: coriander seeds, adsorption, Cu (II), ICP.

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1. Introduction

Technological applications of heavy metals (lead, copper, zinc, cadmium…) in many industrial processes (electroplating, pigments, paper pulp, and textiles, etc.) [1], have produced contaminated wastewaters that are one of the main sources of environmental pollution [2], [3]. Heavy metals is an important issue and have serious ecological and human health consequences, mainly because the heavy metals cannot be destroyed or degraded, have a toxic effect on most life forms, and also tend to accumulate in the environment [4]. Therefore, it is necessary to find some effective methods for removal of heavy metals from industrial wastewaters [5], in order to reduce their discharge into environment [6]. Adsorption of heavy metals from aqueous solutions is a relatively new process that has been confirmed a very promising process in the removal of heavy metal contaminants. The major advantages of adsorption are its high effectiveness in reducing the heavy metal ions and the use of inexpensive adsorbents [7], [8]. Adsorption processes are particularly suitable to treat dilute heavy metal wastewater.

Different forms of plant material such as *iris pseudacorus* [9], sawdust [10], black gram husk [11], eggshell [12], seed shells [13], orange peel [14], sugar-beet pectin gels [15], coffee husks [16], barks of *eucalyptus camaldulensis* [17], sugarcane bagasse [18] etc., have been widely investigated as potential adsorbents for heavy metals.
several depollution techniques such as membrane systems, precipitation [19], ion-exchange resins, electro dialysis are still very expensive [20]. Recently, the fight against metallic pollution has stimulated the search for ecofriendly technologies.

Coriander (Coriandrum Sativum.L) is a popular spice [21] and finely ground seed is a major ingredient of curry powder, an effective antioxidant [22], [23] and a drug for indigestion[24], against worms [25], rheumatism [26], [27]... Coriander seeds have also several properties such as antimicrobial activity [28], insecticidal effect, hypolipidemic activity [29], hypoglycemic action [30]…
The objective of the present work is to investigate the possible use of Coriandrum Sativum seeds as a removal of copper ions from contaminated solutions since its adsorption potential has not been previously reported. The adsorption parameters, contact time and initial ions concentration, were investigated using ICP to evaluate the possible adsorbent-metal ion interactions.

2. Material and methods

2.1. Preparation of adsorbent

The coriander seeds (Coriandrum Sativum) were collected from the west of morocco (Kenitra), washed with double distilled water to remove impurities such as sand and dust, dried in air at 50 °C for 24 hours, ground using mortar, and then sieved, until the grain-size of particles was lower than 250 µm. The obtained powder was dissolved in double distilled water and filtrated several times in order to obtain a clean powder. The resulted material was stored in a desiccator to prevent it from humidity and was used as an adsorbent.

2.2. Preparation of aqueous solution

Aqueous solutions were prepared from copper sulfate salt (purchased from Sigma Aldrich). The stock solutions were then used to obtain the working solutions through dilution with double distilled water. Fresh dilutions were prepared and used for each experiment. 10-1 mol /L HNO3 or NaOH solutions were used to adjust the initial pH of working solutions.

2.3. Adsorption experiments

The extraction experiments were realized by adding the given quantity of adsorbent with 100 mL of aqueous solution with known heavy metal ion concentration, in 200 mL conical flask. The flask was intermittently stirred for an adequate period of time, depending on the purpose of the experiment. All experiments were studied at room temperature (20°C). After adsorption, samples were analyzed using the Inductively Coupled Plasma (ICP) in the University Center for Analysis, Expertise, Transfer of Technology and Incubation, Ibn Tofail University, Kenitra, Morocco.

2.4. Data evaluation

The adsorption process of copper ions by coriander seeds was evaluated using the following parameters, which were calculated from experimental results:
Rate of copper ions removed (%):

$$R = \frac{C0 - Ce}{C0} * 100$$

amount of copper ions retained on mass unit of coriander seeds (mg/g):

$$Qe = \frac{C0 - Ce}{m} * V$$

C0 is the initial concentration of copper ions in the solution (ppm).
Ce is the equilibrium concentration of heavy metal ions in the solution (ppm).
V is volume of solution (L).
m is the mass of coriander seeds (g).
All the data are the mean values of three replicate measurements, and the standard deviation calculated in each case was lower than ± 1.0%.

3. Results and discussion

3.1. Effect of contact time

The influence of contact time on Cu (II) ions adsorption onto coriander seeds, at room temperature (20°C), constant adsorbent mass (0.5 g), initial solution pH of 5.5 and initial heavy metal ions concentration 10 ppm, is illustrated in (Fig.1). The experimental data indicates that the adsorption efficiency of the considered heavy metal ions onto coriander seeds increases with the increase of contact time (ranging from 10 to 240 minutes), and reaches a maximum after 30 min. The increase of pH solution shows that the coriander seeds balance with the metal solution by consuming H+ protons. There is competition between Cu2+ and the protons to be fixed to coriander seeds surface.

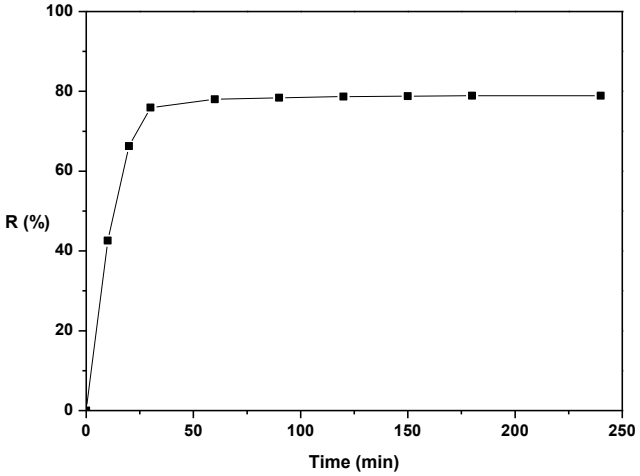

Fig.1. Effect of contact time on the adsorption rate

3.2. Effect of initial metal ion concentration

The effect of initial copper ions concentrations on the adsorption performances of coriander seeds CSS, under optimum experimental conditions (0.5 g of adsorbent; initial solution pH of 5.5 and 4 hours of contact time) is illustrated in (Fig.2. and Fig.3). The study is carried out at different concentrations ranging from 6.5 to 150 ppm .It can be seen that the adsorption capacity of coriander seeds increases with the increase of initial copper ions concentration from 1.03 to 5.58. These significant increases of the adsorption capacity values are expected because high initial copper ions concentrations correlate with a higher probability of collisions between Cu2+ and superficial functional groups of the adsorbent.

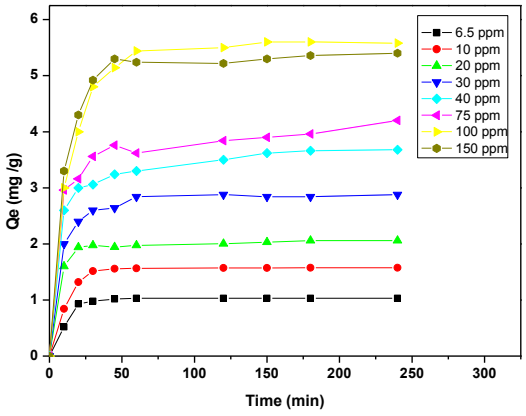

Fig.2. Effect of initial concentration of Cu^{2+} on the adsorption kinetic by CSS

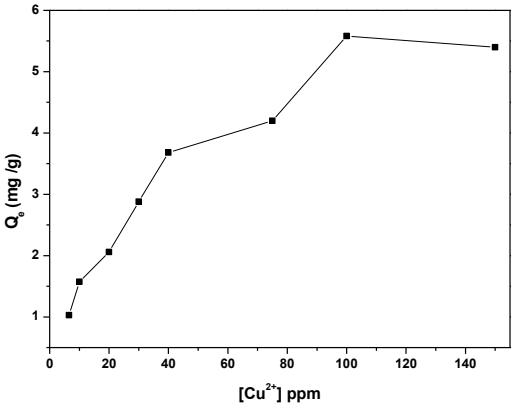

Fig.3. Effect of initial concentration of copper ions on the amount of adsorption

4. Conclusion:

The present investigation emphasizes adsorption potential of Coriandrum Sativum seeds (CSS) as an ecofriendly adsorbent of copper ions from wastewaters.
The following conclusion can be made from this study:
The equilibrium of system metallic solution- CSS was observed after 30 minutes of contact with a low quantity of adsorbent.
Therefore it can be concluded that CSS fulfills the criteria of an effective adsorbent for copper adsorption.

5. Acknowledgment:

The authors are pleased to acknowledge:
- The 6th international congress "water, waste and environment", Sultan Moulay slimane University, Beni Mellal, Morocco for giving the opportunity to publish this work.
- The Ibn Tofail University, Kenitra, Morocco, for providing the facilities for the research. Also the Director of Center of Analysis, Expertise, Transfer of Technology and Incubation (CUAE2TI) "M. Ibn Touhami" is gratefully acknowledged for his kind permission to use their facilities for the analysis.

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