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Cd^{2+} REMOVAL FROM SYNTHETIC WASTEWATERS USING *SCENEDESMUS OPOLIENSIS* GREEN ALGAE

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ABSTRACT. The main purpose of this research paper was to study the Cd^{2+} adsorption capacity of green algae from solutions of heavy metal in different concentrations. In this respect, experimental determinations were carried out using *Scenedesmus opoliensis* species to investigate the power of retention of green algae when it is used as natural biological filter. The adsorption processes was studied using three different concentrations, regime, at normal temperature and pH = 5.2. Heavy metal ion was namely 4.36 mg Cd^{2+}/L, 12.70 mgCd^{2+}/L and 20.49 mg Cd^{2+}/L, in dynamic adsorbed up to a yield of 50-52% over an interval of no more than 120 minutes, with an important increase in the first 10 minutes. The retention capacity, Q_s, of algal material adsorbent grows from 0.67 mg Cd^{2+}/g adsorbent for C_1=4.36 mgCd/L to 3.28 mg Cd^{2+}/g adsorbent for C_3=20.49 mgCd^{2+}/L. The analytical method employed in this study is atomic absorption.

Keywords: *biosorption, heavy metal, Scenedesmus opoliensis* green algae, *adsorption capacity, atomic absorption method*

INTRODUCTION

The rapid industrial development, various wastes containing different metal ions are directly or indirectly discharged into the environment, rising serious environmental pollution problems and threatening marine life [1].

There are many processes that can be used for the removal of metals from wastewaters including chemical precipitation, coagulation, solvent extraction, electrolysis, membrane separation, ion exchange and adsorption [2].

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Microorganisms can remove heavy metal ions by a large variety of processes such as cell walls biosorption, entrapment in extracellular capsules and uptake by membrane transport of the metal ions into cell cytoplasm, microprecipitation and oxidation-reduction reactions. Some or all of these processes could take place in living microorganisms [3].

Metal ions are adsorbed first on the cells surface by the interactions between the metal ions and the metal-functional groups such as carboxyl, phoshate, hydroxyl, amino, sulphur, sulphyde, thiol, etc., present in the cell wall and then they penetrate the cell membrane and enter the cells [4].

Cadmium is one of most toxic heavy metals whose toxicity is attributed in part to its ability to accumulate in tissues. There are some reports on the destruction of the chloroplast by heavy metal ions at higher concentrations [5]. In fact, cadmium ions disorganize chloroplasts and cause the damage of photosynthetic pigments [6]. As a consequence of this, the photosynthetic activity could severely be affected, causing growth inhibition or complete death of the cells [7, 8].

The purpose of this study is to evaluate the biosorption capacity of the *Scenedesmus opoliensis* algae for Cd^{2+} from aqueous solutions.

RESULTS AND DISCUSSION

As biosorbent we used *Scenedesmus opoliensis* green algae, figure 1. Heavy metal ions removal was tested using synthetic Cd^{2+} solutions (C_1=4.36 mg Cd^{2+}/L, C_2=12.70 mgCd^{2+}/L and C_3=20.49 mgCd^{2+}/L), in dynamic regime (under magnetic, continuous stirring at 200 rot/min for 2 h), at room temperature and pH = 5.2.

The biomass of live algae (*Scenedesmus op.*) was added to the synthetic solutions of heavy metal ions. In order to determine residual Cd^{2+} concentration in the solution, 2 ml samples were taken out at specific time intervals.

Figure 1. *Scenedesmus op.* [9].

The difference between the initial and remaining metal concentration was assumed to be taken up by the biosorbent.

Evolution of Cd^{2+} concentration in time as a function of initial concentration is presented in figure 2. We found that in all three cases (three solution containing different quantities of cadmium ions) the concentration of Cd^{2+} significantly decreases, faster in the first 10 minutes from the beginning of the experiment, while the equilibrium was reached after 60 minutes for solution with initial concentration C_1, 70-80 minutes for C_2 and approximately 120 minutes for the most concentrated initial solution C_3 (figure 2).

For adsorption yields, calculated values were placed around 50%, with small differences between the three initial concentrations, increasing from 50.90% for C_1=4.36 mg Cd^{2+}/L to 52.84% for C_3=20.49 mg Cd^{2+}/L (figure 3).

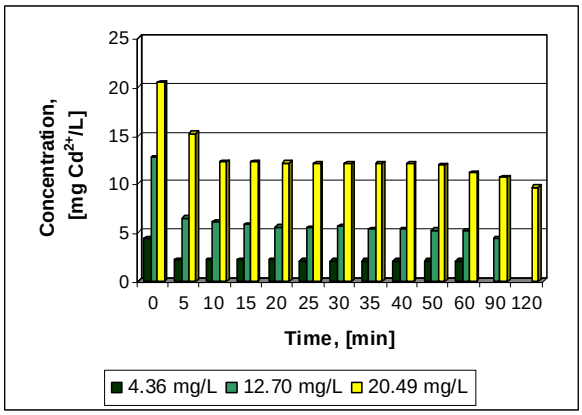

Figure 2. Evolution of Cd^{2+} concentrations in time for initial solutions containing different quantities of cadmium ions; 0.66 g dry mass biosorbent/15 ml solution.

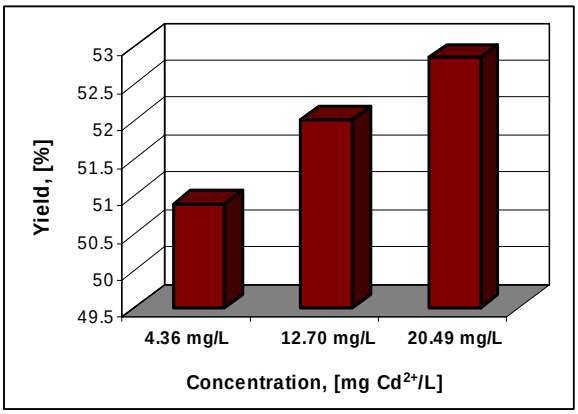

Figure 3. Maximum yield (%) values for Cd^{2+} adsorption on algae biosorbent; influence of the initial concentration of cadmium ions.

The retention capacity, Q_s of algal material adsorbent increases from 0.67 mg Cd^{2+}/g adsorbent for C_1=4.36 mg Cd^{2+}/L to 3.28 mg Cd^{2+} /g adsorbent for C_3=20.49 mg Cd^{2+}/L (figure 4).

Some of our previous studies [10] using dead algae as biosorbents (destroyed through thermal exposure) showed that the biosorption results were comparable with those from present paper (with live algae), or are even better. One possible explanation could be the metabolic extracellular products, which may form complexes with metals to retain them in solution [11].

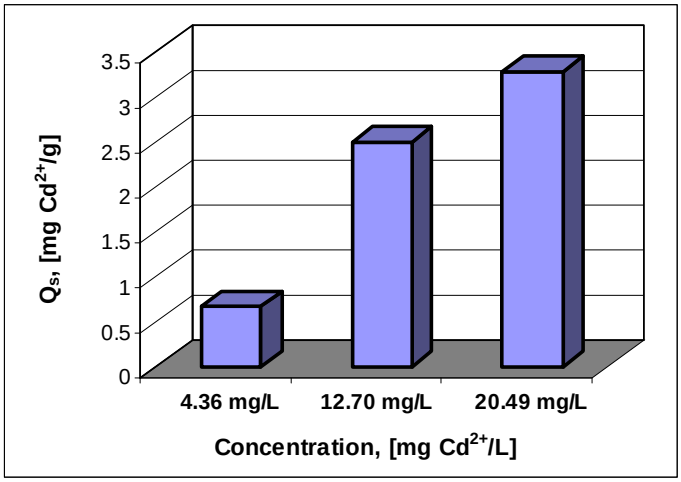

Figure 4. Maximum absorption capacity values for algae biosorbent; influence of the initial concentration of cadmium ions.

CONCLUSIONS

The present study proves that *Scenedesmus oppoliensis* could be an effective biosorbent for the removal Cd^{2+} from wastewaters. In this respect, three quality parameters were investigated: (1) heavy metal ions concentration in solution after contact with algae, (2) the yield calculated for the biosorption process, and (3) heavy metal ions retention capacity of algae.

Residual cadmium in the aqueous solutions, measured after 2 hours exposure periods, showed that the concentrations of Cd^{2+} significantly decrease, faster in initial 10 minutes, achieving the equilibrium after 60 minutes for solution with initial concentration C_1=4.36 mg Cd^{2+}/L, 70-80 minutes for C_2=12.7 mg Cd^{2+}/L and approximately 120 minutes for the most concentrated initial solution, C_3=20.48 mg Cd^{2+}/L.

In conclusion, for the three initial concentrations used in our experiment, cadmium was adsorbed up to yields of 50-52%, with retention capacity values comprised between 0.67 and 3.28 mg Cd^{2+}/g biosorbent.

Hence, it is possible to remove cadmium in a simple treatment using *Scenedesmus oppoliensis* green algae.

EXPERIMENTAL SECTION

The cadmium solution was prepared by dissolving Cd $(NO_3)_2 \times 4H_2O$ (analytically reagent) in deionized water.

Axenic monoalgal cultures of *Scenedesmus opoliensis* P. Richter, obtained from the culture collection of Cluj Biological Research Institute [12], were grown in Kuhl-Lorenzen (KL) nutrient media supplemented [13].

The biosorption process was conducted in batch conditions in a Berzelius flask (beaker) where we poured 15 ml of concentrated algae solution over 150 ml solution of Cd^{2+} of different concentrations (4.35, 12.7 or 20.49 mg Cd^{2+}/L). The solutions thus formed were placed on a magnetic stirrer and there were continuously mixed, at 25ºC. In order to determine residual Cd^{2+} concentration in the solution, 2 ml samples were taken out at specific time intervals with a syringe and filtered using M.E. Cellulose filter with the pore dimension of 0.45 µm. The analytical method employed in the Cd^{2+} concentration measurements was atomic absorption carried out with a Senso AA Spectrometer. Calibration was performed within a linear calibration range of cadmium.

To determine the dry mass of algae 15 ml of initial green solution were dried to constant mass, in a drying oven, at 105ºC. The weighted dried biomass was 0.66 g.

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