Removal of Cadmium Present in the Water of the Chili River Peru, using OpuntiaFicusMucilage

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Abstract

The contamination of water bodies by heavy metals causes an ecological pollution problem and conventional treatments are very expensive to apply and in some cases are inadequate for human health and the ecosystem. In this work, the capacity of Opuntiaficus mucilage as an adsorbent material for the removal of cadmium (Cd) in the water of the Chili River, Arequipa - Peru, was evaluated. To check the efficiency of Opuntiaficus for cadmium removal, 500 ml of water sample were collected and 250 g of mucilage were added, the cadmium was analyzed by atomic absorption spectrophotometry (AAS). The laboratory results obtained were: No treatment pH (8.4), T° (14 °C), Conductivity (1041uS/cm) and Cadmium (0.015 mg/L); for the sample treated with Opuntiaficus mucilage the data obtained were: pH (6.5), T° (14.5), Conductivity (574 uS/cm) and Cadmium (0.003 mg/L). Finally, it is concluded that Opuntiaficus mucilage has a high capacity to remove heavy metals, including Cadmium, which due to its transition is very toxic and even in low concentrations can be harmful to health.

Index Terms Cadmium, heavy metals, opuntiaficus, removal.

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INTRODUCTION

Heavy metals are known environmental pollutants due to their toxicity as they can accumulate in the human body, causing diseases (diarrhea, cancer, etc.) [1]. Among the most dangerous heavy metals are cadmium, lead, thallium and antimony, which are common in industrial operations [2].

Cadmium (Cd) is a highly toxic transition metal, it is not degradable in nature, it is estimated that 30,000 tons of Cd are released into the environment each year [3]. Its toxicity even at low concentrations can cause serious health risks [4]. Heavy metals can become even more toxic when mixed with environmental elements, such as water, soil, and air [2].

The increasing use of the water resources to satisfy the different demands of a system has generated a reduction in environmental flows rates [5].

As municipal, industrial, and agricultural wastes enter the water, biological, chemical, and heavy metal contaminants also enter the receiving body [6]. Rivers not only have the function of supplying drinking water but also have the function of

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recreational and sporting activities which has allowed for the development, growth and progress of communities [6], [1].

The Chili River, located in the highlands of Arequipa as the junction of the Sumbay and Blanco rivers, is open to untreated sewage, runoff and mine tailings wastewater. [6]. Wastewater containing heavy metals causes serious contamination and treatment methods are very costly. [7]. Studies evaluating heavy metals in food, specifically in meat and milk, have found that cadmium, mercury, lead and arsenic are elements that, due to their high impact on health and concentration, must be thoroughly evaluated and monitored [8].

Because of this, there has been a push for research into technologies for the reduction and/or elimination of heavy metals that must be economical, reliable and safe; plant-based materials are the most recommendable as they are renewable and biodegradable [9].

MATERIALS AND METHODS

A. Study area and collection of water samples

The Chili River rises in the heights of Arequipa as a union of the Sumbay and Blanco rivers that finally flows into the Pacific Ocean as the Quilca River [10].

Samples were collected in polyethylene containers and then taken to the laboratory to determine their physicochemical characteristics (pH, temperature, electrical conductivity and cadmium content).

B. Opuntia ficus mucilage extraction

For heavy metal adsorption, mucilage extracted from Opuntia ficus nopales was used. The nopales were collected manually at random and taken to the laboratory and added to the water sample to demonstrate the effectiveness of Opuntia ficus [1] and then added to the water sample to demonstrate the effectiveness of Opuntia ficus and compare the initial results (without treatment) and final results (with "Opuntia ficus" treatment).

1. Description of prickly pear cactus

It is an abundant, cost-effective, and biodegradable natural product that acts as a coagulant, flocculant, and biosorbent for wastewater treatment [11].

Fig. 1. shows the Opuntia ficus plant that was found in the city of Arequipa, with an approximate length of 23 cm.

Fig. 1. Opuntia ficus plant – Nopal.

2. Description of Opuntia ficus mucilage

Opuntia ficus mucilage, also known as nopal slime, are gelatinous substances found in some plants that contain hydrogen, carbon and oxygen. Fig. 2. shows cactus mucilage, which has the ability to remove heavy metals in wastewater [12].

Fig. 2. Mucilage of the plant Opuntia ficus.

3. Procedure for obtaining the mucilage

The application of Opuntia ficus also known as Tuna, Nopal or Cactus is used in rural areas as a coagulant. Fig. 3 details the procedures for obtaining Opuntia mucilage.

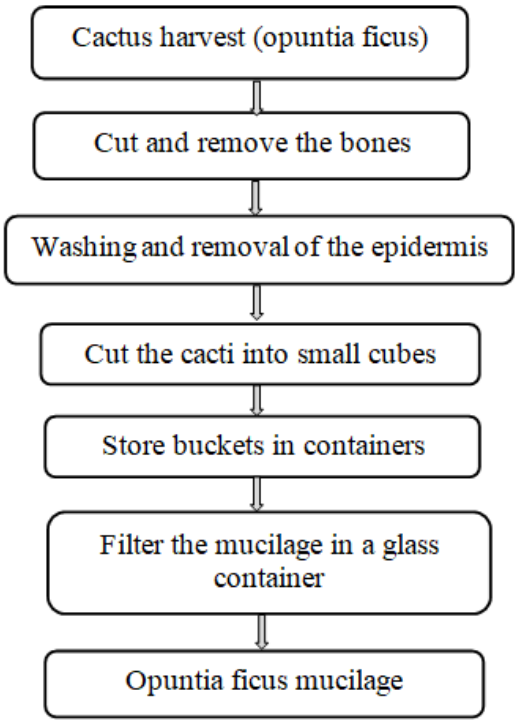

Fig. 3. Diagram of the procedure for obtaining the mucilage.

The plant stalks were subjected to different activities such as cutting and peeling see Fig. 4. Opuntia ficus mucilage has the ability to remove 50% of color, 70% of turbidity and does not alter the pH of raw water with high initial turbidity [13].

Fig. 4. Cut for the extraction of the mucilage.

C. Concentration of Opuntia ficus mucilage to reduce heavy metals such as cadmium

In a volume of 500 ml of water sample from the Chili river, 250 g of Opuntia ficus mucilage was added as shown in Table I, to determine the reduction of cadmium (Cd) in the water.

Table I: Concentration of the Opuntia ficus solution.

Sample	Volume (ml)	**W**eight of "Opuntia ficus" **mucilage** (g)
Water from the Chili river	500	250

RESULTS

The samples were taken by the laboratory Servicios Analiticos Generales S.A.C (testing laboratory accredited by the accreditation body INACAL-DA with registration No. LE-047), which provides inspection, sampling and analytical testing services to major companies in the Hydrocarbons, Mining, Consulting, Energy and Industrial sectors in Latin America.

A. Physicochemical analysis of the untreated sample

Table II shows the results of the physicochemical properties of the water of the Chili River.

Table II: Results of the physicochemical parameters

Parameters	Unit	Sample
Volume	ml	500
pH	pH unit	8.4
Temperature	°C	14
Conductivity	µS /cm	1041

In the course of the Chili River, there is too much contamination. Table III shows the result of the determination of cadmium (Cd), as mentioned above, there are mining tailings that discharge their wastewater into this receiving body.

Table III: Cadmium concentration in the waters of the Chili River.

Heavy metal	Unit	Result
Cadmium	mg/L	0.015

B. Physicochemical analysis for the sample treated with Opuntia ficus mucilage

Table IV shows the results of the determination of physicochemical parameters of the sample treated with Opuntia ficus mucilage.

Table IV: Results for physicochemical parameters

Parameters	Unit	Mucilage-treated sample
Volume	ml	500
pH	unit pH	6.5
Temperature	°C	14.5
Conductivity	µS /cm	574

Table V presents the result of the determination of Cadmium in the sample treated with Opuntia ficus mucilage.

Table V: Cadmium results in the treated sample

Heavy metal	Unit	Result
Cadmium	mg/L	0.003

Based on the results obtained, a descriptive comparison was made.

Hydrogen Potential

The pH is one of the important parameters to determine the quality of the water, where it has adverse consequences if these are acidic or alkaline, however, if it has a neuro pH that varies between 6.5 to 8 where the sample with Opuntia ficus mucilage treatment as shown in Fig. 5. is acceptable and has no harmful effects to health [14].

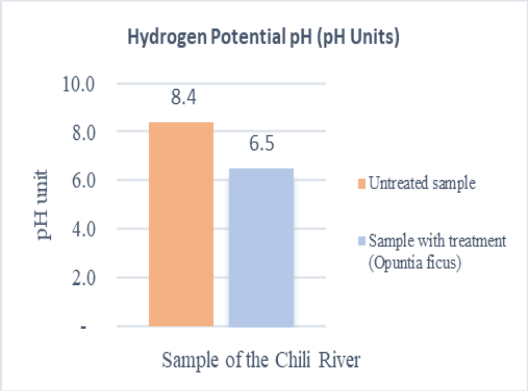

Fig. 5. Analysis of the pH parameter – sample Without treatment and With treatment Opuntia ficus.

Temperature

Fig. 6 shows the results of the temperature parameter, which for the untreated sample showed a result of 14 °C, while for the treated sample it was 14.5 °C. As we can see both results do not have significant variation because they were measured under the same conditions of time and space.

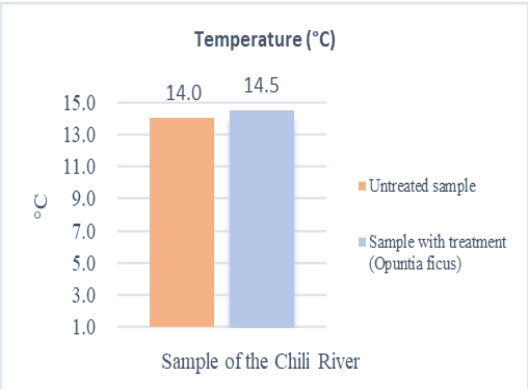

Fig. 6. Analysis of the parameter temperature – sample Without treatment and With treatment Opuntia ficus.

Conductivity

The results obtained for the Conductivity parameter are shown in Fig. 7, for the untreated sample 1041 uS /cm and for the treated sample 574 uS /cm.

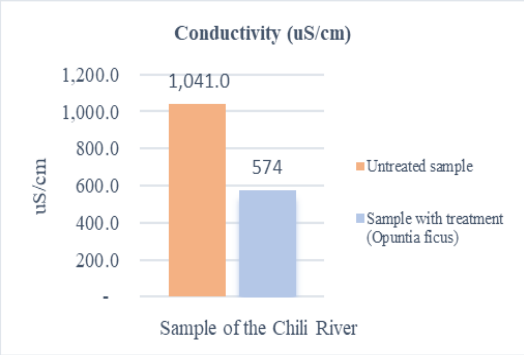

Fig. 7. Analysis of the Conductivity parameter – sample Without treatment and With treatment Opuntia ficus.

C. Presentation of cadmium reduction results

Cadmium was analyzed by atomic absorption spectrophotometry (AAS). The results obtained in the laboratory are shown in Fig. 8. For the sample with treatment, the result was 0.015 mg/L, and for the sample with treatment of Opuntia ficus mucilage, 0.003 mg/L was obtained.

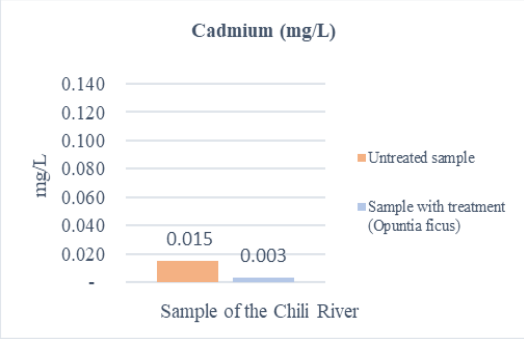

Fig. 8. Cadmium (Cd) removal analysis - Untreated and treated Opuntia ficus sample.

CONCLUSION

The results allowed concluding that Opuntia ficus has the capacity to remove Cadmium content from wastewater. It was established that the material does not significantly alter the pH of the treated water of the Chili River.

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