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Research paper



Comparative Biosorption Capacity of Copper and Chromium by Bacillus Cereus

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Abstract

Biosorption of heavy metals by bacteria is one such effective and eco-friendly method being adopted frequently for environmental applications. The present work reveals the comparative adsorption capacity of Copper and Chromium on the surface of *Bacillus Cereus, a*erobic, gram positive bacteria. Hexavalent chromium is toxic, non-biodegradable and persistent in nature, Copper is equally toxic when exceeds the permissible limit. Batch experimental studies were conducted in shake flask method to optimize the parameters such as pH, Reaction time, Biosorbent dose and Initial metal concentration. One of four parameters was varied keeping the other three constants and the optimum reaction time was found to be 24 hours. At an Optimum pH level of 7±2 with the optimum initial metal concentration of 100ppm the biosorption capacity was found to be 54 percent and 60 percent for Copper and Chromium respectively.

Keywords: *Bacillus Cereus; Biosorption; Chromium; Copper, Heavy metal.*

1. Introduction

Heavy metal is a general collectiveterm that applies to the group of metals and metalloids with density greater than 4±1 g/cm³. Since heavy metals cannot be degraded or destroyed, they persist in the environment. Some of the heavy metals which will pose environmental problems when exceeds their respective permissible limits are cadmium, chromium, copper, mercury, lead, zinc, arsenic, boron, and the platinum group metals. Chromium released in the effluent from chrome tanning and chrome plating industries and copper pollution from mining, milling, refining of copper ores, electroplating and petroleum industries pose serious environmental problem listed in Table 2 below [1].

Chromium and Copper concentration in drinking water should not exceed 0.05 mg/L as per WHO norms and ISI standards as listed in Table 1. Industrial or sewage effluents should not exceed 3.0 mg/L if it is being let out into inland surface or into marine coastal plane.

Heavy metals can enter into lakes, rivers, other water bodies and groundwater by industrial and consumer waste. Heavy metal toxicity can result in damaged or reduced mental and central nervous function and damages blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis [2]

Methods such as, Chemical precipitation, Filtration, Membrane separation, Ion exchange etc available to reduce the heavy metal pollution from effluent or from the environment are expensive, labour consuming and generate secondary wastes which are difficult to manage. On the other hand biosorption serves to be the ecofriendly and comparatively easier method for the reduction of heavy metal pollution from the effluent or from the environment [3].

Table1: Permissible limit for drinking water [4]

Heavy metals	Standards	Permissible limit
Arsenic	IS: 10500-1991	0.05 mg/l
Chromium	IS: 10500-1991	0.05 mg/l
Copper	IS: 10500-1991	0.05 mg/l
Lead	IS: 10500-1991	0.05 mg/l
Mercury	IS: 10500-1991	0.001mg/l
Zinc	IS: 10500-1991	2 mg/l

Table 2: Sources and significance of trace elements

S.No.	Element	Source	Effects and Significance
1	Arsenic	Mining by-product, pesticides, chemical waste	Toxic, possibly carcinogenic
2	Beryllium	Coal, nuclear power and space Industries	Carcinogenic, Acute and chronic toxicity
3	Boron	Coal, detergent formulations, industrial wastes	Toxic to some plants
4	Cadmium	Industrial discharge, mining waste, metal plating, water pipes	Causes high blood pressure and Kidney, Replaces zinc biochemically
5	Copper	Metal plating, industrial and domestic wastes, mining, mineral leaching	Essential trace element, not very toxic to animals, toxic to plants and algae at moderate levels
6	Fluorine (Fluoride)	Natural geological sources, industrial wastes, water additive	Prevents tooth decay at above 1mg / liter, causes mottled teeth and bone damage at around 5mg/liter in water
7	Iodine (Iodide)	Industrial wastes, natural brines,	Prevents goiter

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		seawater intrusion	
8	Iron	Corroded metal, industrial wastes, acid mine drainage, low ph water in contact with iron minerals	Essential nutrient (component of hemoglobin), not very toxic, damages material (bathroom fixtures and clothing)
9	Lead	Industry, mining, plumbing, coal, gasoline	Toxicity (anemia, kidney disease, nervous system), wildlife destruction
10	Manganese	Mining, industrial waste, acid mine drainage, microbial action on manganese minerals at low ph	Relatively nontoxic to animals, toxic to plants at higher levels, stains material (bathroom fixtures and clothing)
11	mercury	Industrial waste, mining, pesticides, coal	Acute and chronic toxicity
12	Molybdenum	Industrial waste, natural sources, cooling-tower water additive	Possible toxic to animals, essential for Plants
13	Selenium	Natural geological sources, sulfur, coal	Essential at low levels, toxic at higher levels, causes "alkali disease" and "blind staggers" in cattle, possibly

2. Materials and Methods

2.1. Biosorbent/Biomass Preparation

Bacillus cereus (a Gram-positive, rod-shaped bacteria) obtained from Central Leather Research Institute was used for the experiment. Bacillus cereus culture from freshly prepared agar plates were inoculated into 1 Litre conical flasks containing 500mL of nutrient broth with beef extract (3.0 g), peptone (6.0 g), disodium phosphate (1.0 g), sodium chloride (3.0 g), dissolved in one liter of distilled water. The pH values of the solutions were adjusted to the optimum values 7±2 using 0.1 N NaOH and 0.1 N HNO_3. The cultures were grown at room temperature on an orbital shaker at 150 rpm for 48 h. Well grown culture solution was used for the biosorption experimental studies [6].

2.2. Aqueous Solution Preparation

Potassium chromate (K_2CrO_4) and copper sulphate ($CuSO_4$) procured are of high pure and laboratory grade (Merck). The aqueous solution prepared by dissolving known quantities of the salts in distilled water are sterilized for about 15 minutes in autoclave and were used for the experiments. Initial and final concentration of the solution before and after the experiments was analysed using UV visible spectrophotometer (Perkin-Elmer B050-7805)[7].

2.3. Experiments

a) Effect of pH

Initial solution concentration being 100ppm, Culture concentration being 10% and the contact time was maintained constant as 24 hours, the effect of pH on the adsoption capacity of Cu and Cr was studied in batch experiments. Solution pH was adjusted by 0.1N NaOH and 0.1N HNO_3. The experiment was repeated thrice and the average value of the three trials was plotted and shown in Fig.1

b) Effect of Time

Initial solution concentration being 100ppm, Culture concentration being 10% and the pH being maintaine at 7±2, batch experiments was conducted to know the optimum time of contact to be maintained for maximum biosrption capacity. The experiment was repeated thrice and the average value of the three trials was plotted and shown in Fig.2

c) Effect of Culture Concentration

Maintaining the solution pH at the optimum value of 7±2 and the Initial solution concentration being 100ppm, the adsorption capacity at 24 hours was observed by variying the culture concentration from 1 to 10%. The experiment was repeated thrice and the average value of the three trials was plotted and shown in Fig.3

d) Effect of Initial Concentration

Maintaining the culture concentration at the optimum level of 10%, optimum pH value at 7±2, the adsorption capacity at 24 hours was observed by variying the initial metal concentration from 100ppm to 500ppm. The experiment was repeated thrice and the average value of the three trials was plotted and shown in Fig.4

3. Results and Discussion

3.1. Effect of pH

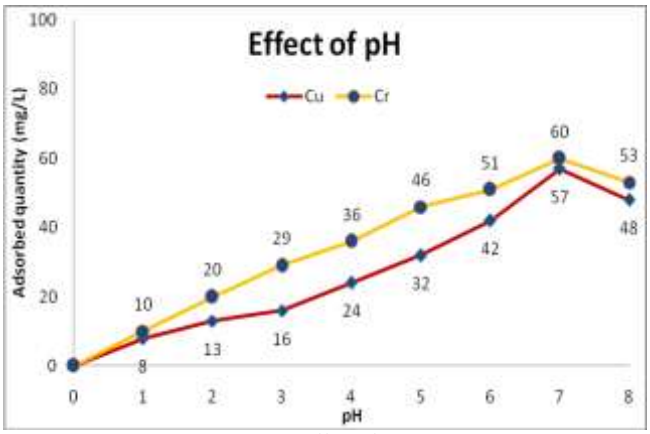


Fig 1: Effect of pH

It was observed that the maximum adsorption capacity of 60mg and 57 mg was observed for chromium and copper respectively at the optimum pH value of 7±2. The ionic interaction between metal ion and the biosorbent functional group varies with varying pH value till 7 beyond which the adsorption capacity decreases because of the formation of soluble metal hydroxide in the solution [8]. The adsorption capacity was more or less equal higher for both chromium and copper due to the lower concentration of H^+ and $H3O^+$ ions in the solution which makes the biomass surface capable of binding positive metal ions [9].

3.2. Effect of Reaction Time

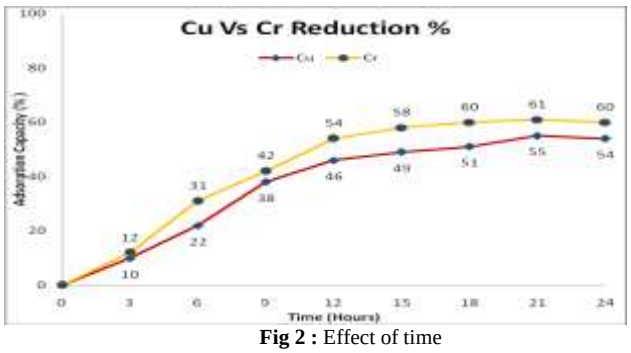


Fig 2 : Effect of time

Maximum adsorption capacity of 55mg for Copper and 61mg for chromium was adsobed by the biomass and equlibirium was attained almost at the end of 12 hours of contact time. More than 90% of maximum adsorption capacity such that 46mg for Copper and 54mg for chromium was attained during the 12 hour operation for both chromium and copper. More amount of metal ions available as adsorbate and more number of active sites avaible for adsorption during the first few hours of operation makes the operation to attain equilibrium posible [10]. The drop in adsorption rate after 24 hours might be due to the non availability of enough active sites or due to the less ionic concentration of the solution [11].

3.3. Effect of Culture Concentration

The biosorption capacity increases with the increase in the culture concentration. When 1% culture was added to the 100ppm solution the adsorption capacity was found to be 14 and 19 mg for copper and chromium respectively and it reaches a maximum value of 58 and 61 mg for the optimum culture concentration of 10%.

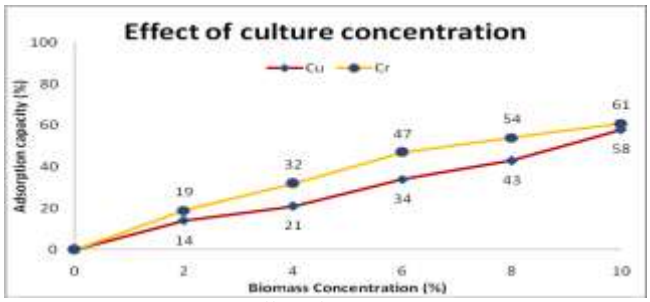


Fig 3: Effect of culture concentration

More amount of active sites available for biosorption when more amount of culture medium/ biosorbent added to the solution might be the reason for the for the increase in biosorption capacity when the biosorbent concentration increases[12]. Increase the concentration beyond 10% leads to the decrease in biosorption due to partial aggregation of cells which decreases the free active cites for metal binding.

3.4. Effect of Initial Concentration

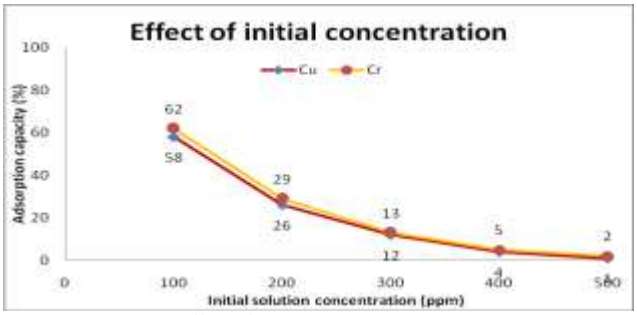


Fig 4: Effect of initial metal concentration

Initial metal concentration was varied from 100 ppm to 500 ppm and the biosorption capacity was observed. Maximum biosorption capacity 62 and 58 mg was observed for Chromium and Copper respectively. Decrease in the biosorption capacity with the increase in the initial concentration might be due to the contamination of cell culture due to the higher concentration of heavy metal in the solution [13]. At about 500pm the adsorption capacity was almost zero and increases when the initial concentration was decreased from 500 to the optimum level of 100pm initial concentration.

4. Conclusion

Comparative analysis of the biosorption capacity of environmentally toxic heavy metals such copper and chromium onto the surface of bacteria, bacillus cereus was experimentally verified and it was found to be almost equal for both the metals. Scanning electron microscopic analysis, energy dispersive Spectroscopic analysis, FTIR would possibly confirm the experimentally obtained results which were presented in this article. Fitting the data's in the adsorption isotherms for validation, verifying the kinetics and thermodynamic parameters of the reaction would be the future scope of the present work presented in this article.

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References

[1] A.K.Shrivastava, A review on copper pollution and its removal from water bodies by pollution control technologies, Indian J. of Environmental Protection, Vol. 29, No. 6, June 2009.
[2] Rashmi Verma and Pratima Dwivedi, Heavy metal water pollution-A case study, Recent Research in Science and Technology, 5(5): 98-99, 2013.
[3] John Rose MercyBenila Smily and Pasumalai ArasuSumithra, Optimization of Chromium Biosorption by Fungal Adsorbent, Trichoderma sp. BSCR02 and its Desorption Studies, HAYATI Journal of Biosciences, Volume 24, Issue 2, April 2017, Pages 65-71
[4] Bureau of Indian Standards, Indian standard drinking water - specification (second revision), IS 10500: 2012
[5] A.Ş.Yargıç et al, Assessment of toxic copper(II) biosorption from aqueous solution by chemically-treated tomato waste, Journal of Cleaner Production, Volume 88, 1 February 2015, Pages 152-159
[6] Hassan Rezaei, Biosorption of chromium by using Spirulina sp., Arabian Journal of Chemistry, Volume 9, Issue 6, November 2016, Pages 846-853
[7] Robson Andreazza, Characterization of copper bioreduction and biosorption by a highly copper resistant bacterium isolated from copper-contaminated vineyard soil, Science of The Total Environment, Volume 408, Issue 7, 1 March 2010, Pages 1501-1507
[8] Mathivanan Krishnamurthy and R. Rajaram, Removal of Cd(II) and Cu(II) from Aqueous Solutions by Pseudomonas stutzeri KMNTT-01 Biomass, Environmental Processes An International Journal, Volume 3 Number 4, (2016) 3:857-874.
[9] MarinaFomina et al, Biosorption: current perspectives on concept, definition and application, Bioresource Technology, Volume 160, May 2014, Pages 3-14
[10] JinsongHe and J. PaulChen, A comprehensive review on biosorption of heavy metals by algal biomass: Materials, performances, chemistry, and modeling simulation tools, Bioresource Technology, Volume 160, May 2014, Pages 67-78
[11] M D Mullen et al, Bacterial sorption of heavy metals, Applied and Environmental Microbiology, December 1989 vol. 55 no. 123143-3149
[12] Hanjun Guo et al, Bioremediation of heavy metals by growing hyperaccumulaor endophytic bacterium Bacillus sp. L14, Bioresource Technology, Volume 101, Issue 22, November 2010, Pages 8599-8605
[13] Mohammad Oves et al, Biosorption of heavy metals by Bacillus thuringiensis strain OSM29 originating from industrial effluent contaminated north Indian soil, Saudi Journal of Biological Sciences, Volume 20, Issue 2, April 2013, Pages 121-129
[14] Shankar Congeevaram et al, Biosorption of chromium and nickel by heavy metal resistant fungal and bacterial isolates, Journal of Hazardous Materials, Volume 146, Issues 1–2, 19 July 2007, Pages 270-277