ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Efficiency of *Opuntia ficus-indica* (L) Mill. in Removal of Chromium from Synthetic Solution.

S Asha*, Tabitha C, Himabindu N, and R Bharath Kumar.

School of Biotechnology, Vignan's University, Vadlamudi, Guntur Dt., Andhra Pradesh, India.

ABSTRACT

Chromium is one of the pollutants in waste waters and many methods are being used to purify the water including natural coagulants of plant origin. Prickly pear mucilage is reported as a natural coagulant and it has been used as water purifier since ancient times. The present study was undertaken to determine the efficiency of prickly pear mucilage in removal of chromium from waste water. Synthetic chromium solution was prepared by using potassium dichromate ($K_2Cr_2O_7$) solution. A standard graph was prepared using different concentrations of chromium (4, 8, 12, 16, and 20µg/ml).Chromium was analyzed by spectophotometric method at 540 nm. Prickly pear mucilage was prepared by boiling 20 g of nopal pads in 150 ml of distilled water for 90 min and filtering the residues. The filtrate was tested for chromium removal. To test the efficiency of prickly pear mucilage in removal of chromium, four parameters i.e., mucilage concentration, time, temperature and agitation speed were optimized. The results showed that 1ml of mucilage for120 min of incubation at 30 ^{0}C temperature and 150 rpm are optimal for higher removal i.e., approximately 98.75% of chromium. It is concluded that prickly pear mucilage is having the potential to reduce chromium concentration in synthetic waste water. Hence, it may be used as a low cost natural coagulant for water treatment.

Key words: Natural coagulant, Prickly pear mucilage, Chromium, Water Purification, Optimization

Corresponding author

ISSN: 0975-8585

INTRODUCTION

Water is essential to the survival of all organisms on the earth [1]. Although, different sources of water like surface, ground water are available, it is being contaminated with several pollutants from various sources like industries and human activities etc. Many techniques like physico-chemical are being used to purify water. Recent research concentrated more on use of plant resources in purification of water [2], mainly due to their low cost [3,4],abundant availability, innocuity, multifunction and biodegradation [5]. Use of plant materials as natural coagulants is not a new approach in removal of water pollutants. Since ancient times plants like *Moringa olifera* (Drumstick tree), *Strichnos potatoram* (Clearing Nut Tree) and *Opuntia* (cactus) [6-11] are used for water purification in countries like Mexico, Peru, Chile, Latin America and India etc.

Different species of Cactus are available in the world. *Opuntia ficus-indica* belongs to the family Cactaceae and it is commonly called as prickly pear in Northen America and as nopal in Mexico. It has different vernacular names in India like Nagphani (Hindi), Bahushala (Sanskrit), Nagajemudu (Telugu) etc.[12]. It is characterized by production of a hydrocolloid, commonly known as mucilage [13] which retains large amounts of water [14]. It is a viscous and complex carbohydrate stored in outer and inner pads. It is reported as natural coagulant and flocculent [15-18]. The coagulation capacity of *Opuntia* is attributed to the active ingredient Galacturonic acid present in the mucilage [19,20].

Some researchers [9,21-23] have reported heavy metal removal using *Opuntia*. However, information regarding removal of chromium using prickly pear mucilage is scanty. Hence, the present study was aimed at determining the efficiency of prickly pear mucilage in removal of chromium from synthetic water.

MATERIALS and METHODS

Collection of nopal pads

Nopal pads of prickly pear are collected from the surrounding areas of VFSTR University Campus, Vadlamudi, Guntur Dt., Andhra Pradesh, India.

Mucilage Extraction from prickly pear

Nopal pads of prickly pear are collected freshly and thorns were removed carefully using knife. Then, the pads were cut into small pieces. 20 g of nopal pad pieces were weighed and took into the beaker containing 150 ml of distilled water and boiled for about 90 min. After boiling, pieces of nopal pads are removed and the solution was filtered through Whatman No. 1 filter paper to remove the debris and filtrate (mucilage) was used for treating the water.

ISSN: 0975-8585

Preparation of chromium stock solution and Estimation of chromium

Chromium stock solution was prepared by dissolving 283 mg dried potassium dichromate ($K_2Cr_2O_7$) in distilled water and making up to 1000 ml in a volumetric flask (1.0 ml =100 µg Cr). Chromium working solution was prepared by dissolving 10.0 ml Chromium stock solution in 490 ml of distilled water (1.0 ml=2.0 µg Cr). A standard curve was prepared using different concentrations of chromium (4, 8, 12, 16, and 20 µg/ml) as shown in Table-1. Chromium was estimated by S-diphenyl carbazide method [24] and O.D was measured at 540 nm in Spectrophotometer. The percentage removal of Cr was calculated using the following formula.

% Removal = [(initial concentration- concentration of Cr in sample)*100] / Initial concentration

To test the efficiency of prickly pear mucilage in removal of chromium four parameters viz., mucilage concentration, time, temperature and agitation speed were optimized as follows.

Table 1: Preparation of chromium standard curve

Volume of working solution (ml)	Volume of distilled water (ml)	Concentration of Chromium (µg/ml)	Volume of 5% H_2SO_4 (ml)	Volume of diphenyl carbazide solution (ml)	Volume of H_3PO_4 (ml)	Make up to 50 ml with distilled water	Incubate at room temperature for 5 min	O.D at 540 nm
2	23	4	10	4	0.4			
4	21	8	10	4	0.4			
6	19	12	10	4	0.4			
8	17	16	10	4	0.4			
10	15	20	10	4	0.4			
Blank	25	------	10	4	0.4			

Optimization of prickly pear mucilage concentration

20 ml of Cr working solution was taken into four conical flasks and different aliquots of prickly pear mucilage i.e., 2, 1, 0.5 and 0.25 ml were added respectively and made up to 25 ml with distilled water. The mixture (sample) was incubated in orbital shaker at 150 rpm for 2 h at 30 ^{0}C. After incubation, 10 ml of H_2SO_4, 4 ml of Diphenyl Carbazide and 0.4 ml of H_3PO_4 were added and made up to 50 ml with distilled water and incubated at room temperature for 5 min and absorbance was measured in spectrophotometer at 540 nm.

Optimization of Time

20 ml of Cr working solution was taken into four conical flasks and one ml of prickly pear mucilage was added and made up to 25 ml with distilled water. The mixture (sample) was incubated in orbital shaker for different time intervals such as 30, 60, 90 and 120 min. After incubation, 10 ml of H_2SO_4, 4 ml of Diphenyl Carbazide and 0.4 ml of H_3PO_4 were added and

ISSN: 0975-8585

made up to 50 ml with distilled water and incubated at room temperature for 5 min and the absorbance was measured in spectrophotometer at 540 nm.

Optimization of Temperature

20 ml of Cr working solution was taken into four conical flasks and one ml of prickly pear mucilage was added and made up to 25 ml with distilled water. The mixture (sample) was incubated in orbital shaker at different temperatures such as 30, 40, 50 and 60 ^{0}C. After incubation, 10 ml of H_2SO_4, 4 ml of Diphenyl Carbazide and 0.4 ml of H_3PO_4 were added and made up to 50 ml with distilled water and incubated at room temperature for 5 min and the absorbance was measured in spectrophotometer at 540 nm.

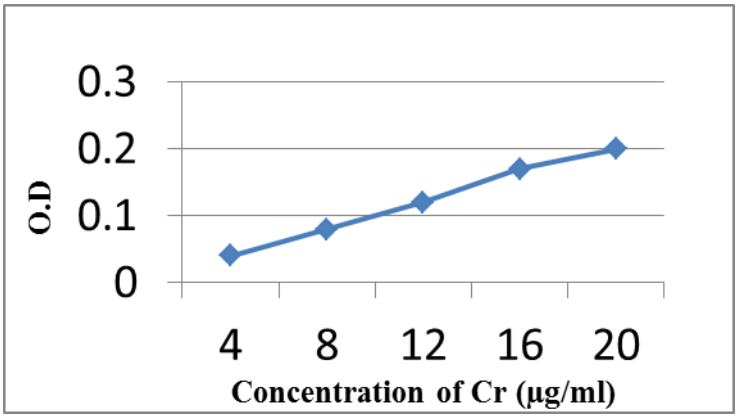
Optimization of agitation

20 ml of Cr working solution was taken into four conical flasks and one ml of prickly pear mucilage was added and made up to 25 ml with distilled water. The mixture (sample) was incubated in orbital shaker at different rpm's such as 100, 200 and 250 at 30 ^{0}C. After incubation, 10 ml of H_2SO_4, 4 ml of Diphenyl Carbazide and 0.4 ml of H_3PO_4 were added and made up to 50 ml with distilled water and incubated at room temperature for 5 min and the absorbance was measured in spectrophotometer at 540 nm.

RESULTS AND DISCUSSION

Synthetic chromium was prepared by using Potassium dichromate (1.0 ml =100 µg Cr) and the working solution was found to be 2µg/ml. After determining the working solution, standard curve was prepared using different concentrations of chromium (4, 8, 12, 16, and 20 µg/ml) and the standard curve was plotted and represented as Graph-1.

To test the efficiency of prickly pear mucilage in removal of chromium, different parameters like mucilage concentration, time, temperature and agitation (rpm) were optimized.

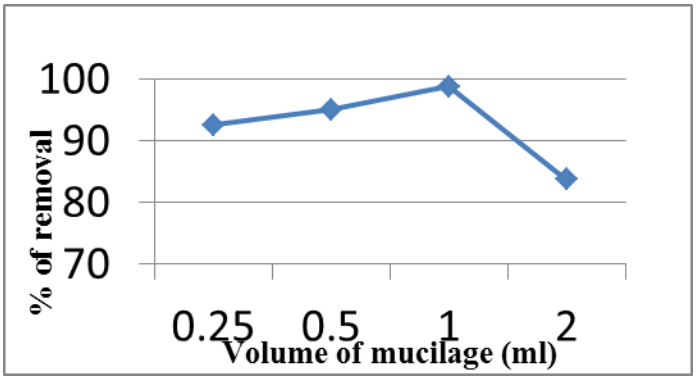


Graph 1: Standard curve of Chromium

ISSN: 0975-8585

Optimization of mucilage concentration

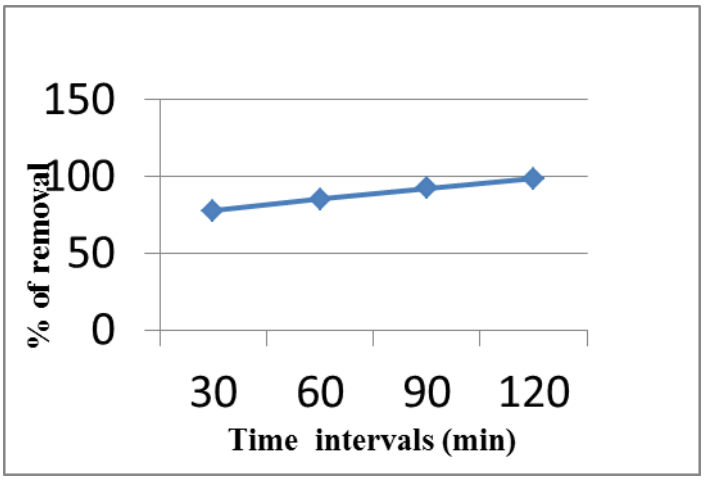
For optimization of mucilage, different aliquots of mucilage such as 0.25, 0.5, 1.0 and 2.0 ml were tested by incubating in the orbital shaker at 150 rpm for 2 h at 30 ^{0}C. The results are represented in Graph-2 and it was observed that 1ml of prickly pear mucilage is more effective in removal of chromium to maximum extent i.e., 98.75% when compared with other concentrations.



Graph 2: % removal of chromium with different concentrations of prickly pear mucilage

Optimization of time

For optimization of time, different time intervals such as 30, 60, 90 and 120 min were tested with 1 ml of mucilage and the results are represented in Graph-3. From the Graph-3, it was observed that highest removal of chromium i.e., 98.75 % was achieved with 1ml of prickly pear mucilage and incubation time of 120 minutes which suggests that 120 min is the optimum time for maximum removal of chromium.

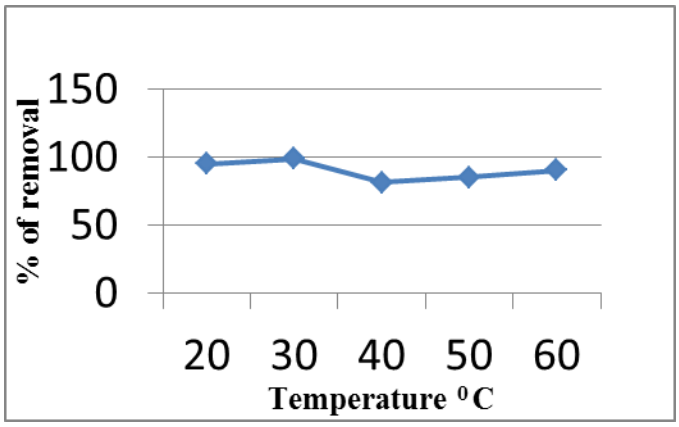


Graph 3: % removal of chromium at different time intervals (min) with 1 ml of prickly pear mucilage

ISSN: 0975-8585

Optimization of temperature

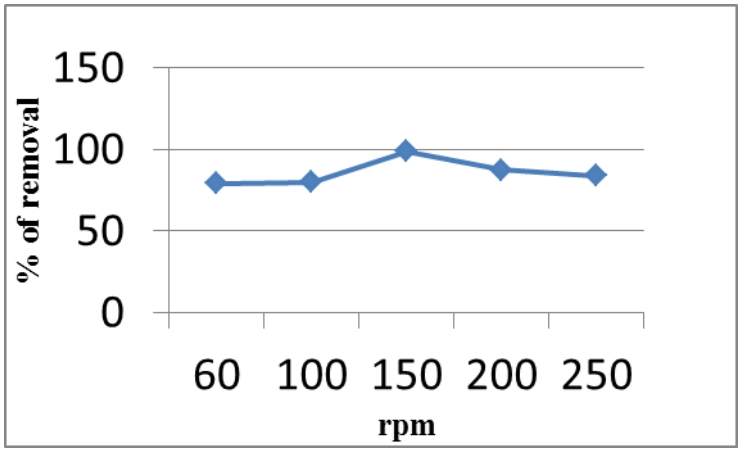
Similarly, for optimization of temperature, different temperatures such as 20, 30, 40, 50 and 60 ^{0}C were tested with 1 ml of mucilage and incubation time of 120 min. The results are depicted in Graph- 4 and it was found that maximum (98.75%) chromium removal was achieved with 1ml of prickly pear mucilage, incubation time of 120 min and 30 ^{0}C temperatures.



Graph 4: % removal of chromium at different temperatures with 1 ml of prickly pear mucilage and 120 min of incubation

Optimization of agitation (rpm)

For optimization of agitation, different rpm's viz., 60, 100, 150, 200 and 250 were tested with 1 ml of mucilage, incubation time of 120 min and 30º C temperature. The results are represented in Graph-5. From the Graph -5, it was found that the removal of chromium is maximum with 1ml of prickly pear mucilage, 120 min of incubation time, temperature of 30 ^{0}C and 150 rpm.



Graph 5: % removal of chromium at different agitations (rpm) with 1 ml of prickly pear mucilage, 120 min of incubation at 30 °C

Similarly, Mane et al., also found that 150 rpm agitation speed at 30 ^{0}C is optimal for chromium removal up to 68 % using *Opuntia* mucilage [23]. However, the concentration of polyelectrolyte and incubation time is in contrast to the present findings. Dorra et al., suggested that the removal of metals depends up on polyelectrolyte concentration and agitation speed [25]. The removal of heavy metals may be due to hydrophilic character of mucilage because of which several hydrogen bonds are formed between polyelectrolyte and water which occupies larger surface area causing its very high viscosity, that are in agreement with the studies of La Mer and Healey and Nozaki et al., who stated that natural polyelectrolyte's have been used as auxiliary of flocculation and coagulation in waste water treatment and water cleaning process [26,27 & 28]. Oliveira et al., suggested that the positive metal ions serve to form a bridge among anionic polyelectrolyte and negatively charged functional groups on colloidal particle surface [26]. Benson reported that composition of mucilage gives prickly pear the capacity to interact with metals, cations and biological substances [29].

CONCLUSION

To test the efficiency of prickly pear mucilage in removal of chromium, four parameters i.e., mucilage concentration, time, temperature and agitation were optimized. It was found that 1ml of mucilage,120 min of incubation, 30 ^{0}C temperature and 150 rpm are optimal for higher removal i.e., approximately 98.75% of chromium. It is concluded from the present study that prickly pear mucilage is efficient in removal of chromium. Hence, it may be used in the removal of heavy metals from polluted water or in the treatment of waste water.

ACKNOWLEDGEMENTS

Authors are expressing their gratitude to the Chancellor and Vice-Chancellor for their encouragement. Authors are thankful to the Director DET, Vignan University, Vadlamudi, for providing facilities and encouragement. Authors are expressing their sincere thanks to Head, School of Biotechnology for providing necessary facilities to carryout fieldwork and laboratory analysis. Authors are also thankful to the Management for extending financial assistance & providing facilities.

REFERENCES

[1] Alison, D Science 2001; 314: 1687-1688.
[2] Jahn SA. A J. Am. Wat. Wks Assoc. 1988; 80: 43–50.
[3] Schulz CR, Okun DA. Surface Water Treatment for Communities in Developing Countries. John Wiley & Sons, New York, 1984.
[4] Ndabigengerese A, Narasiah S, Talbo BGJ. Water Res. 1995; 29: 703-710.
[5] Zhang J, Fang Z, Luo Y, Yang H. Process Biochem, 2006; 41: 730-733.
[6] Gupta A, Chaudhuri M J.Water SRT-Aqua. 1992; 41: 290-298.

[7] Kirchmer Cliff J, Arboleda Jorge V, Maria Lui sa Castro: Polimeros naturales y suaplicacion como ayudantes de floculacion. Serie Documentos Tecnicos 2, Centro Panamericano de Ingenieria Sanitaria y Ciences del Ambiente, Lima (Peru) (1975).
[8] Sutherland JP, Folkard GK, Grant WD. Natural coagulants for appropriate water treatment: a novel approach, Waterlines, 1990; 8(4): 30-32.
[9] Lopez E. Utilizaci !on de productos naturales en la clarificaci !on de aguas para consumo humano. Tesis de Maestr!ıa, Facultad de Ingenier!ıa Qu!ımica, ISPJAE, 2000; Universidad de la Habana, Cuba.
[10] Nobel PS. Cacti: Biology and Uses.2002; University of California: Berkeley, California.
[11] Carmen Saenz,Elena Sepulveda, Betty Matsuhiro J. Arid Environments 2004; 57: 275–290.
[12] Chauhan SP, Sheth NR, Jivani NP, Rathod IS, Shah P.I Syst Rev Pharm. 2011; 1: 146- 151.
[13] Fluxa´ C Extraccio´ n y composicio´ n quı´mica de mucı´lago de tuna. Tesis para optar al Tı´tulo de Quı´mico.Facultad de Ciencias Quı´micas y Farmace´ uticas, Universidad de Chile 1991; 50.
[14] Saag L, Sanderson G, Moyna P,Ramos G J. Science of Food and Agri 1975; 26: 993–1000.
[15] McGarvie D, Parolis P. H Carbohydrate Research 1979; 69: 171–179.
[16] Young K A, Anzalone A, Pichler T, Picquart T, Alcantar N. A. Materials Science of Water Purification (M. A. Shannon, D. Ginley & A. M. Weiss, eds.). 2006; Materials Research Society, Warrendale, PA 930, 0930-JJ01-01.
[17] Thomas Pichler, Kevin Young, Norma Alcantar Water Science and Tech.: Water Supply 2012; 12.2: 179-186.
[18] Shilpaa, BS, Akankshaa Kavita, Girish P. International Journal of Chemical and Environmental Engineering 2012; 3: 187-191.
[19] Miller SM, Fugate EJ, Craver VO, Smith JA, Zimmerman J.B. J.Environ Sci Technol. 2008; 42: 4274–9.
[20] Swati M, Govindan VS. J Indian Water Works Assoc 2005; 37:145–9.
[21] Patricia M, Carolina M, Alejandro CC. Bioresource Technology; 2008; 99: 1211-1217.
[22] Gad AS, Attia M, Ahmed H A. J. American Science; 2010; 6: 79-87.
[23] Mane P, Bhosle AB, Jangam CM, Mukate S.V J. Nat. Prod. Plant Resour. 2011; 1: 75-80.
[24] Thomas GC. Qualitative and Instrumental Analysis of Environmentally Significant Elements, John Wiley and Sons, New York, 1993; 43.
[25] Dorra JE, Lassaad G, Mohammed RBR, Mahmoud D Desalination; 2009; 248: 42-48.
[26] Oliveira MA, Rodrigues Reis CE, M dos, Nozaki J Quim Nova ; 2001; 24.
[27] La Mer Y, Healy T. Rev. Pure AApl. Chem; 1963; 13: 112.
[28] Nozaki J, Messerschimidt I and Rodrigues DG. Arq. Biol. Tecnol 1993; 36: 761.
[29] Benson L. Cacti of the United States and North America. Stanford, CA: Stanford University Press, 1982; pp. 1044.