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Keywords:

AS(III)	pH	Living					Dried				
		Chlorella	***Oscillatoria***	***Scenedesmus***	***Spirogyra***	***Pandorina***	***Chlorella***	***Oscillatoria***	***Scenedesmus***	***Spirogyra***	***Pandorina***
10 mg/l	2.0	4	3	5	4	4	4	4	5	5	4
	4.0	7	6	7	6	7	7	6	7	6	6
	6.0	7	6	7	6	7	7	5	7	6	6
	8.0	5	4	5	4	5	5	4	5	5	5
	10.0	4	3	4	3	4	4	3	4	3	5
20 mg/l	2.0	8	6	9	8	7	9	8	9	9	9
	4.0	11	9	13	12	12	12	11	14	13	15
	6.0	10	9	12	12	14	11	10	14	13	14
	8.0	8	5	8	6	6	7	4	8	7	7
	10.0	5	3	5	3	3	4	2	5	3	3
30 mg/l	2.0	10	9	11	8	8	9	9	10	9	8
	4.0	20	18	23	20	21	21	18	22	20	21
	6.0	19	17	22	20	20	21	18	21	18	19
	8.0	9	7	8	9	8	9	8	8	9	9
	10.0	5	3	5	4	4	5	4	5	4	4
40 mg/l	2.0	10	9	12	11	12	12	9	13	11	11
	4.0	17	16	20	18	19	17	15	19	18	17
	6.0	13	11	14	12	12	14	8	13	13	12
	8.0	11	7	9	8	9	9	7	8	9	8
	10.0	9	6	8	7	7	9	6	7	6	6
50 mg/l	2.0	12	7	11	9	9	12	8	10	9	9
	4.0	14	10	15	13	12	14	11	14	12	12
	6.0	11	8	12	10	9	10	7	11	9	9
	8.0	10	7	9	9	8	9	7	9	8	8
	10.0	8	6	7	8	7	8	6	8	8	8

Table 1: %LRVRUSWLRQ RI $6 ,,, PJ J XQGHU YDULQJ S+

AS(V)	pH	Living					Dried				
		Chlorella	***Oscillatoria***	***Scenedesmus***	***Spirogyra***	***Pandorina***	***Chlorella***	***Oscillatoria***	***Scenedesmus***	***Spirogyra***	***Pandorina***
10 mg/l	2.0	5	4	5	4	4	5	3	5	4	5

e pH of the solution has played a key role in the biosorption of arsenite and arsenate by the microalgae. Aqueous solutions containing As (III) and As (V) were prepared with varying pH ranging from 2.0 to 10.0. Arsenic sorption decreased with increasing pH and the maximum arsenic removal occurred at pH 4.0 for both living and dried biomass. e highest As (III) uptake (Q) of 23 mg/g was recorded with living biomass of Scenedesmus at a initial concentration of 30 mg/l followed by Pandorina (21 mg/g). Maximum uptake of 22 mg/g As (III) was found with the dried biomass of Scenedesmus which was followed by Chlorella and Pandorina (Table 1). e metal sorption of As (V) was highest in living biomass of Scenedesmus (20 mg/g) and the trend was re ected in dried biomass of Chlorella and Pandorina at 30 mg/g (Table 2)

Various temperatures in the range of 23°C - 35°C were used to study the metal uptake by the algal isolates. e results indicated that 32°C was found optimum in which maximum adsorption has taken place and there were no signi cant changes in the metal uptake at temperature below 29°C and above 32°C. e living biomass of Scenedesmus and Chlorella has adsorbed maximum As (III) from the

aqTf -0.13(4e]TJ 0.289 Tw -8)19(t)6(e)-4.9(dnm)19.1863 ..9(t(4e]ToCe9(t(43(a)3(s)55)-6(a)i)3(aro2(r9o s-40(y.00w 4.r-0.004 Tc 0.004

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as they are required as essential nutrients [32] and have been explored for metal removal [33]. e level of metal removal by a microalga depends on biomass concentrations, pH and contact time [34-36]. In this experiment, arsenic sorption values of dried biomass were high in comparison with living biomass. is could be due to the larger surface area due to the destruction of cell membranes during the dried biomass preparation. Non-living microbial cells have lower sensitivity to toxic metal ions concentrations over living cells which o er to use them at adverse operating conditions [37]. e metal sorption capacity was drastically reduced at pH values above 6.0, which could be due to the formation of insoluble metal hydroxides. Further, it was noted that the arsenic uptake was lowered at pH below 4.0. e temperature of the solution could in uence the metal biosorption of living cells [37] and culture temperatures have profound e ects on the chemical composition of the algal cells. e biosorption of As increased with temperatures from 23°C-32°C and the results indicated that elevated temperatures tend to increase the biosorptive properties of isolated microalgae with an optimum temperature of 32°C. However the variations in uptake of As (III) and As (V) based on temperature need to be investigated. It was observed that higher biomass levels have reduced the adsorption amount which was in uenced by the formation of aggregates at higher concentrations that has ultimately resulted in reduced biosorption area [38].

e accumulation of heavy metals in algae involves and rapid uptake initially followed by slower uptake [37,39-41]. e same trend was observed in the experiments as the metal sorption rate was higher in rst 36 hours followed by signi cantly slower uptake in the next hours. Further, As (III) and As (V) sorption was more at initial time (0-36 hrs) followed by almost constant a er 36 hrs of contact time.

Based on the pH studies, As (III) was e ectively removed by both

27. Anderson RA (2005) Algal culture techniques. 1st edition. Elsevier Academic press. California, USA.

28. 6WDQLHUXQLVDZD 5 0DQGHO 0 &RKHQ %DUXFK %DFWHULRO Rev 35: 171-205.

29. Volesky B (1992) Removal of heavy metals by biosorption. In: Ladisch MR, %RVH $ HGV +DUQHVVLQJ ELRWHFKQRORJ\ IRU Washington DC, Pp. 462-466.

30. Zhang L, Zhao L, Yu Y, Chen C (1998) Removal of Pb2+ from aqueous solution by non-living Rhizopus nigricans. Water Res. 32: 1437-1444.

31. Volesky B (1990) Removal and recovery of heavy metals by biosorption. In: 9ROHVN\ % (G %LRVRUSWLRQ RI +HDY\ 0HWDOV &5& 3UHVV %RFD 5DWRQ)OD Pp. 7-43.

32. *DGG* 0 +HDY\ PHWDO DFFXPXODWLRQ E\ EDFWHULD DQG RWKHU microorganisms. Cell Mol Life Sci 46: 834-840.

33. Wilde EW, Benemann JR (1993) Bioremoval of heavy metals by the use of microalgae. Biotechnol Adv 11: 781-812.

34. Aksu Z, Donmez G (2006) Binary biosorption of cadmium(II) and nickel(II) onto dried Chlorella vulgaris: Co-ion effect on mono-component isotherm parameters. Process Biochem. 41: 860-868.

35. Solisio C, Lodi A, Soletto D, Converti A (2008) Cadmium biosorption on Spirulina platensis biomass. Bioresour Technol 99: 5933-5937.

36. 7DQJ <= *LQ .<+ $]L] 0$ (TXLOLEULXP PRGHO IRU FDGPLXP DGVRUSWLRQ by green algae in a batch reactor. J Environ Eng 128: 304-312.

37. Arica MY, Tuzun I, Yalc E¸ Ince O, Bayramoglu G (2005) Utilisation of native, heat and acid-treated microalgae Chlamydomonas reinhardtii preparations for biosorption of CrI) ions, Process Biochemistry, 40: 2351-2358.

38. Ahuja P, Gupta R, Saxena RK (1999) Zn2+ biosorption by Oscillatoria anguistissima, Process Biochemistry, 34: 77-85.

39. +DPGL $\$ %LRVRUSWLRQ RI KHDY\ PHWDOV E\ PD 41: 232-238.

40. Vinoj Kumar V, Sarada R, Ravishankar GA (2006) Biosorption of metals from contaminated water using seaweed, Current Science, 90: 1263-1267.

41. %DWHV 7HVVLHU $ &DPSEHOO 3*& %XIÀH - transport by Chlamydomonas variabilis and Scenedesmus subspicatus (Chlorophyceae) grown in semi-continuous culture. J Phycol. 18: 521-529.

42. Jahan K, Mosto P, Mattson C, Frey M, Derchak L (2006) Microbial removal of arsenic. Aater, air and Soli ollution: Focus 6: 71-82.

43. Monteiro CM, Castro PML, Malcata FX (2009) Use of the microalga Scenedesmus obliquus to remove cadmium cations from aqueous solutions.