

LIST OF FIGURES

FIGURE NO.	FIGURE CAPTION	PAGE NO.
1	Alginate, a linear polysaccharide of (1→4)-linked α-L-guluronate and β-d-mannuronate	I-17
2	Sodium alginate	I-17
3	Building blocks of alginate: β-d-mannuronate and α-L-guluronate	I-17
4	Chelation of alginate with divalent cations of calcium	I-18
5	Human health hazards with Cr VI exposure	II-1
6	pH meter	III-6
7	Vortex mixer	III-7
8	Electronic analytical balance	III-7
9	Electronic analytical balance	III-8
10	Spectrophotometer	III-8
11	Eppendorf Centrifuge	III-9
12	Temperature controlled shaker incubator	III-9
13	Refrigerator	III-10
14	Freezer	III-10
15	Laminar air flow	III-10
16	Autoclave	III-11

FIGURE NO.	FIGURE CAPTION	PAGE NO.
17	Lyophilizer	III-12
18	Ultra-sonicator	III-12
19	Milli Q water-maker	III-13
20	Microscope	III-14
21	Autolab Electrochemical Analyzer	III-15
22	Atomic Absorption Spectrophotometer	III-15
23	Scanning Electron Microscope	III-16
24	Transmission Electron Microscope	III-17
25	Atomic Force Microscope	III-18
26	X-Ray Diffractometer	III-19
27	Energy Dispersive X-Ray Spectroscopy	III-20
28	Fourier Transform Infra-Red Spectrometer	III-21
29	Peristaltic pump	III-21
30	Geopolitical location of CLC Tannery Complex, Bantala, Kolkata, West Bengal, India	IV-1
31	Schematic presentation of serial dilution method	IV-2
32	Growth of isolates in selective medium	V-4
33	Gram characters of the isolates: 33 (a), (b), (c), (e) are Gram Negative; 33 (d), (f) are Gram Positive bacteria	V-5
34	Growth and regular maintenance of isolates on M1 media (with chromium VI)	V-6

FIGURE NO.	FIGURE CAPTION	PAGE NO.
35	Growth and regular maintenance of isolates in LB agar media (without Cr VI)	V-7
36	Nutrient Agar slants (parafilm-sealed) of isolates, preserved in duplicates at 4°C	V-8
37	Phylogenetic tree of <i>E.coli</i> T1, prepared using neighbour joining method	V-12
38	Phylogenetic tree of <i>Enterobacter aerogenes</i> T2, using neighbour joining method	V-12
39	Phylogenetic tree of <i>Aeromonas</i> sp. T4, prepared using neighbour joining method	V-13
40	Phylogenetic tree of <i>Exiguobacterium profundum</i> S1, by neighbour joining method	V-13
41	Phylogenetic tree of <i>Acinetobacter</i> sp. PD 12 S2, using neighbour joining method	V-14
42	Phylogenetic tree of <i>Bacillus</i> sp. G2DM-32 C3, using neighbour joining method	V-14
43	Isolates showing resistance to heavy metal mercury (Hg) only of all metals used	V-17
44	Optimum emperature for maximal growth of T2 and S2 bacteria	V-20
45	Optimum pH for maximal growth of T2 and S2 bacteria	V-21
46	Growth curves of isolates in LB broth medium (without Cr VI)	V-22

FIGURE NO.	FIGURE CAPTION	PAGE NO.
47	Growth of isolates in LB broth, with 19.8 mg/L Cr VI in the batch media	V-22
48	Growth of T2, T4, S2 in M9 media (with 8.8 mg/L Cr VI)	V-23
49	Growth of T1 in LB broth batch culture medium (without Cr VI, as control)	V-23
50	Growth of T1 in LB broth (in presence of Cr VI)	V-24
51	Bioremediation of 8.86 mg/L Cr VI by 1% of <i>Enterobacter aerogenes</i> , at pH 7	V-30
52	Bioremediation of 17.73 mg/L Cr VI by <i>Enterobacter aerogenes</i>	V-30
53	Bioremediation of 26.59 mg/L Cr VI by <i>Enterobacter aerogenes</i>	V-31
54	Bioremediation of Cr VI by <i>Enterobacter aerogenes</i> at pH5	V-31
55	Bioremediation of Cr VI by <i>Enterobacter aerogenes</i> at pH9	V-32
56	Bioremediation of Cr VI by <i>Enterobacter aerogenes</i> with 5% inoculum	V-32
57	Bioremediation of Cr VI by <i>Enterobacter aerogenes</i> with 10% inoculum	V-33
58	Bioremediation of 8.86 mg/L Cr VI by 1% of <i>Acinetobacter</i> sp. PD 12 at pH 7	V-33

FIGURE NO.	FIGURE CAPTION	PAGE NO.
59	Bioremediation of 17.73 mg/L Cr VI by <i>Acinetobacter</i> sp. PD 12	V-34
60	Bioremediation of 26.59 mg/L Cr VI by <i>Acinetobacter</i> sp. PD 12	V-34
61	Bioremediation of Cr VI by <i>Acinetobacter</i> sp. PD 12 at pH5	V-35
62	Bioremediation of Cr VI by <i>Acinetobacter</i> sp. PD 12 at pH9	V-35
63	Bioremediation of Cr VI by <i>Acinetobacter</i> sp. PD 12 with 5 % inoculum	V-36
64	Bioremediation of Cr VI by <i>Acinetobacter</i> sp. PD 12 with 10 % inoculum	V-36
65	Scanning electron microscopic view of S2 (<i>Acinetobacter</i> sp. PD 12) in absence of chromium (control)	V-37
66	Scanning electron microscopic view of diplo cocco- bacilli S2, whose morphology shrunk in presence of chromium-stress	V-38
67	In the absence of metal stress of chromium, SEM images of cells of <i>Enterobacter aerogenes</i> appear to be discrete and individually clear	V-38
68	In the presence of chromium, SEM images of cells of <i>Enterobacter aerogenes</i> form chain-like structures with each other	V-39

FIGURE NO.	FIGURE CAPTION	PAGE NO.
69	Unstained whole mount of a cell of <i>Enterobacter aerogenes</i> as seen under TEM. Scale bar = 200 nm	V-40
70	Unstained whole mount of cells of <i>Enterobacter aerogenes</i> shows interaction with the metal (as shown by the arrow signs) as seen under TEM. Scale bar = 500 nm	V-40
71	Energy Dispersive X-Ray Spectroscopic microanalysis of <i>Enterobacter aerogenes</i>	V-41
72	X-ray diffraction (XRD) of T2 (<i>Enterobacter aerogenes</i>) in the absence Cr VI as grown in LB media, where x axis = 2θ value range and y axis = intensity	V-42
73	X-ray diffraction (XRD) of T2 (<i>Enterobacter aerogenes</i>) in the presence of 40 mg/L Cr VI	V-42
74	<i>Enterobacter aerogenes</i> , grown in the absence of chromium as control, was found to have smooth surface under AFM	V-43
75	<i>Enterobacter aerogenes</i> , grown in the presence of 40 mg/L Cr VI, was found to have discontinuous cell surface under AFM	V-44
76	5 mg/L Cr VI solution (1 L) was added to plant A	V-45
77	Plant B was treated with 5 mg/L Cr VI solution along with T2 bacterial suspension and the plant was visibly unaffected after 7 days, whereas leaves of plant A were affected	V-46

FIGURE NO.	FIGURE CAPTION	PAGE NO.
78	Bioremediation of Cr VI by live cells of <i>Enterobacter aerogenes</i> from tannery effluents	V-47
79	Bioremediation by lyophilized cells of <i>Enterobacter aeronegenes</i> from tannery effluents	V-47
80	Standard curve for protein estimation	V-49
81	Lineweaver-Burk plot for chromium reduction property of <i>Enterobacter aerogenes</i>	V-49
82	Checking of beads dosage for optimum remediation	V-50
83	Continuously stirred lab-level remediation unit	V-51
84	Freshly prepared alginate-T2 beads	V-51
85	Bioremediation of 10 mg/L Cr VI by alginate-T2 beads	V-52
86	Standard curve of Cr VI, based on colorimetric reaction with DPC, at 540 nm	V-52
87	Lab-level plug-flow reactor	V-53
88	Bioremediation of 2mg/L Cr VI from synthetic M2 solution in lab-level plug-flow reactor	V-53
89	Langmiur isotherm of Cr VI ion adsorption on alginate-T2 beads	V-55
90	Freundlich isotherm of Cr VI adsorption on alginate-T2 biosorbent	V-56
91	Dubinin-Radushkevich (D-R) isotherm on alginate-T2 biosorbent	V-57

FIGURE NO.	FIGURE CAPTION	PAGE NO.
92	Decrease in % bioremediation due to desorption from beads after each sorption cycle	V-59
93	Gradual decay of beads' bioremedial efficiency due to protein loss	V-59
94	SEM image of fresh whole alginate-T2 beads; Resolution = 500 μ m	V-60
95	SEM image of used whole alginate-T2 beads; Resolution = 500 μ m	V-60
96	EDS of used beads showing Cr VI accumulation	V-61
97	XRD graphs of used and fresh beads	V-62
98	FTIR spectra of fresh and used alginate-T2 beads	V-63
99	Cyclic voltamogram of various concentrations of Cr VI	V-64
100	Standard calibration curve	V-65
101	Interference checking of various metals in absence of Cr VI	V-67
102	Interference checking of various metals in presence of 40 μ g/L Cr VI	V-67
103	Detection and estimation by biosensor (electrochemical sensing) v/s colorimetric estimation by D.P.C at 540 nm	V-68