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**BIOACCUMULATION AND TOXICITY STUDIES OF HEAVY METALS  
IN *Ankistrodesmus convolutus* CORDA**

by

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"Man's work can make of him a slave  
And lead him to an early grave,  
But if it's done as to the Lord  
His labours bring him great reward" - DID

## ABSTRACT

Nine freshwater microalgal species of Malaysia, *Chlorella vulgaris* (isolate 001), *Scenedesmus* sp. (isolate 039), *Mougeotia* sp. (isolate 069), *Ulothrix* sp. (isolate 071), *Chlorella* sp. (isolate 078), *Ankistrodesmus convolutus* (isolate 101), *Chlorococcum* sp. (isolate 110), *Synechococcus* sp. (isolate 075), *Euglena* sp. (isolate 058), and including two species *Oocystis polymorpha* UTEX 1645 (isolate 169) and *Ankistrodesmus arcuatus* UTEX LB 1379 (isolate 170) from the UTEX Collection, Texas, were used in 96 h single heavy metal (Cd, Co, Cr, Cu, Fe, Mn and Zn) exposure static studies for preliminary toxicity test. This was done by incubating the microalgae in a range of metal concentrations in Bold Basal Medium (BBM) in multiwell plates. Of these species *Ankistrodesmus convolutus* Corda (isolate No. 101) was selected for further toxicity and bioaccumulation tests.

Toxicity tests were conducted to investigate the toxic effect of Cd, Co, Cr, Cu, Fe, Mn and Zn on the growth of *A. convolutus*. Results from the toxicity tests showed that *A. convolutus* is tolerant to most of the heavy metals. The order of toxicity in *A. convolutus* based on 96 h  $IC_{50}$  and  $IC_{25}$  are  $Zn = Mn > Cu > Cd > Cr > Co > Fe$ . *A. convolutus* was most sensitive to Fe ( $IC_{50} = 0.52 \text{ mgL}^{-1}$ ) and most tolerant to Mn ( $IC_{50} = 16.14 \text{ mgL}^{-1}$ ).

*Ankistrodesmus convolutus* was exposed to different concentrations of seven metals (Cd, Co, Cr, Cu, Fe, Mn and Zn) to observed patterns of heavy metal uptake (bioaccumulation) in short-term test.

Four main metal accumulation patterns were observed in this study: **Pattern 1** : rapid metal uptake during the first hour of exposure and followed by a gradual release; **Pattern 2** : continuous uptake appears during the entire hour of exposure till an equilibrium level; **Pattern 3** : rapid uptake during the first hour exposure and followed by a gradual release till equilibrium level is reached; **Pattern 4** : alternating uptake and release of metal.

In general, maximum uptake occurred in the first hour of exposure, followed by further gradual uptake, or gradual release, or an alternating uptake – release pattern. Metal bioaccumulation increased with increasing concentration of metal in the medium. Cells in logarithmic growth were more active in metal bioaccumulation than cells at stationary growth.

## ABSTRAK

Sembilan spesies mikroalga air tawar Malaysia, *Chlorella vulgaris* (isolate 001), *Scenedesmus* sp. (isolate 039), *Mougeotia* sp. (isolate 069), *Ulothrix* sp. (isolate 071), *Chlorella* sp. (isolate 078), *Ankistrodesmus convolutus* (isolate 101), *Chlorococcium* sp. (isolate 110), *Synechococcus* sp. (isolate 075), *Englena* sp. (isolate 058), dan termasuk dua spesies *Oocystis polymorpha* UTEX 1645 (isolate 169) dan *Ankistrodesmus arcuatus* UTEX LB 1379 (isolate 170) dari Koleksi UTEX, Texas, digunakan untuk ujian dalam logam berat tunggal untuk setiap logam berat berikut (Cd, Co, Cr, Cu, Fe, Mn and Zn) selama 96 jam, dalam kajian statik bagi ujian peringkat awal ketoksikan. Ini telah dijalankan dengan menumbuhkan mikroalga di dalam bekas 'multiwell plates' dengan satu siri kepekatan logam berat dalam media 'Bold Basal (BBM)'. Daripada spesies tersebut, *Ankistrodesmus convolutus* Corda (isolate No. 101) telah dipilih untuk ujikaji ketoksikan dan bioakumulasi yang seterusnya.

Ujian ketoksikan dijalankan bagi tujuan mencari kesan toksik Cd, Co, Cr, Cu, Fe, Mn dan Zn ke atas pertumbuhan *A. convolutus*. Keputusan mendapati *A. convolutus* mempunyai daya tahan yang kuat menentang hampir semua ketoksikan logam berat tersebut. Susunan ketoksikan berdasarkan nilai  $IC_{50}$  dan  $IC_{25}$  selama 96 jam kepada *A. convolutus* adalah seperti berikut :  $Zn = Mn > Cu > Cd > Cr > Co > Fe$ . *A. convolutus* sangat sensitif terhadap Fe ( $IC_{50} = 0.52 \text{ mgL}^{-1}$ ) dan paling tahan dengan Mn ( $IC_{50} = 16.14 \text{ mgL}^{-1}$ ).

*Ankistrodesmus convolutus* didedahkan dalam berbagai kepekatan daripada tujuh logam berat (Cd, Co, Cr, Cu, Fe dan Zn) bagi memerhati corak penyerapan (bioakumulasi) logam berat dalam jangka masa yang singkat. Empat corak akumulasi yang asas telah diperolehi dalam kajian ini: **Corak 1** : penyerapan yang kerap pada waktu pendedahan jam yang pertama diikuti oleh pelepasan yang bersiri; **Corak 2** : pengambilan yang berterusan sepanjang waktu pendedahan sehingga mencapai tahap

yang seimbang; **Corak 3** : penyerapan yang kerap dalam jam yang pertama diikuti dengan pelepasan yang bersiri sehingga mencapai tahap yang seimbang; dan **Corak 4** : penyerapan dan pelepasan logam berat yang berselang-seli.

Secara umum, penyerapan logam berat yang maksimum berlaku pada waktu jam pendedahan yang pertama diikuti dengan penyerapan yang bersiri, atau pelepasan yang bersiri, atau corak penyerapan dan pelepasan yang berselang-seli. Akumulasi logam berat bertambah dengan bertambahnya kepekatan logam berat dalam media. Bioakumulasi yang aktif berlaku pada pertumbuhan sel yang muda berbanding dengan fasa tua (stationari).

# TABLE OF CONTENTS

<b>KNOWLEDGEMENTS</b>	<b>i</b>
<b>ASTRACT</b>	<b>ii</b>
<b>ABSTRAK</b>	<b>iv</b>
<b>LIST OF TABLES</b>	<b>xi</b>
<b>LIST OF FIGURES</b>	<b>xiii</b>
<b>LIST OF PLATES</b>	<b>xxi</b>
<b>LIST OF APPENDICES</b>	<b>xxiii</b>

## CHAPTER 1

1.0	Introduction	1
1.1	Water Pollution	1
1.2	Heavy Metal Pollution	1
1.3	River Pollution in Malaysia	4
1.4	Scheduled Wastes Management	7
1.5	Strategy for Pollution Management	11
1.6	Aims and Objective	14

## CHAPTER 2

2.0	Literature Review	15
2.1	Heavy Metal in the Environment	15
2.1.1	<i>Definition of Heavy Metal</i>	15
2.1.2	<i>Mechanisms of Metal Ion Toxicity</i>	17
2.2	Sources of Heavy Metal Pollution	18
2.2.1	<i>Contaminated Sediment</i>	23
2.2.2	<i>Non-point Sources</i>	23
2.3	Monitoring Heavy Metal Pollution	24
2.4	Characterics of a Good Biological Indicator	26

2.5	Microalgae : Good Biological Indicators	29
2.6	Interaction Between Algae and Heavy Metal	32
2.7	Mechanisms of Heavy Metal Tolerance in Algae	35
2.7.1	<i>Extracellular Binding and Precipitation</i>	36
2.7.2	<i>Impermeability and Exclusion</i>	38
2.7.3	<i>Internal Detoxification</i>	40
2.7.4	<i>Metal Transformation</i>	41
2.8	Effects of Environment Factors on Heavy Metals Toxicity	43

### CHAPTER 3

3.0	Materials and Methods	46
3.1	Preparation of Container	46
3.2	Microalgal Culture	46
3.2.1	Source of Materials	46
3.2.2	Stock Culture Maintenance	47
3.2.3	Preparation of Inoculum	47
3.2.4	Determination of Cell Density	49
3.3	Heavy Metals	
3.3.1	Preparation of Metal Stock Solutions	49
3.3.2	Preparation of Test Solutions	50
3.4	Preliminary Study : Range Finding Toxicity Test	51
3.4.1	Microalgal Species	51
3.4.2	Metal Tested	51
3.4.3	Preparation of Test Solutions	51
3.4.4	Type of Test	53
3.4.5	Duration of Test	53
3.4.6	Test Procedure	53
3.5	Reference Toxicant	53
3.6	Definitive Toxicity Test	53



3.6.1	<i>Toxicity Test</i>	56
3.6.1.1	Test organism and test material	56
3.6.1.2	Metal tested	56
3.6.1.3	Type of test	56
3.6.1.4	Duration of test	57
3.6.1.5	Test procedure	57
3.6.1.6	Calculation of toxicity parameter	57
3.6.2	<i>Bioaccumulation Studies</i>	57
3.6.2.1	Microalga	58
3.6.2.2	Metals tested	58
3.6.2.3	Type of test	58
3.6.2.4	Duration of test	58
3.6.2.5	Experiment procedure	58
3.6.2.6	Digestion of sample	60
3.6.2.7	Statistical data analysis	60
3.6.2.8	Instrument operation for the determination of metal level in <i>Ankistrodesmus convolutus</i> (isolate 101)	61

## CHAPTER 4

4.0	Results	63
4.1	Preliminary Toxicity Test	63
4.2	CdCl <sub>2</sub> as the Reference Toxicant	67
4.3	Definitive Toxicity Test with <i>Ankistrodesmus convolutus</i> (isolate 101)	70
4.3.1	<i>Cadmium (Cd) Toxicity Test</i>	70
4.3.2	<i>Cobalt (Co) Toxicity Test</i>	70
4.3.3	<i>Zinc (Zn) Toxicity Test</i>	75
4.3.4	<i>Manganese (Mn) Toxicity Test</i>	75
4.3.5	<i>Chromium (Cr) Toxicity Test</i>	75
4.3.6	<i>Copper (Cu) Toxicity Test</i>	81
4.3.7	<i>Iron (Fe) Toxicity Test</i>	81
4.3.8	<i>IC<sub>50</sub> and IC<sub>25</sub> Values</i>	87
4.4	Bioaccumulation Studies	87
4.4.1	Uptake of Cadmium by <i>Ankistrodesmus convolutus</i>	87

(a)	Logarithmic Phase Culture Exposed to $1\text{mgL}^{-1}$ Cd	87
(b)	Logarithmic Phase Culture Exposed to $25\text{mgL}^{-1}$ Cd	91
(c)	Stationary Phase Culture Exposed to $25\text{mgL}^{-1}$ Cd	91
(d)	Logarithmic Phase Culture Exposed to $80\text{mgL}^{-1}$ Cd	91
(e)	Stationary Phase Culture Exposed to $80\text{mgL}^{-1}$ Cd	95
4.4.2	Uptake of Cobalt by <i>Ankistrodesmus convolutus</i>	95
(a)	Logarithmic Phase Culture Exposed to $1\text{mgL}^{-1}$ Co	95
(b)	Logarithmic Phase Culture Exposed to $30\text{mgL}^{-1}$ Co	101
(c)	Stationary Phase Culture Exposed to $30\text{mgL}^{-1}$ Co	101
(d)	Logarithmic Phase Culture Exposed to $50\text{mgL}^{-1}$ Co	101
(e)	Stationary Phase Culture Exposed to $50\text{mgL}^{-1}$ Co	105
4.4.3	Uptake of Zinc by <i>Ankistrodesmus convolutus</i>	105
(a)	Logarithmic Phase Culture Exposed to $1\text{mgL}^{-1}$ Zn	105
(b)	Logarithmic Phase Culture Exposed to $100\text{mgL}^{-1}$ Zn	105
(c)	Stationary Phase Culture Exposed to $100\text{mgL}^{-1}$ Zn	110
(d)	Logarithmic Phase Culture Exposed to $300\text{mgL}^{-1}$ Zn	110
(e)	Stationary Phase Culture Exposed to $300\text{mgL}^{-1}$ Zn	110
4.4.4	Uptake of Manganese by <i>Ankistrodesmus convolutus</i>	115
(a)	Logarithmic Phase Culture Exposed to $1\text{mgL}^{-1}$ Mn	115

(b)	Logarithmic Phase Culture Exposed to 80mgL <sup>-1</sup> Mn	115
(c)	Stationary Phase Culture Exposed to 80mgL <sup>-1</sup> Mn	115
(d)	Logarithmic Phase Culture Exposed to 100mgL <sup>-1</sup> Mn	120
(e)	Stationary Phase Culture Exposed to 100mgL <sup>-1</sup> Mn	120
4.4.5	Uptake of Chromium by <i>Ankistrodesmus convolutus</i>	120
(a)	Logarithmic Phase Culture Exposed to 1mgL <sup>-1</sup> Cr	125
(b)	Logarithmic Phase Culture Exposed to 25mgL <sup>-1</sup> Cr	125
(c)	Stationary Phase Culture Exposed to 25mgL <sup>-1</sup> Cr	125
(d)	Logarithmic Phase Culture Exposed to 50mgL <sup>-1</sup> Cr	125
(e)	Stationary Phase Culture Exposed to 50mgL <sup>-1</sup> Cr	125
4.4.6	Uptake of Copper by <i>Ankistrodesmus convolutus</i>	131
(a)	Logarithmic Phase Culture Exposed to 1mgL <sup>-1</sup> Cu	131
(b)	Logarithmic Phase Culture Exposed to 175mgL <sup>-1</sup> Cu	131
(c)	Stationary Phase Culture Exposed to 175mgL <sup>-1</sup> Cu	131
(d)	Logarithmic Phase Culture Exposed to 500mgL <sup>-1</sup> Cu	135
(e)	Stationary Phase Culture Exposed to 500mgL <sup>-1</sup> Cu	135
4.4.7	Uptake of Iron by <i>Ankistrodesmus convolutus</i>	135
(a)	Logarithmic Phase Culture Exposed to 1mgL <sup>-1</sup> Fe	135
(b)	Logarithmic Phase Culture Exposed to 50mgL <sup>-1</sup> Fe	135

(c)	Stationary Phase Culture Exposed to 50mgL <sup>-1</sup> Fe	140
(d)	Logarithmic Phase Culture Exposed to 200mgL <sup>-1</sup> Fe	140
(e)	Stationary Phase Culture Exposed to 200mgL <sup>-1</sup> Fe	145
4.4.8	Summary	145

## CHAPTER 5

5.0	Discussion	151
5.1	Preliminary test	151
5.2	Toxicity test of different metals in a <i>Ankistrodesmus convolutus</i> (isolate 101)	153
(i)	Iron (Fe)	154
(ii)	Cobalt (Co)	154
(iii)	Chromium (Cr)	155
(iv)	Copper (Cu)	155
(v)	Cadmium (Cd)	157
(vi)	Zinc (Zn)	160
(vii)	Manganese (Mn)	161
5.3	Bioaccumulation	162
5.3.1	Effect of concentration	166
5.3.2	Effect of Time	169
5.3.3	Effect of age	171

## CHAPTER 6 : CONCLUSION 173

## REFERENCES 176

## APPENDICES 193

## List of Tables

<b>Table 1:</b>	The signs and symptoms of metal toxicity to humans	3
<b>Table 2:</b>	Recommended Malaysia water quality criteria for heavy metal	5
<b>Table 3:</b>	Interim National Water Quality Standards proposed for Malaysia	6
<b>Table 4:</b>	List of algal useful for heavy metal monitorin	13
<b>Table 5:</b>	Some EC50 values of heavy metals on microalgae	19
<b>Table 6:</b>	Effects of heavy metals on photosynthesis and respiration in microalgae	20
<b>Table 7:</b>	Range of optimal nutrient levels required by microalgae as shown in <i>Chlorella</i> , <i>Spirulina</i> , <i>Dunaliella</i> , <i>Cyanidium</i>	22
<b>Table 8:</b>	Status of mineral nutrition of <i>Chlorella</i>	22
<b>Table 9:</b>	Some bioindicators used in monitoring heavy metal pollution	27
<b>Table 10:</b>	Heavy metal content in three microalgae species	31
<b>Table 11:</b>	Algal cultures	48
<b>Table 12:</b>	Test solution	52
<b>Table 13:</b>	Effect of the seven metals on the growth of the eleven microalgal species tested	64
<b>Table 14:</b>	Heavy metal tolerance of the microalgal tested	66
<b>Table 15:</b>	Percentage inhibition of microalgal growth in different concentration of CdCl <sub>2</sub>	68
<b>Table 16:</b>	IC <sub>50</sub> and IC <sub>25</sub> values for Cd toxicity to six microalgal species	68
<b>Table 17:</b>	Effect of Cd on the growth of <i>Ankistrodesmus convolutus</i>	72

<b>Table 18:</b>	Effect of Co on the growth of <i>Ankistrodesmus convolutus</i>	74
<b>Table 19:</b>	Effect of Zn on the growth of <i>Ankistrodesmus convolutus</i>	77
<b>Table 20:</b>	Effect of Mn on the growth of <i>Ankistrodesmus convolutus</i>	79
<b>Table 21:</b>	Effect of Cr on the growth of <i>Ankistrodesmus convolutus</i>	82
<b>Table 22:</b>	Effect of Cu on the growth of <i>Ankistrodesmus convolutus</i>	84
<b>Table 23:</b>	Effect of Fe on the growth of <i>Ankistrodesmus convolutus</i>	86
<b>Table 24:</b>	IC <sub>50</sub> and IC <sub>25</sub> in the <i>Ankistrodesmus convolutus</i> (101) toxicity studies	88
<b>Table 25:</b>	Bioaccumulation summary table	148
<b>Table 26:</b>	Correlation factor (r) of analysis to show effect of metal concentration on metal accumulation	168

## List of Figures

<b>Figure 1:</b>	Quantity of scheduled waste generated according to waste category, 1995	9
<b>Figure 2:</b>	Distribution of scheduled waste generated according to state, 1995	10
<b>Figure 3:</b>	The periodic table of the elements	16
<b>Figure 4:</b>	Biological response of living system essential and toxic elements	21
<b>Figure 5a:</b>	Growth curves (cell count) of <i>Ankistrodesmus convolutus</i> in the various concentration of C	71
<b>Figure 5b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Cd	71
<b>Figure 6a:</b>	Growth curves (cell count) of <i>A.convolutus</i> in the various concentration of Co	73
<b>Figure 6b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Co	73
<b>Figure 7a:</b>	Growth curves (cell count) of <i>A.convolutus</i> in the various concentration of Zn	76
<b>Figure 7b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Zn	76
<b>Figure 8a:</b>	Growth curves (cell count) of <i>A.convolutus</i> in the various concentration of Mn	78
<b>Figure 8b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Mn	78
<b>Figure 9a:</b>	Growth curves (cell count) of <i>A.convolutus</i> in the various concentration of Cr	80
<b>Figure 9b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Cr	80
<b>Figure 10a:</b>	Growth curves (cell count) of <i>A.convolutus</i> in the various concentration of Cu	83
<b>Figure 10b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A.convolutus</i> in the various concentration of Cu	83

<b>Figure 11a:</b>	Growth curves (cell count) of <i>A. convolutus</i> in the various concentration of Fe	85
<b>Figure 11b:</b>	Growth curves (OD <sub>620</sub> ) of <i>A. convolutus</i> in the various concentration of Fe	85
<b>Figure 12ai:</b>	Cd content in <i>A. convolutus</i> grown at 1mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	89
<b>Figure 12aii:</b>	Cd content in <i>A. convolutus</i> grown at 1mgL <sup>-1</sup> Cd (Scale maximised to show Cd bioaccumulation in detail)	89
<b>Figure 12aiii:</b>	Cd content in the external medium of culture grown at 1 mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	90
<b>Figure 12aiv:</b>	Cd content in the external medium of culture grown at 1 mgL <sup>-1</sup> Cd (Scale maximised to show uptake of Cd from medium in detail)	90
<b>Figure 12bi:</b>	Cd content in <i>A. convolutus</i> grown at 25mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	92
<b>Figure 12bii:</b>	Cd content in <i>A. convolutus</i> grown at 25mgL <sup>-1</sup> Cd (Scale maximised to show Cd bioaccumulation in detail)	92
<b>Figure 12biii:</b>	Cd content in the external medium of culture grown at 25 mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	93
<b>Figure 12biv:</b>	Cd content in the external medium of culture grown at 25 mgL <sup>-1</sup> Cd (Scale maximised to show uptake of Cd from medium in detail)	93
<b>Figure 12ci:</b>	Cd content in <i>A. convolutus</i> grown at 25mgL <sup>-1</sup> Cd (Stationary phase culture were used)	94
<b>Figure 12cii:</b>	Cd content in the external medium of culture grown at 25 mgL <sup>-1</sup> Cd (Stationary phase culture were used)	94
<b>Figure 12di:</b>	Cd content in <i>A. convolutus</i> grown at 80mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	96



<b>Figure 12dii:</b>	Cd content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Cd (Scale maximised to show Cd bioaccumulation in detail)	96
<b>Figure 12diii:</b>	Cd content in the external medium of culture grown at 80 mgL <sup>-1</sup> Cd (Logarithmic phase culture were used)	97
<b>Figure 12div:</b>	Cd content in the external medium of culture grown at 80 mgL <sup>-1</sup> Cd (Scale maximised to show uptake of Cd from medium in detail)	97
<b>Figure 12ei:</b>	Cd content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Cd (Stationary phase culture were used)	98
<b>Figure 12eii:</b>	Cd content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Cd (Scale maximised to show Cd bioaccumulation in detail)	98
<b>Figure 12eiii:</b>	Cd content in the external medium of culture grown at 80 mgL <sup>-1</sup> Cd (Stationary phase culture were used)	99
<b>Figure 12eiv:</b>	Cd content in the external medium of culture grown at 80 mgL <sup>-1</sup> Cd (Scale maximised to show uptake of Cd from medium in detail)	99
<b>Figure 13ai:</b>	Co content in <i>A.convolutus</i> grown at 1mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	100
<b>Figure 13aii:</b>	Co content in the external medium of culture grown at 1 mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	100
<b>Figure 13bi:</b>	Co content in <i>A.convolutus</i> grown at 30mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	102
<b>Figure 13bii:</b>	Co content in the external medium of culture grown at 30 mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	102
<b>Figure 13ci:</b>	Co content in <i>A.convolutus</i> grown at 30mgL <sup>-1</sup> Co (Stationary phase culture were used)	103
<b>Figure 13cii:</b>	Co content in the external medium of culture grown at 30 mgL <sup>-1</sup> Co (Stationary phase culture were used)	103

<b>Figure 13di:</b>	Co content in <i>A.convolutus</i> grown at 50mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	104
<b>Figure 13dii:</b>	Co content in the external medium of culture grown at 50 mgL <sup>-1</sup> Co (Logarithmic phase culture were used)	104
<b>Figure 13ei:</b>	Co content in <i>A.convolutus</i> grown at 50mgL <sup>-1</sup> Co (Stationary phase culture were used)	106
<b>Figure 13eii:</b>	Co content in the external medium of culture grown at 50 mgL <sup>-1</sup> Co (Stationary phase culture were used)	106
<b>Figure 14ai:</b>	Zn content in <i>A.convolutus</i> grown at 1mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	107
<b>Figure 14aii:</b>	Zn content in the external medium of culture grown at 1 mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	107
<b>Figure 14bi:</b>	Zn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	108
<b>Figure 14bii:</b>	Zn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Zn (Scale maximised to show Zn bioaccumulation in detail)	108
<b>Figure 14biii:</b>	Zn content in the external medium of culture grown at 100 mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	109
<b>Figure 14biv:</b>	Zn content in the external medium of culture grown at 100 mgL <sup>-1</sup> Zn (Scale maximised to show uptake of Zn from medium in detail)	109
<b>Figure 14ci:</b>	Zn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Zn (Stationary phase culture were used)	111
<b>Figure 14cii:</b>	Zn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Zn (Scale maximised to show Zn bioaccumulation in detail)	111
<b>Figure 14ciii:</b>	Zn content in the external medium of culture grown at 100 mgL <sup>-1</sup> Zn (Stationary phase culture were used)	112

<b>Figure 14civ:</b>	Zn content in the external medium of culture grown at 100 mgL <sup>-1</sup> Zn (Scale maximised to show uptake of Zn from medium in detail)	112
<b>Figure 14di:</b>	Zn content in <i>A.convolutus</i> grown at 300mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	113
<b>Figure 14dii:</b>	Zn content in the external medium of culture grown at 300 mgL <sup>-1</sup> Zn (Logarithmic phase culture were used)	113
<b>Figure 14ei:</b>	Zn content in <i>A.convolutus</i> grown at 300mgL <sup>-1</sup> Zn (Stationary phase culture were used)	114
<b>Figure 14eii:</b>	Zn content in the external medium of culture grown at 300 mgL <sup>-1</sup> Zn (Stationary phase culture were used)	114
<b>Figure 15ai:</b>	Mn content in <i>A.convolutus</i> grown at 1mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	116
<b>Figure 15aii:</b>	Mn content in the external medium of culture grown at 1mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	116
<b>Figure 15bi:</b>	Mn content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	117
<b>Figure 15bii:</b>	Mn content in the external medium of culture grown at 80mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	117
<b>Figure 15ci:</b>	Mn content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Mn (Stationary phase culture were used)	118
<b>Figure 15cii:</b>	Mn content in <i>A.convolutus</i> grown at 80mgL <sup>-1</sup> Mn (Scale maximised to show Mn bioaccumulation in detail)	118
<b>Figure 15ciii:</b>	Mn content in the external medium of culture grown at 80mgL <sup>-1</sup> Mn (Stationary phase culture were used)	119
<b>Figure 15civ:</b>	Mn content in the external medium of culture grown at 80 mgL <sup>-1</sup> Mn (Scale maximised to show uptake of Mn from medium in detail)	119

<b>Figure 15di:</b>	Mn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	121
<b>Figure 15dii:</b>	Mn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Mn (Scale maximised to show Mn bioaccumulation in detail)	121
<b>Figure 15diii:</b>	Mn content in the external medium of culture grown at 100mgL <sup>-1</sup> Mn (Logarithmic phase culture were used)	122
<b>Figure 15div:</b>	Mn content in the external medium of culture grown at 100 mgL <sup>-1</sup> Mn (Scale maximised to show uptake of Mn from medium in detail)	122
<b>Figure 15ei:</b>	Mn content in <i>A.convolutus</i> grown at 100mgL <sup>-1</sup> Mn (Stationary phase culture were used)	123
<b>Figure 15eii:</b>	Mn content in the external medium of culture grown at 100mgL <sup>-1</sup> Mn (Stationary phase culture were used)	123
<b>Figure 16ai:</b>	Cr content in <i>A.convolutus</i> grown at 1mgL <sup>-1</sup> Cr (Logarithmic phase culture were used)	124
<b>Figure 16aii:</b>	Cr content in the external medium of culture grown at 1mgL <sup>-1</sup> Cr (Logarithmic phase culture were used)	124
<b>Figure 16bi:</b>	Cr content in <i>A.convolutus</i> grown at 25mgL <sup>-1</sup> Cr (Logarithmic phase culture were used)	126
<b>Figure 16bii:</b>	Cr content in the external medium of culture grown at 25mgL <sup>-1</sup> Cr (Logarithmic phase culture were used)	126
<b>Figure 16ci:</b>	Cr content in <i>A.convolutus</i> grown at 25mgL <sup>-1</sup> Mn (Stationary phase culture were used)	127
<b>Figure 16cii:</b>	Cr content in <i>A.convolutus</i> grown at 25mgL <sup>-1</sup> Cr (Scale maximised to show Cr bioaccumulation in detail)	127
<b>Figure 16ciii:</b>	Cr content in the external medium of culture grown at 25mgL <sup>-1</sup> Cr (Stationary phase culture were used)	128

<b>Figure 16civ:</b>	Cr content in the external medium of culture grown at $Cr\text{ mgL}^{-1}$ Cr (Scale maximised to show uptake of Cr from medium in detail)	128
<b>Figure 16di:</b>	Cr content in <i>A.convolutus</i> grown at $50\text{mgL}^{-1}$ Cr (Logarithmic phase culture were used)	129
<b>Figure 16dii:</b>	Cr content in the external medium of culture grown at $50\text{mgL}^{-1}$ Cr (Logarithmic phase culture were used)	129
<b>Figure 16ei:</b>	Cr content in <i>A.convolutus</i> grown at $50\text{mgL}^{-1}$ Cr (Stationary phase culture were used)	130
<b>Figure 16eii:</b>	Cr content in the external medium of culture grown at $50\text{mgL}^{-1}$ Cr (Stationary phase culture were used)	130
<b>Figure 17ai:</b>	Cu content in <i>A.convolutus</i> grown at $1\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	132
<b>Figure 17aii:</b>	Cu content in the external medium of culture grown at $1\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	132
<b>Figure 17bi:</b>	Cu content in <i>A.convolutus</i> grown at $175\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	133
<b>Figure 17bii:</b>	Cu content in the external medium of culture grown at $175\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	133
<b>Figure 17ci:</b>	Cu content in <i>A.convolutus</i> grown at $175\text{mgL}^{-1}$ Cu (Stationary phase culture were used)	134
<b>Figure 17cii:</b>	Cu content in the external medium of culture grown at $175\text{mgL}^{-1}$ Cu (Stationary phase culture were used)	134
<b>Figure 17di:</b>	Cu content in <i>A.convolutus</i> grown at $500\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	136
<b>Figure 17dii:</b>	Cu content in the external medium of culture grown at $500\text{mgL}^{-1}$ Cu (Logarithmic phase culture were used)	136

<b>Figure 17ei:</b>	Cu content in <i>A.convolutus</i> grown at 500mgL <sup>-1</sup> Cu (Stationary phase culture were used)	137
<b>Figure 17eii:</b>	Cu content in <i>A.convolutus</i> grown at 500mgL <sup>-1</sup> Cu (Scale maximised to show Cu bioaccumulation in detail)	137
<b>Figure 17eiii:</b>	Cu content in the external medium of culture grown at 500mgL <sup>-1</sup> Cu (Stationary phase culture were used)	138
<b>Figure 17eiv:</b>	Cu content in the external medium of culture grown at 500 mgL <sup>-1</sup> Cu (Scale maximised to show uptake of Cu from medium in detail)	138
<b>Figure 18ai:</b>	Fe content in <i>A.convolutus</i> grown at 1mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	139
<b>Figure 18aai:</b>	Fe content in the external medium of culture grown at 1mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	139
<b>Figure 18bi:</b>	Fe content in <i>A.convolutus</i> grown at 50mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	141
<b>Figure 18bii:</b>	Fe content in the external medium of culture grown at 50mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	141
<b>Figure 18ci:</b>	Fe content in <i>A.convolutus</i> grown at 50mgL <sup>-1</sup> Fe (Stationary phase culture were used)	142
<b>Figure 18cii:</b>	Fe content in the external medium of culture grown at 50mgL <sup>-1</sup> Fe (Stationary phase culture were used)	142
<b>Figure 18di:</b>	Fe content in <i>A.convolutus</i> grown at 200mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	143
<b>Figure 18dii:</b>	Fe content in <i>A.convolutus</i> grown at 200mgL <sup>-1</sup> Fe (Scale maximised to show Fe bioaccumulation in detail)	143
<b>Figure 18diii:</b>	Fe content in the external medium of culture grown at 200mgL <sup>-1</sup> Fe (Logarithmic phase culture were used)	144

<b>Figure 18div:</b>	Fe content in the external medium of culture grown at 200 mgL <sup>-1</sup> Fe (Scale maximised to show uptake of Fe from medium in detail)	144
<b>Figure 18ei:</b>	Fe content in <i>A.convolutus</i> grown at 200mgL <sup>-1</sup> Fe (Stationary phase culture were used)	146
<b>Figure 18eii:</b>	Fe content in <i>A.convolutus</i> grown at 200mgL <sup>-1</sup> Fe (Scale maximised to show Fe bioaccumulation in detail)	146
<b>Figure 18eiii:</b>	Fe content in the external medium of culture grown at 200mgL <sup>-1</sup> Fe (Stationary phase culture were used)	147
<b>Figure 18eiv:</b>	Fe content in the external medium of culture grown at 200 mgL <sup>-1</sup> Fe (Scale maximised to show uptake of Fe from medium in detail)	147

## List of Plates

<b>Plate 1:</b>	Mutiwell plate	54
<b>Plate 2:</b>	Algal cultures incubated for four days in the various concentrations of heavy metals	64
<b>Plate 3:</b>	<i>Ankistrodesmus convolutus</i> Corda (isolate 101)	69



## List of Appendices

<b>Appendix 1:</b>	Bold basal medium (BBM) for freshwater algae	193
<b>Appendix 2:</b>	Detail of parameters used in the determination of the amounts of salts for preparation of the stock solutions	194
<b>Appendix 3:</b>	Amount of salt needed for preparing 100 mg of metal ions in 1L volumes	195
<b>Appendix 4:</b>	Wavelengths and detection limit for Cu, Cr, Cd, Co, Fe, Mn and Zn	196
<b>Appendix 5:</b>	Standard used in bioaccumulation studies	197
<b>Appendix 6(1):</b>	Using the ICPIN programme (Norberg-King, 1993)	199
<b>Appendix 6(2):</b>	Output from analysis by ICPIN programme	200
<b>Appendices 7a &amp; b:</b>	Cadmium (Cd) toxicity test	201
<b>Appendices 8a &amp; b:</b>	Cobalt (Co) toxicity test	202
<b>Appendices 9a &amp; b:</b>	Zinc (Zn) toxicity test	203
<b>Appendices 10a &amp; b:</b>	Manganese (Mn) toxicity test	204
<b>Appendices 11a &amp; b:</b>	Chromium (Cr) toxicity test	205
<b>Appendices 12a &amp; b:</b>	Copper (Cu) toxicity test	206
<b>Appendices 13a &amp; b:</b>	Iron (Fe) toxicity test	207
<b>Appendices 14a,b,c,d &amp; e:</b>	Cadmium (Cd) bioaccumulation test	208
<b>Appendices 15a,b,c,d &amp; e:</b>	Cobalt (Co) bioaccumulation test	211
<b>Appendices 16a,b,c,d &amp; e:</b>	Zinc (Zn) bioaccumulation test	214
<b>Appendices 17a,b,c,d &amp; e:</b>	Manganese (Mn) bioaccumulation test	217

<b>Appendices 18a,b,c,d &amp; e:</b>	Chromium (Cr) bioaccumulation test	220
<b>Appendices 19a,b,c,d &amp; e:</b>	Copper (Cu) bioaccumulation test	223
<b>Appendices 20a,b,c,d &amp; e:</b>	Iron (Fe) bioaccumulation test	