

Annexure I

5 Accumulation, distribution and ultra-structural changes of *Monochoria hastata* plant exposed to Cadmium

5.3.2 Total chlorophyll content

In chlorophyll concentration, there is significant difference between the control and Cd treated *M. hastata* plant.

Table 5.3.2.1 Anova: Single Factor

SUMMARY

| Groups | Count | Sum | Average | Variance |
|--------|-------|------|--------------|--------------|
| Row 1 | 3 | 0.84 | 0.28 | 0 |
| Row 2 | 3 | 0.61 | 0.2033333333 | 0.0002333333 |
| Row 3 | 3 | 0.35 | 0.1166666667 | 0.0004333333 |
| Row 4 | 3 | 0.27 | 0.09 | 0.0004 |

ANOVA

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|----------|----------|----------|
| Between Groups | 0.067292 | 3 | 0.022431 | 84.11458 | 2.17E-06 | 4.066181 |
| Within Groups | 0.002133 | 8 | 0.000267 | | | |
| Total | 0.069425 | 11 | | | | |

5.3.3 Metal Concentrations in morphological tissues

In 5 mg/L Cd concentration, there is significant difference in Cd concentrations in different plant parts.

Table 5.3.3.1 Anova: Single Factor

SUMMARY

| Groups | Count | Sum | Average | Variance |
|--------|-------|--------|---------|----------|
| Root | 3 | 3384 | 1128 | 7410.248 |
| Shoot | 3 | 1100.4 | 366.8 | 3062.821 |
| Leaf | 3 | 201 | 67 | 307.5687 |

ANOVA

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|---------|----------|----------|
| Between Groups | 1795026 | 2 | 897513.2 | 249.757 | 1.67E-06 | 5.143253 |
| Within Groups | 21561.27 | 6 | 3593.546 | | | |
| Total | 1816588 | 8 | | | | |

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In 10 mg/L Cd concentration, there is significant difference in Cd concentrations in different plant parts.

Table 5.3.3.2 Anova: Single Factor

| SUMMARY | | | | |
|---------------|--------------|------------|----------------|-----------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
| Root | 3 | 7899.9 | 2633.3 | 5866.874 |
| Shoot | 3 | 1323.9 | 441.3 | 5402.18 |
| Leaf | 3 | 240 | 80 | 455.1616 |

| ANOVA | | | | | | |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 11454743 | 2 | 5727371 | 1465.524 | 8.53E-09 | 5.143253 |
| Within Groups | 23448.43 | 6 | 3908.072 | | | |
| Total | 11478191 | 8 | | | | |

In 15 mg/L Cd concentration, there is significant difference in Cd concentrations in different plant parts.

Table 5.3.3.3 Anova: Single Factor

| SUMMARY | | | | |
|---------------|--------------|------------|----------------|-----------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
| Root | 3 | 11943.9 | 3981.3 | 14161.54 |
| Shoot | 3 | 1749.6 | 583.2 | 3747.12 |
| Leaf | 3 | 267.9 | 89.3 | 631.2571 |

| ANOVA | | | | | | |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 26938685 | 2 | 13469342 | 2179.515 | 2.6E-09 | 5.143253 |
| Within Groups | 37079.83 | 6 | 6179.972 | | | |
| Total | 26975765 | 8 | | | | |

Annexure II

6 Accumulation and Localization of Antimony in *Trapa natans* and *Eichhornia crassipes* grown within a hydroponic system

6.4.2 Sb disturbance on chlorophylls and photosynthetic activities

In case of *T. natans*, there is a significance difference between the chlorophyll content of control and Sb treated plants. There was significant difference in chlorophyll content in different concentrations of Sb on 3rd day ($p < 0.05$)

Table 6.4.2.1 Anova: Single Factor

| SUMMARY | | | | |
|---------------|--------------|------------|----------------|-----------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
| 0.18 mg/L | 3 | 0.49 | 0.163333 | 0.000633 |
| 5.17 mg/L | 3 | 0.41 | 0.136667 | 0.000133 |
| 7.47 mg/L | 3 | 0.33 | 0.11 | 0.0004 |

| ANOVA | | | | | | |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 0.004267 | 2 | 0.002133 | 5.485714 | 0.044187 | 5.143253 |
| Within Groups | 0.002333 | 6 | 0.000389 | | | |
| Total | 0.0066 | 8 | | | | |

There was significant difference in chlorophyll content in the three concentrations of Sb on 5th day ($p < 0.05$).

Table 6.4.2.2 Anova: Single Factor

| SUMMARY | | | | |
|---------------|--------------|------------|----------------|-----------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
| 0.18 mg/L | 3 | 0.45 | 0.15 | 0.0004 |
| 5.17 mg/L | 3 | 0.37 | 0.123333 | 0.000233 |
| 7.47 mg/L | 3 | 0.2 | 0.066667 | 3.33E-05 |

| ANOVA | | | | | | |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 0.010867 | 2 | 0.005433 | 24.45 | 0.001305 | 5.143253 |
| Within Groups | 0.001333 | 6 | 0.000222 | | | |
| Total | 0.0122 | 8 | | | | |

There was significant difference in chlorophyll content in different concentrations of Sb on 10th day ($p < 0.05$).

Table 6.4.2.3 Anova: Single Factor

| SUMMARY | | | | | | |
|-----------|-------|------|----------|----------|--|--|
| Groups | Count | Sum | Average | Variance | | |
| 0.18 mg/L | 3 | 0.26 | 0.086667 | 3.33E-05 | | |
| 5.17 mg/L | 3 | 0.2 | 0.066667 | 3.33E-05 | | |
| 7.47 mg/L | 3 | 0.14 | 0.046667 | 3.33E-05 | | |

| ANOVA | | | | | | |
|---------------------|--------|----|----------|----|----------|----------|
| Source of Variation | SS | df | MS | F | P-value | F crit |
| Between Groups | 0.0024 | 2 | 0.0012 | 36 | 0.000455 | 5.143253 |
| Within Groups | 0.0002 | 6 | 3.33E-05 | | | |
| Total | 0.0026 | 8 | | | | |

In case of *E. crassipes*, there is a significance difference between the chlorophyll content of control and Sb treated plants.

Table 6.4.2.4 Anova: Single Factor

| SUMMARY | | | | | | |
|----------|-------|------|----------|----------|--|--|
| Groups | Count | Sum | Average | Variance | | |
| Column 1 | 3 | 1.49 | 0.496667 | 0.000233 | | |
| Column 2 | 3 | 1.22 | 0.406667 | 3.33E-05 | | |
| Column 3 | 3 | 0.6 | 0.2 | 1E-04 | | |

| ANOVA | | | | | | |
|---------------------|----------|----|----------|----------|----------|----------|
| Source of Variation | SS | df | MS | F | P-value | F crit |
| Between Groups | 0.138822 | 2 | 0.069411 | 567.9091 | 1.45E-07 | 5.143253 |
| Within Groups | 0.000733 | 6 | 0.000122 | | | |
| Total | 0.139556 | 8 | | | | |

6.4.5 Accumulation of Sb by the plants

In 0.18 mg/L Sb concentration, there is significant difference between the accumulations of Sb in *T. natans* in different days.

Table 6.4.5.1 Anova: Single Factor

| SUMMARY | | | | |
|-----------------------|-------|------|----------|----------|
| Groups | Count | Sum | Average | Variance |
| 2 nd days | 3 | 0.19 | 0.063333 | 3.33E-05 |
| 4 th days | 3 | 0.22 | 0.073333 | 3.33E-05 |
| 6 th days | 3 | 0.26 | 0.086667 | 3.33E-05 |
| 8 th days | 3 | 0.26 | 0.086667 | 3.33E-05 |
| 10 th days | 3 | 0.27 | 0.09 | 0.0001 |

ANOVA

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|----------|----------|---------|
| Between Groups | 0.001533 | 4 | 0.000383 | 8.214286 | 0.003343 | 3.47805 |
| Within Groups | 0.000467 | 10 | 4.67E-05 | | | |
| Total | 0.002 | 14 | | | | |

In 5.17 mg/L Sb concentration, there is significant difference between the accumulations of Sb in *T. natans* in different days.

Table 6.4.5.2 Anova: Single Factor

SUMMARY

| Groups | Count | Sum | Average | Variance |
|-----------------------|-------|-------|----------|----------|
| 2 nd days | 3 | 6.2 | 2.066667 | 0.005633 |
| 4 th days | 3 | 6.54 | 2.18 | 0.0001 |
| 6 th days | 3 | 7.52 | 2.506667 | 0.002633 |
| 8 th days | 3 | 9.65 | 3.216667 | 0.012133 |
| 10 th days | 3 | 12.26 | 4.086667 | 3.33E-05 |

ANOVA

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|----------|----------|---------|
| Between Groups | 8.510107 | 4 | 2.127527 | 518.0666 | 1.53E-11 | 3.47805 |
| Within Groups | 0.041067 | 10 | 0.004107 | | | |
| Total | 8.551173 | 14 | | | | |

In 7.47 mg/L Sb concentration, there is significant difference between the Sb accumulations in *T. natans* in different days.

Table 6.4.5.3 Anova: Single Factor

SUMMARY

| Groups | Count | Sum | Average | Variance |
|-----------------------|-------|-------|----------|----------|
| 2 nd days | 3 | 3.44 | 1.146667 | 0.000233 |
| 4 th days | 3 | 5.52 | 1.84 | 0.0049 |
| 6 th days | 3 | 9.35 | 3.116667 | 0.000933 |
| 8 th days | 3 | 10.26 | 3.42 | 0.0592 |
| 10 th days | 3 | 11.92 | 3.973333 | 0.000233 |

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---------------------|----------|----|----------|----------|----------|---------|
| Between Groups | 16.39749 | 4 | 4.099373 | 312.9293 | 1.86E-10 | 3.47805 |
| Within Groups | 0.131 | 10 | 0.0131 | | | |
| Total | 16.52849 | 14 | | | | |

In 0.18 mg/L Sb concentration, there is significant difference between the accumulations of Sb in *E. crassipes* in different days

Table 6.4.5.4 Anova: Single Factor

| SUMMARY | | | | | | |
|----------------------------|--------------|------------|----------------|-----------------|----------------|---------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> | | |
| 2 nd days | 3 | 83.09 | 27.69667 | 0.028033 | | |
| 4 th days | 3 | 99.9 | 33.3 | 0.04 | | |
| 6 th days | 3 | 116.6 | 38.86667 | 0.043333 | | |
| 8 th days | 3 | 116.4 | 38.8 | 0.01 | | |
| 10 th days | 3 | 150 | 50 | 0.04 | | |
| ANOVA | | | | | | |
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 819.8474 | 4 | 204.9618 | 6350.811 | 5.66E-17 | 3.47805 |
| Within Groups | 0.322733 | 10 | 0.032273 | | | |
| Total | 820.1701 | 14 | | | | |

In 5.17mg/L Sb concentration, there is significant difference between the accumulations of Sb in *E. crassipes* in different days.

Table 6.4.5.5 Anova: Single Factor

| SUMMARY | | | | | | |
|----------------------------|--------------|------------|----------------|-----------------|----------------|---------------|
| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> | | |
| 2 nd days | 3 | 120.01 | 40.00333 | 3.33E-05 | | |
| 4 th days | 3 | 126.5 | 42.16667 | 0.093333 | | |
| 6 th days | 3 | 145.1 | 48.36667 | 0.023333 | | |
| 8 th days | 3 | 185.9 | 61.96667 | 0.023333 | | |
| 10 th days | 3 | 236.73 | 78.91 | 0.0013 | | |
| ANOVA | | | | | | |
| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
| Between Groups | 3153.736 | 4 | 788.434 | 27892.71 | 3.47E-20 | 3.47805 |
| Within Groups | 0.282667 | 10 | 0.028267 | | | |
| Total | 3154.018 | 14 | | | | |

In 7.47 mg/L Sb concentration, there is significant difference between the accumulations of Sb in *E. crassipes* in different days.

Table 6.4.5.6 Anova: Single Factor

SUMMARY

| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
|-----------------------|--------------|------------|----------------|-----------------|
| 2 nd days | 3 | 46.17 | 15.39 | 0.0036 |
| 4 th days | 3 | 73.88 | 24.62667 | 0.000633 |
| 6 th days | 3 | 124.9 | 41.63333 | 0.102933 |
| 8 th days | 3 | 137.17 | 45.72333 | 0.001633 |
| 10 th days | 3 | 159.43 | 53.14333 | 0.047433 |

ANOVA

| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| Between Groups | 2922.729 | 4 | 730.6822 | 23384.33 | 8.37E-20 | 3.47805 |
| Within Groups | 0.312467 | 10 | 0.031247 | | | |
| Total | 2923.041 | 14 | | | | |

Annexure III**7 Uptake of Arsenic by *Navicula* sp. into cellular components: An X-ray energy dispersive study****7.3.5 ICP-OES study**

In 3 mg/L solution, the As concentration decreases in solution. There is a significant difference in As accumulation by diatom *Navicula* sp.

Table 7.3.5.1 Anova: Single Factor**SUMMARY**

| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
|---------------|--------------|------------|----------------|-----------------|
| 3 mg/L | 3 | 6.3 | 2.1 | 0.01 |
| 8 mg/L | 3 | 4.5 | 1.5 | 0.03 |
| 14 mg/L | 3 | 3.8 | 1.266667 | 0.003333 |
| 55 mg/L | 3 | 3.7 | 1.233333 | 0.023333 |

ANOVA

| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| Between Groups | 1.449167 | 3 | 0.483056 | 28.98333 | 0.00012 | 4.066181 |
| Within Groups | 0.133333 | 8 | 0.016667 | | | |
| Total | 1.5825 | 11 | | | | |

In 8 mg/L, there is significant difference in the As concentration after 21 days.

Table 7.3.5.2 Anova: Single Factor**SUMMARY**

| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
|---------------|--------------|------------|----------------|-----------------|
| 3 mg/L | 3 | 16.2 | 5.4 | 0.04 |
| 8 mg/L | 3 | 16 | 5.333333 | 0.003333 |
| 14 mg/L | 3 | 6.46 | 2.153333 | 0.000233 |
| 55 mg/L | 3 | 3.65 | 1.216667 | 3.33E-05 |

ANOVA

| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| Between Groups | 41.98669 | 3 | 13.99556 | 1283.997 | 4.54E-11 | 4.066181 |
| Within Groups | 0.0872 | 8 | 0.0109 | | | |
| Total | 42.07389 | 11 | | | | |

In 14 mg/L As concentration, there is significant difference in As concentration decrease after 21 days.

Table 7.3.5.3 Anova: Single Factor

SUMMARY

| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
|---------------|--------------|------------|----------------|-----------------|
| 3 mg/L | 3 | 38.7 | 12.9 | 0.04 |
| 8 mg/L | 3 | 35.2 | 11.73333 | 0.023333 |
| 14 mg/L | 3 | 33 | 11 | 0.01 |
| 55 mg/L | 3 | 16.8 | 5.6 | 0.03 |

ANOVA

| <i>Source of Variation</i> | <i>SS</i> | <i>Df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| Between Groups | 94.1825 | 3 | 31.39417 | 1215.258 | 5.65E-11 | 4.066181 |
| Within Groups | 0.206667 | 8 | 0.025833 | | | |
| Total | 94.38917 | 11 | | | | |

In 55 mg/L concentration, there is significant difference in As concentration decrease after 21 days.

Table 7.3.5.4 Anova: Single Factor

SUMMARY

| <i>Groups</i> | <i>Count</i> | <i>Sum</i> | <i>Average</i> | <i>Variance</i> |
|---------------|--------------|------------|----------------|-----------------|
| 3 mg/L | 3 | 159.8 | 53.26667 | 0.023333 |
| 8 mg/L | 3 | 153.9 | 51.3 | 0.13 |
| 14 mg/L | 3 | 144.8 | 48.26667 | 0.413333 |
| 55 mg/L | 3 | 120 | 40 | 0.04 |

ANOVA

| <i>Source of Variation</i> | <i>SS</i> | <i>df</i> | <i>MS</i> | <i>F</i> | <i>P-value</i> | <i>F crit</i> |
|----------------------------|-----------|-----------|-----------|----------|----------------|---------------|
| Between Groups | 307.5758 | 3 | 102.5253 | 675.9908 | 5.86E-10 | 4.066181 |
| Within Groups | 1.213333 | 8 | 0.151667 | | | |
| Total | 308.7892 | 11 | | | | |