# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Fig. No.</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 3.1 Set up of continuous column study apparatus.</td>
<td>61</td>
</tr>
<tr>
<td>Fig. 4.1.1: FTIR spectra of biomass, CDA.</td>
<td>67</td>
</tr>
<tr>
<td>Fig. 4.1.2: FTIR spectra of biomass, MSA.</td>
<td>68</td>
</tr>
<tr>
<td>Fig. 4.1.3: FTIR spectra of biomass, OPP.</td>
<td>69</td>
</tr>
<tr>
<td>Fig. 4.1.4: FTIR spectra of biomass, CCA.</td>
<td>70</td>
</tr>
<tr>
<td>Fig. 4.1.5: FTIR spectra of granulated activated carbon, GAC.</td>
<td>71</td>
</tr>
<tr>
<td>Fig. 4.2.1 Scanning electron micrographs of biomass, CDA.</td>
<td>74</td>
</tr>
<tr>
<td>Fig. 4.2.2 Scanning electron micrographs of biomass, CCA.</td>
<td>75</td>
</tr>
<tr>
<td>Fig. 4.2.3 Scanning electron micrographs of biomass, MSA.</td>
<td>76</td>
</tr>
<tr>
<td>Fig. 4.2.4 Scanning electron micrographs of biomass, OPP.</td>
<td>77</td>
</tr>
<tr>
<td>Fig. 4.2.5 Scanning electron micrographs of Granulated activated carbon (GAC).</td>
<td>78</td>
</tr>
</tbody>
</table>

Fig. 4.3.1 Influence of pH on amount of Cr(VI) adsorbed per unit weight (Q_e) for five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C). | 97 |

Fig. 4.3.2 Effect of pH on percentage adsorption of Cr(VI) onto five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C). | 97 |

Fig. 4.3.3 Effect of adsorbent dose on amount of Cr(VI) adsorbed per unit weight (Q_e) onto five different adsorbents (initial metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C). | 98 |
Fig. 4.3.4 Effect of adsorbent dose on the percentage adsorption of Cr(VI) onto five different adsorbents (initial metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.5 Influence of initial Cr(VI) concentration (C₀) on amount of Cr(VI) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.6 Effect of initial Cr(VI) concentration (C₀) on the percentage adsorption of Cr(VI) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.7 Influence of initial Cr(VI) concentration (C₀) on amount of Cr(VI) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.8 Effect of initial Cr(VI) concentration (C₀) on the percentage adsorption of Cr(VI) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.9 Influence of initial Cr(VI) concentration (C₀) on amount of Cr(VI) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.10 Effect of initial Cr(VI) concentration (C₀) on the percentage adsorption of Cr(VI) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.11 Adsorption equilibrium isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.3.12 Adsorption equilibrium isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 6.2, equilibration time = 24 h, temperature = 25 ± 1°C).
Fig. 4.3.13 Adsorption equilibrium isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose=1.5g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.14 Langmuirian plots of 1/C_e vs. 1/Q_e for Cr(VI) adsorption onto five different adsorbents (adsorbent dose=0.5g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.15 Langmuirian plots of 1/C_e vs. 1/Q_e for Cr(VI) adsorption onto five different adsorbents (adsorbent dose=1.0g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.16 Langmuirian plots of 1/C_e vs. 1/Q_e for Cr(VI) adsorption onto five different adsorbents (adsorbent dose=1.5g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.17 Freundlich adsorption isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose=0.5 g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.18 Freundlich adsorption isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose =1.0g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.3.19 Freundlich adsorption isotherms for Cr(VI) adsorption onto five different adsorbents (adsorbent dose =1.5g, pH = 6.2, equilibration time =24h, temperature = 25 ± 1°C).

Fig. 4.4.1 Influence of pH on amount of Ni(II) adsorbed per unit weight (Q_e) for five different adsorbents (adsorbent dose = 1 g, metal ion concentration=500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).
Fig. 4.4.2 Effect of pH on percentage adsorption of Ni(II) onto five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.3 Effect of adsorbent dose on the percentage adsorption of Ni(II) onto five different adsorbents (initial metal ion concentration = 500 mg/L, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.4 Effect of adsorbent dose on amount of Ni(II) adsorbed per unit weight (Qe) onto five different adsorbents (initial metal ion concentration = 500 mg/L, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.5 Influence of initial Ni(II) concentration (C0) on amount of Ni(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.6 Effect of initial Ni(II) concentration (C0) on the percentage adsorption of Ni(II) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.7 Influence of initial Ni(II) concentration (C0) on amount of Ni(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.8 Effect of initial Ni(II) concentration (C0) on the percentage adsorption of Ni(II) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.9 Influence of initial Ni(II) concentration (C0) on amount of Ni(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.10 Effect of initial Ni(II) concentration (C0) on the percentage adsorption of Ni(II) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).
adsorption of Ni(II) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.11 Adsorption equilibrium isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.12 Adsorption equilibrium isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.13 Adsorption equilibrium isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.14 Langmuirian plots of 1/Ce vs. 1/Qe for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.15 Langmuirian plots of 1/Ce vs. 1/Qe for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.16 Langmuirian plots of 1/Ce vs. 1/Qe for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.17 Freundlich adsorption isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.4.18 Freundlich adsorption isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).
Fig. 4.4.19 Freundlich adsorption isotherms for Ni(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 7.0, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.1 Influence of pH on amount of Cu(II) adsorbed per unit weight (Qe) for five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.2 Effect of pH on percentage adsorption of Cu(II) onto five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.3 Effect of adsorbent dose on the percentage adsorption of Cu(II) onto five different adsorbents (initial metal ion concentration = 500 mg/L, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.4 Effect of adsorbent dose on amount of Cu(II) adsorbed per unit weight (Qe) onto five different adsorbents (initial metal ion concentration = 500 mg/L, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.5 Influence of initial Cu(II) concentration (C0) on amount of Cu(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.6 Effect of initial Cu(II) concentration (C0) on the percentage adsorption of Cu(II) onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.7 Influence of initial Cu(II) concentration (C0) on amount of Cu(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig. 4.5.8 Effect of initial Cu(II) concentration (C0) on the percentage adsorption of Cu(II) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).
adsorption of Cu(II) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.9 Influence of initial Cu(II) concentration (C₀) on amount of Cu(II) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose=1.5 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.10 Effect of initial Cu(II) concentration (C₀) on the percentage adsorption of Cu(II) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.2, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.11 Adsorption equilibrium isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.12 Adsorption equilibrium isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.13 Adsorption equilibrium isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.14 Langmuirian plots of 1/Cₑ vs. 1/Qₑ for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.15 Langmuirian plots of 1/Cₑ vs. 1/Qₑ for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.16 Langmuirian plots of 1/Cₑ vs. 1/Qₑ for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).
Fig 4.5.17 Freundlich adsorption isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.18 Freundlich adsorption isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.19 Freundlich adsorption isotherms for Cu(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.2, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.5.17 Influence of pH on amount of Co(II) adsorbed per unit weight (Qe) for five different adsorbents (adsorbent dose = 1 g, metal ion concentration=500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.2 Effect of pH on percentage adsorption of Co(II) onto five different adsorbents (adsorbent dose = 1 g, metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.3 Effect of adsorbent dose on amount of Co(II) adsorbed per unit weight (Qe) onto five different adsorbents (initial metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.4 Effect of adsorbent dose on the percentage adsorption of Co(II) onto five different adsorbents (initial metal ion concentration = 500 mg/L, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.5 Influence of initial Co(II) concentration (C0) on amount of Co(II) ions adsorbed per unit weight (Qe) onto five different adsorbents (adsorbent dose=0.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.5.6 Effect of initial Co(II) concentration (C0) on the percentage adsorption of Co(II) onto five different adsorbents (adsorbent dose = 0.5 g,
pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.7 Influence of initial Co(II) concentration (C₀) on amount of Co(II) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.8 Effect of initial Co(II) concentration (C₀) on the percentage adsorption of Co(II) onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.9 Influence of initial Co(II) concentration (C₀) on amount of Co(II) ions adsorbed per unit weight (Qₑ) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.10 Effect of initial Co(II) concentration (C₀) on the percentage adsorption of Co(II) onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.11 Adsorption equilibrium isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.12 Adsorption equilibrium isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.13 Adsorption equilibrium isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).

Fig 4.6.14 Langmuirian plots of 1/Cₑ vs. 1/Qₑ for Co(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.8, equilibration time = 24 h, temperature = 25 ± 1°C).
Fig 4.6.15 Langmuirian plots of $1/C_e$ vs. $1/Q_e$ for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.8, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.6.16 Langmuirian plots of $1/C_e$ vs. $1/Q_e$ for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.8, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.6.17 Freundlich adsorption isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 0.5 g, pH = 5.8, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.6.18 Freundlich adsorption isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.0 g, pH = 5.8, equilibration time=24h, temperature = 25 ± 1°C).

Fig 4.6.19 Freundlich adsorption isotherms for Co(II) adsorption onto five different adsorbents (adsorbent dose = 1.5 g, pH = 5.8, equilibration time=24h, temperature = 25 ± 1°C).

Fig. 4.7.1.1 Breakthrough curve in terms of effluent concentration ($C_{ef}$) and time for Ni(II) in continuous column (Flow rate=20 mL/min, mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature=25±1°C).

Fig. 4.7.1.2 Breakthrough curve in terms of effluent concentration ($C_{ef}$) and time for Ni(II) in continuous column (Flow rate=32.5 mL/min, mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature=25±1°C).

Fig. 4.7.1.3 Breakthrough curve in terms of effluent concentration ($C_{ef}$) and time for Ni(II) in continuous column (Flow rate=43.5 mL/min, mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0,
temperature=25±1°C).

Fig. 4.7.1.4 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and effective volume (V_{ef}) for Ni(II) in continuous column (Flow rate = 20.0 mL/min, mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L, pH= 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.5 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and effective volume (V_{ef}) for Ni(II) in continuous column (Flow rate = 32.5 mL/min, mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L, pH= 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.6 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and effective volume (V_{ef}) for Ni(II) in continuous column (Flow rate = 43.5 mL/min, mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L, pH= 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.7 Breakthrough curve in terms of effluent concentration (C_{ef}) and time for Ni(II) in continuous column (Flow rate=20 mL/min, mass of GAC in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature=25±1°C).

Fig. 4.7.1.8 Breakthrough curve in terms of effluent concentration (C_{ef}) and time for Ni(II) in continuous column (Flow rate=32.5 mL/min, mass of GAC in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature=25±1°C).

Fig. 4.7.1.9 Breakthrough curve in terms of effluent concentration (C_{ef}) and time for Ni(II) in continuous column (Flow rate=43.5 mL/min, mass of GAC in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature=25±1°C).

Fig. 4.7.1.10 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and effective volume (V_{ef}) for Ni(II) in continuous column (Flow rate = 20.0 mL/min,
mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.11 Breakthrough curve in terms of concentration ratio ($C_\text{ef}/C_\text{o}$) and effective volume ($V_\text{ef}$) for Ni(II) in continuous column (Flow rate = 32.5 mL/min, mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.12 Breakthrough curve in terms of concentration ratio ($C_\text{ef}/C_\text{o}$) and effective volume ($V_\text{ef}$) for Ni(II) in continuous column (Flow rate = 43.5 mL/min, mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.13 Effect of flow rates (20, 32.5 and 43.5 mL/min) on the percentage removal of Ni(II) in continuous column (mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature = 25 ± 1°C).

Fig. 4.7.1.14 Effect of flow rates (20, 32.5 and 43.5 mL/min) on the percentage removal of Ni(II) in continuous column (mass of GAC in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 7.0, temperature = 25 ± 1°C).

Fig. 4.7.2.1 Breakthrough curve in terms of effluent concentration ($C_\text{ef}$) and time for Cu(II) in continuous column (Flow rate = 20 mL/min, mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.2 Breakthrough curve in terms of effluent concentration ($C_\text{ef}$) and time for Cu(II) in continuous column (Flow rate = 32.5 mL/min, mass of CDA in column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2, temperature = 25 ± 1°C).
Fig. 4.7.2.3 Breakthrough curve in terms of effluent concentration (C_{ef}) and
time for Cu(II) in continuous column (Flow rate=43.5 mL/min, mass of CDA in
column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2,
temperature=25±1°C).

Fig. 4.7.2.4 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and
effective volume (V_{ef}) for Cu(II) in continuous column (Flow rate= 20.0 mL/min,
mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L,
pH= 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.5 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and
effective volume (V_{ef}) for Cu(II) in continuous column (Flow rate= 32.5 mL/min,
mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L,
pH= 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.6 Breakthrough curve in terms of concentration ratio (C_{ef}/C_0) and
effective volume (V_{ef}) for Cu(II) in continuous column (Flow rate =43.5 mL/min,
mass of CDA column = 70.0 g, initial metal ion concentration = 200 mg/L,
pH=5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.7 Breakthrough curve in terms of effluent concentration (C_{ef}) and
time for Cu(II) in continuous column (Flow rate=20 mL/min, mass of GAC in
column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2,
temperature=25±1°C).

Fig. 4.7.2.8 Breakthrough curve in terms of effluent concentration (C_{ef}) and
time for Cu(II) in continuous column (Flow rate=32.5 mL/min, mass of GAC in
column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2,
temperature=25±1°C).

Fig. 4.7.2.9 Breakthrough curve in terms of effluent concentration (C_{ef}) and
time for Cu(II) in continuous column (Flow rate=43.5 mL/min, mass of GAC in
column = 70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2,
temperature=25±1°C).

Fig. 4.7.2.10 Breakthrough curve in terms of concentration ratio \( \frac{C_{ef}}{C_0} \) and effective volume \( V_{ef} \) for Cu(II) in continuous column (Flow rate =20.0mL/min, mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH=5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.11 Breakthrough curve in terms of concentration ratio \( \frac{C_{ef}}{C_0} \) and effective volume \( V_{ef} \) for Cu(II) in continuous column (Flow rate =32.5mL/min, mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH= 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.12 Breakthrough curve in terms of concentration ratio \( \frac{C_{ef}}{C_0} \) and effective volume \( V_{ef} \) for Cu(II) in continuous column (Flow rate =43.5mL/min, mass of GAC column = 70.0 g, initial metal ion concentration = 200 mg/L, pH= 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.13 Effect of flow rates (20, 32.5 and 43.5 mL/min) on the percentage removal of Cu(II) in continuous column (mass of CDA in column=70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2, temperature = 25 ± 1°C).

Fig. 4.7.2.14 Effect of flow rates (20, 32.5 and 43.5 mL/min) on the percentage removal of Cu(II) in continuous column (mass of GAC in column=70.0 g, initial metal ion concentration = 200 mg/L, pH = 5.2, temperature = 25 ± 1°C).