## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE 1</td>
<td>Source of ammonia in waters</td>
<td>2</td>
</tr>
<tr>
<td>FIGURE 2a and 2b</td>
<td>Eutrophication in Fuhu River, China</td>
<td>5</td>
</tr>
<tr>
<td>FIGURE 3</td>
<td>Chilika lake waters with high ammonia concentrations, Odissa, India</td>
<td>6</td>
</tr>
<tr>
<td>FIGURE 4</td>
<td>Production of ammonia in various parts of the world</td>
<td>44</td>
</tr>
<tr>
<td>FIGURE 5</td>
<td>Solubility graph of ammonia in water</td>
<td>47</td>
</tr>
<tr>
<td>FIGURE 6</td>
<td>Nitrogen cycle in environment</td>
<td>49</td>
</tr>
<tr>
<td>FIGURE 7</td>
<td>Colony morphology of the Bacterial isolate</td>
<td>75</td>
</tr>
<tr>
<td>FIGURE 8</td>
<td>Gram staining of the isolate</td>
<td>76</td>
</tr>
<tr>
<td>FIGURE 9</td>
<td>Indole test</td>
<td>83</td>
</tr>
<tr>
<td>FIGURE 10</td>
<td>Motility test on semi-solid dip Agar</td>
<td>83</td>
</tr>
<tr>
<td>FIGURE 11</td>
<td>Urease test</td>
<td>84</td>
</tr>
<tr>
<td>FIGURE 12</td>
<td>Methyl red test</td>
<td>84</td>
</tr>
<tr>
<td>FIGURE 13</td>
<td>Starch agar test</td>
<td>84</td>
</tr>
<tr>
<td>FIGURE 14</td>
<td>Gelatin liquefaction test</td>
<td>84</td>
</tr>
<tr>
<td>FIGURE 15</td>
<td>Picture showing biochemical strip KB013 results for Bacillus cereus SB1</td>
<td>85</td>
</tr>
<tr>
<td>FIGURE 16</td>
<td>Gel electrophoresis of the isolated 16s rRNA sequence of the isolate</td>
<td>87</td>
</tr>
<tr>
<td>FIGURE 17</td>
<td>Screening capture of 16s rRNA sequences selected for phylogenetic analysis of isolate from NCBI gene bank data base</td>
<td>88</td>
</tr>
<tr>
<td>FIGURE 18</td>
<td>Construction of phylogenetic tree using maximum likely hood method with thousand boot strap analysis</td>
<td>89</td>
</tr>
<tr>
<td>FIGURE 19</td>
<td>Growth of the isolate under autotrophic conditions</td>
<td>105</td>
</tr>
</tbody>
</table>
FIGURE 20: Growth of the isolate under heterotrophic conditions

FIGURE 21: Variation of ammonia concentrations and optical density at different C/N ratio and glucose as carbon source

FIGURE 22: Growth of the isolate at fixed carbon to nitrogen ratio at varying incubation period

FIGURE 23: Effect of temperature on growth of the isolate

FIGURE 24: Effect of pH on growth of the isolate & ammonia concentrations

FIGURE 25a&b: Effect of agitation speed and corresponding DO on ammonia remediation

FIGURE 26: Percent removal of ammonia with increasing ammonia concentration

FIGURE 27: Growth of the isolate with increasing ammonical nitrogen concentration

FIGURE 28: Concentrations of nitrite and nitrate nitrogen at different incubation periods from shakeflask studies

FIGURE 29: Ammonia removal using free cells at optimised environmental conditions

FIGURE 30: Formation of beads at 10:1,8:4 and 8:1 PVA and sodium alginate compositions

FIGURE 31: Plate showing testing of immobilised beads per cell leakage

FIGURE 32: Ammonia removal using immobilised cells

FIGURE 33: Nitrite and nitrate concentrations in immobilised batch experiment

FIGURE 34: Optimization of hydraulic retention time

FIGURE 35: A&B-Immobilized beads in column and continuous reactor setup

FIGURE 36: Ammonia removal in a packed bed reactor
LIST OF TABLES

TABLE.1 Utilization of nitrogen fertilizers in the world during the period 1960 to 2003 3

TABLE.2 Health effects due to excess Nitrate intake from drinking water 8

TABLE.3: Industrial discharge limits for various industries 10

TABLE.4: Standards for ammonia discharge into water bodies recommended by national and international organizations 11

TABLE 5: Annual production of ammonia in the world 43

TABLE.6: Ammonia uses in different types of industries 45

TABLE.7: Physical and chemical properties of ammonia 46

TABLE.8: Identification of anammox bacteria and their sources 55

TABLE.9: Comparison between Autotrophic and Heterotrophic ammonia removal 58

TABLE.10: Medium composition (brierley and wood, 2001) 62

TABLE.11: Morphological features of isolated bacterial colonies 75

TABLE.12: Gram staining observations 76

TABLE.13: Results for biochemical test for the isolated bacterial species 82

TABLE.14: Summary of identified isolated by biochemical characterisation 83

TABLE.15: Variation total nitrogen and ammonical nitrogen + nitrite nitrogen + nitrate nitrogen at different C/N Ratios 111

TABLE.16: Variation of total nitrogen and ammonical nitrogen at different incubation periods 112

TABLE.17: Effect of temperature on bioremediation of ammonical nitrogen 116
TABLE.18: Effect of pH on bioremediation of ammonia using *Bacillus cereus* SB1 119

TABLE.19: Effect of agitation speed on ammonia bioremediation 121

TABLE.20: Effect of initial ammonia concentration on ammonia bioremediation by the *Bacillus cereus* after 48hrs of incubation 123

TABLE.21: Variations in pH nitrite, nitrate and ammonical nitrogen in batch experiments 130

TABLE.22: Results of Batch experiments conducted with immobilised cells 141

TABLE.23: Operation of continous packed bed reactor with immobilised cells 146