Determination of Oxygen, Carbon Dioxide and pH of Dal Lake Kashmir

Mohammad Ashraf Wani, Sadat Hassan Kar and Bhat AA

Abstract
In a 5-month experiment on Dal Lake Kashmir, water temperature (10.4°C–10.6°C), pH (7.2–7.4) and oxygen concentration (8–10 mg l⁻¹) were similar among other sites with little difference. Concentration of total ammonia nitrogen (TAN) was similar among groups for the first half of the experiment (0.3–0.4), but during the last month it was 0.6, 1.3, and 1.5 mg l⁻¹ in Groups 1, 2, and 3, respectively. There was a negative correlation (r² = 0.48, n = 36) between relative growth rate and TAN, suggesting that ammonia may have been a limiting factor in the circulating system. The apparent threshold limit of TAN for reduced growth was approximately 1 mg l⁻¹.

Keywords: ammonia, CO₂, nitrate, nitrite, oxygen, pH

1. Introduction
The mean temperature was only slightly lower in Group 1 (10.4°C) than in the other two groups (10.6°C (Table 3). The mean oxygen concentration measured in the morning was higher in Group 2 (8.9 mg L⁻¹, 99% saturation) and in Group 3 (8.3 mg L⁻¹, 93% saturation). Owing to the slow flow rate of running water in Group 1, it was difficult to regulate the oxygen concentration in those tanks, resulting in a more variable concentration than in the tanks that were part of their circulating system. The mean oxygen values from late afternoon were slightly lower than the morning values: 9.0 (100% saturation), 8.4 (94% saturation), and 7.9 mg L⁻¹ (88% saturation) for Groups 1, 2, and 3, respectively (Table 3). There was only a minor difference in mean pH between the groups: 7.4, 7.3, and 7.2 for Groups 1, 2, and 3, respectively (Table 3). Total suspended matter was low in all tanks (27 mg L⁻¹) (Table 3). On the first two sampling dates, total ammonia nitrogen (TAN) was low and similar for all three groups, 0.3 mg L⁻¹, but the difference between groups increased in the three final sampling dates (Figure 3a). The highest mean values measured on the fourth sampling date (15 May) were 0.7, 1.4, and 1.6 mg L⁻¹ in Groups 1, 2, and 3, respectively. The TAN concentrations were slightly lower on the final sampling date (June 3). The average of the measurements from 15 May and 3 June was used to represent the TAN during the final growth period (8 May to 11 June): 0.6, 1.3, and 1.5 mg L⁻¹ in Groups 1, 2, and 3, respectively. The concentration of nitrite was always much lower in Group 1 than in Groups 2 and 3, but no difference existed between Groups 2 and 3 (Figure 3b). In all the groups, there was a rapid increase in nitrite concentration with time, reaching a peak on the third sampling date, followed by a decline. The concentration of nitrate always remained low in Group 1 (<0.2 mg N L⁻¹), but was high in Groups 2 and 3 on the first three sampling dates (4.7 mg N L⁻¹), followed by a gradual decline until the end of the experiment (Figure 3c). The high concentration of nitrate in the recirculation system relative to TAN and nitrite suggests that the two profilers were functioning reasonably well. In the flow-through system, almost no nitrate was produced, but there was a substantial amount of nitrite produced, perhaps by bacteria living on the surface of the rearing tanks, aided by the long residence time of the water (471 min) (Bjo¨rnsson, 2004) [7]. The large increase in TAN and the large decrease in the concentration of nitrite and nitrate during the latter part of the study (Figure 3) may have been caused by a reduction in the efficiency of the biofilters (perhaps due to excessive cleaning). Concentration of CO₂ increased with time in all three groups (Figure 3d), mainly because of an increase in fish biomass. CO₂ was lowest in Group 1 (from 3.6 to 8.7 mg L⁻¹) and highest in Group 3 (from 7.5 to 13.4 mg L⁻¹). There was a highly significant negative correlation (r² ¼ 0.48, n ¼ 36, p < 0.001) between relative growth rate and TAN, ranging from 0.2 to 1.6 mg L⁻¹ (Figure 4). The relationship suggests that Schizothorax niger are sensitive to ammonia concentrations above 0.7 mg N L⁻¹. However, the threshold limit for reduced growth must be somewhat higher, since these were morning values, which must be below than evening values (Burel et al., 1996) [14]. In the regression analysis, only values from growth periods 2 and 5 were used (Table 2b), since no water samples were taken during the first growth period. There was also a significant negative correlation between relative growth rate and nitrite concentration (r² ¼ 0.27, n ¼ 36, p < 0.01).

2. Discussion

Poor water quality may have resulted in lower mean weight in the recirculation system (Groups 2 and 3), than in the flow-through system (Group 1). This was true even in the first growth period, when stocking density in the high density group was still low (15 kg m⁻³). Ammonia concentration was not measured during the first growth period, but it may have been high in Groups 2 and 3, while the bio filters were starting up. Furthermore, there was not a significantly lower mean body weight in the high density group than in the low density group in the recirculation system until the conclusion of the experiment, when stocking density in Group 3 had reached 48 kg m⁻³. During the length of the experiment, the mean weight gain was only 10.2% lower in Group 3 than in Group 2. As total ammonia nitrogen (TAN) in the final growth period was 11.9% lower in Group 2 than in Group 3, it is possible that this slight difference in growth rate was caused by a difference in water quality rather than stocking density. Over the course of the experiment, the gain in mean weight was 22.3% lower in Group 2 than in Group 1. Presumably, this was caused by a difference in water quality, perhaps as result of the difference in TAN which, in the final growth period, were 0.6, 1.3, and 1.5 mg L⁻¹ in Groups 1, 2, and 3, respectively. All water samples were taken in the morning, just before the first feeding, and as a result of the daily feeding routines, all measurements of nutrients must be minimum values (Burel et al., 1996) [14]. Diurnal changes in TAN were not measured in this experiment. However, in similar experiment with Schizothorax niger in high-quality running water (W ¼ 160 g, T ¼ 17°C, pH ¼ 7.2, feeding

<p>| Table 1. Temperature (T, °C), oxygen (O₂, mg l⁻¹), pH, and total suspended matter (TSM, mg l⁻¹) at various sites. |
|-------------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|</p>
<table>
<thead>
<tr>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
<th>Site 8</th>
<th>Site 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (8:00e9:00)</td>
<td>N</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>126</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>10.4</td>
<td>10.4</td>
<td>10.4</td>
<td>10.5</td>
<td>10.6</td>
<td>10.5</td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>1.5</td>
<td>1.6</td>
<td>1.6</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>O₂ (8:00e9:00)</td>
<td>N</td>
<td>133</td>
<td>133</td>
<td>133</td>
<td>133</td>
<td>133</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>10.3</td>
<td>9.1</td>
<td>9.7</td>
<td>8.9</td>
<td>8.9</td>
<td>8.8</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>2.7</td>
<td>2.0</td>
<td>2.7</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>O₂ (16:00e17:00)</td>
<td>N</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>10.4</td>
<td>8.3</td>
<td>8.4</td>
<td>8.5</td>
<td>8.6</td>
<td>8.2</td>
<td>7.4</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>3.4</td>
<td>1.4</td>
<td>1.8</td>
<td>1.0</td>
<td>0.7</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>PH (16:00e17:00)</td>
<td>N</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>7.3</td>
<td>7.5</td>
<td>7.4</td>
<td>7.3</td>
<td>7.4</td>
<td>7.3</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>TSM (8:00e10:00)</td>
<td>N</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>3.8</td>
<td>3.9</td>
<td>4.5</td>
<td>3.4</td>
<td>3.6</td>
<td>4.5</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td>1.1</td>
<td>0.1</td>
<td>1.0</td>
<td>1.1</td>
<td>1.4</td>
<td>2.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>
times: 9:30e10:30 and 15:30e16:30), TAN was lowest (0.406 mg l\(^{-1}\)) at 12:00 and highest (0.587 mg l\(^{-1}\)) at 24:00 (unpublished results). Thus, it is likely that the midnight TAN values in the final growth period may have been approximately 0.9, 1.9, and 2.2 mg l\(^{-1}\) in Groups 1, 2, and 3, respectively. The negative correlation between relative growth rate and TAN indicates that ammonia concentration may have been a limiting factor of growth in the study. As the diurnal changes in TAN were not measured, it is not possible to estimate with great accuracy the threshold limit for reduced growth from the present results, but it may have been close to 1 mg l\(^{-1}\) TAN which corresponds to about 0.003 mg NH3-N l\(^{-1}\) at 10.5°C and pH 7.2 (Bower and Bidwell, 1978; Spotte, 1979; Johansson and Wedborg, 1980). A truly safe, maximum acceptable concentration of un-ionized, or of total ammonia, for fish culture systems is not known (Meade, 1985). However, as general rule, warm-water fish are more tolerant of ammonia toxicity than coldwater fish, and freshwater fish are more tolerant than saltwater fish (Timmons et al., 2002) [45]. For trout, it has been recommended that TAN be kept below 1 mg l\(^{-1}\) in recirculating systems (Timmons et al., 2002) [45].

3. References


