Chapter 6

Biovolume Calculations

Algal counts can be misleading because the cells vary in size from very tiny (<2 µm diameter) to nearly macroscopic (>1 mm diameter). In addition, some cells are too tiny or indistinct to count accurately, so the algae are counted as colonies. Algal biovolume is often used to adjust for variations in size by estimating the total volume occupied by each type of algae.

Algal biovolume is estimated by collecting cell or colony measurements from a representative number of algae, then the biovolume is estimated using a similar geometric shape. Cell biovolume estimates are included for many of the species in this volume using the equations listed in Table 6.1 (page 776). Examples of each shape and solved biovolume calculations are illustrated in Figures 6.1–6.9.

The biovolume approach used in this manual is based on personal observations and recommendations by EPA (2010), Hillebrand, et al., (1999), Olenina, et al., (2006), and Sun & Liu (2003); all equations in Table 6.1 are from Hillebrand, et al. (1999) or EPA (2010). My approach was to use the simplest geometric approximation because the accuracy that is saved by using a “better” geometric shape is rarely worth the extra time required to make complex measurements.

Where possible, the biovolume summary statistics were based on at least 5–10 cells collected from different sites. Estimates based on fewer than 5 cells were flagged. The biovolume summary statistics (min., med., max.) were generated from original cell measurements, not averages, and were rounded to three significant figures. Colony biovolume estimates were not usually not included because they are too variable.
### Shape Measurements

<table>
<thead>
<tr>
<th>Shape</th>
<th>Measurements¹</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere: spherical cells; circular in cross-section (Figure 6.1)</td>
<td>width (W)</td>
<td>( \frac{\pi}{6} \times W^3 )</td>
</tr>
<tr>
<td>Spheroid: oval or bluntly elliptical cells; circular in cross-section (Figure 6.2)</td>
<td>width (W); length (L)</td>
<td>( \frac{\pi}{6} \times W^2 \times L )</td>
</tr>
<tr>
<td>Ellipsoid: oval or bluntly elliptical cells; flattened in cross-section (Figure 6.3)</td>
<td>width (W); length (L); depth (D)</td>
<td>( \frac{\pi}{6} \times W \times L \times D )</td>
</tr>
<tr>
<td>Cone + half-sphere: club-shaped cells; circular in cross-section (Figure 6.4)</td>
<td>cone width (W); cone length (L)</td>
<td>( \frac{\pi}{12} \times W^2 \times (L + W) )</td>
</tr>
<tr>
<td>Cylinder: cylindrical cells with flat ends; circular in cross-section (Figure 6.5)</td>
<td>width (W); length (L)</td>
<td>( \frac{\pi}{6} \times W^2 \times L )</td>
</tr>
<tr>
<td>Cylinder + 2 half-spheres: bluntly rounded cylindrical cells; circular in cross-section (Figure 6.6)</td>
<td>cylinder width (W); cylinder length (L)</td>
<td>( \pi \times W^2 \times \left( \frac{L}{4} - \frac{W}{6} \right) )</td>
</tr>
<tr>
<td>Fusiform: narrow, acutely pointed cells (may be curved); circular in cross-section (Figure 6.7)</td>
<td>cone width (W); cone length (L)</td>
<td>( \frac{\pi}{6} \times W^2 \times \frac{L}{2} )</td>
</tr>
<tr>
<td>Elliptical prism: circular or oval cells/colonies; rectangular in cross-section (Figure 6.8)</td>
<td>width (W); length (L); depth (D)</td>
<td>( \frac{\pi}{4} \times W \times L \times D )</td>
</tr>
<tr>
<td>Rectangular box: rectangular cells/colonies; rectangular in cross-section (Figure 6.9)</td>
<td>width (W); length (L); depth (D)</td>
<td>( W \times L \times D )</td>
</tr>
</tbody>
</table>

¹Width is equivalent to diameter; length is equivalent to height.

Table 6.1: Biovolume equations (adapted from EPA, 2010; Hillebrand, et al., 1999; Olenina, et al., 2006; Sun & Liu, 2003).
Sphere = $\frac{\pi}{6} \times W^3$

$= \frac{\pi}{6} \times 150.9^3 = 1,799,146 \mu m^3$

$= 1,800,000 \mu m^3$ (3 sig. figs)

Figure 6.1: Biovolume example - sphere (Eremosphaera).
Spheroid = \( \frac{\pi}{6} \times W^2 \times L \)

\[ = \frac{\pi}{6} \times 13.6^2 \times 19.5 = 1,888 \mu m^3 \]

\[ = 1,890 \mu m^3 \text{ (3 sig. figs)} \]

Figure 6.2: Biovolume example - spheroid (Oocystis).
Ellipsoid = \( \frac{\pi}{6} \times W \times L \times D \)

= \( \frac{\pi}{6} \times 13.6 \times 16.3 \times 7.6 = 882 \, \mu m^3 \)

Figure 6.3: Biovolume example - ellipsoid (*Tetraselmis*).
cone + half sphere  =  \frac{\pi}{12} \times W^2 \times (L + W)

= \frac{\pi}{12} \times 6.3^2 \times 26.4 = 274 \, \mu m^3

Figure 6.4: Biovolume example - cone + half sphere (Paradoxia).
Cylinder $= \frac{\pi}{4} \times W^2 \times L$

$= \frac{\pi}{4} \times 48.9^2 \times 27.0 = 50,707 \mu m^3$

$= 50,700 \mu m^3$ (3 sig. figs)

Figure 6.5: Biovolume example - cylinder (*Ulothrix*).
Cylinder + 2 half spheres = \( \pi \times W^2 \times \left( \frac{L}{4} - \frac{W}{6} \right) \)

\[
= \pi \times 3.7^2 \times \left( \frac{25.7}{4} - \frac{3.7}{6} \right) = 250 \mu m^3
\]

Figure 6.6: Biovolume example - cylinder + 2 half-spheres (Quadrigula).
Fusiform = $\frac{\pi}{6} \times W^2 \times \frac{L}{2}$

= $\frac{\pi}{6} \times 6.0^2 \times 38.6 = 728 \mu m^3$

Figure 6.7: Biovolume example - fusiform (Ankyra).
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Elliptical prism  =  \frac{\pi}{4} \times W \times L \times D

= \frac{\pi}{4} \times 16.6 \times 15.0 \times 5.0 = 978 \mu m^3

Figure 6.8: Biovolume example - elliptical prism (Pediastrum).
Rectangular box (colony) = W \times L \times D

= 10.3 \times 10.4 \times 10.3 = 1,103 \mu m^3

= 1,100 \mu m^3 \text{ (three sig. figs)}

Figure 6.9: Biovolume example - rectangular colony (Crucigenia).