

Activity: Ecological Accounting

Objective

Synthesize sample data from multiple activities to create a mathematical model for a sustainable biosphere and identify some of the limitations of modeling and propose modifications to address them.

Materials and Equipment

- Calculator
- Pencil

Problems – Balancing the Equation

NOTE: Record all work, including tables, data, diagrams, and answers, into your notebook.

1. The data in Table 1 was obtained experimentally by measuring the carbon dioxide levels inside a sealed environment containing only the sample.

Table 1. Carbon dioxide production rates for biosphere calculations

Sample	Carbon Dioxide Production Rate
1 Shrimp	50.00 ($\mu\text{mol/hr}$)
Sandy Substrate	5.00 [$(\mu\text{mol/hr})/100.0 \text{ mL}$]
Gravel Substrate	3.00 [$(\mu\text{mol/hr})/100.0 \text{ mL}$]
<i>Elodea</i> in darkness	0.050 [$(\mu\text{mol/hr})/\text{cm}^2$]
<i>Elodea</i> in direct sunlight	-0.25 [$(\mu\text{mol/hr})/\text{cm}^2$]

A terrestrial biosphere was built that contained all the samples in Table 1, and used the parameters below.

- Total volume of 4 L
 - 12 hours of direct sunlight (6:00 am to 6:00 pm), the remaining 12 hours of darkness
 - Plants with a total leaf surface area of 600.0 cm^2
 - 200.0 mL of each substrate
 - Starting CO_2 concentration of 400.0 ppm
- a. Determine the net change of carbon dioxide (in μmoles) over a 24-hour period.
- b. Determine the net change in concentration (in ppm) over a 24-hour period.
2. Using the data in Table 1, graph the net carbon dioxide levels in parts per million over a 24-hour period in two-hour increments. Use the same parameters you used in Problem 1. The graph should run from 12:00 am–12:00 am. At your teachers discretion the included spreadsheet modeling tool may help you with the calculations.

NOTE: Carbon dioxide levels cannot fall below 0 ppm (or $0 \mu\text{mol}$).

3. Compare your results from Problems 1 and 2. Was the CO_2 concentration at the end of 24 hours different? If so, what would explain the difference in your calculations?
4. In the 24-hour period, did the carbon dioxide levels ever rise above 3% in the biosphere? This is the level at which most organisms experience respiratory stress.
5. Based on your analysis, what would you predict will happen to the carbon dioxide levels in the biosphere over the period of one week?
6. What changes, if any, to the biosphere volume, substrate ratios or amounts, and plant surface area could you make to stabilize the carbon dioxide levels so the net change day-to-day is minimal? Support your response with calculations to demonstrate the feasibility of your solution.

Questions

NOTE: Record all work, including calculations and answers, into your notebook.

1. List 3 to 5 assumptions that are made in the calculations you completed.
2. Complete the questions in the Challenge: Biosphere handout for this activity.