

# Lab 2: Miscellaneous Calculations

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### **i** Date

- **Lab Date:** 23 September 2024 (Monday)
- **Due Date:** 7:00, 30 September 2024 (Monday)

## 1 Background

Students will work as individuals; assignments are per individual. This lab is due on Monday 30 September 2024 at 7:00 on iKamva.

### 1.1 Pre-Lab

Read this lab and contextualise within the pertinent material in your text.

### 1.2 Post-Lab

Upon completion of this lab:

- transcribe all tables and questions (Exercises A-E) to an electronic document and submit on iKamva. To submit online on Monday 30 September 2024 at 7:00.

## 2 Questions

### 2.1 Question 1: Dilutions (10 marks)

A 1.5% (mass:volume) carrageenan gel consists of 0.75g of carrageenan dissolved in 50 ml of 1% KCl. You accidentally added 0.87g to the 50 ml.

- What percentage gel have you inadvertently prepared?
- How much additional water must be added to the 50 ml to achieve the desired 1.5% gel?
- Carrageenan is a polysaccharide. Identify its biological origin: which photoautotrophs synthesise it?
- Explain its ecological role in those organisms.
- Describe how humans exploit carrageenan's properties in food or industry.

### 2.2 Question 2: Quantum Light Measurements (4 marks)

monochromatic blue light source (420 nm) provides a photon flux density of 120  $\mu\text{mol photons.m}^{-2}.\text{s}^{-1}$ .

How many photons will fall on an area of 25  $\text{cm}^2$  over a 2-hour period?

*(Be sure to convert the area into square metres, and assume flux density remains constant.)*

### 2.3 Question 3: Plant Growth Rates (9 marks)

For each scenario below:

- Identify the biological process the measurements represent;
- Write down a suitable equation for calculating the process;
- Calculate the rate;
- State the resulting units.

| Scenario i (4 marks)   | Scenario ii (5 marks)   |
|--|---|
| <ul style="list-style-type: none"><li>Day 1: Plant biomass of 99 g</li><li>Day 100: Plant biomass of 149 g</li></ul> | <ul style="list-style-type: none"><li>Time, 0 minutes: 7.95 mg/L <math>\text{O}_2</math></li><li>Time, 20 minutes: 11.39 mg/L <math>\text{O}_2</math></li><li>Algal biomass: 2.3 g fresh mass</li></ul> |

*(In Scenario ii, calculate the oxygen production rate per gram of algal fresh mass.)*

### 2.4 Question 4: Light Attenuation (15 marks)

You are a marine scientist assessing light penetration in the water column off Richards Bay, KZN. Measurements are taken in 5 m increments down to 50 m. Two stations are sampled:

- 1 km from shore (incident radiation at surface, 8:00: 1,213  $\mu\text{mol photons.m}^{-2}.\text{s}^{-1}$ )
- 20 km from shore (incident radiation at surface, 9:35: 2,166  $\mu\text{mol photons.m}^{-2}.\text{s}^{-1}$ )

Unfortunately, your submersible light meter was left in the lab; only surface values are available.

- Using the Beer-Lambert law  $I_z = I_0 e^{-kz}$ , construct vertical light intensity curves for each site (surface to 50 m). State any assumptions made about the attenuation coefficient  $k$ .

2. Justify why these theoretical curves are a reasonable approximation of reality.
3. Identify physical and methodological factors that would cause deviation from the actual in situ profiles.

### 2.5 Question 5: Photosynthetic Rate Calculation (10 marks)

A leaf in full sunlight absorbs 10 mol of photons per square meter per second ( $\text{mol m}^{-2} \text{s}^{-1}$ ). Its quantum yield is 0.05 mol of  $\text{CO}_2$  fixed per mol of photons absorbed.

Calculate the photosynthetic rate (in  $\mu\text{mol CO}_2 \text{ m}^{-2} \text{s}^{-1}$ ) of the leaf under these conditions.

### 2.6 Question 6: Relative Growth Rate (RGR) (5 marks)

The biomass of a plant at time  $t_0$  is 50 g. After 10 days (time  $t_1$ ), the biomass is 80 g.

Calculate the relative growth rate (RGR) in  $\text{g g}^{-1} \text{day}^{-1}$  using the equation:

$$RGR = \frac{\ln(W_1) - \ln(W_0)}{t_1 - t_0}$$

Where:

- ( $W_1$ ) is the biomass at time ( $t_1$ )
- ( $W_0$ ) is the biomass at time ( $t_0$ )

Explain why logarithmic growth is used instead of simple arithmetic increase.

### 2.7 Question 7: Respiration Rate and Plant Carbon Balance (5 marks)

A plant in darkness consumes 5 mg  $\text{CO}_2$  per hour for respiration. During the day, its photosynthetic rate is 15 mg  $\text{CO}_2$  per hour. Assume 12 hours light and 12 hours dark.

Calculate the net carbon balance of the plant over a 24-hour period. Is it positive or negative?

*(Clarify whether the rates refer to whole-plant values or per unit biomass in your calculation.)*

### 2.8 Question 8: Additive Light Intensity at Different Depths in Water (10 marks)

In an aquatic experiment, photon flux density at 2 m depth arises from multiple sources:

- Direct sunlight =  $400 \mu\text{mol photons m}^{-2} \text{s}^{-1}$
  - Diffuse underwater reflections =  $120 \mu\text{mol photons m}^{-2} \text{s}^{-1}$
  - Scattered light from particles =  $50 \mu\text{mol photons m}^{-2} \text{s}^{-1}$
1. Calculate the total photon flux density at a depth of 2 meters.
  2. If a plant requires  $\geq 500 \mu\text{mol photons m}^{-2} \text{s}^{-1}$  for photosynthesis, is the requirement met?
  3. Briefly discuss how turbidity or scattering would affect these additive contributions in natural waters.

### 2.9 Question 9: Spectrally Resolved Attenuation and the Euphotic Boundary (12 marks)

At noon the surface PAR is  $I_0 = 1,800 \mu\text{mol photons m}^{-2} \text{s}^{-1}$ . Treat the incident spectrum as two quasi-monochromatic bands:

- “Blue–green” centred at 490 nm, comprising 45% of  $I_0$ , with diffuse attenuation  $k_{BG} = 0.040 \text{ m}^{-1}$ .
- “Red–yellow” centred at 620 nm, comprising 55% of  $I_0$ , with diffuse attenuation  $k_{RY} = 0.25 \text{ m}^{-1}$ .

Assume independent exponential loss with depth and no internal sources.

1. Write an explicit expression for total PAR at depth  $z$  as the sum of the two bands,  $I(z) = I_{BG}(z) + I_{RY}(z)$ . State the units at each step.
2. Compute the 1% light level  $z_{1\%}$  defined by  $I(z_{1\%}) = 0.01 I_0$ . Because the sum of two exponentials lacks a closed-form inverse, determine  $z_{1\%}$  to the nearest metre by a transparent numerical bracketing (show at least three evaluated depths and your final interpolation).
3. At  $z = 30 \text{ m}$  and  $z = 60 \text{ m}$ , calculate the fractional contribution of the blue–green band to total PAR, i.e.,  $f_{BG}(z) = I_{BG}(z)/I(z)$ . Interpret the change in  $f_{BG}$  with depth in one or two sentences.

*(Note. Answers that hide the unit conversions or skip the bracketing will be penalised.)*

## Bibliography