Experiment to calculate gross primary productivity (GPP) and net primary productivity (NPP)

The easiest way to measure gross primary productivity (GPP) and net primary productivity (NPP) is by using aquatic plants. To calculate GPP and NPP, measurements of photosynthesis and respiration need to be taken. Photosynthesis and respiration either produce or use oxygen. Measuring dissolved oxygen will, therefore, give an indirect measurement of the amounts of photosynthesis and respiration in aquatic plants (but not a direct measure of the amount of energy fixed).

Net primary productivity can be estimated by measuring the increase in dissolved oxygen when aquatic plants are put in the light. In the light, both photosynthesis and respiration will be occurring but photosynthesis is the bigger process, and it produces more oxygen than the plant uses in respiration.

Gross primary productivity can be calculated using the equation:

NPP = GPP – R

where R = respiratory loss

Respiration can be calculated by measuring the decrease in dissolved oxygen when aquatic plants are put in the dark. In the dark, only respiration will occur and not photosynthesis. The equation can be rearranged to calculate GPP:

GPP = NPP + R

An aquatic plant was put in light and dark conditions. Dissolved oxygen was measured before and after the plant was put in light and in the dark. In this experiment, gross primary productivity (GPP) and net primary productivity (NPP) were measured by using changes in dissolved oxygen in milligrams of oxygen per litre per hour.

Plant in the light

Amount of dissolved oxygen at the start of the experiment = 10 mg of oxygen per litre

Amount of dissolved oxygen at the end of the experiment = 12 mg of oxygen per litre

Increase in dissolved oxygen = 2 mg of oxygen per litre

The increase in dissolved oxygen is a measure of NPP. The experiment lasted 1 hour and so the indirect measurement of NPP = 2 mg of oxygen per litre per hour (this could be used to estimate the amount of new biomass produced).

Plant in the dark

Amount of dissolved oxygen at the start of the experiment = 10 mg of oxygen per litre

Amount of dissolved oxygen at the end of the experiment = 7 mg of oxygen per litre

Loss of dissolved oxygen = 3 mg of oxygen per litre per hour. The loss of dissolved oxygen is a measure of respiration (R).

NPP = GPP − R, so GPP = NPP + R

Therefore indirect estimation of GPP = 2 + 3 = 5 mg of oxygen per litre per hour (this could be used to estimate the amount of glucose produced).

## **Experiment to calculate gross secondary productivity (GSP) and net secondary productivity (NSP)**

You need to be able to calculate the values of both gross secondary productivity (GSP) and net secondary productivity (NSP) from given data, as in the table below.

A total of 10 stick insects were fed privet leaves for 5 days.

|  |  |  |
| --- | --- | --- |
| **Start of experiment End of experiment** | | |
| mass of leaves / g | 29.2 | 26.3 |
| mass of stick insect / g | 8.9 | 9.2 |
| mass of faeces / g | 0.0 | 0.5 |

Calculating NSP

NSP can be calculated by measuring the increase in biomass in stick insects over a specific amount of time. The increase in biomass in stick insects (NSP) is equal to the mass of food eaten minus biomass lost through respiration and faeces.

In this experiment NSP = mass of stick insects at end of experiment − mass of stick insects at start of experiment.

Over a 5-day period: NSP = 9.2 − 8.9 = 0.3 g

Therefore, NSP = 0.3/5 = 0.06 g per day.

Calculating GSP

GSP can be calculated using the following equation:

GSP = food eaten − faecal loss

Food eaten = mass of leaves at start of the experiment − mass of leaves at end of the experiment.

Food eaten = 29.2 − 26.3 = 2.9 g

Also, faecal loss = mass of faeces at end of experiment = 0.5 g Therefore, over a 5-day period: GSP = 2.9 − 0.5 = 2.4 g Therefore, GSP = 2.4/5 = 0.48 g per day.

GSP represents the amount of food absorbed by the consumer.

Calculating respiration

Respiration (R, the loss of glucose as respiration breaks it down) can be calculated from the equation:

NSP = GSP − R

The equation can be rearranged:

R = GSP − NSP

Therefore, R = 0.48 − 0.06 = 0.42 g per day.

1. Define the terms *gross productivity*, *net productivity*, *primary productivity*, and *secondary productivity*.
2. How is NPP calculated from GPP? Which figure represents the biomass available to the next trophic level?
3. Define the terms *gross secondary productivity (GSP)* and *net secondary productivity (NSP)*. Write the formula for each.
4. NPP, mean biomass, and NPP per kg biomass vary in different biomes, depending on levels of insolation, rainfall, and temperature. Mean NPP for tropical rainforest is greater than tundra because rainforest is hot and wet, so there is more opportunity to develop large biomass than in tundra. However, NPP per kg biomass is far lower in rainforest than tundra because rainforest has a high rate of both photosynthesis and respiration, so NPP compared to total biomass is low. Tundra is cold and dry and has low rates of photosynthesis and respiration; plants are slow growing with a gradual accumulation of biomass but relatively large growth in biomass per year.

The table below shows values for these parameters for different biomes.

|  |  |  |  |
| --- | --- | --- | --- |
| **Biome** | **Mean net primary productivity**  **(NPP) / kg m−2 yr−1** | **Mean biomass / kg m−2** | **NPP per kg biomass per year** |
| desert | 0.003 | 0.002 |  |
| tundra | 0.14 | 0.60 | 0.233 |
| temperate grassland | 0.60 | 1.60 | 0.375 |
| Savannah grassland | 0.90 | 4.00 | 0.225 |
| temperate forest | 1.20 | 32.50 | 0.037 |
| tropical rainforest | 2.20 | 45.00 | 0.049 |

1. Calculate the NPP per kg of biomass per year for the desert biome.
2. How does this figure compare those for other biomes? Explain the figure you have calculated in terms of NPP, and NPP per kg biomass.
3. Compare the figures for NPP in temperate and tropical grassland. Explain the difference.