Zeitschrift: Berichte des Geobotanischen Institutes der Eidg. Techn. Hochschule, Stiftung Rübel

Herausgeber: Geobotanisches Institut der Eidg. Techn. Hochschule, Stiftung Rübel

Band: 34 (1962)

Artikel: A simple method for "integrated light" measurements

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DOI: https://doi.org/10.5169/seals-377637

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A simple method for «integrated light» measurements[1]

By H. van Groenewoud[2]

The following method was developed to compare light conditions under different forest canopies. Photochemical reactions form a practical basis for ecological light measuring techniques which involve large numbers of measurements.

Small vials[3], closed by bakelite screw caps with cork liners, are filled with a photosensitive solution made with equal parts of the following: (a) A 1% solution of uranyl nitrate in distilled water, and (b) ethyl alcohol. The vials are stored in the dark until the moment they are used.

The vials are exposed during 24 hours on wooden slats, which are grooved on the top, to provide a uniform background. The amount of light received by the vials under the canopy can be expressed as a percentage of the light received by duplicate vials concurrently exposed in the nearest open areas. The results are expressed as Lux-hours (or foot-candle-hours).

Upon exposure to light the uranyl nitrate is reduced to uranyl oxide, which is black and remains in colloidal suspension. The relative darkening of the solution is proportional to the amount of light received. Since the reaction is easily reversed upon exposure to air, care should be taken that the vials are completely filled and closed airtight.

To measure the degree of darkening of the solution in a vial, a simple photometer was constructed. Essentially it consisted of a small box, partitioned into two sections. A photocell is mounted on the wall of the one section. The other section contains a microscope lamp whose intensity can be regulated by a potentiometer of approximately 10 ohms and a capacity of 15–25 watts.

In the middle of the wooden partition a vertical hole is drilled which extends through the cover. Its diameter is slightly larger than that of the vials used, so they will slide easily in and out of this vial carrier. Windows, approximately 8 mm wide and 40 mm long, are cut in the opposite sides of the vial carrier to let the light through the vials, to the photocell.

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[1] Work done at the Geobotanical Institute of the Swiss Federal Institute of Technology, Zürichbergstr. 38, Zurich 44

[2] Forest Pathology Laboratory, Saskatoon, Saskatchewan, Canada. (Canada Department of Forestry, Ottawa, Canada).

[3] Anmerkung der Redaktion für deutschsprachige Leser: Glas-Ampullen.

In the vial carrier a wooden plug of the same diameter as the vials rests on a weak coil spring. This wooden plug blocks the windows when the photometer is not in use. When a measurement is taken the vial to be measured is pushed down into the vial carrier, until the top of the vial cap is flush with the cover, and held there. The bakelite cap now shuts out scattered light, which might have interfered with the measurement. The wooden plug has now been pushed out of the way and the light is able to reach the photocell after passing through the two windows and the vial. After removal of the vial the wooden plug again blocks the windows, thus preventing a lowering of the sensitivity of the photocell through exposure to continuous light.

Before measuring the transmittance of a vial, the galvanometer first is set at 100% transmittance with a water blank, by varying the intensity of the microscope lamp. The galvanometer, belonging to the lightmeter used in this experiment, has a scale divided into one hundred equal sections. It has two ranges (1x and 10x) which make possible an accurate reading of the low transmittance percentages. The only satisfactory power supply for the lamp was found to be a 6 volt car battery; other sources were too variable.

The absorption spectrum of the solution was determined with a Beckman Model DU spectrophotometer. It shows that the reduction takes place at wavelengths less than 4500 Å, with an optimum at 3000 Å. It should be realized that there are differences between calibration curves if the calibration is executed under different conditions. The lightmeters used in these calibrations are sensitive over a wide range, and they measure the total effect over this range. To get accurate measurements, different calibration curves should be used, corresponding with the conditions under which the measurements are made. No calibration curves are presented here, as their shape depends on the vials used.

Temperature effect is negligible within a reasonable range (7°–25° C). When, however, the temperature of the solution rises appreciably above this, the readings should be adjusted for this error. At low temperatures (less than —5° C) the molecules appear to go into an excited state only and no darkening of the solution takes place. Upon heating to room temperature the reaction takes place with accompanying darkening of the solution. Under the conditions of this study there was a threshold intensity of between 300 and 500 Lux (30–50 foot-candles), below which no darkening took place.

I would like to thank Mr. Siegl of the Geobotanical Institute who suggested the use of uranyl nitrate and whose further help was greatly appreciated.