A New Method of Evaluating the Mineralization of Particulate and Dissolved Photoassimilated Organic Matter*

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Abstract: A new method of evaluating the rate of mineralization of photoassimilated organic matter is described. This method enables us to compare the rate of direct mineralization of particulate organic carbon (POC) to CO₂ with the rate of solubilization of photoassimilated organic carbon followed by the mineralization of the resultant dissolved organic carbon (DOC) under the same conditions. The direct mineralization of photoassimilated carbon from POC to CO₂ is a more significant process compared with the mineralization of extracellular released organic carbon. The first-order rate coefficients range from 0.132 to 0.434 day⁻¹ for direct mineralization and 0.034 to 0.189 day⁻¹ for solubilization.

1. Introduction

The mineralization of photoassimilated organic matter has been investigated by many researchers (e.g. VON BRAND et al., 1937; GRILL and RICHARDS, 1964; OTSUKI and HANYA, 1972; ITURRIAGE and HOPPE, 1977). In the mineralization of photoassimilated organic matter, two paths are possible: one is the direct mineralization of particulate organic matter (POM), the other is the solubilization of POM followed by the mineralization of the resultant dissolved organic matter (DOM). The direct path may be operating in the respiration of phytoplankton and in the mineralization of POM by sessile bacteria, while the second path may be followed in the case of autolysis, extracellular release and bacterial resolubilization.

VON BRAND et al. (1937) observed the regeneration of inorganic nitrogen from net plankton, and concluded that the direct path is important in the regeneration of nitrogen. GRILL and RICHARDS (1964) analyzed the change of organic and inorganic forms of nitrogen and phosphorus in a darkened microcosm. They analyzed mathematically the mineralization of phosphorus by a simple two-step process; solubilization of particulate phosphorus into organic dissolved form followed by bacterial utilization of the dissolved phosphorus.

OTSUKI and HANYA (1972) studied the patterns and kinetics of the mineralization of carbon and nitrogen from freeze-dried Scenedesmus sp., and found the aerobic decomposition of Scenedesmus sp. could be approximated by a first-order reaction from day 5 to day 30. They suggested that the decomposition of the freeze-dried green algae followed three steps; a very quick dissolution of particulate organic components before day 5, a relatively rapid decomposition of labile POM from day 5 to day 30, and a slow decomposition of refractory POM after day 30. They also developed a kinetic model for the mineralization of nitrogen with two paths: one path is the direct mineralization of POM, the other is the solubilization of POM followed by mineralization of the resultant DOM. They found the rate constant for direct mineralization, solubilization and mineralization of dissolved organic nitrogen after day 5 to be 0.056, 0.013 and 0.011 day⁻¹, respectively.

During photosynthesis a portion of photoassimilated organic matter is released from phytoplankton (e.g. FOGG, 1952; HELLEBURST, 1965; WATT, 1966; ANDERSON and ZEUTSCHEL, 1970; and M RUG et al., 1980). These extracellular products can be utilized by bacteria (HERBST and OVERBECK, 1978; BELL, 1980; BELL and SAKSHAUG, 1980; ITURRIAGA and HOPPE, 1977). BELL (1980) and BELL and SAKSHAUG (1980) observed the uptake and mineralization of ¹⁴C-labeled extracellular products from Skeletonema costatum by a natural population of bacteria during a bloom of the
algae. Bell found that the extracellular products stimulated the activity of the bacterial flora and a dynamic equilibrium was attained between release and consumption of extracellular products.

Iturriaga and Hoppe (1977) proposed a new method for measuring the heterotrophic utilization of released and particulate photoassimilated organic matter by a natural population of phytoplankton. After 6 hrs of incubation with $^{14}$C-bicarbonate, the sample is filtered at a low vacuum pressure ($<$100 mm Hg). The filtrate is used as a substrate for the measurement of the heterotrophic uptake of extracellular products, and the particulate materials are homogenized, and used for the measurement of the mineralization of photoassimilated POM.

Very little information is now available on the kinetics of the mineralization of photoassimilated organic matter. The purpose of the present study is to evaluate the relative importance of the two paths of mineralization: the direct mineralization of photoassimilated POM and the solubilization of photoassimilated POM followed by mineralization of the resultant DOM.

2. Materials and methods

Materials

Samples were collected at five stations in Osaka Bay. Sampling locations are shown in Fig. 1. In April 1979, samples were collected both from 2 m below the surface and from 3 m above the bottom with a 6-l Van Dorn sampler.

In July, at stations A, C, D and E, samples were taken from the same depths as in April, and at Stn. E one extra sample from 4 m below the surface was taken, but no sample was taken at Stn. B. After collection in 2-l polyethylene bottles sterilized with 1N HCl, samples were filtered with a 384 µm net to remove large zooplankton, and stored at 4°C in the dark. The storage time did not exceed 7 hrs.

Assimilation

The scheme of preparation of labeled organic matter is shown in Fig. 2. Two 200 ml portions from each sample were dispensed in 300 ml sterilized BOD bottles. One bottle out of each pair was spiked with $^{14}$C-bicarbonate (labeled bottle) and incubated along with the unspiked bottle (non-labeled bottle) under eight fluorescent lamps (10 W) at 15°C in April and at 25°C in July. The incubation time was 18 hrs in April and 48 hrs in July. The $^{14}$C-bicarbonate solu-