Vol. 135: 309-310, 1996 | MARINE ECOLOGY PROGRESS SERIES Mar Ecol Prog Ser | Published May 17

COMMENT

Photodegradation or photoalteration? Microbial assay of the effect of UV-B on dissolved organic matter

T. Naganuma[1,*], S. Konishi[1], T. Inoue[1], T. Nakane[2], S. Sukizaki[2]

[1]Faculty of Applied Biological Science, Hiroshima University 1-4-4 Kagamiyama, Higashi-Hiroshima 739, Japan
[2]Marine Biological Research Institute of Japan, 4-3-16 Yutaka-cho, Shinagawa-ku, Tokyo 142, Japan

*E-mail: takn@ue.ipc.hiroshima-u.ac.jp

Photodegradation of dissolved organic matter (DOM) has been a focus of studies on the effects of ultraviolet-B radiation (UV-B) on aquatic ecosystems. Oceanic DOM, most of which is believed to be allochthonous and refractory, can be photodegraded by sunlight (Kieber et al. 1989, Mopper et al. 1991, De Haan 1993) and cleaved into more available substrates that support microbial production (Lindell & Rai 1994, Moran & Hodson 1994). By contrast, Thomas & Lara (1995) reported that phytoplankton-exudate DOM, which is the major DOM source for bacterial production (e.g. Azam & Cho 1987), was resistant to photodegradation by natural levels of UV-B. However, no change in bioavailability was shown, and thus it seems appropriate to investigate whether qualitative alteration of the phytoplankton-exudate DOM occurs that might not be detected by quantitative analyses.

UV irradiation is also known to decrease bacterial activity (e.g. Herndl et al. 1993), and bacterial sensitivity has been directly used as a bio-dosimeter of UV-B radiation (Karentz & Lutze 1990). In contrast, our use of bacteria was indirect. Non-UV-exposed *Escherichia coli* was grown on 0.5% peptone in distilled water (used as DOM) previously exposed to UV-B (280 to 320 nm). The UV-B was applied at naturally occurring intensities of 0, 25, 80, 155 and 300 mW m^{-2} (standardized at 290 nm) for 12, 24, 36 and 48 h. The total UV-B dosage was expressed as kJ m^{-2}

The concentrations of dissolved organic carbon (DOC) and nitrogen (DON) were not affected by the UV-B irradiation, remaining at constant levels of 3.67 ± 0.48 g C l^{-1} and 1.19 ± 0.16 g N l^{-1} (Fig. 1). The C and N concentrations were determined with a CHN corder (MT-5, Yanako, Tokyo) after acidification and vacuum evaporation. The C/N ratio remained almost unchanged at 3.07 ± 0.01 (Fig. 1). This suggests that complete degradation of DOC to CO_2 did not occur to a significant extent, as shown by Thomas & Lara (1995).

The UV-exposed peptone, in turn, reduced the *Escherichia coli* growth activity by greater than 60% at the maximum UV-B irradiation (Fig. 2), due possibly to

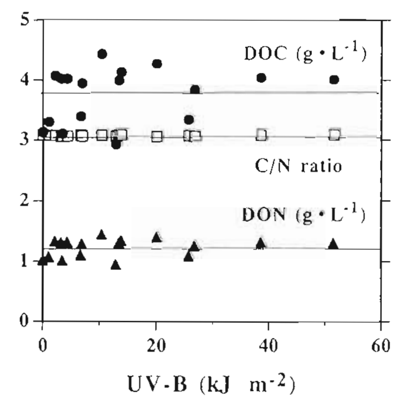

Fig. 1 Concentrations of dissolved organic C (DOC) and nitrogen (DON) and the C/N ratio of the 0.5% peptone solution irradiated with UV-B at different intensities

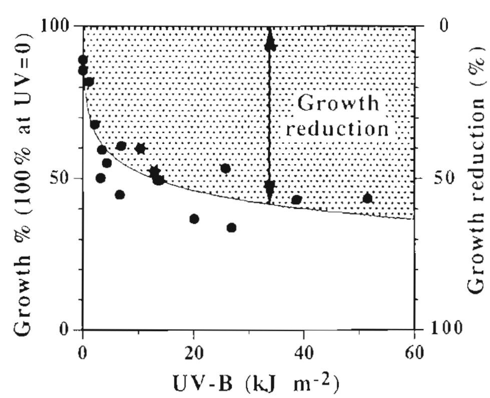

Fig. 2. Growth of the bacterium *Escherichia coli* on 0.5% peptone solution irradiated with UV-B at different intensities. 100% growth was the average growth with the non-UV-dosed peptone. Growth reduction (shaded area) is calculated as 100% − growth %

the photoalteration of peptonic DOM. The relationship between photoalteration (= growth reduction) and the UV-dosage was well described by the Michaelis-Menten equation. The linear regression from the Lineweaver-Burke plot of Fig. 2 is:

$$[\text{Growth reduction } (\%)]^{-1} = 0.016 + 0.038\ [\text{UV-B } (\text{kJ m}^{-2})]^{-1}$$
$$(r = 0.93,\ n = 15)$$

The maximum growth reduction (%) is estimated to be 62.5 (= 1/0.016); and the half-saturation UV-B intensity is estimated to be 2.4 (= 0.038/0.016) kJ m^{-2}.

Earlier studies suggested that UV-exposed DOC becomes more bioavailable and thus enhances bacterial production (Lindell & Rai 1994, Moran & Hodson 1994). In contrast, our results suggested that UV irradiation reduces the ability of DOM to support bacterial growth. The disagreement may be ascribed to the different nature of different DOMs, namely refractory pelagic DOM and readily available DOM such as peptone and phytoplankton exudate. It seems that refractory DOM is photodegraded and becomes more bioavailable. On the other hand, readily consumable DOM seems to be photoaltered and to become less bioavailable. Thus the role that UV-B plays in controlling the dynamics of DOM and bacteria may be more complicated than previously thought.

LITERATURE CITED

Azam F, Cho B (1987) Bacterial utilization of organic matter in the sea. In: Fletcher M, Gray TRG, Jones JG (eds) Ecology of microbial communities. Cambridge University Press, Cambridge, p 261–281

De Haan H (1993) Solar UV-light penetration and photodegradation of humic substances in peaty lake water. Limnol Oceanogr 38:1072–1076

Herndl GJ, Müller-Niklas G, Frick J (1993) Major role of ultraviolet-B in controlling bacterioplankton growth in the surface layer of the ocean. Nature 361:717–718

Karentz D, Lutze LH (1990) Evaluation of biologically harmful ultraviolet radiation in Antarctica with a biological dosimeter designed for aquatic environments. Limnol Oceanogr 35:549–561

Kieber DJ, McDaniel J, Mopper K (1989) Photochemical source of biological substrates in sea water: implications for carbon cycling. Nature 341:637–639

Lindell MJ, Rai H (1994) Photochemical oxygen consumption in humic waters. In: Williamson CE, Zagarese HE (eds) Impact of UV-B radiation on pelagic freshwater ecosystems. Advances in Limnology 43, E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, p 145–155

Mopper K, Zhou X, Kieber RJ, Kieber DJ, Silkorski RJ, Jones RD (1991) Photochemical degradation of dissolved organic carbon and its impact on the oceanic carbon cycle. Nature 353:60–62

Moran MA, Hodson RE (1994) Support of bacterioplankton production by dissolved humic substances from three marine environments. Mar Ecol Prog Ser 110:241–247

Thomas DN, Lara RJ (1995) Photodegradation of algal dissolved organic carbon. Mar Ecol Prog Ser 116:309–310