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# Effect of UV-B Radiations on the Pigment Concentrations of Three Antarctic Plant Species

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## ABSTRACT

The decrease in total column ozone shall lead to enhanced levels of UV-B doses, capable of limiting the life forms over Antarctica. Organisms which are not accustomed to high level of UV-B radiation will get suppressed and photoautotrophic production will decline. If the primary producers are threatened it will be difficult for the survival of organisms at higher trophic level. Algae, mosses and lichens are the common floral elements of Antarctica and are characterized by adaptations essential for survival on harsh environmental conditions. Three different plants, i.e., *Spirogyra* sp., *Bryum argentinum* and *Xanthuria elegans*, which are naturally growing, around Indian research station "Maitri", East Antarctica, were analyzed for the presence of UV-B absorbing compounds.

Concentrations of UV-B absorbing compounds and phenolics were higher in *B. argentinum* and *X. elegans* as compared to *Spirogyra* sp. Terrestrial plants are getting UV exposure directly as compared to aquatic algae *Spirogyra* sp and therefore, induction of UV-B absorbing pigments is higher in land plants than that in the aquatic plant.

**Key Words:** *Bryum argentinum*, *Xanthuria elegans*, *Spirogyra* sp. UV-B radiations, UV absorbing pigments, East Antarctca.

## INTRODUCTION

Springtime depletion of the ozone layer above the Antarctica was first observed by ground based measurements from Halley Bay station from 1979-1984 (Forman et. al., 1985). Ever since, there has been great concern about ozone depletion and consequences for the biosphere, because lower ozone concentrations lead to increased exposure to harmful solar ultraviolet radiations especially UV-B. Today's ozone depletion and increased UV-B levels are mainly caused by man-made chemicals, especially chlorofluorocarbons (CFCs), (Frederik et al., 1994, Xiong et al., 2001).

Increased levels of UV-B radiations reaching the earth's surface has heightened interest in the effects of UV-B on plants. To survive in Antarctica, plants need to be able to withstand severe physiological stresses, such as repeated freezing and thawing, desiccation, changes to the cellular chemical environment and enhanced UV-B radiation. The flora of Antarctica consists primarily of lichens, bryophytes (mosses and liverworts), algae and fungi. Two flowering plants (a grass and a small cushion- forming plant) are found on the northern and western part of the Antarctic Peninsula, (Seppelt and Conell, 2004). Among the major floral elements of Antarctica such as lichens, mosses, algae and fungi, lichens have a number of adaptations that enable them to survive in this extreme continent. Many lichens contain secondary compounds, often termed as lichen products, which mostly are phenolics with major absorption bands in the UV-B waveband. Like the lichens, the bryophytes can be found in almost all areas capable of supporting plant life in the Antarctic, though they are not as widespread. Many of the mosses have tightly packed stems and shoots to minimize water loss. Some mosses have orange carotenoid pigments which help in preventing photosystem damage during growing season. Algae have successfully adapted to their harsh environment through the development of a number of adaptive features which include pigments, sugars and lipids, mucilage sheath, motile stages and spore formation. Pigments protect the cells from high light and UV damage during the summer months. The cells of some species also secrete copious amounts of mucilage which enable them to adhere to one another and to snow crystals and prevent the cells from being washed away by melt water. The mucilage also forms a protective coat and delays desiccation. It may have an additional function as an UV shield.

During the 24$^{th}$ Indian Scientific Expedition to Antarctica studies on the UV-B radiations and induction of UV absorbing pigments were carried out with the aquatic algae, moss and lichens growing around Indian research station Maitri, Schirmacher Oasis, East Antarctica.

## MATERIALS AND METHODS

### Study Area

Naturally UV exposed plants of aquatic algae (*Spirogyra* sp.), *Bryum argentium* **(Fig.1a)** and lichen *Xanthuria elegans* (Link) Th. Fr, **(Fig.1b)**, were collected from the nearby area of Indian second research station "Maitri," situated at Schirmacher Oasis, East Antarctica. Schirmacher Oasis is a typical desert oasis of Antarctica. It is situated 70 km away from the Prince Astric coast. The Oasis is basically 'moraine' formed by the east Antarctic glacier as dry polar desert soils, and their occurrence is limited to the deglaciated area. It lies between the latitude 70°44'33"S to 70°44'30"S and longitude 11°22'40"E to 11°54'00"E.

*Fig. 1: (a) Moss (Bryum argentium) and (b) Lichen (Xanthuria elegans), selected for studies, growing naturally around the Indian research station "Maitri"*

**UV-B Radiation and Ozone Measurements**

Hourly UV-B and ozone measurements from 8.00 am to 20.00 pm were recorded from the sites of collection of plants, with the help of a Microtops II and Ozone monitor with a Sun photometer of Solar light Co., made in USA.

**UV Absorbing Pigments**

As a measure for the total amount of UV-B absorbing compounds in selected plant species, the absorbance of whole plant methanolic extracts at 300 nm was performed (Day et al., 2001).

**Phenolic Estimation**

Analysis for the presence of phenolics in the exposed plants was performed by the methodology of Garg et al., (1994).

**Statistical Analyses**

All the experiments were conducted in triplicate and average values represented. The relative standard deviations of means of triplicate measurement were less than 5%. The student't' test described by Fisher (1950) was employed to calculate the statistical significance values.

## RESULTS

### UV-B Radiations and Ozone Column

Hourly observations of UV-radiation at 305, 312 320 nm and columnar ozone values were recorded from December 2004 to February 2005. Irradiance values at 320 nm were always higher than 312 and 305 nm. When comparison of daily irradiance during the study period was made, maximum irradiance values were recorded on 13$^{th}$ January 2005, and minimum values on 27$^{th}$ February 2005. Daily maximum ozone values of 320 DU were recorded on 31$^{st}$ December 2004 and minimum values of 253.7 DU on 26$^{th}$ Jan 2005. Interestingly, when ozone levels were minimum on 26$^{th}$ January, UV irradiance values at all the three wavelengths were higher as compared to other days **(Figs 2 & 3)**.

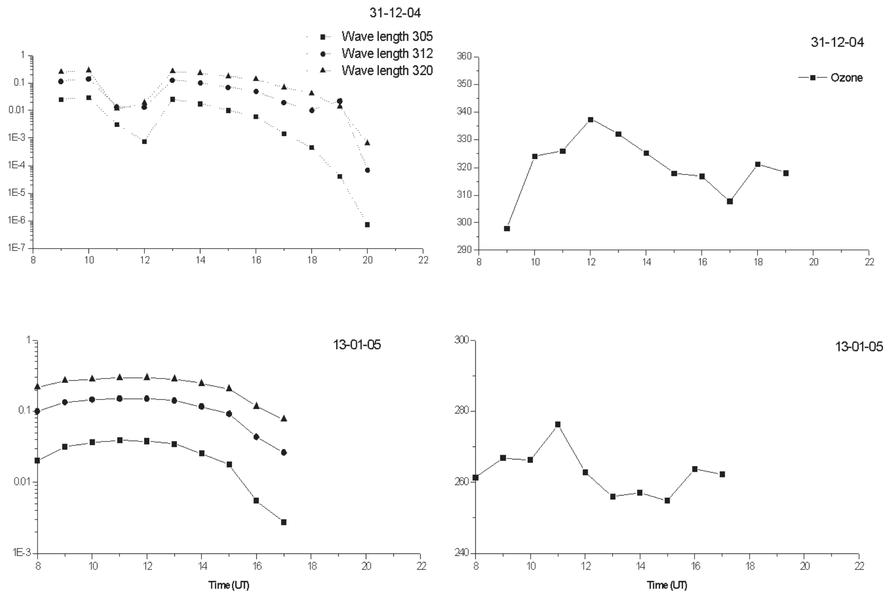


*Fig. 2 : Changes in hourly surface spectral irradiances at 305, 312 & 320 nm and hourly columnar ozone levels maître*

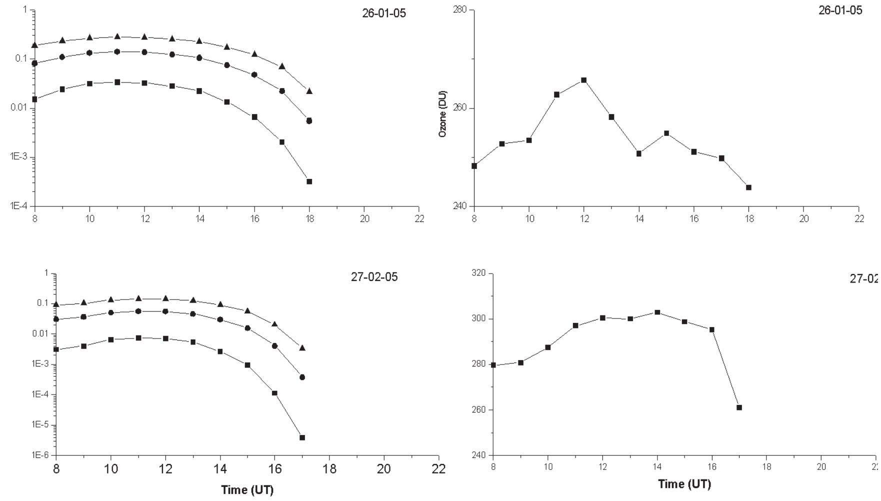


*Fig. 3 : Chanes in hourly surface spectral irradiances at 305, 312 & 320 nm and hourly columnar ozone levels at Maitri*

## UV-B Absorbing Pigments

Concentrations of UV-B absorbing compounds is represented in **Table 1.** Higher concentration of UV-B absorbing compounds were observed in *B. argentium* and *X. elegans* as compared to *Spirogyra* sp. Total phenolics were also higher in these two plants as compared to *Spirogyra* sp. **(Table 1).** Results indicate presence of UV-B absorbing pigments in higher concentrations in land plants as compared to aquatic *Spirogyra* sp.

**Table 1—Total Phenolics and UV-B absorbing compound of three different plant species collected from Schirmacher Oasis**

(Absorbance units per gram F.wt/ml)

| **Name of Plants** | **Absorbance at 300nm** | **Total Phenolics** |
|---|---|---|
| *1. Bryum argentium* | 1.71±0.16 | 0.354±0.01 |
| *2. Spirogyra sp.* | 0.118±0.01 | 0.11±0.01 |
| *3. Xanthuria elegans* | 1.51+0.12 | 0.475±0.013 |

## DISCUSSION

Aquatic algae growing in water gets protection against UV radiations as water act as a filter for harmful UV radiations and therefore, induction of UV-B absorbing pigments is less as compared to land plants, as land plants are getting direct exposure of UV-B radiations. Simple UV-B absorbing compounds in aquatic plants, such as MAAs are as efficient as the more complex flavonoids in terrestrial higher plants (Rozema et al., 2002). The results of our studies with *Spirogyra* sp. and other two plants support this hypothesis also.

In lichens only phenolic acids have been reported (Huneck and Yoshimura, 1996) while in mosses flavoinds have been reported. It has been reported that elevated levels of UV-B induce increased synthesis of UV-B absorbing compounds (Rosa et al., 2001). Species originating from locations with different natural UV-B fluxes or other natural protection measures may differ in synthesis of phenolic compounds when confronted with rising levels of UV-B radiations.

Rozema et al., (2002) reported that UV-B absorbing compounds either phenolic acids or flavonoids are chemically relatively preserved well under special environmental conditions. Flavonoid levels of the *B. argentium* collected between 1957 and 1989 from the Ross sea area of continental Antarctica showed that when Antarctic stratospheric ozone concentrations decreased from 1971 to 1980, both UV-B absorbance and relative flavonoid levels have increased (Markham et al., 1990).

However, in case of lichens UV protection has been tentatively ascribed to secondary compounds, also called lichen compounds (Fahselt 1994; Rikkinen 1995; Huneck 1999). Most lichen compounds absorb strongly UV, and some, such as parietin, additionally absorb photosynthetically active radiation (PAR) (Solhaug et al., 2003; Hill and Woolhouse, 1966). The widely distributed and common compounds parietin, atranrin, usnic acid as well as the structurally less known fungal melanins are cortical pigments, forming a screen above the photobiont.

Ozone changes directly alter the UV-B received at the surface. However, relating surface UV-B levels to the overhead ozone concentration has proven difficult because ozone variability has multiple causes, the ground based database is not available and changes in cloud cover and other climate parameters can modify the surface UV-B. Day et al., (2001) found that the relative reductions in leaf elongation in *D. antarctica* and leaf longevity in *C. quitensis* attributable to UV-B exposure tended to increase over the 4 years of the experiment, suggesting that the effects of

UV-B on the growth of these species may be cumulative over successive years. Flavonoids and lignin, both products of phenolic polymer metabolism, occur in the gymnosperm and angiosperms, but are lacking in most algae. Simpler phenolics occur in the lower plants, such as sphagnum acid, and these may have acted as UV- filters in the progenitors of vascular plants, UV-A radiation is less potent per photon than UV-B, its damaging and inhibiting effect on growth and photosynthesis of aquatic and terrestrial plants can also be considerable, since its flux rate is higher than that of UV-B. It is clearly shown in the case of Antarctic phytoplankton that UV-A may also induce increased amounts of UV absorbing pigments (Smith et al., 1992).

Rozma et al., (2002), have concluded that the more simple UV-absorbing compounds in aquatic plants, such as MAAs, are as efficient as the more complex flavonoids in terrestrial higher plants. Screening of pigments in some evolutionary ancient photosynthetic organisms (cyanobacteria) revealed the presence of (include) scytonemins , in addition to MAAs. Scytonemins have some absorption in the UV-C range, which may have an advantage under the then oxygen free atmosphere which also transmitted UV-C. MAAs play a vital role as osmotic regulators (Oren,1997), as well as antifreeze compounds in some organisms, and such alternative roles may have given rise to first UV screening MAAs. MAAs have been reported in several eukaryotic algae (Sinha et. al. 1999) and it is likely that they were passed to the eukaryotic algae by cyanobacteria in the plastidic line. Recently protective role of MAAs as UV absorbers was confirmed both for photosynthesis and for motility in cyanobacteria and phytoplankton organisms.

## CONCLUSION

Based on the data from the experiments, it can be concluded that UV-B absorbing compounds are present in varying concentrations in the UV-B exposed three different plant species viz. *Spirogyra* sp., *Bryum argentium* and Lichen *Xanthuria elegans*.

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