Indian J. Fish., 47(4) : 359-363, Oct.-Dec., 2000

Note

Seasonal variation in the essential micro-nutrients of *Gracilaria* spp. of Tamil Nadu coast

REETA JAYASANKAR* AND KAILASH POLYWAL

Madhurai Kamaraj University, Madhurai, Tamil Nadu-625 021, India

ABSTRACT

Essential micro-nutrients such as manganese, copper, lead and zinc were analysed in three species of *Gracilaria* for 12 months from August 1994 to July, 1995. Comparative data on the interspecific variation of essential micro-nutrients have been explained. Seasonal variation of the trace element within the species were also analysed. Zinc content was found to be maximum in all the species of *Gracilaria*. In general, the decreasing trend of essential micro-nutrients was Zn>Pb>Cu>Mn. Manganese and copper content were found to be comparatively higher in *G. edulis* whereas lead dominated in *G. crassa*.

Seaweeds belonging to the red and brown algae, in addition to being the source of several polysaccharides of industrial importance, also supplement to human and animal diets. At least 56 elements have been reported to be present in seaweeds (Vinogradov, 1953) of which, sodium, potassium, calcium, magnesium, sulfur and phosphorus occur in relatively high quantities and are utilised directly or indirectly for the cellular building blocks (De Boer, 1981). Trace elements like manganese, copper, lead and zinc are present in very less quantities and are considered as the essential micro-nutrients for proper growth of the plants. Seaweeds are also wonderful agents of filtering heavy metals like zinc, cadmium, copper, nickel and iron and some potential carcinogens from sea water. They remove the toxic materials from the environment and accumulate in the body cell, which may be 4,000–20,000 times more than the surrounding water.

In India *Gracilaria* species are harvested from the natural beds for preparation of agar-agar of food grade. They are used for the preparation of jam, jelly and other variety of food products. The coastal fisher-folk use the plant for preparation of porridge. It is thus essential to compare the nutrient content particularly the trace metal in the system which may be harmful for human consumption when biomagnified in the cells of edible seaweeds. Many works have been carried out on the mineral constituents of different species of algae from Saurashtra coast (Rao and Indusekhar, 1987a, b; 1989; Oza *et al.*, 1983). Few data are available on the chemical constituents of the marine algae growing in the vicinity of Mandapam (Pillai, 1955; 1956; 1957). Due to increasing awareness about

*Present address: *Central Marine Fisheries Research Institute, Kochi-14, Kerala, India.*

environmental pollution, it is desirable to have comparative data on the nutrient accumulation on seaweeds from time to time.

Monthly samples of three different species of *Gracilaria* such as *G. edulis, G. crassa* and *G. corticata* were collected during August 1994 to July 1995 from the near-shore area of Gulf of Mannar near Mandapam and transported to the laboratory in plastic bags. After brushing off the epiphytes, they were washed several times in sterilised seawater and dried in a pre-heated oven at 90°C. After complete drying, they were powdered and sieved. Dried algal powder of 250 mg was taken in 75 ml digestion tube and digested in triple acid mixture (5 ml of nitric acid, 2 ml of perchloric acid and 0.5 ml of sulphuric acid) till the mixture became colourless. They were cooled to room temperature and diluted to 50 ml with deionised water and filtered through Whatman 42 filter paper. Triplicate were taken from each sample to find maximum accuracy. Elemental analyses of manganese, copper, lead and zinc were performed by the flame atomic absorption spectrophotometer using recommended guidelines for wavelength selection and linear working range (Perkin Elmer, 1982).

Manganese, copper, lead and zinc are considered as the essential micronutrients of seaweeds. They are required in very small quantity for better growth of the plant but when accumulated in excess are considered as harmful. Manganese accumulation in seaweed was first examined by Slowey *et al.* (1965) after the fall out of radioactive product of nuclear weapon. Stable Mn++ also got accumulated in algae ranging from a concentrated factor of 3,900 in *Ascophyllum nodosum*, 4,600 to 26,000 for *Fucus vesiculosus* (Foster, 1976), 10,000 to 20,000 for *Laminaria japonica* (Yoshimura *et al.*, 1976). It is considered as essential but adverse effect was documented when concentration increased from 0.1 mg/l (Noro, 1978). In the present experiment, variation was noticed on the concentration of manganese among the three species of *Gracilaria*, also seasonally within the species. It is found to be maximum in *G. edulis* than *G. crassa* and *G. corticata*. In *G. edulis*, the manganese content showed two peak values during October (0.0069) and April (0.0083) and two crest in January (0.0042) and June (0.0052) (Fig. 1A). The variation in the manganese content in *G. corticata* and *G. crassa* were marginal. It showed almost a similar trend throughout the year. There was a gradual increase in manganese content in *G. corticata* till March showing peak value of 0.0046 and till May in *G. crassa* (0.0061). Compared to other essential micro-nutrient the concentration of manganese and copper was found to be less than zinc and lead.

Bio-accumulation of trace elements in seaweeds depeds on the proximity to heavily populated or industrialised area, surrounding seawater, geographical area,

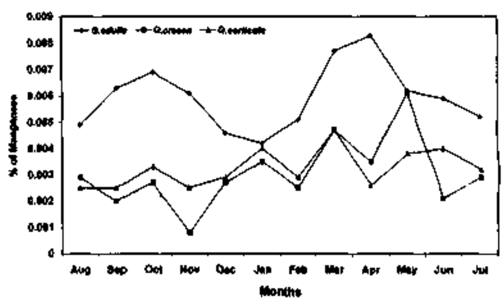

Fig. 1A. Seasonal variation of manganese in *Gracilaria* spp. (expressed in percentage).

age of the plant and the season of collection. It also depends on the pH, salinity, dissolved oxygen and the osmotic potential of the system (Styron *et al.*, 1976). In the present experiment, the collection center is not facing a threat of industrial waste or thickly populated city. To some extent the area are affected by motorised boat. Thus is may not account as a bio-indicator of pollution. The availability of trace metal in the plants may account for the osmotic potential of the plant and the surrounding seawater.

Copper is found in still less concentration than manganese in all the species of *Gracilaria*. There was a sharp decline of copper content during December (0.0007 to 0.0023) and June (0.0019-0.0024). *G. corticata* showed least quantity of copper than other two important species of *Gracilaria* and not much variation was noticed throughout the year in the particular species except a sharp decline during December. In *G. edulis*, there was a gradual decline in copper content from August to December and then increased. Maximum was noticed during July (0.0047), whereas in *G. crassa*, it showed an increasing trend throughout the year reaching a peak during July (0.0060) (Fig. 1B). Intergeneric and interspecific variability in copper content is extremely large. It is readily accumulated over seawater concentration by factors estimated at 6000 to 20,000 for *Ascophyllum nodosum* (Foster, 1976), 2,000 for *Sargassum* (Ishii *et al.*, 1978), 3,600 to 27,000 for *Fucus vesiculosus* (Seeliger and Edwards, 1977). There is some evidence that algae reared or found in high-copper environments can tolerate additional level of this element more readily than algae growing in low-copper environment. These differences are genetic and adaptive. Usually Ocean going freighters painted with copper based antifouling bottom are one source of threat of copper accumulation in species like *Ectocarpus* (Russel and Morris, 1970). While comparing the recorded data, it was observed that the copper content in *Gracilaria* spp. collected from Gulf of Mannar was very less.

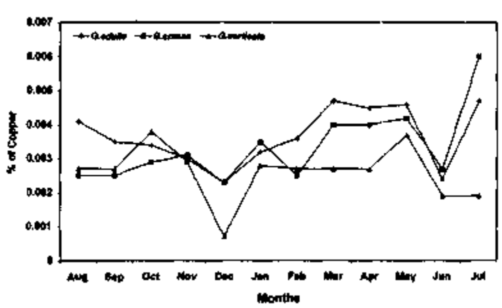

Fig. 1B. Seasonal variation of copper in *Gracilaria* spp. (expressed in percentage).

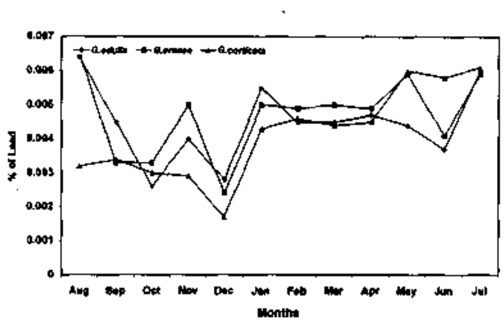

Fig. 1C. Seasonal variation of lead in *Gracilaria* spp. (expressed in percentage).

Lead is also considered as heavy metal and is found proportionately in large quantities in all the species of *Gracilaria* compared to copper and manganese (Fig. 1C). High bio-magnification of lead from ambient seawater by marine plants is documented by several investigators. Concentration ranged from 13,000 to 82,000 for algae from Raritan Bay and New Jersey (Seeliger and Edwards, 1977) and from 1,200 to 26,000 in algae of Surf Jordan, Norway (Melhuus *et al.*, 1978). In the present experiment concentration of lead did not show a regular pattern from August to December but exhibited an increase from January to July with a decline in June in all the species. It may be explained here that the decline of manganese, copper and lead during November and December may be due to heavy downpour and dilution of seawater. Lead content was found to be high in *G. crassa* than in *G. edulis* and *G. corticata* ranging from 0.0024 to 0.0065%.

Among all the essential micronutrients, zinc was found to be maximum (Fig. 1D). Zinc is especially abundant in marine flora with many values recorded in excess of 1,000 mg/kg of dry weight. This elevated level of zinc is usually associated with nearby industrial or domestic outfalls. Increasing zinc acumulation was observed in various species of marine algae with decreasing light intensities (Gutknecht, 1961), decreasing pH (Parry and Hayward, 1973) and increasing temperature (Styron *et al.*, 1976). The physical process of absorption or cation exchange

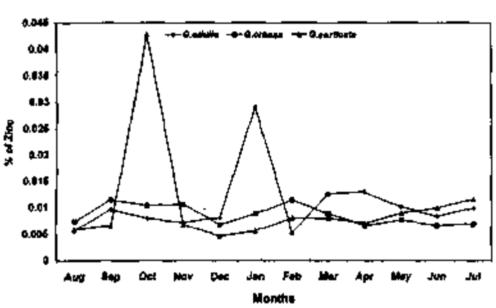

Fig. 1D. Seasonal variation of zinc in *Gracilaria* spp. (expressed in percentage).

was primarily responsible for zinc uptake in algae. Zinc in the field collection of macrophytes was almost always several times greater than the surrounding seawater (Foster, 1976; Ishi *et al.*, 1978). Reports say that in general red and brown algae are the most effective bioaccumulators of zinc (Eisler, 1980). In *G. corticata*, the zinc concentration was found to be very high during October and in *G. edulis* it accumulated during January.

In general the decreasing trend of essential micro-nutrients are Zn>Pb>Cu>Mn in all the species of *Gracilaria*. This result is in contrary to Rao (1992), which explained manganese concentration, to be higher in all the three groups of algae than zinc. While studying the seasonal variation Rao and Indusekhar (1989) opined that accumulation of trace element is more related to phenological stages of algae rather than ambient medium concentration. In the present experiment none of the trace elements showed any significant correlation with biomass of the plant. Thus it may be explained that the accumulation of trace element many depend on the combination of factors such as membrane permeability, mobility, valency, affinity of metal to the protein binding group in the cell wall, ambient seawater concentration, growth and phenology of the algae.

Acknowledgments

The first author is thankful to Dr. P.S.B.R. James, former Director, CMFRI for granting study leave to carry out this works and to the present Director for his constant encouragement. The Senior author is also thankful to the Indian Council of Agricultural Research for providing Senior Research Fellowship.

References

De Boer, J.A. 1981. Nutrients. *In* : C.S. Lobban and M.J. Wynne (Eds.). *The Biology of Seaweeds*, p. 356-391, Blackwell Scientific Publications, Oxford.

Eisler, R. 1980. Accumulation of zinc by marine biota. *In:* J.O. Nriagu (Ed.). *Zinc in Environment. Part 2: Health Effects.* John Wiley, NY, p. 259-351.

Foster, P. 1976. Concentration and concentration factors of heavy metals in brown algae. *Environ. Poll.*, **10** : 45-53.

Gutknecht, J. 1961. Mechanism of radioactive zinc uptake by *Ulva lactuca. Limnol. Oceanogr.*, **6** : 426-431.

Ishii, T., H. Suzuki and T. Koyanagi 1978. Determination of trace elements. In; *Marine Organisms – I. Factors for Variation of Concentration of Trace Element. Bull. Japan. Soc. Sci. Fish.*, **44** : 155-162.

Noro, T. 1978. Effect of Mn on the growth of marine green alga, *Dunaliella tertiolecta. Japan J. Phycol.*, **26** : 69-72.

Oza, R.M., H.V. Joshi, R.G. Parekh and V.D. Chauhan 1983. Preliminary observations on a *Monostroma* sp. from the Okha coast, Gujarat. *Indian. J. Mar. Sci.*, **12** : 115-117.

Parry, G.D.R. and J. Hayward 1973. The uptake of ^{65}Zn by *Dunaliella tertiolecta* Butcher. *J. mar. biol. Assn. U.K.*, **53** : 915-922.

Perkin Elmer Corporation 1982. *Analytical Methods for Atomic Absorption Spectroscopy.* Perkin Elmer Corporation, Norwalk, CT, USA.

Pillai, V.K. 1955. Water soluble constituents of *Gracilaria lichenoides. J. Sci. Indust. Res.*, **14**B : 473-477.

Pillai, V.K. 1956. Chemical studies on Indian seaweeds. I. Mineral constituents. *Proc. Indian. Acad. Sci.*, **44**B : 3-29.

Pillai, V.K. 1957. Chemical studies on Indian seaweeds. II. Partition of nitrogen. *Proc. Indian Acad. Sci.*, **45**B : 43-63.

Rao Keseva Ch. 1992. Elemental composition of Indian marine algae – A biogeochemical perspective. *Indian J. Mar. Sci.*, **21** : 167-177.

Rao Keseva Ch. and V.K. Indusekhar 1987a. Carbon, nitrogen and phosphorus ratios in seawater and seaweeds of Saurashtra, northwest coast of India. *Indian J. Mar. Sci.*, **16** : 117-121.

Rao Keseva Ch. and V.K. Indusekhar 1987b. Chromium, lead and cadmium contents of certain seaweeds from Saurashtra coast. *Phykos*, **26** : 1-7.

Rao Keseva Ch. and V.K. Indusekhar 1989. Seasonal variation in chemical constituents of certain Brown seaweeds and seawater from Saurashtra coast. I. Carbon, nitrogen and phosphorus. *Mahasagar*, **22**(2) : 63-72.

Russel, G. and O.P. Morris 1970. Copper tolerance in the marine fouling alga *Ectocarpus siliculosus. Nature*, **228** : 288-289.

Seeliger, U. and P. Edwards 1977. Correlation coefficient and concentration factors of copper and lead in seawater and benthic algae. *Mar. Poll. Bull.*, **8** : 16-19.

Slowey, J.F., D. Hayes, B. Dixon and D.W. Hood 1965. Distribution of gamma-emitting radionucleides in the Gulf of Mexico. *Occ. Publs.* Narragansett Mar. Lab. Univ. Rhode Island, Kingston and RI 3 : 109-129.

Styron, C.E., T.M. Hagan, D.R. Campbell, J. Harvin, N.K. Whittenburg, G.A. Baughman, M.E. Bransford, W.H. Saunders, D.C. Williams, C. Woodle, N.K. Dixon and C.R. McNeill. 1976. Effects of temperature and salinity on growth and uptake of Zn-65 and Cs-137 for six marine algae. *J. mar. biol. Assn. U.K.*, **56** : 13-20.

Vinogradov, A.P. 1953. The elementary chemical composition of marine organisms. *Sears Foundation of Marine Research, Memoir*, no. 2, Yale University.

Yoshimura, A., H. Tada, M. Sakai, T. Harada and K. Oishi 1976. Distribution of inorganic constituents of Kombu blade - III. Inorganic constituents of acceleratedly cultured ma-kombu at various growth stages. *Bull. Jap. Soc. Sci. Fish.*, **42** : 661-664.