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EFFECT OF COPPER ON THE ULTRASTRUCTURE OF MARINE PHYTOPLANKTON

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Abstract

Electron microscopy technique was used to study the copper induced ultrastructural changes in the blue green alga, *Synechocystis salina.* Wislouch and golden yellow flagellate *Isochrysis galbana* Parke. The blue green alga exhibited significant deterioration in the cell's internal organisation.Presence of membrane whorls. disorganisation of cell envelop . Photosynthetic lamelleae at certain regions of the cell, reduction in cellsize increase in number of polyhedral bodies and absence of lipid inclusion was observed . Drastic change was not noticed in the golden yellow flagellate except for the presence of enlarged vacuoles and more number of osmophilic bodies. Toxicity and detoxification mechanisms are discussed and the utilization of electron microscopic analysis is established in the studies of metal toxioity at the cellular level

Introduction

One of the most commonly observed effects of heavy metal poisoning is a change in cell size or morphology. This has been observed in a wide variety of organisms including representatives from the Chlorophyceae (Rosko and Rachlin.1977) Chrysophycese (Davies. 1974.) and Bacillariophyceae.

The application of electron microscopic morphometry to evaluate and quantify intracellular effects of heavy metals on phytoplankton became evident only after the publications of Weibel and Bolender.(1973)and Sickogoad and Stoermer (1979) An understanding of the internal anatomy of cells exposed to heavy metals would provide a first step towards documenting the physiological effects of heavy metal pollution at the cellular level.

Except for the study on morphological aberration s in diatom cells (Thomas *et al* (1982-1984) Rai *et al* (1990) to date, there is no information on metal toxicity on the ultrastructural changes in marine phytoplankton used as live feed for marine bivalve larvae

The purpose of the present study is to examine the copper induced intracellular structural changes in *Synechocystie salina,* Wislouch and *Isochrysis galbana* Parke using transmission electron microscope.

Materials and Methods

The two unicellular algae. *Synechocystis salina* Wislouch (blue green alga) and *Isochrysis galbana* Parke (golden yellow flage llate) were grown in Miquel's medium under a light intensity of $34.6.1x10^{15}$ quanta cm^2xsec^{-1} light /dark cycle of 10:14hrs. Temperature ranging from 24°c -30°c and a salinity of 15-20ppt for *S. salina and 30-35 ppt* for I.galbana. Cultures were obtained from CMFRI. Cochin laboratory collection.Cultures from the exponential phase were used for the toxicity tests. Batch cultures of S.salina and I.galbana were exposed to $0.200.\mu gm1^{-1}$ of copper and control cells to metal free distilled water . Cells were harvested, washed fixed, embedded in spurr resin, sectioned and examined by transmission electron microscopy using a carl zeiss Electron microscope. Negative staining technique was adopted to study the fine structure of I.galbana. A drop of culture suspension was applied to formvar coated carbon grid stained with 0.5% ammonium molybdate. dried and observed in TEM.

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Table 5: Occurrence of agar, carrageenan and algin yielding seaweeds in other parts of Indian coast

Name of the seaweed	Place of occurrence
Agarophytes	
Gelidiella acerosa	Okha, Dwarka, Porbandar, Diu, Veraval, Lakshadweep and Andaman-Nicober
Gracilaria edulis	Lakashadweep and Andaman-Nicobar
G. crassa	Andaman-nicobar
G.corticata var corticata	Dwaraka.Bombay.Karwar. Goa,Tikkoti Quilon.Varkala. Vizhinjam. Visakhapatnam.and Andaman-Nicobar
G.foliifera	Gopnath.Okha,Bombay Tikkoti, and Andaman-nicobar
G.verrucosa	Okha,Bombay,Goa,Chilka and Andaman-Nicobar
Alginophytes	
Sargassum wightii	Bombay,Goa,Alleppey.,Vizhinjam.and Andaman -Nicobar
S.tenerrimum	Gulf of Kutch,Okha,Dwaraka, Bombay, Goa,Karwar,Visakhapatnam and Andaman-Nicobar
S. myriocystum	Andaman-Nicobar
S.ilicifolium	Bombay,Goa,Karwar,Visakhapatnam,and Andaman -Nicobar
S. cinereum var. berberifolia	Gulf of Kutch, Bombay,Goa, Karwar,and Vishinjam.
S. johnstonii	Okha
S.vulgare	Dwaraka,Okha and Visakhapatnam
S.duplicatum	Lakshadweep and Andaman -Nicobar
Turbinaria conoides	Lakshadweep, and Nadaman -Nicober
T.ornata	Dwarka, Lakshadweep and Andaman -Nicobar
T.decurrens	Andaman -Nicobar
Cystoseira trinodis	Okha,and Andaman -Nicobar
Hormophysa triquetra	Okha and Andaman-Nicobar
Carrageenophytes	
Hypnea musciformis	Gopnath,Okha,Dwarka, Bombay,Goa, Karwar,Visakhapatnam, Laksha dweep and Andaman-Nicobar
H.valentiae.	Bombay,Tikkoti, Vizhinjam and Lakshadweep

Table 4: Time-table for commercial harvest of economically important seaweeds from Tamil Nadu Coast

Name of the seaweed	Period of Occurrence	Suitable period for harvest
Agarophytes		
Gelidiella acerosa	Throughout the year	January to March July to September
Gracilaria edulis	--do--	January to March & August to September
G.crassa	--do--	--do--
G.foliifera	--do--	--do--
G. corticata var corticata	--do--	June to August November to December
G.verrucosa	March to November	May to August
Alginophytes	Through out the year	October to December
sargassum wightii		
S. myriocystum	--do--	May to August
S.ilicifolium	--do--	July to September
Turbinaria conoides	--do--	October to December
T.ornata	--do--	--do--
T.decurrens	--do---	December -January
Carrageenophytes		
Hypnea musciformis	--do--	December to March.
H.valentiae	--do--	January to March

The commercial exploitation of seaweeds is concentrated for several years only along south Tamil Nadu coast. The natural resources of algin yielding seaweeds *Sargassum* and *Turbinaria* in Tamil Nadu coast are adequate. At present only about 50% of the standing crop is harvested and there is no paucity for these plants. The agar yielding seaweeds *Gelidiella acerosa, Gracilaria edulis, G. crassa, G. corticata* var. *coricata, G. foliferra* and *G. verrucosa;* algin yielding seaweeds *Sargassum* spp, *Turbinaria* spp, *Cystoserira trinodis* and *Hormophysa triquetra* and carrageenan yielding seaweeds *Hypnea musciformis* and *H. valentiae* growing in harvestable quantities in other parts of Indian coast, Lakshadweep and Andaman- Nicobar Islands (Table -5) may be exploited during their maximum growth periods to meet the raw material requirements of Indian seaweed industries and to conserve the seaweed beds of Tamil Nadu coast. This will provide additional employment to the people living in the coastal areas and to earn more foreign exchange to the country by promoting the export of seaweeds in semi processed form and value added seaweed products namely agar, sodium alginate and carrageenan.

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All these seaweeds are harvested since 1966 from the natural seaweed beds occurring in south Tamil Nadu coast from Rameswaram to Kanyakumari (Kalimuthu *et al* 1990 and Kalimuthu and Kaliaperumal 1996). Data were collected monthly from 1978 to 1995 on the quantity of seaweeds harvested from this area and landed at different centres. During the period 1978 to 1995, the quantity of agar yielding seaweeds *Gelidiella acerosa, Gracilaria edulis, G. crassa* and *G. foliifera* exploited in a year varied from 248 to 1289 tons (dry wt), algin yielding seaweeds *Sargassum* spp and *Turbinaria* spp from 651 to 5537 tons (dry wt) and all the above seaweeds from 1173 to 6420 tons (dry wt) depending on the availability of seaweeds in the natural beds and raw material requirements from the seaweed industries (Table 2). The total quantity of seaweeds landed in 1994 was 3571 tons (dry wt) consisting of 2867 tons of *Sargassum* spp, 256 tons of *Turbinaria* spp, 261 tons of *Gelidiella acerosa* and 187 tons of *Gracilaria edulis*. During the year 1995 out of 3006 tons (dry wt) of total seaweeds landed, *Sargassum* spp contributed 2249 tons, *Turbinaria* spp 307 tons, *Gelidiella acerosa* 232 tons, *Gracilaria edulis* 108 tons and *G. foliifera* 110 tons.

Many agar and algin manufacturing industries are coming up every year in India. As the demand for raw material of agar yielding plants is more and their natural resources are less in Tamil Nadu, the agarophytes *Gelidiella acerosa* and *Gracilaria edulis* are being over exploited. Because of extensive and unrestricted commercial harvest of these seaweeds throughout the year, there is depletion in the stock of these red algae in the seaweed beds of Tamil Nadu. So it is necessary to conserve the natural stock of these two agar yielding plants by adopting rational way of commercial exploitation.

Based on the studies made on the growth, fruiting behaviour, effect of repeated harvesting on the growth and phycocolloid contents of agar, algin and carrageenan yielding seaweeds of Tamil Nadu, a time - table for commercial harvest of these seaweeds is given in Tabel 4. In order to conserve the natural stock of economically important seaweeds of Tamil Nadu coast and also to get consistant crop every year, the seaweed collections have to follow this time - table. This will ensure the regeneration and regrowth of seaweeds by vegetative and reproductive growth to harvestable size plants in the next harvesting season by means of giving sufficient interval between one harvest and the other. A single harvest in a year is recommended for all species. However, the harvesting may be done twice in a year during the periods indicated in Table 4 for *Gelidiella acerosa* and *Gracilaria* spp in areas with rich growth of these algae.

Discussion

The resources of *Gracilaria corticata* var. *corticata* available in exploitable quantity in the east and west coast of India remains unexploited at present. It may be harvested and used along with *Gelidiella acerosa* and other *Gracilaria* spp for agar production. Similarly *Gracilaria verrucosa* occurring abundantly in Chilka Lake, Pulicat Lake and in the estuaries and backwaters of Tamil Nadu, Pondicherry and other maritime states may be exploited and used for agar manufacture. The carrageenan yielding red algae *Hypnea musciformis* and *H. valentiae* occur abundantly in Gulf of Mannar islands, near shore areas, estuaries and backwaters in different localities of Tamil Nadu and other parts of Indian coast including Lakshadweep and Andaman - Nicobar Islands. This potential resource could be utilised for the production of carrageenan in India. Some precautionary measures have to be taken while collecting the seaweeds. The regeneration of algae takes place as long as basal remnants of plants are intact with the substratum. Hence harvest has to be made by pruning the plants leaving the basal part instead of removing the whole plants. The other seaweeds growing in the harvesting area should not be removed to avoid the damage to the seaweed ecosystem .

Table 3. Quantity of seaweeds landed (dry wt in tons) at different landing centres of Tamil Nadu during 1994 and 1995

	Sargassum spp		Turbinaria spp		Gelidiella acerosa		Gracilaria edulis		Gracilaria foliifera	
	1994	1995	1994	1995	1994	1995	1994	1995	1994	1995
Rameswaram	--	10	--	12	34	21	5	9	--	--
	85	65	--	5	49	52	24	13	--	--
Mandapam	40	87	--	30	--	--	44	40	--	110
	285	343	5	15	--	--	114	43	--	--
Seeniappa Darga	380	513	--	--	--	--	--			
Periapatnam	800	320	55	--	--	--	--	--	--	--
Kilakikarai	960	765	156	220	102	79	--	3	--	--
	217	145	40	25	53	61	--	--	--	--
Valinokkam	75	1	--	--	--	--	--	--	----	--
	25	--	--	--	--	--	--	--	--	
Tharavaikulam	--	--	--	--	23	19	--	--	--	--
	2867	2249	256	307	261	232	187	108	--	110

Table 2. Seaweed landings (dry weight in tons) from Tamil Nadu during 1978 to 1995

Agar yielding seaweeds				Algin yielding seaweeds		Total
Gelidiella acerosa	*Gracilaria edulis*	*Gracilaria crassa*	*Gracilaria foliifera*	*Sargassum spp*	*Turbinaria* spp	
288	395	--	--	3636	1021	5340
541	342	--	--	4256	1281	6420
247	213	--	--	3090	438	3988
131	117	--	--	2522	222	2992
102	225	--	--	3176	704	4207
293	291	85	--	2070	375	3114
210	320	96	--	780	235	1641
189	269	45	--	2096	385	2984
261	233	28	--	491	160	1173
217	317	34	--	868	250	1686
366	330	15	--	2605	523	3839
370	400	2	--	3106	459	4337
307	982	--	--	2867	224	4380
274	318	--	3	5000	160	5755
312	399	--	50	2921	122	3804
261	187	--	--	2867	256	3571
232	105	--	110	2249	307	3006

Drupa margariticula, Janthira sp., *Pyrene* sp., *Trochus* sp., *Turbo* sp., *Cronia* sp., *Chiton* ., and *Acanthychitona* sp. and Echinoderms like *Ophiocnamics* sp. are found sheltered in the sediments retained by the holdfast of macro algae.

Discussion

The present study coincides with the earlier studies (Varma, 1960; Mahadevan and Nagappan Nair, 1967, Srinivasan, 1969 & 1973; Kaliaperumal and Pandian, 1984; and Nair *et al* 1986) made from the east coast mainly in the floral list. The study showed the occurrence of a rather rich diversity in flora which could be attributed to the less polluted environment this coast is having when compared to the other nearby areas. The inter-relationship between the fauna associated with algal community needs further study. S uch a study will contribute much to the conservation of the fauna and judicious exploitation of the flora for human use.

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