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Effect of Treated Sewage on Growth of Marine Algae

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Eight algal species belonging to Chlorophyta, Rhodophyta and Phaeophyta were used to assess the effect of different concentrations of secondary treated sewage on their growth. Chlorophyta and Rhodophyta members, *Ulva fasciata* and *Gracilaria verrucosa* respectively, showed good growth as compared to the control in 5% sewage-seawater medium. Phaeophyta members did not show satisfactory growth. However, in 5 and 10% sewage-seawater media growth was observed in *Padina tetrastromatica*, *Stoechospermum marginatum* and *Spatoglossum asperum*, while *Sargassum* sp. was found to be least tolerant to sewage pollution. Correlation coefficients between algal growth (weight) and nutrients showed that *U. fasciata* and *G. verrucosa* can be cultivated in diluted sewage effluent as tertiary sewage treatment species to remove nutrients in high concentrations and toxic substances from the sewage polluted areas.

Pollution of coastal waters very often influences the growth of certain species of *Ulva* and *Enteromorpha*. Growth of *Ulva* in relation to sewage pollution is studied[1-5]. The utility of waste water effluent for mass culture of marine algae is also stressed[6,7].

The present study has been undertaken to assess the effect of different concentrations of treated sewage-seawater mixture on the growth of different algae and their tolerance to the sewage.

Materials and Methods

Algal samples were collected from intertidal areas along the Goa coast, brought to the laboratory in seawater and sand particles and epiphytes, if any were removed. Algae were then acclimatized to laboratory conditions (temp. 28° to 32°C, normal day light) for 24 h.

Treated sewage, collected from the PWD treatment plant, Panaji, was filtered through Whatman filter paper (No.1) to remove the suspended particles. Sewage concentrations of 50,20,10 and 5% were made with filtered seawater collected from Dona Paula jetty.

Eight algae, viz. Chlorophyta [*Ulva fasciata* Delile, *Chaetomorpha media* (C. Agardh) Kutzing], Phaeophyta [*Padina tetrastromatica* Hauck., *Spatoglossum asperum* J. Ag., *Stoechospermum marginatum* J. Ag., *Sargassum* sp.] and Rhodophyta [*Acanthophora spicifera* (Vahl.) Boergs., *Gracilaria verrucosa* (Huds) Papenfuss] were used. Algal material was inoculated and cultured in 1 l of sewage-seawater mixture. Two control flasks contained only algae in filtered seawater. Duplicate set of flasks were used for each sewage concentration. Seawater in the control flasks was changed every 3 d whereas in the experimental flasks the particular sewage-seawater mixture remained unchanged throughout the experiment. The flasks were aerated continuously and kept in a culture chamber with an illumination of 5000 lux under 12:12 L:D regime.

The experiment was carried out for 6 weeks, after every 8 d water sample was removed from each flask for analysis. Nutrients (phosphate, nitrate, nitrite and ammonia) and *p*H were analysed[8] and total nitrogen was analysed by persulphate oxidation[9]. Relationship between growth (x_1) and nutrients (x_2) was analysed using the formula

$$\text{Correlation } (r) = \frac{\text{Covariance } (X_1, X_2)}{\text{Variance } (X_1)\ \text{Variance } (X_2)}$$

and its significance was tested. The combined effect of nutrients and growth was further tested by multiple correlation coefficient analysis.

Results and Discussion

Ulva fasciata showed good growth in 5% conc. of sewage-seawater mixture (Fig.1) perhaps due to the ability of green alga to utilize organic nitrogen in the form of ammonia[2,10]. This is evident from the rapid decrease in ammonia observed at all concentrations of sewage-seawater in which the alga was grown. In the control flasks, *U. fasciata* showed degeneration after the 32 d which may be attributed to the low concentration of available nutrients in the seawater or to some other unknown limiting factors.

Correlation analysis between growth of *U. fasciata* and nutrient was not significant in control (Table 1) which was probably because of the insufficient data as a result of early degeneration of the alga. However, ammonia and its relation with the growth of *U. fasciata* in other concentrations (Table 1) indicated that it could not survive in the control because of the lack of ammonia.

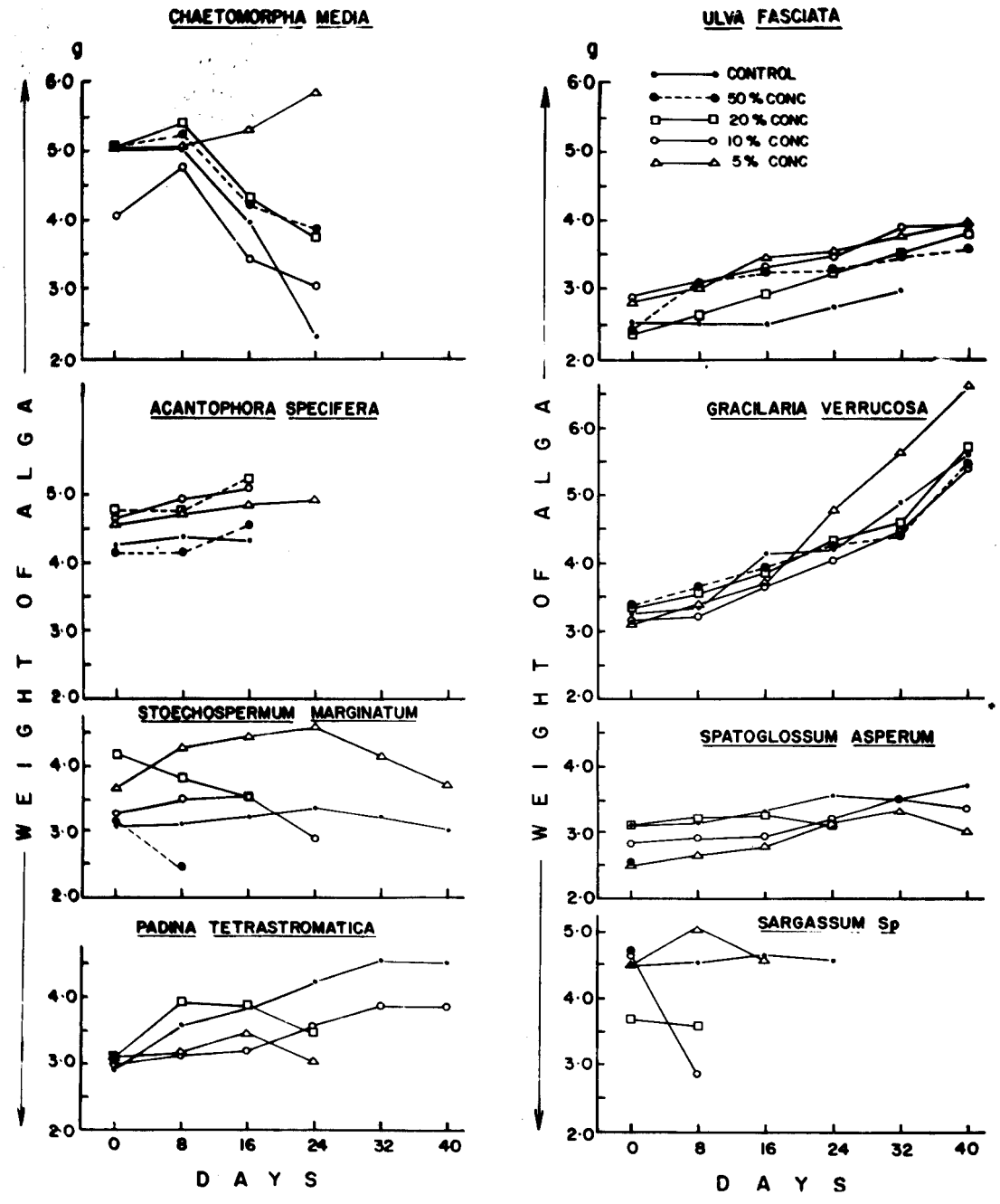

Fig. 1— Effect of different concentrations of sewage-seawater on growth of different marine algal species

Chaetomorpha media showed growth up to 8 d in all concentrations except in 5% where 10% growth was recorded on the 24 d (Fig.1). No definite trend in nutrient was observed in any of the concentrations. As a result of algal degeneration in all other concentrations including control, correlation coefficients could not be worked out (Table 1). However, the trend indicated that the high nutrients are harmful for the growth of this alga: In 5% conc., correlation coefficient values showed that ammonia and nitrogen were closely related with the growth of *C. media*. Degeneration of the algal fronds were observed in all the concentrations with *C. media* after the 24th day whereas *U. fasciata* showed greater tolerance to sewage pollution at all the concentrations.

In Rhodophyta, *Acanthophora spicifera* showed growth up to 16 d in all the concentrations except in 5% where growth was noticed up to the 24 d. However, in the control, growth was seen only up to 8 d followed by degeneration (Fig.1). The degeneration of *A. spicifera* at all concentrations was probably due to the high nutrient concentrations which might have produced toxic effect[11,12].

Gracilaria verrucosa showed good growth as

Table 1—Correlation between Nutrients and Algal Growth

Conc. (%)	NO_2	NO_3	NH_4	Tot.N	PO_4
		Padina tetrastromatica[a]			
C	−0.80**	−0.86**	−0.58*	−0.17	−0.05
20	−0.11	−0.08	−0.86**	−0.93**	−0.74**
10	−0.77**	−0.89**	−0.70**	−0.79**	−0.76**
5	−0.34	−0.25	−0.06	−0.50	−0.31
		Stoechospermum marginatum[b]			
C	−0.31	−0.13	−0.49	−0.17	−0.63*
5	−0.58*	−0.58*	−0.58*	−0.83*	−0.60*
		Spatoglossum asperum[c]			
C	−0.61*	−0.60*	−0.40	−0.85**	−0.70**
20	−0.32	−0.42	−0.82**	−0.08	−0.66*
10	−0.76**	−0.88**	−0.07	−0.70**	−0.81**
5	−0.58*	−0.66*	−0.40	−0.66*	0.75**
		Gracilaria verrucosa			
C	−0.63*	−0.84**	−0.49	−0.80**	−0.59*
50	0.39	−0.02	0.76*	0.15	−0.71**
20	0.39	−0.40	0.70	−0.84**	−0.66*
10	−0.69*	−0.79**	0.73**	−0.68*	−0.67*
5	−0.91**	−0.62*	0.93**	−0.88**	−0.55
		Ulva fasciata			
C	−0.07	0.33	−0.55	−0.59*	−0.54
50	−0.04	0.33	−0.90**	−0.59*	−0.24
20	−0.40	−0.41	−0.73**	−0.78**	−0.27
10	−0.40	−0.54	−0.67*	−0.90**	−0.03
5	−0.44	−0.64*	−0.81**	−0.84**	−0.09
		Chaetomorpha media[d]			
5	−0.03	−0.49	−0.77**	−0.87**	−0.59*

C = control

Level of significance P: * < 0.25 and ** < 0.1

Alga degenerated in concentrations—[a]50%; [b]10,20 and 50%; [c]50%; [d]10,20 and 50% and also in control

compared to the control in 5% conc. till the end of the experiment. In other concentrations eventhough the growth was not good the alga was healthy. In all the concentrations phosphate was high in the beginning which started decreasing at the rate of 48% till the end of the experiment. Ammonia concentration was low in all the sewage-seawater concentrations and did not show any significant variation. In general, *G. verrucosa* showed good growth in 5% conc. The maximum growth rate recorded on the 24 d was 35.51%, whereas in other concentrations, it survived even though the growth was less than that of control (Fig.1). Correlation analysis showed that the growth of *G. verrucosa* depends on the combined effect of several nutrients in 5% sewage ($r_{1235} = 0.74$). On the basis of these observations *G. verrucosa* appears to be a sewage tolerant species, while *A. spicifera* appears to be an intermediate in its response.

Phaeophyta members did not show significant growth in any of the concentrations. *S. marginatum* however, showed moderate growth up to the 24 d in 5% and in the control (Fig.1). In 10 and 20% conc. the growth was very poor, while in 50% all the Phaeophyta members showed degeneration soon after the beginning of the experiment. The significant change in the nutrients with increase in the sewage concentration seems to be harmful to *S. marginatum*.

Spatoglossum asperum showed growth up to 32 d in 5 and 10% conc. while the growth in the control was observed till the end of the experiment (Fig.1). Correlation coefficient values (Table 1) for control, 5 and 10% sewage conc. showed that the growth was closely associated with the decline in nutrient concentrations.

Padina tetrastromatica showed moderate growth in 10% and a consistant growth up to 40 d in control (Fig.1). In 20% conc., the growth increased in the beginning, showing a decrease thereafter, while in 50% conc. the alga degenerated. More growth in 20% sewage-seawater medium in the beginning may be due to the optimum uptake of essential nutrients in this concentration. Correlation coefficient indicated that this alga utilizes nutrient in different proportions at different concentrations.

Sargassum sp. did not show growth in any of the concentrations. In the control it started degenerating after the 24 d and in all the sewage-seawater conc. after 8 d. *Sargassum* sp. appears to be least sewage tolerant species while other 3 species are intermediate in sewage tolerance.

Sewage-seawater media at 5% conc. in which *Padina*, *Stoechospermum* and *Spatoglossum* were grown, initially showed high nitrate concentrations which started decreasing from 8 to 24 d and thereafter remained at very low levels till the end of the experiment. The probable reason may be that these species derive nitrogen from nitrate present in the sewage as suggested for other seaweeds[13,14].

Phosphate values, initially showed decreasing trend in 5 and 10% sewage-seawater media, with minor variations containing Phaeophyta and Rhodophyta species, till the end of the experiment, which is due to the utilization by the algae.

During the present investigation *p*H and nutrient values did not show regular trend in most of the cases, due to the degeneration of the algal fronds which might have changed the *p*H and nutrient concentration. Moreover, there could also be utilization of nutrients by micro-organisms which was not monitored in the present experiment.

These results indicate that out of the 8 algal species studied, only *Ulva fasciata* and *Gracilaria verrucosa* can be cultivated in dilute sewage effluents, which are sources of protein and agar respectively. These species

may also be used in tertiary sewage treatment to remove nutrients which are in high concentration from the sewage which otherwise are released in the coastal waters leading to eutrophication.

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