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VARIATIONS IN CARBON AND NITROGEN CONTENTS DURING DECOMPOSITION OF THREE MACROALGAE INHABITING SANDSPIT BACKWATER, KARACHI

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Abstract

Macroalgae constitute a diverse group of photoautotroph contributing to the primary production in the area. It provides food and habitats (directly or indirectly) to many other inhabitants of the marine and coastal communities and hence forms the foundation for food chain prevailing mangrove environment. Variations in carbon and nitrogen content during decomposition of three macroalgal species, *viz. Enteromorpha intestinalis, E. clathrata* and *Ulva reticulata* occurring commonly in mangrove environment, were estimated in laboratory using litter bag technique. Known amount of each macroalgal species was decomposed in separate nylon net bags (1 mm^2 mesh) incubated in well aerated seawater tanks. Significant increases in organic nitrogen and decreases in total organic carbon content were recorded during decomposition (p-value < .001) for all algal species studied. Macroalgae appear to be a key component in mangrove environment taking part in the release of particulate and dissolved nutrients and hence play very important role in nutrient dynamics and food web.

Introduction

Macroalgae constitute a diverse group of photoautotrophs. They are macroscopic, growing in the shallow waters wherever suitable substrate is available. Macroalgae are classified according to their pigmentation as brown (Phaeophyta), red (Rhodophyta) and green (Chlorophyta). Macroalgae are considered as primary producers, convert sun's energy and nutrients into organic materials, which provide food and habitats, directly or indirectly for many other inhabitants of the marine and coastal communities and hence form the foundation for food chains. Because macroalgae are rich in protein, carbohydrate, vitamins and other minerals so they are used as food and fodder in many countries of the world (Rao & Tipins, 1964; Chapman & Chapman, 1980; Blanchard *et al.,* 2000; Lamare & Wing, 2001; Zodape, 2001). Marine algae are also used as manure in coastal areas of various part of the world (Bhosle *et al.,* 1975). They are also the oxygenators for aquatic environments.

The chemical and biochemical composition of various macroalgae have been studied in different part of the world including Pakistan (Black, 1955; Qari & Qasim, 1988; Vasantha *et al.,* 1998; Lamare & Wing, 2001). Pakistani coastal area is rich in algal diversity and biomass because of warm climate and nutrient enrichment through upwelling. A number of green, red and brown macroalgae have been reported from the coast of Pakistan (Anand, 1940; Shameel & Tanaka, 1992; Tanaka & Shameel, 1992), where they occur in high abundance (Shameel & Nizamuddin, 1972; Saifullah, 1973; Saifullah & Nizamuddin, 1977; Qasim, 1980; Shameel, 1987; Qari & Qasim, 1988; Saifullah and Rasool, 1998; Shameel, 2001; Abbas and Shameel 2012).

Detritus has been considered as important food source in aquatic ecosystem (Paine & Vadas, 1969; Mann, 1972). Major input of detritus in the coastal areas is through decaying plant material, for example, from mangroves, seagrasses and macroalgae. During decomposition initially soluble organic compounds are leached very rapidly from decaying material (Grando & Cabellero, 1996; Hoq *et al.*, 2002; Meziane & Tsuchiya, 2002). Microbial colonization also increases the protein content of detritus (Fell & Master, 1973; Chtistoffersen *et al.,* 2002). Some macro-invertebrates reduce the size of large detrital particle during their feeding activity, where as some convert small particle into large particles in the form of fecal material (Robertson & Mann, 1980). The complex process of decomposition seems to be regulated by multitude of organisms, a) including bacteria, fungi, insects and many invertebrates (Suberkropp & Klug, 1976; Hay & Fenical, 1992;), b) physicochemical properties of the material, and c) environmental factors including temperature, salinity, humidity, evaporation and nature of the substratum (Howart & Hobbie, 1981).

Mangrove detrital system has been studied in Pakistan (Siddiqui & Qasim, 1990; 1994; Siddiqui *et al*., 2009), but not much information is available for macroalgal decomposition from mangrove swamps except for one recent study (Shafique *et al*., 2010; Farooqui *et al*., 2012) where decomposition rate and variations in total organic, inorganic and chlorophyll contents were recorded. In the present study three species of macroalgae growing commonly in the sheltered mangrove environment, viz., *Ulva reticulata*, *Enteromorpha intestinalis* and *Enteromorpha clathrata,* were selected for decomposition study. These species are known to form thick mats over a considerable area. This study deals with the changes in the biochemical parameters in the decomposing seaweed, such as, total organic carbon, total nitrogen and C:N ratio.

Materials and Methods

The decomposition of macroalgae was studied in the laboratory using nylon mesh bags. Three species including *E. intestinalis*, *E. clathrata* and *U. reticulata* were collected from Sandspit backwaters in November, 2000 and brought to the laboratory in polythene bags, sorted and washed. Known amount (50 g) of blot-dried sample of each species was placed separately in nylon bags (40X60 cm) of 1 mm^2 mesh. Sets of 15 bags for each species were incubated in a series of well aerated tanks containing 5 liters of seawater. Triplicate samples of each species were taken prior to incubation and treated as initial samples. A set of three bags for each species was recovered after 2, 5, 7, 14 and 30 days. Material from each bag was gently removed, blot dried and weighed. The dried recovered material was ground and stored for estimation of total organic carbon and total nitrogen using chromic acid wet oxidation method (Strickland & Parson, 1972) and Micro-Kjeldal distillation method (Hawk *et al.,* 1954), respectively. Two-way analysis of variance (ANOVA) was used to evaluate differences in the variation in total nitrogen and organic carbon of three species of macroalgae. Pearson Correlation coefficient was also used to determine the relationship between changes in total nitrogen, total organic carbon and C:N ratio in each species.

Results

All three species of macroalgae had high initial nitrogen content which further increased with time during decomposition (Fig. 1). The rate of increment in nitrogen content was variable among three species studied. In case of organic carbon, the higher initial values showed decreases with time. The highest organic carbon was recorded for *U. reticulata* followed by *E. intestinalis* and *E. clathrata.* The two-way analysis of variance showed that the pattern of decreases in organic carbon and increases in total nitrogen varies significantly (p-value < 0.001) within and among the species. The interaction between incubation period and seaweed species (*E. intestinalis E. clathrata* and *U. reticulata*) also shows significant variation (p-value < 0.001). It may be noted that *E. clathrata* and *U. reticulata* had low C:N values (high nitrogen content) compared to *E. intestinalis.* Carbon to nitrogen ratio in all species (*U. reticulata E. intestinalis* and *E. clathrata*) decreased with time during decomposition (Fig. 2). Pearson correlation was evaluated between total nitrogen, total organic carbon and C:N ratio and it showed significant positive correlation between three species of macroalgae (Tables 1-3).

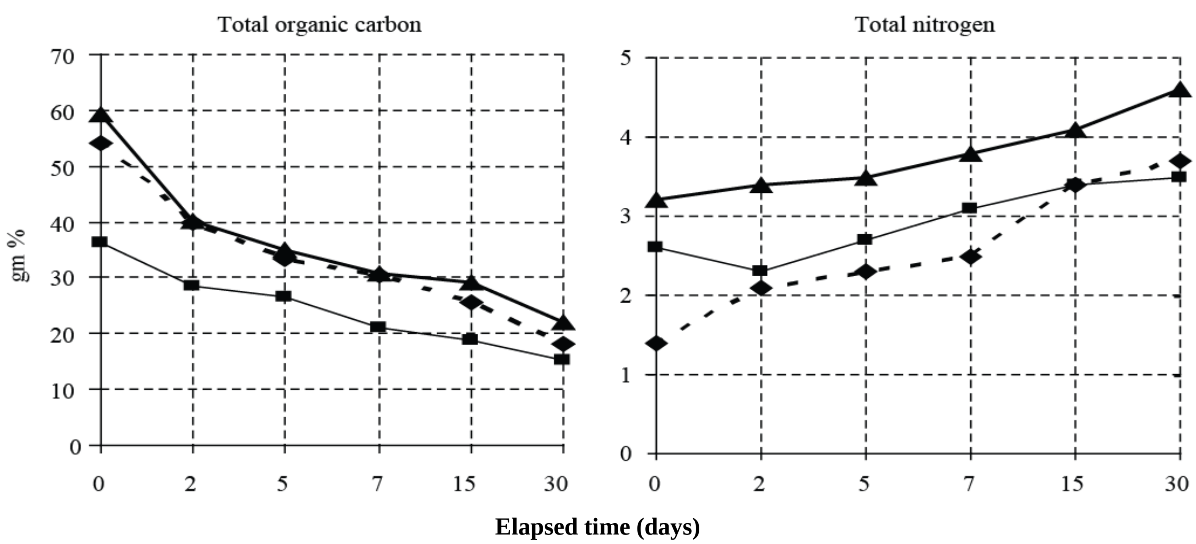

Fig. 1. Variations in total organic carbon and nitrogen content in three species of macroalgae (*E. intestinalis* (-♦-), *E. clathrata* (-■-) and *U. reticulata* (-▲-) during decomposition.

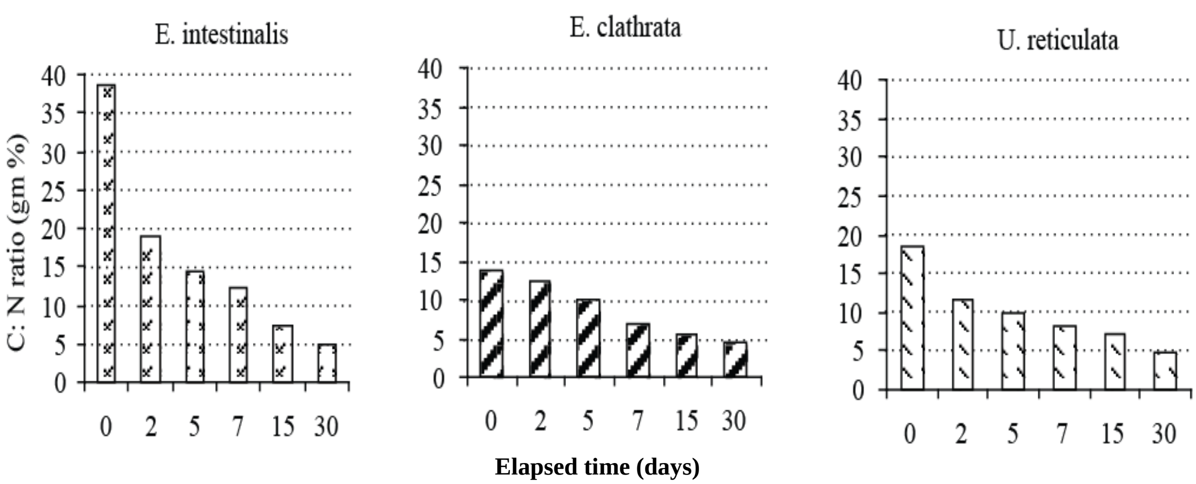

Fig. 2. Variations in C:N ratio with respect to elapsed time in three species of macroalgae during decomposition.

Table 1. Pearson correlation coefficient matrix showing relationship between changes in total organic carbon during decomposition of three species of macroalgae.

	E. intestinalis	*E. clathrata*
E. clathrata	***0.984	
U. reticulata	***0.993	***0.982

*** = Significant at probability 0.001

Table 2. Pearson correlation coefficient matrix showing relationship between changes in total nitrogen during decomposition of three species of macroalgae.

	E. intestinalis	*E. clathrata*
E. clathrata	***0.843	
U. reticulata	***0.962	***0.895

*** = Significant at probability 0.001

Table 3. Pearson correlation coefficient matrix showing relationship between changes in C:N ratio during decomposition of three species of macroalgae

	E. intestinalis	*E. clathrata*
E. clathrata	***0.902	
U. reticulata	***0.993	***0.93

*** = Significant at probability 0.001

Discussion

Macroalgae grow significantly over a large area of mud flats within the mangrove forest at Sandspit backwaters and along the Indus river delta. Algal puffs of *Cladophora* sp. are also recorded from a restricted area in Sandspit backwater in the mangrove forest (Siddiqui *et al.,* 2000). Such algal mats however are not significantly distributed in proximity of mangrove stands at Sonmiani Bay (personal observation). Presence of seaweeds at the former two sites may be associated with the high loads of nutrients in the industrial and domestic sewage being drained in these waters (Khan & Saleem, 1988; Rizvi *et al.,* 1988). In contrast to the higher plant detritus, for example, mangrove leaves (t_{50}= 16 to 48 days; Siddiqui & Qasim 1988; Siddiqui *et al.,* 2009), algal material being less fibrous, decomposes at a very high rate (t_{50} 2 to 6 days) (Shafique *et al*., 2010).

Fine algal strands provide more surface area for colonization of bacteria and fungi, the main decomposers of plant material (Suberkropp & Klung 1976; Zhuang *et al.,* 2000). Microbial colonization of detritus on one hand determines the rate of decomposition (Fell & Master, 1973; Christoffersen *et al.,* 2002), while on the other hand, it improves the nitrogenous value of the detritus (Fell & Master, 1973) and thus reduces C:N values as recorded in this study. Given that algal mats covering considerable area, the continuous release of particulate and dissolved organic material from the mats may contribute significantly in the food web operating in the mangrove ecosystem. Increases in nitrogen content and decreases in C:N values during decomposition of algae is in good agreement with other studies on mangrove detritus and sea grasses (Nixon *et al.,* 1984; Shunula & Whittick, 2001; Valiela *et al.,* 1984). The fact that nitrogen content of algal detritus increases may suggest that algae forms suitable food for may detritivorous, for example, gastropods as demonstrated earlier for sea grass detritus (Valiela *et al.,* 1984; Kharlamenko *et al.,* 2001; Russo *et al.,* 2002) where it has been shown that nitrogen values of detritus act as major queue in the choice of food. Gastropods (Cerithidea species) constitute on of the most abundant component in mangroves at Sandspit and Indus delta which consumes algal detritus better over mangrove leaf-detritus (Shafique, 2006).

The present study suggests that macroalgae with high initial nitrogen and low C:N ratio forms a more nutritive food to detritus feeders as compared to mangrove detritus (Lamare & Wing, 2001; Hoq *et al.,* 2002). Therefore, macroalgae appear to be a key component in mangrove environment taking part in the release of particulate and dissolved nutrients in water at a considerable rate and hence play very important role in nutrient dynamics and food web.

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