The seagrass and associated macroalgae at selected beaches along Dar es Salaam coast

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ABSTRACT

Intertidal seagrasses and macroalgae were studied at a sewage-polluted beach (Ocean Road) and a control site at Kunduchi beach, with a view to assessing the effect of sewage discharge on macrophyte species composition, abundance and above-ground biomass. A total of six species of seagrasses were recorded at Ocean Road of which two, *Thalassia hemprichii* and *Cymodocea rotundata* were the most abundant. Eight species of seagrasses were recorded at Kunduchi. Two species, *Syringodium isoetifolium* and *Thalassodendron ciliatum* were dominant in areas with strong oceanic influence. *Halodule wrightii* and *Halophila ovalis* were widely distributed in the two study areas. The mean biomass of seagrasses between Ocean Road and Kunduchi beaches was not significantly different ($z = 4.053$; $p = 0.001$; d.f. = 54). A total of 25 and 24 macroalgae species were recorded at Ocean Road and Kunduchi beaches, respectively. The total biomass of macroalgae was higher at Ocean Road than at Kunduchi ($t = 4.838$; $p>0.001$). While the biomass of brown macroalgae was higher at Kunduchi ($t = 2.115$; $p = 0.039$), that of red algae was similar at both sites ($t = 1.986$; $p = 0.052$). Of the 11 epiphytic species of macroalgae recorded on *T. ciliatum* at Kunduchi area, 73% were red algae, 18% green algae and 9% brown algae. The dominant species on this beach was the brown alga *Cystoseira myrica*. It was concluded that elevated levels of ammonium at Ocean Road is a likely cause of the observed higher biomass of green macroalgae at this site.

INTRODUCTION

Seagrasses are marine angiosperms that are adapted to live permanently submerged in seawater. Worldwide, there are about 58 known species (Bandeira, 1995; Richmond, 1997) and about 12 of them are found in the East African region (Phillips and Menez, 1988). In this region, the main seagrass beds are located in between the coral reefs, mangal ecosystems, and on reef flats (Uku, 1996).

Seagrasses occupy a wide range of substrates (mostly soft sediments) exploiting nutrients found within the sediment. Apart from stabilising the substratum, their most notable role is that they provide breeding, nursery and feeding areas for many invertebrates and vertebrate species, many of which are of commercial and recreational importance (Fortes, 1988; Walker, 1989). As a result both artisanal and commercial fishery activities in several parts of the world are carried out in seagrass beds (Bandeira, 1995). A large proportion of their biomass goes into the detritus food chain (Walker, 1989). In some parts of the world (such as Philippines and Kenya), seagrasses are also used directly for making paper, green manure and fodder (Thayer et al., 1975; Coppejans et al., 1992; Bandeira, 1995).

Worldwide, seagrasses are subjected to stresses resulting from human activities, among them is sewage disposal. The use of coastal areas as dumping ground for domestic sewage and industrial discharge poses a threat to this ecosystem. Apart from organics, chlorine and some heavy metals, this discharge contains inorganic nutrients, in particular nitrogen and phosphate (Lobban and Harrison, 1994). In small volumes and with adequate diffusing pipes, it is difficult to detect any long-term effect of nutrient on the seagrass communities. However, in large volumes and in semi-enclosed embayments, high nutrient levels can be destructive.

Like in many tropical regions, the Dar es Salaam coast has well developed seagrass communities (Semesi and Shushu, 1988). One of its beaches, Ocean Road area receives domestic sewage through a pipe that drains the city centre. This pipe discharges onto the mud flats that are exposed at low tides from several leaks in the pipe. Therefore the intertidal seagrasses of the area are prone to the effects of sewage because they lie close to the outfall pipe. Another area, Kunduchi, located about 25km north of Ocean Road area, receives no direct sewage discharge.

The present study set out to investigate the effect of elevated nutrient levels resulting from sewage discharge on the composition and biomass of macroflora. To achieve this objective, Ocean Road was selected as the test site and Kunduchi as the control site.

MATERIALS AND METHODS

Study sites

The study sites were Ocean Road and Kunduchi along Dar es Salaam coast. Ocean Road is on the northern side of the Dar es Salaam Harbour (Figure 1), a short distance from the entrance to the harbour. This beach extends northwards to the mouth of Msimbazi creek. To the south, the beach is protected from open sea by the Kigamboni headland as a result of change of the coastal alignment across the harbour, and Inner and Outer Makatumbe islands. The substrate is diverse, but mainly consists of coarse/ medium sand; at other places, however, one sinks knee-deep in the mud.

The intertidal mudflat of Kunduchi is located off Silver Sands Hotel (about 1km north of Kunduchi Marine Biological Station, Figure 1). During the rainy season the area receives discharges from Tegeta River and the water becomes extremely turbid. This condition may prevail throughout the rainy period, but as the flow decreases the creek is sealed off for most of the year by the shifting sand. The sediment consists of

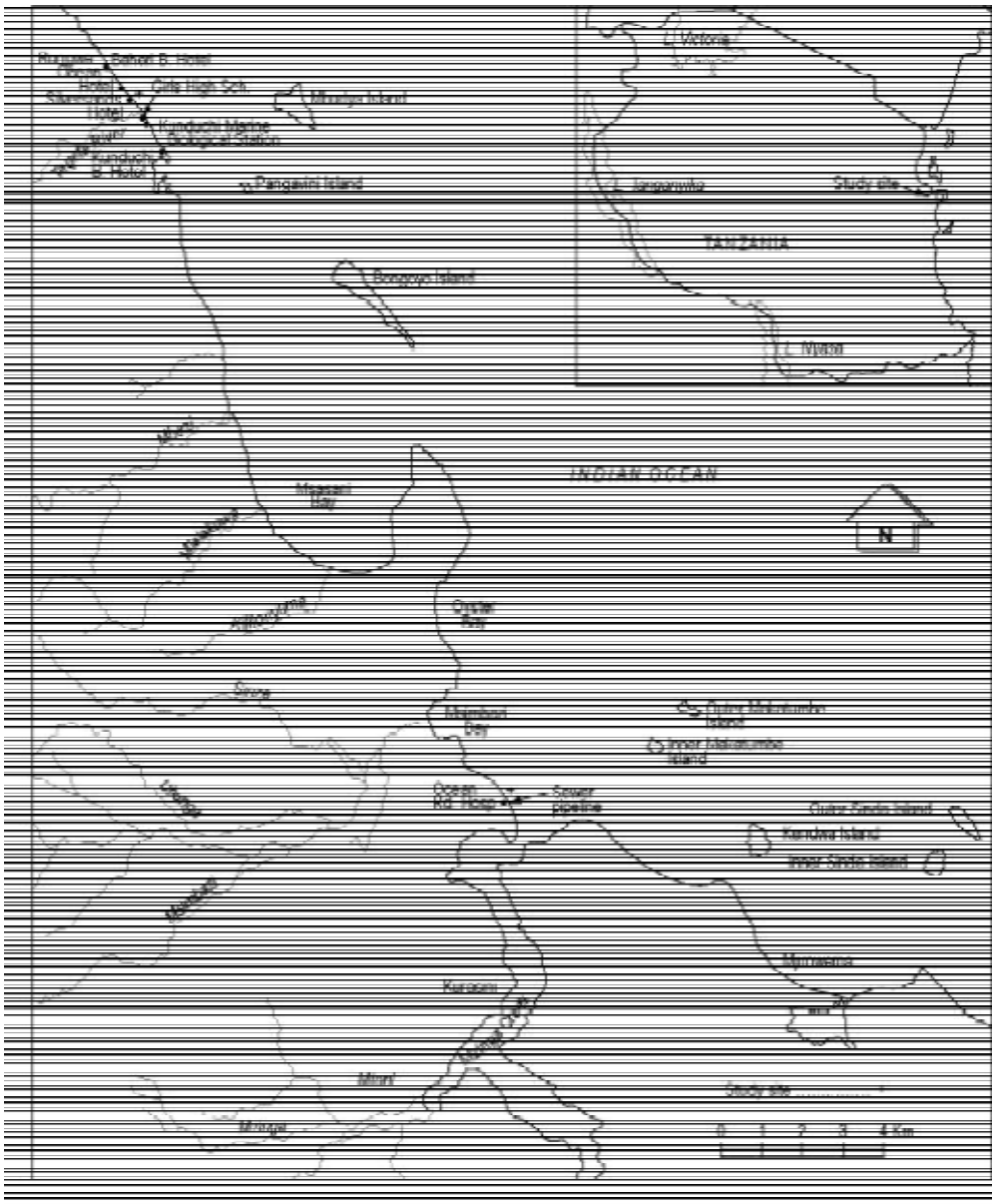


Figure 1. A map of Dar es Salaam coast showing study sites

fine sand except during the rainy season when fine mud persists. Well developed, mixed seagrass beds occur at both sites.

Sampling stations

Three transects were established at each study site. The transects were perpendicular to the shore and extended seaward from the upper seagrass zone to 100m, and were 150m apart. At Ocean Road area the three transects were established northwards from the sewage outfall pipe while at Kunduchi area, the transects covered the area in front of Silver Sands Hotel, to the area adjacent to Rungwe Oceanic Hotel.

Sampling was undertaken monthly for over one year starting from August 1996 to July 1997 (except June 1997). In most cases, sampling was carried out during the low spring tides as this was when the seagrass beds were exposed and easily accessible.

Seagrass and algal species composition, biomass and abundance

A taxonomic survey of seagrasses and associated algae was undertaken along the line transects. A quadrat measuring 0.0625m^2 was placed at intervals of 10, 30, 50, 70, and 90m from the upper seagrass limit in the intertidal area towards the sublittoral zone. Identification of floral species was undertaken with the help of botanical keys by Isaac and Isaac (1968), den Hartog (1970), Jaasund (1976), Phillips and Menez (1988), Moorjani and Simpson (1988).

To determine biomass, samples of seagrasses and the associated macroalgae were cropped from the quadrat and sealed in numbered bags and taken to the laboratory. The seagrass samples were divided into leaves and rhizomes. The leaves and the macroalgae were oven-dried at 65°C to a constant weight. This provided the estimate of the above-ground and macroalgae biomasses.

The abundance was expressed as a percentage, calculated as the number of quadrats in which a particular species was observed divided by the total number of quadrats sampled in the area over the study period and multiplied by one hundred.

Nutrient analysis

Seawater samples were collected in 100ml plastic bottles washed with 10% hydrochloric acid. The samples were filtered through GF/C microfibre filters and then frozen at -20°C to avoid metabolism by microorganisms (Uku, 1996). The inorganic nitrate, ammonium and phosphate were determined using methods described by Parsons et al. (1989). All the reagents used were of the analytical grade.

To determine pore water nutrient, a corer of 6.8cm diameter and 10cm length was used to sample the sediment to a depth of 5cm. Samples were taken to the laboratory where plant parts, living macrofauna, shells and large stones were removed. Pore water was subsequently extracted by suction using a vacuum pump and followed by filtration using Whatman GF/C filters. The filtrate obtained was analysed for ammonium and phosphates as detailed in Parsons et al. (1989).

Temperature, salinity, pH, DO and BOD

During each field visit, the surface water temperature, salinity and pH were recorded at each sampling point. Dissolved oxygen (DO) and biological oxygen demand (BOD) were determined by the Winkler method (Parsons et al., 1989).

Data collected were analysed statistically using the following tests: t - test or its non-parametric equivalent, Mann-Whitney U-test (Zar, 1984) and Friedman's non-parametric randomised block ANOVA. All statistical inferences were based on a significance level of $\alpha = 0.05$.

The z symbol was used for Mann-Whitney test instead of U symbol because the d.f. exceeded 40.

RESULTS

Species composition, abundance and biomass of seagrasses

The families Potamogetonaceae and Hydrocharitaceae were well represented at both sites. All seven seagrass genera known for the tropical Indo-West Pacific (den Hartog, 1970) were represented among the 9 species identified. Table 1 shows the seagrass species and their overall abundance recorded during the study. A total of six species of seagrasses were recorded at Ocean Road of which *Thalassia hemprichii* and *Cymodocea rotundata* were the most abundant. Eight species were recorded at Kunduchi, with two, *Syringodium isoetifolium* and *Thalassodendron ciliatum*, being dominant.

Table 1. Seagrass species composition and abundance at Ocean Road and Kunduchi areas

	Ocean Road transects			Kunduchi transects		
Species	OR1	OR2	OR3	K1	K2	K3
Thalassodendron ciliatum	-	-	-	-	6+	6+
Cymodocea serrulata	-	-	-	1+	5+	3+
Cymodocea rotundata	6+	6+	6+	-	2+	3+
Syringodium isoetifolium	-	-	-	2+	6+	6+
Enhalus acoroides	-	-	6+	-	-	-
Thalassia hemprichii	3+	6+	6+	-	3+	1+
Halophila ovalis	4+	3+	-	3+	1+	-
Halodule wrightii	3+	5+	-	6+	3+	2+
Halodule uninervis	2+	3+	-	6+	2+	3+
Total number of species	5	5	3	5	8	7

-: absent in all quadrats sampled per transect throughout the year.
1+: present in 1–9% of all of the quadrats sampled per transect during the year.
2+: present in 10–19% of all of the quadrats sampled per transect during the year.
3+: present in 20–29% of all of the quadrats sampled per transect during the year.
4+: present in 30–39% of all of the quadrats sampled per transect during the year.
5+: present in 40–49% of all of the quadrats sampled per transect during the year.
6+: present in 50% and over for all quadrats sampled per transect during the year.

The highest mean biomass value (±SD) recorded was 135.29 ± 37.29g dw/m^2 and the lowest was 0.25 ± 0.44g dw/m^2. Seasonal fluctuation in biomass was not significant ($z = 4.08$; $p > 0.05$; $z = 4.0483$; $p < 0.05$ at Ocean Road and Kunduchi, respectively). Also, a Mann-Whitney U test showed that mean biomass at the two study areas was not significantly different ($z = 4.053$; $p > 0.05$). Friedman's randomised block ANOVA revealed that the distribution of seagrass across these beaches was significantly different ($\chi^2 = 22.036$; d.f. = 4, $p = 0.000$; $\chi^2 = 38.594$; d.f. = 4; $p < 0.001$) for Ocean Road and Kunduchi areas respectively. This test was followed by Dunn's multiple comparison test using InStat statistical program (Table 2).

Table 2. Results of Dunn's multiple comparisons test for difference in biomass of seagrass between pairs of stations (For each station, n=11)

Ocean Road area	Station	1	2	5	3	4
	Rank-sum	13	30	37	42	43
Kunduchi area	Station	1	2	3	4	5
	Rank-sum	11.5	26.5	31	41	55

Species composition, abundance and biomass of macroalgae

Table 3 shows the species of macroalgae and their overall abundance at Ocean Road and Kunduchi. A total of 25 and 24 species were recorded at Ocean Road and Kunduchi, respectively. Of the 24 species recorded at Kunduchi, 11 occurred as epiphytes on *Thalassodendron ciliatum* (Table 4). *Ulva reticulata*, *Chaetomorpha indica* and *Enteromorpha ramulosa* occurred in all transects at Ocean Road with *Ulva reticulata* being the most abundant. The biomass of green algae at Ocean Road was significantly higher than at Kunduchi ($t = 4.8380$; $p = 0.001$; d.f. = 54).

Conversely, the biomass of brown macroalgae at Kunduchi was significantly higher than at Ocean Road ($t = 2.1152$; $p = 0.039$; d.f. = 54). However, the biomass of red algae at the two areas was not significantly different ($t = 1.9862$; $p = 0.052$; d.f. = 54). Red algae were the most represented group (19 species) followed by green algae (9 species). Brown algae were the least represented. Generally, the macroalgal biomass was relatively lower than seagrass biomass.

Physico-chemical parameters

Data on some meteorological and other physico-chemical parameters are presented in Figure 2. The water temperature ranged from 24 to 35°C, salinity from 16 to 37‰, pH from 6.9 to 8.6, dissolved oxygen from 2.42 to 3.86mg/l and BOD from 0.1 to 3.1mg/l.

Table 3. Species composition and abundance of macroalgae at Ocean Road and Kunduchi

	Ocean Road transects			Kunduchi transects		
Species	OR1	OR2	OR3	K1	K2	K3
Green macroalgae						
Caulerpa sertularioides (Gmelin) Howe	1+	-	-	-	-	-
Chaetomorpha crassa (Ag.) Kütz.	1+	1+	-	2+	1+	1+
Chaetomorpha indica Kütz.	1+	1+	1+	-	-	1+
Cladophora fascicularis (Mert.) Kützing	-	1+	-	-	1+	1+
Enteromorpha ramulosa (J.E. Smith) Hooker	2+	1+	1+	1+	1+	-
Ulva fasciata Delile	1+	1+	1+	-	-	1+
Ulva reticulata Forskaal	3+	2+	2+	1+	1+	1+
Udotea palmetta Descaine	-	-	-	1+	-	-
Udotea orientalis Weber van Bosse	-	-	-	1+	-	-
Brown macroalgae						
Cystoseira myrica (Gmelin) C. Agardh	-	-	-	2+	3+	3+
Dictyota divaricata Lamouroux	1+	-	1+	-	-	-
Padina gymnospora (Kütz.) Vickers	-	-	1+	-	-	1+
Stoechospermum marginatum (Ag.) Kütz.	1+	-	-	-	-	-
Spatoglossum aspermum J. Ag.	1+	-	1+	-	-	-
Sargassum torvum J. Agardh	-	1+	1+	2+	2+	2+
Red macroalgae						
Acrosorium amphiroae Jaasund	-	1+	1+	-	-	-
Amphiroa fragilisima (L.) Lamouroux	-	-	-	1+	-	-
Ceramium codii (Richards.) Feldmann-Mazoyer	-	-	-	1+	1+	-
Gelidiella acerosa (Forsk.) Feldmann et Hamel	-	-	-	-	1+	2+
Gellidiopsis variabilis (Grev.) Schmitz	-	-	-	-	1+	1+
Gracilaria corticata J. Agardh	-	1+	1+	1+	2+	2+
Gracilaria crassa Harvey	-	-	1+	-	-	-
Gracilaria millardetii J. Agardh	-	-	-	-	-	1+
Gracilaria sp.	-	1+	1+	-	1+	-
Halymenia venusta Börgesen	-	1+	-	-	-	-
Hypnea cornuta (Lamour.) J. Agardh	1+	1+	-	-	-	-
Hypnea hamulosa (Turn.) Montagne	-	-	1+	-	1+	1+
Hypnea musciformis (Wulfen) Lamouroux	1+	1+	-	1+	1+	-
Hypnea ridifica J. Agardh	-	-	1+	-	-	-
Jania adherens Lamouroux	1+	1+	1+	1+	1+	1+
Sarconema scinaioides Börgesen	-	-	1+	-	-	-
Sarconema filliforme (Sonder) Kylin *sensu* Papenfuss and Edelstein	-	-	1+	-	1+	2+
Soliera robusta (Grev.) Kylin	-	-	1+	-	-	-
Wrangelia bicuspidata Börgesen	-	-	-	1+	2+	2+

-: absent in all quadrats sampled per transect during the year.
1+: present in 1–9% of all the quadrats sampled per transect during the year.
2+: present in 10–19% of all the quadrats sampled per transect during the year.
3+: present in 20–29% of all the quadrats sampled per transect during the year.
OR1, OR2, OR3: transects 1, 2, 3 at Ocean Road; K1, K2, K3: transects 1, 2, 3 at Kunduchi.

Table 4. Epiphytic macroalgae found on the seagrass *Thalassodendron ciliatum* at Kunduchi area. R = red alga; B = brown alga; G = green alga

Species	Group
Chaetomorpha indica (Ag.) Kütz.	G
Ulva fasciata Delile	G
Padina gymnospora (Kütz.) Vickers	B
Wrangelia bicuspidata Börgesen	R
Gelidiella acerosa (Forsk.) Feldmann et Hamel	R
Gelidiopsis sp.	R
Herposiphonia insidiosa (Grev.) Falkenberg	R
Hypnea musciformis (Wulfen) Lamouroux	R
Ceramium sp.	R
Gracilaria corticata J. Agardh	R
Jania adherens Lamouroux	R

Nutrients in the water column

The highest mean concentration of nitrate (±SD) recorded was 2.41 ± 0.14μM and the lowest was 0.18 ± 0.02μM at Ocean Road (Figure 3). At Kunduchi, mean nitrate concentration was 2.41μM and the lowest was 0.22μM (Figure 3). At both sites, the nitrate levels during the rainy season were significantly higher than during the dry season (Ocean Road: $t = 4.5794$; $p = 0.0004$; d.f. = 14; Kunduchi: $t = 3.6222$; $p = 0.0028$; d.f. = 14). The levels of water nitrate were higher at Kunduchi than at Ocean Road ($t = 4.9099$; $p = 2.5817 \times 10^{-5}$; d.f. = 29).

At Ocean Road, the highest mean level of ammonium recorded was 8.9μM (Figure 3). The difference in ammonium levels between the dry and rainy seasons was not significant ($t = 1.8771$; $p = 0.0815$; d.f. = 14). The highest mean level of ammonium at Kunduchi was 2.01μM (Figure 3). The levels recorded in the rainy season were significantly higher than in the dry season ($t = 2.5251$; $p = 0.0243$; d.f. = 14). Overall, the ammonium levels in the water column at Ocean Road were significantly higher than at Kunduchi ($t = 3.997$; $p = 0.0002$; d.f. = 29).

At Ocean Road area the highest phosphate level (±SD) recorded was 1.47 ± 1.24 μM (Figure 3). The levels of water column phosphate during the rainy and dry season was not significantly different ($t = 0.9199$; $p = 0.3732$; d.f. = 14). At Kunduchi, the highest recorded mean value (±SD) was 0.87 ± 0.04μM (Figure 3). The levels of water column phosphate during the rainy period were significantly higher than those of the dry period ($t = 7.7148$; $p = 0.001$; d.f. = 14). The water column phosphate levels at the two study areas was not significantly different ($t = 1.2186$; $p = 0.2328$; d.f. = 29).

Nutrients in the pore water

At Ocean Road, the mean pore water ammonium peaked in March when a mean of 77.01μM was recorded (Figure 3). There was no significant difference between the pore water ammonium recorded in the rainy period and in the dry period ($t = 1.2798$; $p = 0.2214$; d.f. = 14). At Kunduchi area, the highest mean concentration recorded

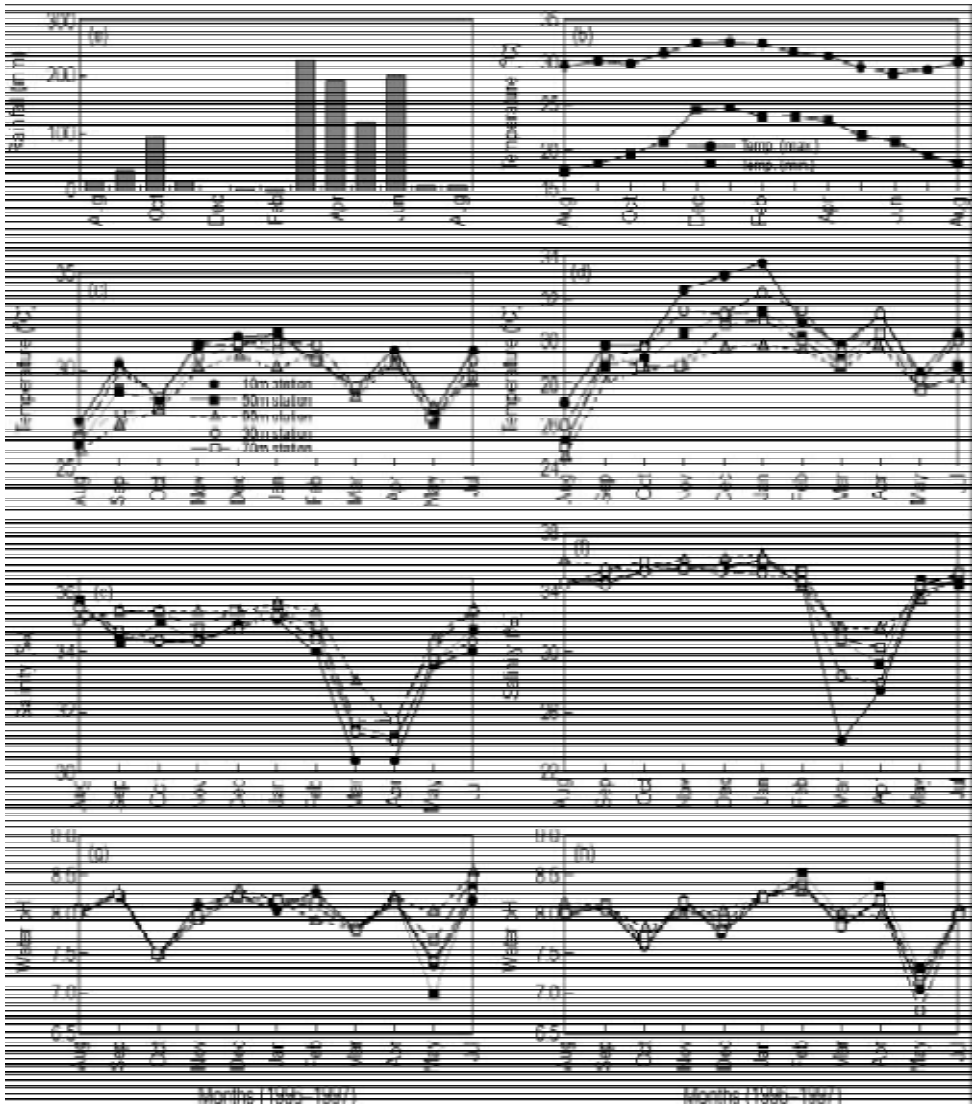


Figure 2. Variations in (a) rainfall, (b) air temperature, (c) water temperature at Ocean Road, (d) water temperature at Kunduchi, (e) salinity at Ocean Road, (f) salinity at Kunduchi, (g) water pH at Ocean Road, (h) water pH at Kunduchi during the sampling period. The distances shown in 2c apply to 2d through 2h

was 50.84μM (Figure 3). The ammonium recorded in the pore waters of Ocean Road was significantly higher than that of Kunduchi ($t = 2.9666$; $p = 0.0029$; d.f. = 29). The seasonal variations were not statistically significant ($t = 2.1174$; $p = 0.0523$; d.f. = 14). The levels of pore water ammonium were significantly higher than those of the water column at both study areas (Ocean Road: $t = 5.7088$; $p = 3.55 \times 10^{-6}$; d.f. = 29; Kunduchi: $t = 5.4621$; $p = 7.03 \times 10^{-6}$; d.f. = 29).

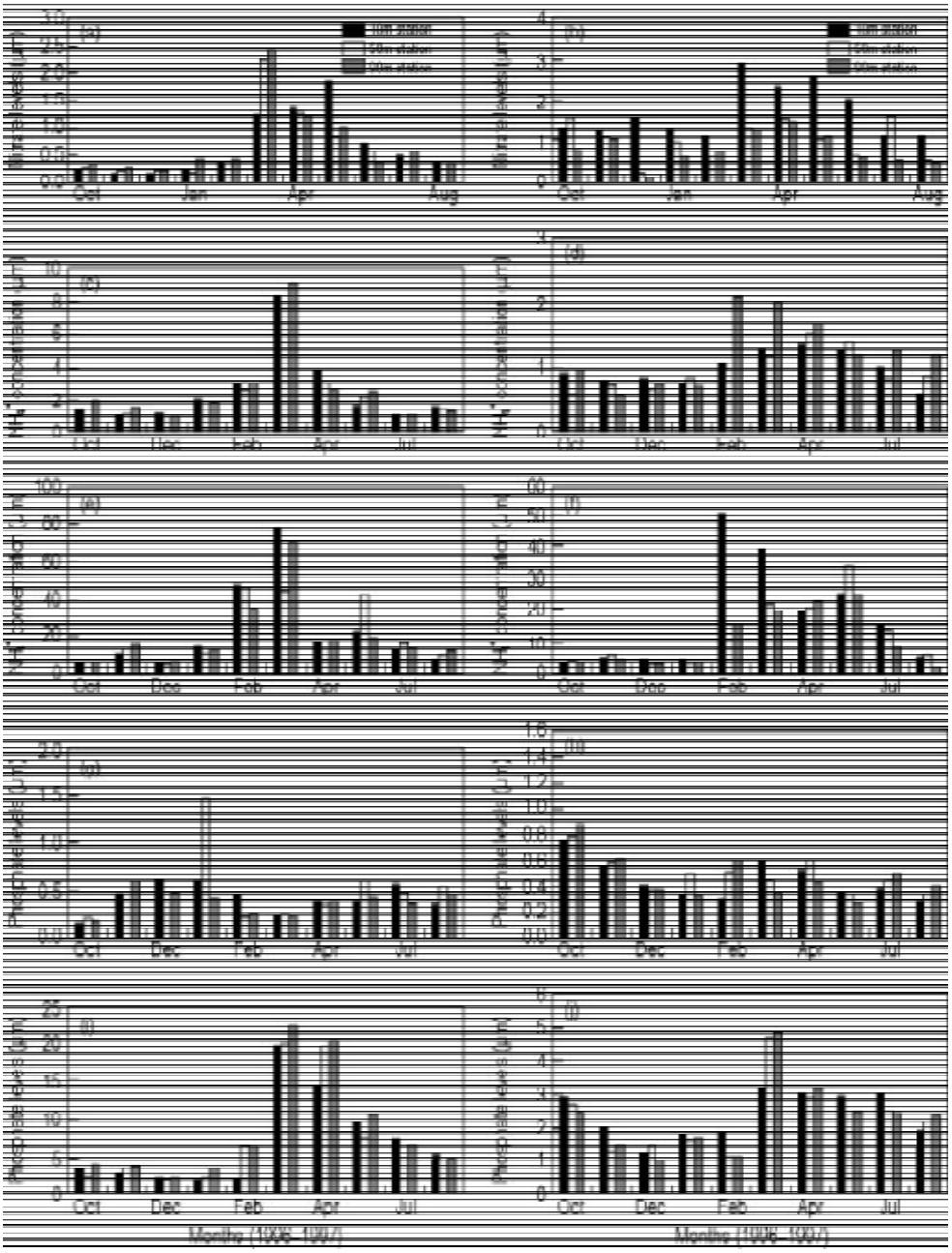


Figure 3. Variations in (a) water column nitrate at Ocean Road, (b) water column nitrate at Kunduchi, (c) water column ammonium at Ocean Road, (d) water column ammonium at Kunduchi, (e) pore water ammonium at Ocean Road, (f) pore water ammonium at Kunduchi, (g) water column phosphate at Ocean Road, (h) water column phosphate at Kunduchi, (i) pore water phosphate at Ocean Road, (j) pore water phosphate at Kunduchi

A highest mean pore water phosphate concentration (±SD) of 22.16 ± 7.24μM and 4.92 ± 0.21μM was recorded at Ocean Road and Kunduchi, respectively (Figure 3). The levels of pore water phosphate recorded in the rainy period were significantly higher than during the dry season ($t = 4.6951$; $p = 0.0003$; d.f. = 14). The levels of pore water phosphate at Ocean Road area were significantly higher than at Kunduchi ($t = 4.9076$; $p = 0.000$; d.f. = 29). Furthermore, the levels of pore water phosphate were significantly higher than those of the water column at both sites (Ocean Road: $t = 5.9651$; $p = 0.001$; d.f. = 29; Kunduchi: $t = 5.9759$; $p = 0.001$; d.f. = 29).

DISCUSSION

Seagrass species composition, abundance and distribution

The fluctuations in environmental factors at different zones of the intertidal area are responsible for the distribution of some species encountered during this study. For example, seagrass species like *H. uninervis* which is tolerant to fluctuations in salinity (den Hartog, 1970) was found at the beach end of Kunduchi area where salinity was normal during dry season, and dropped in abundance during rainy season due to the influence of the Tegeta River.

The seagrass distribution at both study areas is more or less similar to that described by den Hartog (1977). The smaller species, i.e. the parvozosterids (*Halodule* spp.) and halophilids (*Halophila* spp.) inhabit the upper levels of the beach. The coarser magnozosterids (*Thalassia* sp. and *Cymodocea* spp.) and amphibolids (*Thalassodendron* sp.) were found in the seaward sections of the transects.

Thalassia hemprichii and *Cymodocea rotundata* were the dominant seagrass species at Ocean Road area. At Kunduchi area, *Thalassodendron ciliatum*, *Syringodium isoetifolium* and *Halodule uninervis* were the dominant species. *Halodule wrightii* dominated the seagrass community only in limited areas where physical conditions precluded dense stands of *T. hemprichii* and *C. rotundata*. In a similar work in Florida, Lapointe et al. (1994) concluded that *Thalassia testudinum* is an indicator of oligotrophic conditions while *Halodule wrightii* is an indicator of eutrophic conditions. The occurrence of several species of seagrasses at Ocean Road and the lack of dominance of *H. wrightii* might indicate that Ocean Road area has not yet experienced the shift in seagrass species that is typical of eutrophic areas. It might also indicate that *H. wrightii* does not always dominate eutrophic areas as reported by Lapointe et al. (1994). *Halodule wrightii* was dominant in the shores of Kunduchi. However, its association with other species points to the influence of other physico-chemical factors other than eutrophication.

Although Ocean Road receives sewage discharge, seagrasses grow well in the intertidal area indicating that the concentrations of nutrients have not yet reached limiting levels that would lead to dominance of macroscopic algae and phytoplankton. This could be attributable to high flushing rates of sewage in the area such that few, if any, nutrients were reaching the intertidal area.

Seagrass biomass

The seagrass community at Ocean Road occurs in patches. As a result there is no uniform pattern in biomass distribution among the transects. This patchy distribution is either due to deterioration of a once-continuous meadow, or to an environmental limitation. Physical removal of seagrass by researchers, local fishermen in search of baits and/or some edible mollusc and octopus (pers. observ.) can lead to substantial damage.

The seaward increase in biomass observed at Kunduchi transects can be attributed to the size distribution of the species (Uku et al., 1996). The smaller species like *Halophila* spp. and *Halodule* spp. contributed to the low biomass levels at the beach end while the larger species like *Syringodium isoetifolium* and *Thalassodendron ciliatum* contributed to the higher biomass seaward (Uku, 1996).

Biomass and productivity of seagrasses exhibit seasonal variation, which has been attributed to periodical fluctuation of environmental factors such as light, nutrient availability, temperature, salinity, herbivory and hydrological conditions. However, there were no variations in biomass with seasons in either study area. Being within the tropics, the comparatively uniform temperature and day length allow rather constant growth throughout the year and consequently a uniform biomass throughout the year (Stapel, 1997).

Macroalgae species composition, abundance, distribution and biomass

The higher biomass of green macroalgae observed at Ocean Road compared to Kunduchi area could be explained by the algae's response to high levels of nitrogen in the water column. Although the nitrate level in the water column at Ocean Road was lower than at Kunduchi area, there was a significantly higher level of ammonium in the water column at Ocean Road. Usually ammonium is the preferred form of nitrogen and is generally taken up in preference to all other nitrogen sources (Lobban and Harrison, 1994). Response of seaweeds to high nutrient levels is well documented (Sawyer, 1965; Tewari, 1972; Waite and Mitchell, 1972; Harlin and Thorne-Miller, 1981; Lobban and Harrison, 1994). Harlin and Thorne-Miller (1981) observed a bloom of *Enteromorpha plumosa* and *Ulva lactuta* in response to nitrate and ammonium enrichment.

The epiphytic macroalgae found in this study showed an exceptional preference for the stems of *Thalassodendron ciliatum*. The rough surface of the stems renders them suitable for the settlement of algal spores and, unlike leaves which are shed off easily, the longevity of the stems provides an opportunity for the algae to grow (Semesi, 1988; Uku et al., 1996). Similar observation of high epiphytic algae biomass on the stems of *T. ciliatum* was reported by Uku et al. (1996) in Diani and Galu beaches, Kenya. They suggested that the high epiphytic load recorded at these beaches was due to the availability of appropriate substratum rather than the effect of eutrophication. This could explain the situation prevailing at Kunduchi area, where the highest epiphytic macroalgal biomass was recorded in the seaward end where *T. ciliatum* occurred.

Nutrients

In this study, the floral communities appear unable to remove all nutrients from the water column, as significant measurable levels were detectable. This suggests that there are surplus nutrients not being utilised by the communities. This indicates that the significant nutrient levels recorded in the study areas must have an external source other than the ocean itself. The influence of sewage at Ocean Road area and seasonal stream inflow at Kunduchi area are possibly the major sources of nutrients. There could also be ground water input into the area. The activity of nitrogen fixing cyanobacteria present in the waters could also be of importance (Bryceson, 1977; McClanahan, 1988; Lyimo, 1995).

The significant high pore water nutrient levels recorded under this study compared to those of the water column conforms with observation made by other authors (Stapel, 1997; Harlin and Thorne-Miller, 1981), and seem to confirm that sediment pore water nutrients are the primary source of nutrient for seagrass growth (Johnson and Johnstone, 1995; Fourqurean et al., 1992). Uptake by phytoplankton, macroalgae and vascular plants (Uku, 1996; Stapel, 1997) could explain the low nutrient resource in the water column compared to the much higher resources in the pore water where macroalgae and phytoplankton have no direct access.

The seagrass communities under study appear to cope well with the elevated levels of nutrients, but it is unclear as to whether it would continue to tolerate further elevation of dissolved nutrient levels. Given the relative high nutrient levels observed and involvement of macroalgae biomass, it may be that the seagrass community of Ocean Road area are presently at their upper threshold for nutrient loading. In the long term, such stress may cause severe deleterious effects (Tomasko and Lapointe, 1991; Shepherd et al., 1989).

In conclusion, this study is in agreement with a previous study by Semesi and Shushu (1988), which concluded that the seagrass beds of Dar es Salaam consist of mixed seagrass species. Furthermore, the nutrient levels have not yet reached those of intense eutrophication which would result in monospecific seagrass beds, as reported elsewhere (Stapel, 1997). However, the abundance of green macroalgal species at Ocean Road points to elevated levels of nutrients in the area.

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