THE KUNDUCHI MANGROVE BASIN

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Abstract

The pattern of tidal submergence and exposure in the Kunduchi mangrove basin is determined by contour mapping and by relating the contours to published tide predictions. Salinity of the creek effluent is measured at spring and neap tides in both wet and dry seasons. The vegetation of the basin, up to the highest high water level, is described briefly.

Introduction

Kunduchi is a fishing village on the coast of the Tanzanian mainland at latitude 6° 40' S, approximately 18 Km north of Dar es Salaam. At this point the coastline is protected from the Indian Ocean swell by inshore reefs and islands and thus affords suitable habitats for the growth of mangrove communities. The mean annual rainfall is in the vicinity of 1050 mm — the nearest stations for which long-term records are available are Dar es Salaam, 1041 mm, and Bagamoyo, 1052 mm (East African Meteorological Department 1966) — with peaks in late March-May and November-December.

A small tidal creek flows into the ocean just south of Kunduchi village. It consists of a south arm and a west arm traversing a basin, much of which is below mean high water level and therefore subject to regular tidal submergence. The two arms merge about 1 Km from the mouth to form a creek 30-50 m broad (fig. 1A). Soils in the basin are of a coarse, sandy texture except for a small area along the western and southern fringe where a fine, silty clay predominates.

A map of the area (Ministry of Lands, Settlement and Water Development 1966) shows three creeks flowing into the basin, one of which, Manyema Creek, appears to be a continuation of the south arm of the tidal creek. However no creek or surface drainage channel can be seen flowing into the basin now, except for a small flow of seepage from a hill below a large village, Kunduchi Maweni, on the western side (fig. 1A).

The following study deals with two environmental factors in the mangrove basin : tidal submergence and salinity of the creek water. Investigations of soil factors will be described in a later publication.

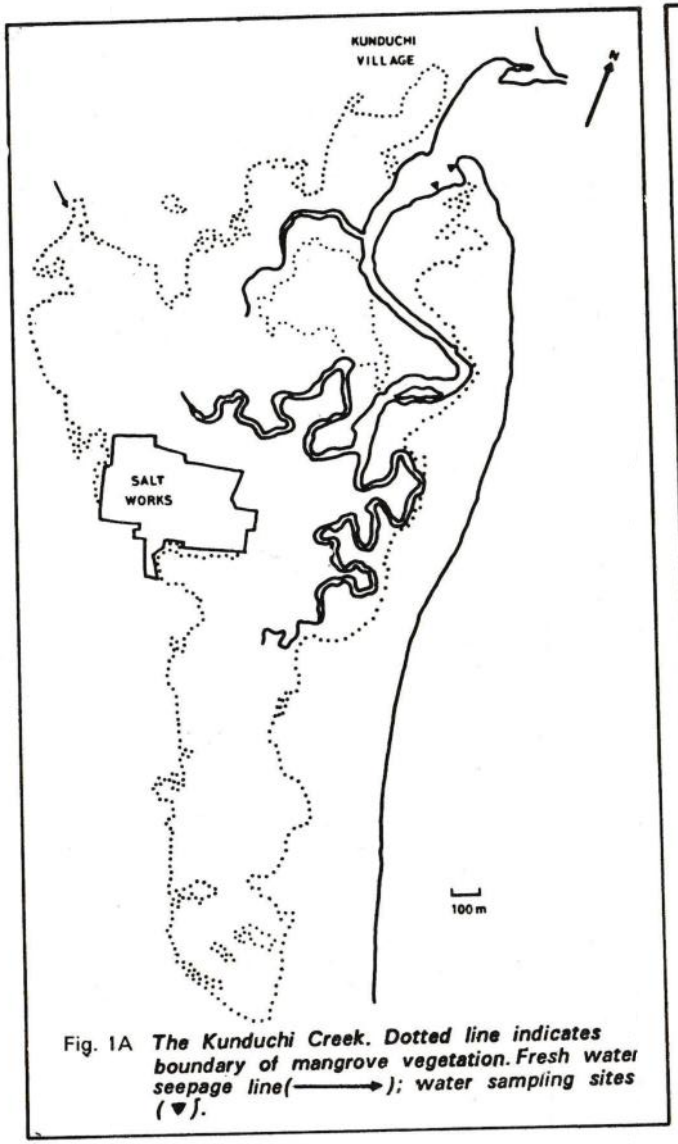

Fig. 1A *The Kunduchi Creek. Dotted line indicates boundary of mangrove vegetation. Fresh water seepage line(⟶); water sampling sites (▼).*

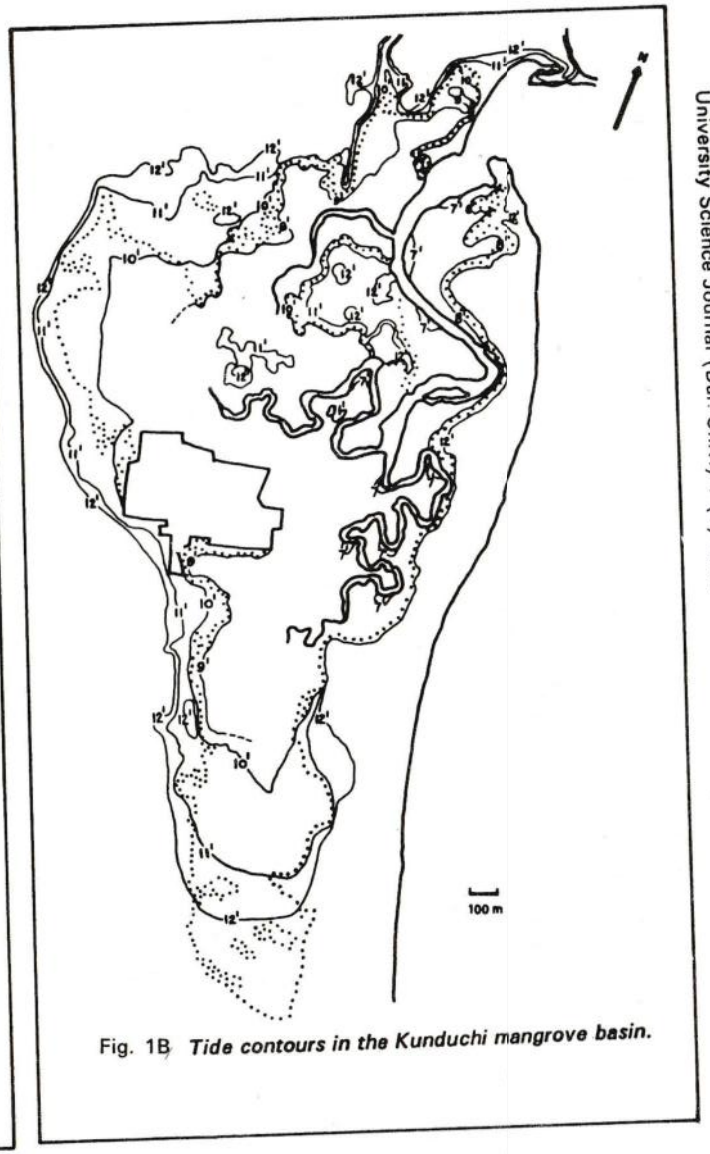

Fig. 1B *Tide contours in the Kunduchi mangrove basin.*

Tidal Submergence

Predicted heights of tides at Dar es Salaam are published annually (East African Harbours Corporation). Figures for two representative months, March and August, 1970, were graphed (fig. 2) and a rather complex tidal pattern was revealed. The cycle is synodic, with the spring tides lagging 1-3 days behind the full and new moons. Although there are two high tides and two low tides daily the pattern is not a classical semi-diurnal one (Macmillan 1966) but a mixed tide with a diurnal component which is more prominent at neap tides than at springs.

The tidal range for Dar es Salaam varied, in 1970, from 13.1 ft. (4.0 m) on 8 February and 17 September to 0.7 ft (0.2 m) on 16 March, with a mean range of 7.5 ft (2.3 m)*. It was observed that in the Kunduchi Creek the tide rises for a shorter period and falls for a longer period than in open water, as is usual in the case of estuaries. The fall of the tide near the creek mouth was measured on two days, 20 August, 1970 (spring) and 25 August, 1970 (neap) by taking readings at approximately hourly intervals on a scale nailed to a mangrove tree near the creek mouth. The scale was levelled against the predicted high water level for Dar es Salaam on 20 August (11.4 ft. at 0604 hrs). The results are shown in fig. 3, in which the heights of the high and low waters at Dar es Salaam are included for reference.

Vertical movement of water in the creek is less than the tidal range for Dar es Salaam harbour. The difference is due, at least in part, to a sand bar at the mouth of the creek which is about 6 ft above datum; thus at the lowest neap high water virtually no water enters the creek at all. A 7 ft. tide flows into the creek but is almost completely contained within its banks, while higher tides overflow the banks and submerge part of the mangrove basin. Contour lines marking the levels reached by tides of certain predicted heights were drawn on a map of the basin (fig. 1B). Along much of the eastern side the bank is steep and the 8-11 ft. contour lines virtually coincide with the boundary of the mangrove vegetation. On the western side and at the southern tip the slope is very gradual and broad zones with different frequencies of submergence can be distinguished.

Approximate numbers of submergences per annum and longest periods of continuous exposure at each 1 ft contour line are given in table 1. The figures are actual counts for the year 1971 prepared from tide tables (i.e. predicted heights).

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*Tide tables for the years up to and including 1971 were published in feet; from 1972 onwards a metric scale has been used.

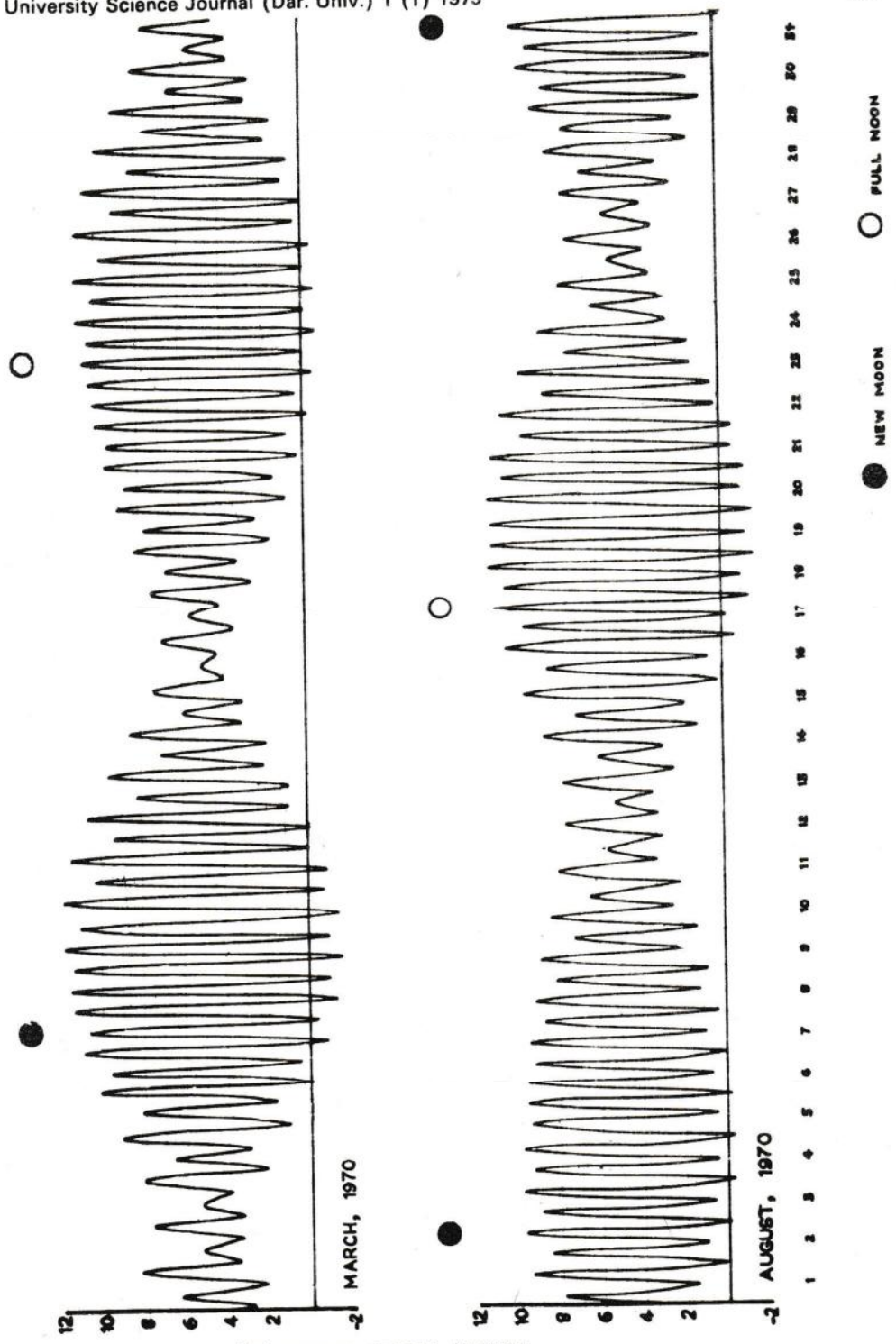


Fig. 2. *Tide curves for Dar es Salaam, March and August, 1970.*

TABLE 1

Tidal submergence and exposure at different contour levels

Contour level (ft.)	Submergences per annum	Longest exposure period (days)*
8	491	5½
9	327	9
10	165	13½
11	44	103
12	3	192**

* Actual values for 1971.
** In 1969-70 the tide did not reach this level at all.

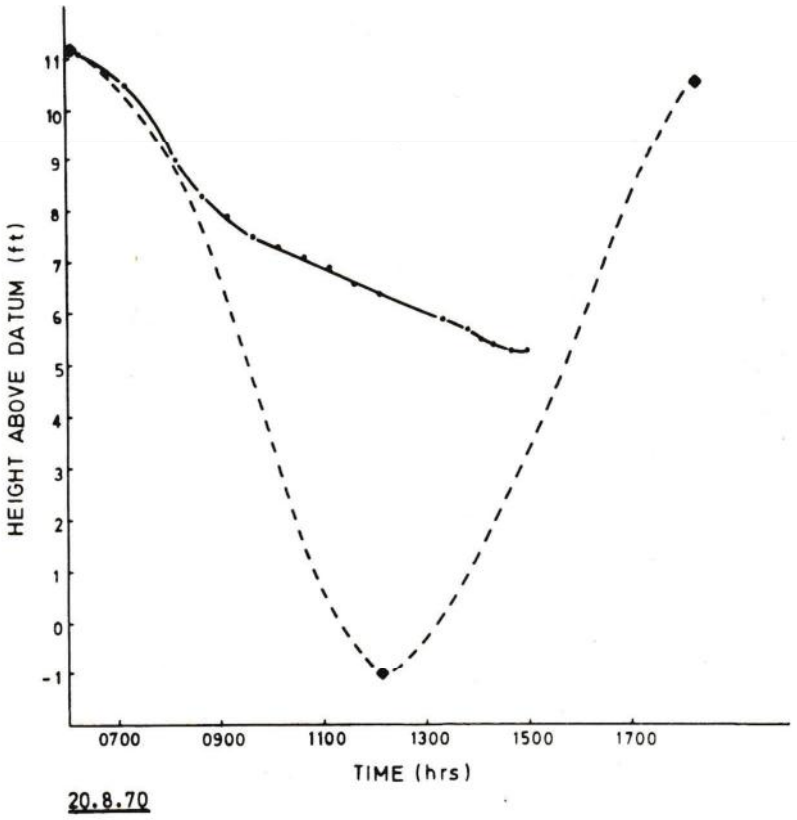
The pattern of submergence and exposure at any part of the basin may be determined by comparing its contour level (fig. 1B) with fig. 4, in which the height of the higher of every two consecutive high tides is plotted for one year (1971). It is apparent, for example, that a site at the 11 ft. contour is submerged once or on up to five consecutive days a month between late January and late May, and between early September and early December, and not at all during the remainder of the year, whereas a site at the 10 ft. contour is never exposed for more than 12 days consecutively.

Salinity

Water samples for determination of salinity were collected near the creek mouth at two sites (fig.1A). Sampling was carried out just below the surface of flowing water at the seaward fringe of the mangrove under the following conditions :

(a) at low water on three consecutive spring tides during the long rains (22 April — 23 May, 1970);
(b) at low water on three consecutive neap tides during the long rains (29 April — 29 May, 1970);
(c) at low water every day form one neap tide to the next during the dry season (13-25 August, 1970);
(d) at high water and at approximately 1-hourly intervals as the tide receded on two days in the dry season (20 August, 1970, spring tide, and 25 August, 1970, neap tide).

Chloride estimation was made by R. J. Best's Electrometric Titration Method (Piper 1942) and the corresponding salinity values were read off from published tables (Strickland and Parsons 1965). The results are given in tables 2-5.



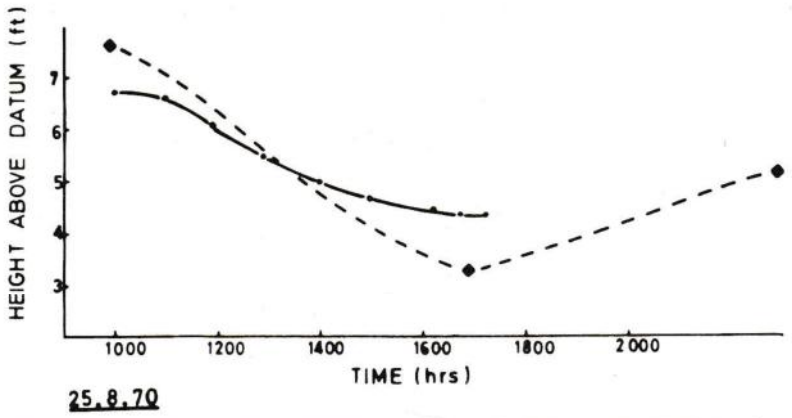


Fig. 3. *Fall of the tide in the Kunduchi Creek on 20.8.70 and 25.8.70 (•——•); published tide levels for Dar es Salaam (◆ — — —◆).*

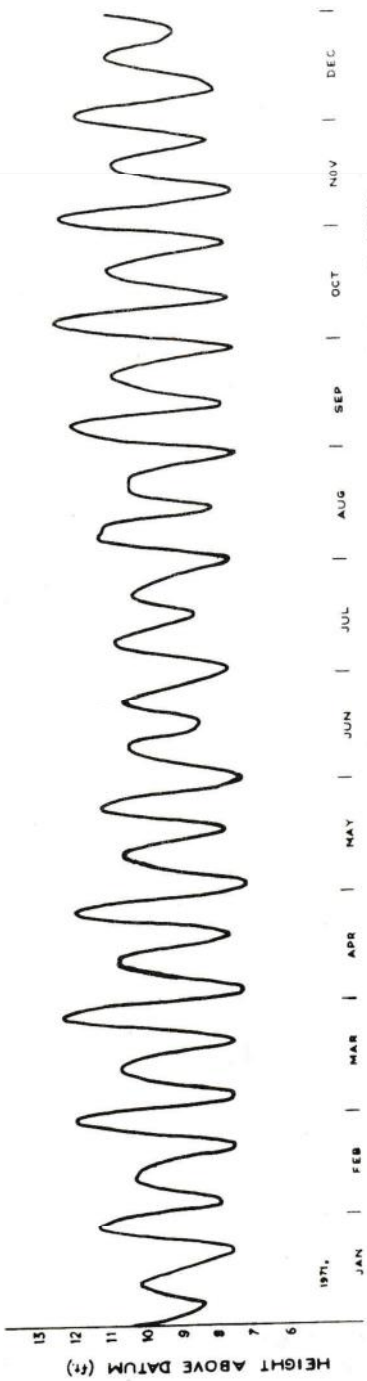


Fig. 4. *Height of the higher of every two consecutive tides at Dar es Salaam in 1971 (from published predictions).*

TABLE 2

Salinity of Kunduchi Creek effluent at low water during long rains

Date	Tide	L.W. (ft.)	Rainfall* (mm)	Salinity (‰)
22.4.70	spring	-0.2	17.3	28.1
6.5.70	spring	-0.1	44.5	19.9
23.5.70	spring	0.3	11.9	32.7
29.4.70	neap	3.2	7.9	32.8
14.5.70	neap	3.6	—	34.4
29.5.70	neap	2.4	—	28.6

* Total for previous two days at Wazo Hill Meteorological Station.

TABLE 3

Salinity of Kunduchi Creek effluent at low water during dry season

Date	Preceding H.W. (ft.)	Tides L.W. (ft.)	Rainfall* (mm)	Salinity (‰)
13.8.70	5.2	3.4	—	35.4
14.8.70	6.0	2.9	—	37.6
15.8.70	7.1	1.8	—	35.9
16.8.70	8.4	0.7	—	35.9
17.8.70	9.5	-0.2	—	35.6
18.8.70	10.4	-0.9	—	35.8
19.8.70	11.0	-1.2	—	35.8
20.8.70	11.2	-1.0	—	35.1
21.8.70	11.0	-0.5	—	35.4
22.8.70	10.5	0.3	—	35.4
23.8.70	9.6	1.4	—	35.3
24.8.70	8.6	2.5	—	35.6
25.8.70	7.6	3.3	—	35.3

* For previous two days at Wazo Hill Meteorological Station.

TABLE 4

Salinity of Kunduchi Creek effluent — receding tide series 20.8.70

High water — 0604 hrs, 11.2ft. Low water — 1208 hrs. — 1.0ft.

Time (hrs.)	Water Level* (ft.)	Salinity (‰)
0604	11.2	34.7
0704	10.6	34.6
0804	9.1	34.6
0904	7.9	34.9
1002	7.3	34.9
1104	6.9	34.9
1202	6.5	34.7
1332	5.8	35.3
1402	5.5	35.3
1502	5.3	35.1

* Levelled against the predicted high water level for Dar es Salaam harbour at 0604 hrs.

TABLE 5

Salinity of Kunduchi Creek effluent — receding tide series, 25.8.7.

High water — 0955 hrs, 7.6 ft. Low water — 1655 hrs, 3.3 ft.

Time (hrs)	Water level* (ft.)	Salinity (‰)
1000	6.7	34.7
1100	6.6	34.6
1155	6.1	35.8
1255	5.5	34.9
1400	5.0	36.3
1500	4.7	36.1
1615	4.5	35.1
1655	4.4	35.3

* Levelled against the predicted high water level for Dar es Salaam harbour at 0604 hrs on 20.8.70.

Salinity of the effluent was remarkably constant during the dry season. Of the 33 determinations made in August, 1970 (tables 3-5) all but one fell within the range 34.6-36.3‰. The mean value was 35.6‰. On 14 August an unusually high value of 37.6‰ was recorded. The values were virtually the same at spring and neap tides and there was little variation on one day as the tide receded (tables 4 and 5).

The values obtained here correspond closely with those of Newell (1957) for off-shore waters between Mafia and Pemba and Wickstead (1963) for shallow, inshore waters in the Zanzibar Channel, and thus verify that there is no signficant flow of fresh water into the Kunduchi basin during the dry season.

During the long rains the salinity was consistently below the dry season range, although it did reach 34.4‰ on 14 May. The lowest record, 19.9‰ on 6 May, was only 56% of the mean dry season value. Inspection of the figures in table 2 shows that the salinity on any one day bears some relation to the rainfall on the previous two days. The value of 34.4‰ recorded on 14 May is comparable with Wickstead's 34.2‰ at the same season in another year. This single result suggests that there is no signficant steady flow of fresh water into the basin even during the rainy season, and that the only fresh water which could influence the vegetation of the basin on a wide scale is that derived from rainfall in the basin itself and the immediate surroundings, which is flushed out by the tide within a few days of its falling.

It may be inferred, therefore, that the whole of the mangrove vegetation at Kunduchi, with the exception of the very small area below Kunduchi Maweni, is inundated by saline rather than brackish water and that its habitat combines the shelter of an estuary with the salinity of an open coastline.

Vegetation

The banks of the creek coincide very closely with the 7ft. tide contour. A mixed mangrove forest extends from the bank to the 9 ft. contour, being reduced to bushland height (see Pratt et al. 1966) on very well-drained sites. The following six species comprise these communities :

Sonneratia alba Sm. (Sonneratiaceae)
Rhizophora mucronata Lam. (Rhizophoraceae)
Ceriops tagal (Perr.) C.B. Robinson (Rhizophoraceae)
Bruguiera gymnorrhiza (L.) Lam. (Rhizophoraceae)
Avicennia marina (Forsk.) Vierh. (Avicenniaceae)
Xylocarpus granatum Koen. (Meliaceae)

Rhizophora mucronata and **Ceriops tagal** are the most abundant species, the latter rarely exceeding 4 metres in height and forming an almost continuous understorey in bushland areas. **Sonneratia alba** is abundant at the 7 ft. contour but drops out rapidly above. **Bruguiera gymnorrhiza** and **Xylocarpus granatum** extend approximately to the 9 ft.

contour and in the 9-10 ft. zone the vegetation consists of pure or mixed stands of **R. mucronata** and **C. tagal. Avicennia marina,** which is abundant in the mixed forest of the lower levels and virtually absent at intermediate levels where **Rhizophora—Ceriops** bushland predominates, reappears suddenly at the 10 ft. contour forming pure stands of woodland, very sharply demarcated from the adjacent bushland. On the outward fringe the trees of **A. marina** become progressively sparser and more stunted, with only isolated plants extending to the 11ft. contour, except at the southern end of he basin. Old trees 2-3 m in height are common on the outer fringe but the extreme stunting reported by Macnae (1968) at Inhambane, Mocambique, where this species forms copses rarely exceeding waist height, was not observed here. The 10-12 ft. zone, which is up to 100 m broad along the western margin, is colonised above the **Avicennia** by the prostrate, perennial dwarf shrub **Arthrocnemum indicum** Moq., which forms a continuous pink-tinged mat over extensive areas of sand and by an erect, succulent annual herb, **Salicornia pachystachya** (Bunge ex) Ungern-Sternb. which germinates during the long rains and dies off in October-November. In some seasons this species is very abundant whereas in other years it is difficult to find a single plant. Near the 12 ft. contour these halophytes give way to a sward of **Sporobolus virginicus** (L.) Kunth, a grass with extremely xeromorphic leaves.

On the eastern margin of the mangrove, where the bank is steep, mangrove forest gives way directly to terrestrial bushland, a few flat, occasionally submerged sandy areas being colonised by mats of **Sesuvium portulacastrum** Linn. or by the halophytic shrub, **Pemphis acidula** Forst.

Two species commonly associated with mangrove vegetation in East Africa, **Acrostichum aureum** L. and **Lumnitzera racemosa** Willd, occur in the area of fresh-water seepage. The former is quite confined to that site, whereas the latter is also represented by a few scattered plants at the extreme northern end of the swamp close to Kunduchi village.

The extent of the mangrove at the southern end of the basin is about 200 metres beyond the present highest high water level. This area supports **Avicennia marina** woodland, giving way to bushland of **A. marina** and **Suaeda monoica** Forsk. ex J.F. Gmel. at the margins, with patches of **Arthrocnemum indicum** in clearings within the bushland. The nature of this vegetation suggests that it was formed under conditions similar to those obtaining in the 10-11 ft. zone on the western side of the basin, and it is assumed that changes in the level of sand in the creek bed have recently cut this area off from tidal submergence. It is apparently low-lying, and rain water lies there for long periods in the wet season, becoming saline by dissolution of salts from the surface soil.

Discussion

Walter and Steiner (1936), who made extensive studies of mangrove vegetation at Tanga, Tanzania, distinguished between estuarine mangroves (Flussmündungs-Mangroven) and coastal mangroves (Küstenmangroven), a characteristic difference between the two types being the absence from the

former of a seaward fringe of **Sonneratia alba** which has a very low tolerance of variation in salinity. At Kunduchi the appearance of the mangrove basin is that of an estuary, the rise and fall of the tide follows an estuarine pattern, and the protection of the shoreline from wave action is virtually complete. However the absence of any significant fresh-water influence results in a mangrove habitat which is analogous to that characteristic of coastal rather than of estuarine mangroves. **Sonneratia alba** is abundant in the forest fringing the creek. Upstream, where tidal submergence is less frequent, conditions become progressively more saline rather than more brackish. The absence of **Heritiera littoralis** Dryand. in Ait., which is common in estuarine mangrove swamps of tropical Eastern Africa, and the extreme restriction of **Lumnitzera racemosa** and **Acrostichum aureum** are further pointers to the fact that the Kunduchi basin is not now (if it ever was) truly an estuarine habitat.

Xylocarpus granatum, however, which Walter and Steiner (1936) found to be associated with brackish conditions at Tanga, is abundant in the Kunduchi mangrove swamp. The salinity tolerance of this species merits further investigation.

Acknowledgements

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