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RESIPIENTVURDERING AV SJØOMRÅDET UTENFOR MOMBASA, KENYA

II Analysis of introductory samples of phytoplankton and benthic algae

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C O N T E N T S

FOREWORD

This is the second report sponsored by Norconsult A/S in connection with the Mombasa Water Pollution and Waste Disposal Study conducted for the Kenyan Government. The first report (December 3, 1974) gives a summary of information regarding biological resources which could possibly be affected by future sewage outfall. In addition a program was outlined for baseline and subsequent monitoring studies.

The present report comprises the results of analyses of a few samples of phytoplankton and benthic algae collected in October 1974. Taking into consideration the very few publications on algae from the Kenyan coast, it is felt justified to present the data as an initial introduction to the algal communities of the study area.

Mr. Erik Jaasund of Tromsø University, Norway, has been so kind as to identify the benthic algae. The plankton samples have been analysed by Mrs. Eli-Anne Lindstrøm. Thanks are due to Dr. G. Lambert, University of Durban, South Africa, for information on useful algological literature concerning East African benthic algae.

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1. INTRODUCTION

Published accounts of benthic marine algae in Kenya are few (Gerloff 1960; Wm. E. Isaac 1967, 1968, 1971; Isaac & Isaac 1968; Moorjani 1969 a, b). Publications with respect to phytoplankton do not seem to exist. From the study area itself there are just a couple of records (Isaac 1971).

The samples accounted for in the present report were collected to obtain introductory information about the algal communities and species of the area. Species which could possibly serve as biological indicators for future monitoring purposes, were also sought after.

2. MATERIALS AND METHODS

The sampling stations for seston (P) [x)] and benthic algae (B) are shown in Fig. 1. The localities were:

- P1: Port Tudor, near the slaughter house 30/9/74
- P2: Port Tudor 12/10/74
- P3: Port Reitz 12/10/74
- P4: Lagoon outside Kenya Beach 12/10/74
- B1: Fort Jesus, reef flat 0 - 0.5 m above low water
- B1a: Fort Jesus, cliff overhang 1.5 - 2 m above low water
- B2: Reef flat outside Kenya Beach Hotel, about low water mark
- B3: Kilindini Harbour, concrete pier, 1 m above low water
- B4: Lagoon outside Kenya Beach Hotel, sand covered stone 0 - 0.5 m above low water.

The plankton was collected by surface net hauls (25 µm pores) and quantitatively in 100 ml water samples (0 m). Benthic algae were picked by hand. All samples were preserved in formalin. Of the plankton samples, merely the net samples were analysed in any detail, as the quantitative samples

x) Living and non-living particulate matter swimming or floating in the water = Plankton + dead particulate matter.

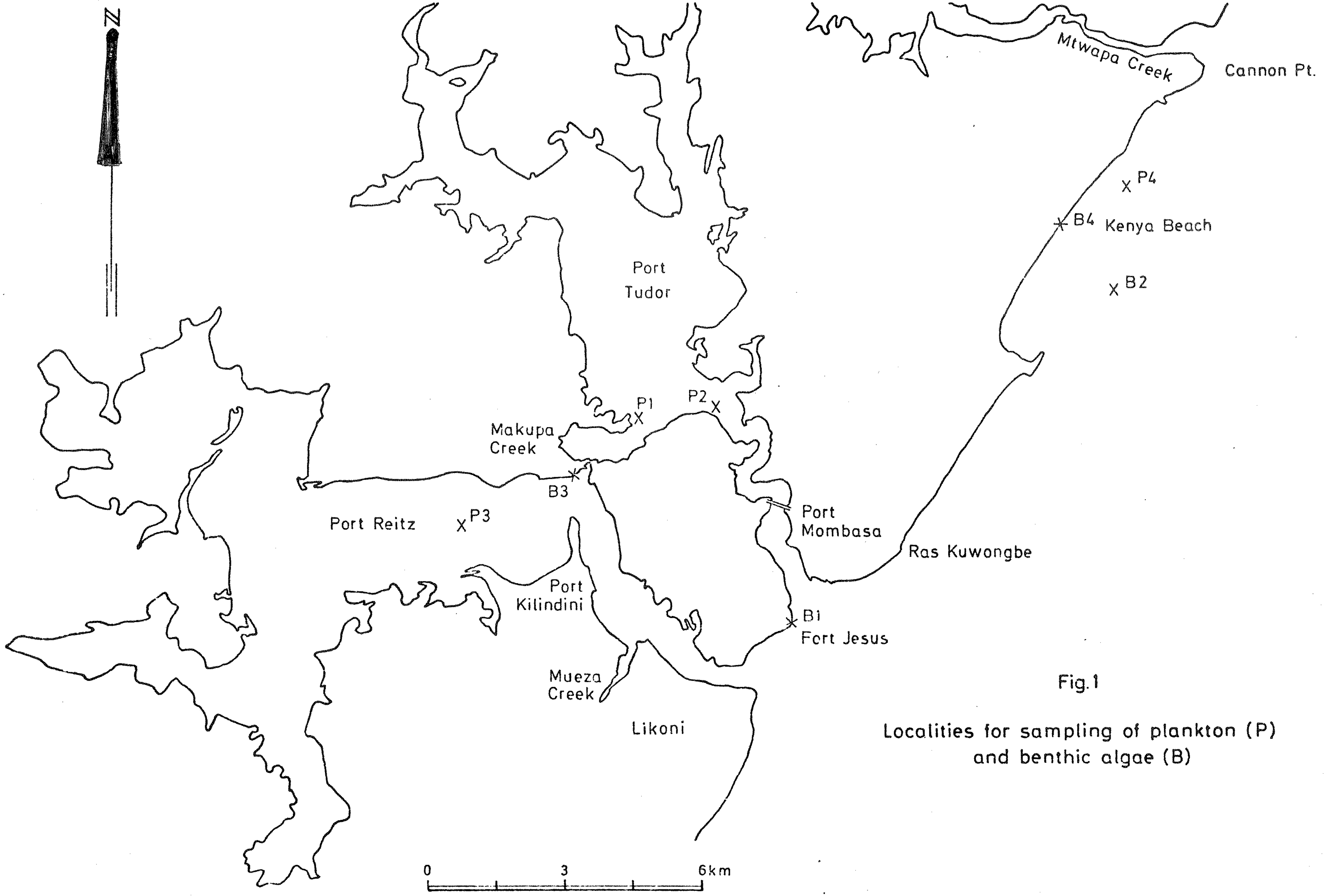

Fig.1

Localities for sampling of plankton (P) and benthic algae (B) mostly contained detritus and microalgae which would have taken longer to identify than the results could be expected to justify. Consequently, merely the ~~algal~~ total counts are indicated. Abundance of net plankton species is given according to a subjective scale:

- \+ One specimen observed
- 1 Very rare
- 2 Rare
- 3 Common
- 4 Frequent
- 5 Predominant

For the identification of phytoplankton mostly Hustedt (1930-59) and Schiller (1933-37) have been used. In contrast to the planktonic species, which have a near world wide distribution, there are no readily applicable handbooks for the benthic algae. A selection of relevant papers and books is to be found in annex 1.

3. RESULTS

Phytoplankton observations based on net hauls are listed in Table 1. Most of the species are common, more or less neritic (coastal) forms, some of them with a more pronounced preference for warm waters than others (e.g. *Biddulphia sinensis*, *Ditylum sol*, *Hemiaulus sinensis*, *Rhizosolenia calcar avis*).

Besides the predominance of diatoms at all localities (annex micrographs depict some of the more frequent species in the samples from Port Reitz and Port Tudor), it is worth noting that detritus constituted a quantitatively important component of the organic material filtered from the water. As could be expected, sand particles were abundant in the lagoon, the unfavourable environment also resulting in less plankton than at the other stations.

Table 1. Seston in net samples from the Mombasa area September - October 1974

ORGANISMS	St. P1	St. P2	St. P3	St. P4
BACILLARIOPHYCEAE (Diatoms)				
Achnanthes spp.			1	
Amphiprora sp.	+	+	+	
Bacteriastrum cf. delicatulum		+		
Biddulphia sinensis	2	2		+
Cerataulina bergoni	+	4		1
Chaetoceros cf. decipiens	2			
Chaetoceros glandazii		1		
Chaetoceros spp.		3	1	2-3
Climacosphenia moniligera			+	
Corethron hystrix	+		+	
Coscinociscus spp.	2	1		+
Ditylum cf. brightwellii	1			+
Ditylum sol		1		
Eucampia zoodiacus		2	+	2
Fragilaria sp.	+			
Guinardia flaccida		+		1
Gyrosigma spp.	1			
Hemiaulus sinensis		1		+
Hemidiscus sp.	+			
Isthmia cf. enervis	+		+	
Leptocylindrus cf. danicus		2		2-3
Lichmophora spp.	+		2	
Navicula spp.				+
Nitzschia closterium	1	+	+	1-2
Nitzschia longissima	+	+		
Nitzschia spp.	+	1	1	+
cf. Pleurosigma spp.	1-2	+		
Rhizosolenia alata				+
Rhizosolenia calcar avis		1		1
Rhizosolenia imbricata var. schrubsolei		2-3	+	4
Rhizosolenia stolterfothii		1		2
Synedra spp.			+	
DINOPHYCEAE (Dinoflagellates)				
Ceratium furca	1-2	2		
Ceratium sp.	+			
Dinophysis cf. rotundata	+			
Peridinium cf. pellucidum	2	2-3		
Peridinium spp.	1-2			
Phalacroma sp.	1-2			
Prorocentrum sp.	+			

Table 1 (cont.)

ORGANISMS	St. P1	St. P2	St. P3	St. P4
CHRYSOPHYCEAE				
Dictyoca sp.	+			
ZOOPLANKTON				
Copepods	3	2	1	1
Nauplius larvae	3	2		1
Protozoa	3	2	1	1
MISCELLANEOUS				
Unidentified flagellates		1		+
Swamp spicules	1	1	1-2	
Detritus	4	3	3	3
Inorganic particles	1	1	4	

The quantitative phytoplankton samples were more or less (i.e. in Port Reitz) characterized by considerable amounts of organic and inorganic particles. Estimated quantities of unidentified nanoplanktonic algae x) range from about 500 - 1000 x 10^3 cells/l (lagoon waters, st. P3) to 1000 - 2000 x 10^3 (Port Tudor), 1000 - 4000 x 10^3 (Port Reitz) and about 5000 x 10^3 cells per l in Mtwapa Creek. Net plankton played a minor role in all quantitative samples except from Port Reitz, where *Leptocylindrus cf. danicus, Rhizosolenia imbricata* var. *shrubsolei, Rhizosolenia stolterfothii* and *Chaetoceros spp.* together amounted to an estimated 1000 x 10^3 cells/l.

The benthic algae (Table 2) are for the most part known from previous observations of Kenyan littoral habitats (Gerloff 1960; Isaac 1967, 1968, 1971). The latter author lists all species mentioned in Table 2 except *Chondria armata, Griffithsia tenuis, Hypnea pannosa, Turbinaria decurrens, Cladophorpsis sundanensis, Codium dwarkense* and *Codium geppii, Ulva pulchra, Rhizoclonium cf. kochianum.* This may be explainable in terms of nomenclatural differences *(Turbinaria, Ulva, Codium, Hypnea)* or the cause is simply that the hitherto performed studies are few and unsystematic. .

Quantities were not estimated, but as common species of st. B1 (Fort Jesus) the following green algae may be mentioned: *Ulva spp., Cladophoropsis sundanensis, Dictyosphaeria cavernosa, Halimeda spp;* the red algae *Gracilaria corticata, Hypnea pannosa, Carpopeltis regida;* and the brown algae *Cystoseira myrica* and *Turbinaria decurrens.* Excepting *Dictyosphaeria,* more or less the same species were found at st. B2. In addition *Padina sp.* were frequently encountered in sandy rock pools. In addition to the tabulated species the following were found as drift weed on the shore of Kenya Beach: *Boodlea composita, Chaetomorpha crassa, Ulva fasciata, Halimeda opuntia* (Chlorophyceae); *Colpomenia sinuosa, Cystoseira trinodis, Sargassum iliciforlium, S. marginatum, S. subrepandum, Sphacelaria furcigera, Turbinaria conoides* (Phaeophyceae); *Gelidiopsis intricata* and *Gracilaria corticata* (Rhodophyceae).

x) Species so small that they slip through the pores (25 µm) of ordinary phytoplankton nets.

Table 2. Benthic algae collected in the Mombasa area September - October 1974

ORGANISMS	B1	B1a	B2	B3	B4
CYANOPHYCEA (Blue-green algae)					
Lyngbya sp.		x		x	
Oscillatoria sp.				x	
RHODOPHYCEAE (Red algae)					
Cf. Acrocystis nana	x				
Amphiroa fragilissima			x		
Bostrychia tenella		x			
Carpopeltis rigida	x				
Catenella cf. opuntia		x			
Champia irregularis					x
Chondria armata	x				
Gelidiella acerosa	x				
Gracilaria corticata	x		x		
Gracilaria salicornis	x				
Griffithsia tenuis			x		
Haliptylon subulata			x		
Hypnea cornuta					x
Hypnea pannosa	x				
Leveillea jungermannioides			x		x
Liagora mauritania			x		
Spyridia aculeata			x		x
Spyridia filamentosa					x
PHAEOPHYCEAE (Brown algae)					
Cystoseira myrica	x		x		x
Cystoseira trinodis					x
Padina commersonii			x		
Padina gymnospora			x		x
Sargassum cf. binderi	x				x
Sargassum duplicatum			x		
Sargassum ilicifolium	x		x		
Spatoglossum asperum	x				
Stoechospermum marginatum	x				
Turbinaria decurrens	x		x		
CHLOROPHYCEAE (Green algae)					
Chaetomorpha crassa	x				
Cladophoropsis sundanensis	x				
Codium geppii			x		
Codium dwarkens			x		
Dictyosphaeria cavernosa	x				
Halimeda discoidea					x
Halimeda incrassata	x				
Halimeda opuntia					x
Halimeda renschii			x		
Rhizoclonium cf. kochianum				x	
Ulva pulchra				x	
Ulva reticulata	x		x		
Ulva regida f. tropica	x		x		

4. DISCUSSION

As far as is known none of the recorded phytoplankton species are particularly abundant under eutrophic conditions. Generally, most indicator species are small forms, often belonging to some group of flagellates. There is a possibility that such species can be observed by further investigations, but the fact remains that the concept of indicator species is somewhat dubious with the present insight into the ecology of individual planktonic species. Consequently, future plankton monitoring of areas presumed to be affected by sewage effluent should preferably be based on other criteria than indicator species. Among useful parameters are analyses of community structure, for example by means of diversity indices [x)].

Experiences from other areas indicate that pollutional loading results in predominance of a few tolerant or favoured species with a resulting lowering of diversity. When diatoms is the predominant group, plankton samples can be analysed on filter after filtration of a fixed volume of water. Representatives of other plankton groups will be more or less deformed and difficult to identify on dried filters.

A more profound understanding of the phytoplankton community of the creeks necessitates analysis of quantitative samples, coupled with chlorophyll and zooplankton registrations (grazing effects), analysis of nutrient salts and measurements of primary production, preferably also algal assay to indicate growth potential of the water and limiting factors. The optimal combination of parameters and sampling frequency will depend on both local conditions (geographical and seasonal variations) as well as a closer definition of objects.

As to the benthic algae, it was mentioned in the previous report (Norwegian Institute for Water Research, Dec. 3rd 1974) that the green alga *Dictyosphaeria cavernosa* had experienced extensive growth as a probable result of increased concentrations of nutrients from sewage outfalls (Johannes 1972). In this particular case the growth had deleterious

[x)] Example of diversity index (richness or variety index):

$D = \frac{S-1}{\log N}$, S being number of species, N number of individuals.

effects on the reef community, smothering the corals. Thus it seems worth while to record the present occurrence and distribution of *Dictyosphaeria* in the area. (It would for instance be of interest to find out whether the species were more abundant at near shore localities than on the reef flats. Only very premature conclusions can be drawn from the incidental observations summarized in Table 2).

In comparison with planktonic species it is a well established fact that benthic organisms can be useful as indicators of pollution, mainly because communities of sessile organisms are not subject to such irregular and often sudden changes that are characteristic for the plankton. (It follows from this that plankton studies will as a rule also require more frequent sampling).

With certain reservations it is a common experience that blue-green and green algae are more favoured than other groups by eutrophic conditions. In particular, it is known from many localities that species of the chlorphycean genera *Ulva* and *Enteromorpha* will to a large extent displace other algae in heavily polluted environments. Regular observations of such species thus could contribute to the purpose of monitoring. Aerial surveys by infrared photography, subsequent to preparation of keys based on field studies to interpret the pictures, would be worth trying in an area with constant weather conditions for long periods. Nevertheless, detailed community analysis would undoubtedly be a more reliable approach for benthic algae also, instead of basing the monitoring studies solely on indicator species or groups.

For a broader discussion of baseline and monitoring studies the above mentioned report from this institute is referred to.

5. SUMMARY AND CONCLUSIONS

I Sampling of plankton and benthic algae has been performed to obtain introductory information about the species present in the Mombasa area. The recordings of net plankton and littoral benthos are presented in the tables.

II No well known indicator species for eutrophic environments have been recorded among the planktonic algae. There are several reasons why plankton studies are unlikely to be best suited for monitoring purposes.

III The chlorophycean (green) alga *Dictyosphaeria cavernosa* has been found in moderate quantities at one locality. Presumably being favoured by high nutrient concentration, it is possible that this species can serve as indicator of the effects from domestic sewage loading. This may also be the case as regards representatives of other chlorophycean genera (*Ulva, Enteromorpha*, etc.). More reliable information would result, however, if the whole community structure were taken into account.

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ANNEX 2: <u>Micrographs of net plankton</u> (10 copies only)

Fig. 1: Net plankton from Port Reitz, Oct. 12 1974, showing Rhizosolenia imbricata var. shrubsolei, R. stolterfothii, Eucampia zoodiacus, Cerataulina bergoni, cf. Leptocylindrus danicus. 80x

Fig. 2: Net plankton from Port Tudor, Oct. 12 1974, showing among others Cerataulina bergoni, Biddulphia sinensis, Rhizosolenia imbricata var. shrubsolei and Eucampia zoodiacus. 80x

(Photo: Eli-Anne Lindstrøm)