REPORT OF A SCIENTIFIC VISIT

by DR. F. DEHAIRS

TO THE K.M.F.R.I., MOMBASA-KENYA

(JUNE 23TH TILL JULY 24TH).

OVERVIEUW OF ACTIVITIES.

I. Discussions with R.O. J. Kazungu.

The experimental work performed by R.O. J. Kazungu and his technicians has provided many interesting results on the seasonal variation or the nutrient concentration in Tudor and Kilindini (see technical reports by J. Kazungu). This research is extremely valuable and should be continued to cover at least one year.
We discussed the possibilities of a further optimisation of sampling procedures and sample handling. It was convened that in general sample volume would be reduced.
For NO_3^-, this together with use of several correctly calibrated Cd columns will significantly speed up the analysis time.
Also, comparitive studies between fresh seawater samples, analyzed immediately after collection and samples that were first deep-frozen will be performed. This will ascertain whether any artefactial change in concentration occurs as a result of the sample storage procedure.
The sampling scheme as used now, should be extended, at least for some nutrients (NO_3^-, NH_4^+...), to obtain a more detailed profile along Tudor Creek. This is of importance to detect any additional input of N- components, other than river input and land drainage, along the Creek. Several sources are in fact possible : domestic sewage disposal from Mombasa ; sewage disposal from the meat factory ; inputs from the side creek located in front of the meat factory and extending more land inwards than the Tudor Creek - Kombeni river system. In fact this site is already sampled for prawns by M. Wakwabi.

Besides measuring concentrations or stocks, the strength of some of the N- input functions should be assessed.
* River input: nutrient concentrations in rivers should be assessed in the different seasons. By knowing discharges rates, (Norconsult, Hydrological services), input to the creek can be estimated.

* Rain: nutrient concentrations in rain should be measured. Again by knowing the rainfall (Meteorological service, Norcunsult, from raincollectors on the roof of the institute), input to the creek can be estimated.

* Epibenthic fluxes: N- nutrients in interstitial water of the mangrove sediments were measured (see below), showing up to a 100 fold increase relative to the water column content. From the known gradient and the use of appropriate diffusion coefficients, outflux of nutrients can be estimated. The value of this "overall" diffusion coefficient can be obtained by measuring first a component whose concentration is affected only by its thermodynamic equilibrium constant, and not by bacterial production or consumption.
H_4SiO_4 can be used for that purpose (Berner, 1980 ; early diagenesis in sediments: a theoretical approach).
These same diffusion coefficient can then be applied to N- nutrients.
Assuming a steady state situation (input = output), the mass conservation equation

$$\frac{dc}{dt} = o = D.\frac{\partial^2 c}{\partial x^2} + \omega \frac{\partial c}{\partial x} - P$$

can then be made to fit the experimental profile in the sediments. However, this requires also ω, the sedimentation rate to be known.
Sedimentation rate can be obtained from Pb-210 geochronology. We will try to measure a Pb-210 profile in the sediments, either in Belgium (IRE) or France (CFR - CNRS Gif/Yvette).
Once ω is known, the curve fitting will allow to estimate P, the production - consumption term. The latter can also be obtained indepently, by measuring for instance respiration rates of the sediments (see below) and knowing C/N ratios of POM in the sediments.

* Land - drainage and seepage: while it is possible to measure the nutrient content of these two sources (a seepage sample from Gazi has been analysed), estimation of the discharge rate is much more complicated.
However, in hydrology such problems can be solved by measuring δO^{18} values in the different sources and from modelling.
At present the V.U.B. is equipped with a mass-spectrometer and O_2 extraction chain to perform such measurements.

* Sewage disposal: can be estimated from existing official reports.

FIGURE 1

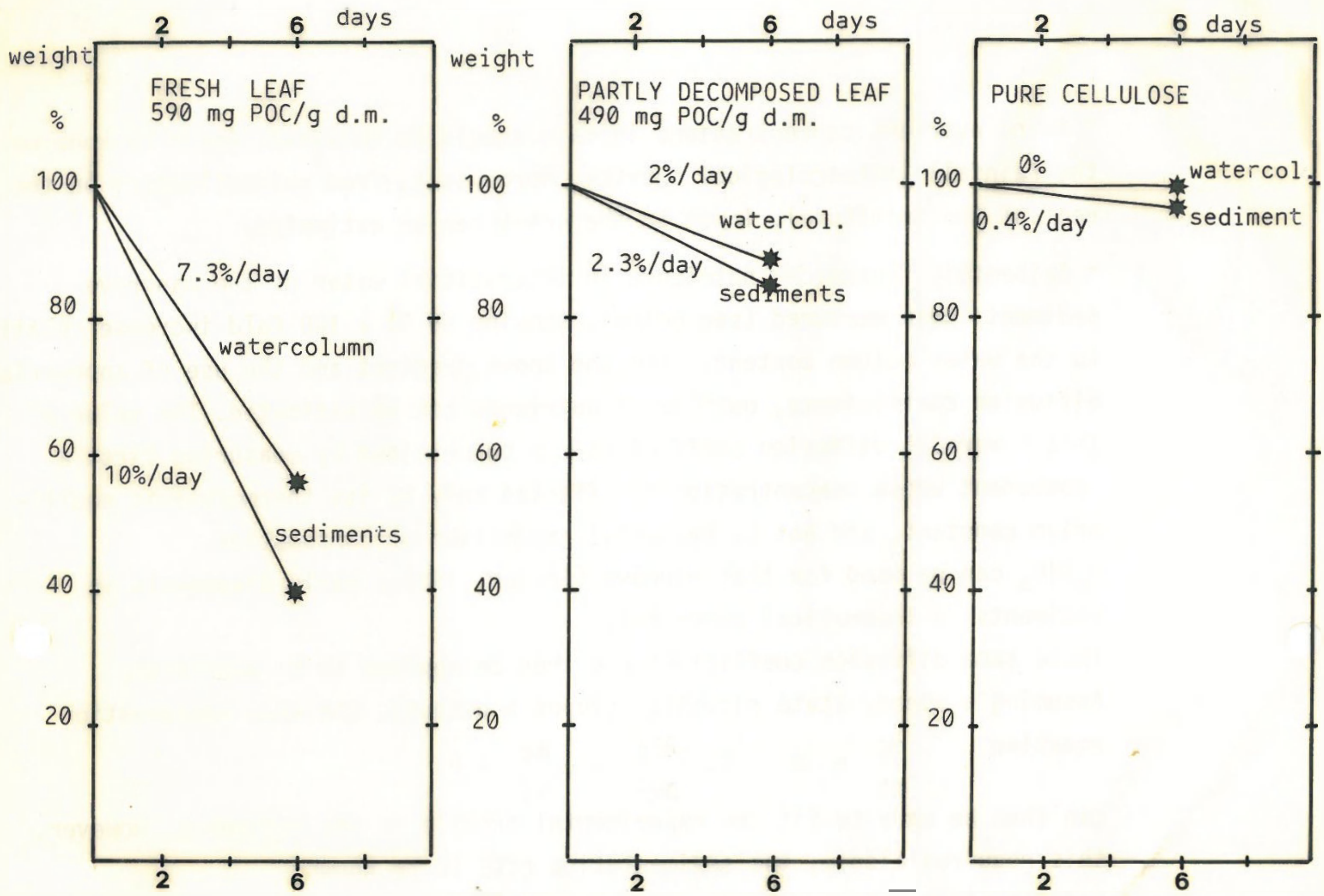
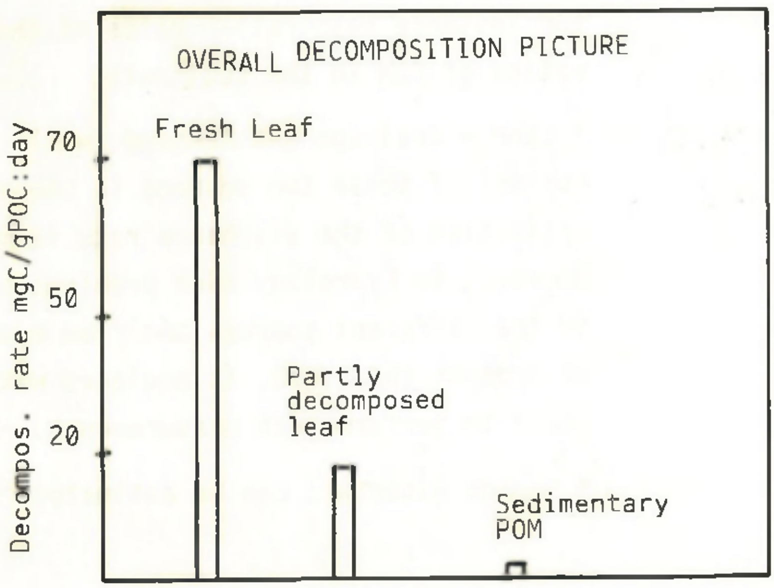


FIGURE 2



* In situ N- fixatiation: ~~Fungi~~ bacteria, that colonize ~~dead~~ fallen mangrove leaves in the water, have been described to possess the capacity for atmospheric N_2 fixation, thus forming an additional N- source to the creek system. This process probably increases the nutritive value of mangrove litter (decreasing C/N ratio with time) and could be one of the reasons why mangroves are sustaining such high biomasses (oysters, prawns, fish). The techniques for studying N_2 - fixation capacity are mastered by other researchers at ANCH-V.U.B., and a gas-chromatograph required for these analyses is available at Government Laboratories.
It is clear that at present not all these input functions can be estimated. However, we are confident that much of the unknowns will be studied in the future. This could be done in the framework of a Kenyan - Belgian research proposal to the C.E.C.

II. Experiments performed or started in collaboration with R.O. Kazungu and technicians Joseph... and Sheldrack...

II.1. Participation to cruises.

DATE	SITE	TYPE OF SAMPLE/MEASUREMENT.
26/06	Tudor Creek	- salinity - nutrients - POC - sediment cores - mangrove leafs
02/07	Kilindini Creek	salinity, dissolved nutrients ; POC ; Chl
08/07	Tudor Creek	salinity, dissolved nutrients ; POC ; Chl ; sediment cores mangrove litter decomposition ; sediment respiration
09/07	Gazi	salinity, dissolved nutrients in creek waters + seepage waters ; POC ; Chl ; sediment cores.

II.2. Overvieuw of experiments.

a. Optmisation of the Wet-oxidation - spectrophotometric method for POC determination in suspended matter, sediments and mangrove leaves.

b. Sampling and sample conditioning of mangrove sediments for subsequent determination of: porosity, POC, PN, particulate Al, Fe, Mn, and trace metals, nutrients in interstitial solutions.

II.3 Results and discussion.

In the following only original research started during the period of stay at the institute is discussed.

1. Sediments: - porosity and (NH_4^+) in interstitial solution.As an example results obtained for a sediment core from Tudor Creek (08/07/86) are given.

Section cm	Porosity vol%	NH_4^+ µg. at/dm^3 water or wet sediment.
supernatant		3.29
0 - 1.5	59.4	44.11
1.5 - 3.0	56.2	46.62
3.0 - 5.0	52.3	173.29
5.0 - 7.0	54.0	229.63
7.0 - 9.0	51.1	256.36
9.0 - 11.0	56.9	212.39
11.0 - 13.0	62.9	242.45
13.0 - 15.0	65.9	242.79
15.0 - 17.0	65.8	195.67
17.0 - 19.0	61.2	276.96
19.0 - 21.0	64.8	202.16
21.0 - 23.0	63.7	-
23.0 - 25.0	64.0	-
25.0 - 27.0	65.3	-
27.0 - 29.0	64.2	-
29.0 - 31.0	65.7	-

(-) : no data.

Thus sediments carry up to 100 times more NH_4^+ in their interstitial waters as compared to the water overlaying these sediments.

This gradient will sustain NH_4^+ outflow to the watercolumn, were NH_4^+ will be oxidized to NO_2^- and NO_3^-.
For comparison,sediments from the Belgian coast collected during the fall ~~in the North Sea~~ can contain up to 5,000 µg-at NH_4/liter, or about 25 times more than in Tudor Creek.
Porosity in sediment cores sampled under the oyster racks in Gazi is lower in average ~35 vol.%, indicating the high contribution of sand in these sediments. For this reason, no interstitial water could be recovered, with the centrifugation method applied here; therefore no nutrient data for interstitial water at Gazi are available.

For all cores it was convened that POC, PN will be determined on the solid substrate at K.M.F.R.I. Later analysis af Al, Fe, Mn, trace metals can be performed at the V.U.B., by M. Oteko.
Very recently, sediment cores collected in Tudor Creek during February 1985 were measured for Cd. Cores sampled up-creek, (i.e. in the area extending after the meat factory) contain very low concentrations. Two cores taken in that part of the creek next to Mombasa island, show very high Cd. concentrations (up to 100 µg/g dry sediment !).
Such high values were never observed in the sediment of the Belgian coastal area, but can be present in the suspended matter and sediments of the highly polluted Scheldt estuary.
So, trace metal studies around Mombasa island are certainly worthwhile !
Part of this work can be started by M. Oteko here at the V.U.B.

2. Mangrove - litter decomposition experiment.

A. Mangrove leaves decomposition rate.

Both fresh leaves and partly decomposed leaves floating on the water-surface were sampled.
They all belonged to the *Rhizophora mucronata* sp.
The leaves were dried, weighed and packed in perforated plastic petri dishes.
We also packed cellulose filter paper in plastic petri - dishes.
These petri-dishes were stored in (1) plankton bags, left floating in the water ; (2) PVC-made cleaverlike containers that were pushed in the sediments down to - 30 cm. In both cases water had free access to the leaves and filter paper.
5 plankton bags and 3 sediment-cleavers were set out on 08/07/86, up Tudor Creek.

On 14/07 one planktonbag and one cleaver were recovered. The mangrove leaves in the plankton bags were covered with a slimy layer; this was not observed for the leaves packed in the sediment cleavers.
The leaves and filter paper were rinsed with tap-water and dried. They were then weighed to check for weight loss.
The weight losses are given in figure 1.
It is seen after 6 days that fresh leaves experience the largest weight loss (up to 60% for these sediments), while pure cellulose is not affected in the watercolumn and only slightly ($\sim$3%) in the sediments. The other bags will be recovered on per week, thus covering a total of 5 weeks of POM degradation.

B. Sediment respiration experiment.

A bulk sediment ($\sim 1 dm^3$) was sampled in Tudor Creek on 08/07/86.
In the laboratory aliquots of $\sim$50 g (wet weight) were stored in 1l. glass containers that could be sealed from the atmosphere. To each container we added a small beaker containing 10 ml. of a IN NaOH solution (of acurrately known titer). The containers were closed thightly and stored in the dark at room temperature. Blanks, containing no sediments, were run in parallel.
These experiments were started on 11/07/86; 10.30.
The CO_2 produced during the bacterial decomposition of organic matter is captured by the NaOH solution according to the reaction:

$$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

On 16/07/86; 11.00 the experiment was interupted for the first time.
To the NaOH solution we added 5 ml of a saturated $Ba(NO_3)_2$ solution, to fixate the remaining NaOH and prevent further uptake of CO_2 from the atmosphere.

$$Na_2CO_3 + Ba(NO_3)_2 \rightarrow 2NaNO_3 + BaCO_3$$

$$2NaOH + Ba(NO_3)_2 \rightarrow 2NaNO_3 + Ba(OH)_2$$

After adding the phenolphtaleïn indicator the $Ba(OH)_2$ in this solution is titrated using IN HCl (standardized titrisol).
From each sample value(S) the blank value(B) is substracted:

$$S' = S - B$$

This S' value, times the HCl titer (1.0 N) gives the mumber of NaOH moles (Z) that have not reacted with CO_2.
So, the original number of NaOH moles present minus those remaining, gives the number of NaOH that reacted with CO_2. An average value of 13 µmole CO_2/g dry sediment/day is obtained. This is equivalent to 31 µg C/g d.w./day.

We can now compare degradation rates of the fresh and partly decomposed organic matter in the water-column and sediments with older, more refractory POM in sediments.
In figure 2 we have expressed this degradation as loss of C/g POC/day.
The original POC content of the 3 substrates was:

- fresh Rhizophora leaf : 590 mg POC/g d.m
- partly decomposed Rhizophora leaf : 420 mg POC/g d.m
- sediments used for respiration experiment : 35 mg POC/g d.m

For the leaves we have assumed that weight loss affected POC proporstionally to the original ratio of total POC weight/total dry matter weight.

The overall process is probably as follows:

1 proteins, lipids, carbohydrates.

↓

2 amino acids, fathy acids
sugar

(1–2: Fast degradation as observed for the leaves.)

↓

3 geopolymers: fulvic acid
humic acid
kerogen

(3: Slow degradation as seen in the sediments.)

These respiration experiments can be continued several times by introducing again 10 ml. of the original NaOH solution; and allowing the beakers to stand in the dark for about 6 days.
It would be most interesting, during both these types of experiments, to monitor C/N ratio, both in the leaves and the sediments. For the sediments respiration experiment this may give information on the remineralisation of N- species.
For the leaves one may either observe an increase of the C/N ratio or a decrease, depending on whether N_2 - fixation is going on by the ~~fungi~~ bacteria colonizing these leaves, or not.

CONCLUSIONS:

At this stage, we are gathering basic information on the mangrove-creek ecosystem. They are the basis for further research needed in that field. Some aspects of this future research are very complex, requiring not only the actual interdisciplinary research started at K.M.F.R.I. to continue, but also other research units, from Nairobi University and Universities in Belgium (V.U.B. - R.U.G.) to join efforts.