Mangrove Dynamic of Bunce river (Sierra Leone)

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INTRODUCTION

The Bunce river is a partially enclosed body of water with an area of just over 34 ha and is in fact a tributary of the Sierra Leone river estuary. Along its banks and in its upper reaches are a maze of creeks and channels fringed with mangroves covering an area of about 1 800 hectares. The mouth of the Bunce river is relatively wide about 2 km and in its upper reaches it is 1 - 1.5 km wide.

Apart from the information obtained from a general study of the Sierra Leone river estuary in the late 1950's and early 1960's, information on the hydrology of the Bunce river has been scanty. The study undertaken on the Bunce river as part of the COMARAF programme has helped to provide some recent informations on the hydrology of the Bunce river.

This paper presents the main features of the hydrology of the Bunce river and its associated mangrove areas. Influence of the mangroves on circulation patterns in the tidal creeks is also discussed.

GENERAL FEATURES

The Bunce river is a tributary of the Sierra Leone river estuary (Fig.1). It flows in a general south west direction between relatively narrow banks fringed with mangrove vegetation constituting basically of well developed red mangroves, *Rhizophora racemosa*.

The environmental condition in the vicinity of the Bunce river and its associated mangrove areas shows a well marked alternation of wet and dry seasons (Watts, 1958). In the catchment area of the Bunce river an annual rainfall of between 100 and 125 inch over 80 % falls during the months from May to October. The dry season usually lasts from November to April.

In the region of the Sierra Leone river estuary monthly means of salinity show a maximum value of 34.8 ‰ for April or May and a minimum of 32.6 ‰ for August and September. The horizontal and vertical range of temperature is small with values of 0.4°c and 0.2°c respectively, and there are only minor seasonal fluctuations. Extinction coefficient varied from 3.4 to 0.6 with a mean of 1.26 and at neaps from 0.9 to 0.3 with a mean of 0.54 (Bainbridge, 1960).

The widest part of the Bunce river is at its mouth roughly between Corvette jetty and Robene, where it joins the main channel of the Sierra Leone river estuary (Rokel). Numerous creeks can be found flowing into the Bunce river, the largest being Waterloo creek.

The Bunce river is about 12 km in length while its width varies from 2 km towards the mouth to 1.5 km in its upper reaches with an average of 1.0 km. In its upper reaches it is very shallow. At a distance of about 4.5 km

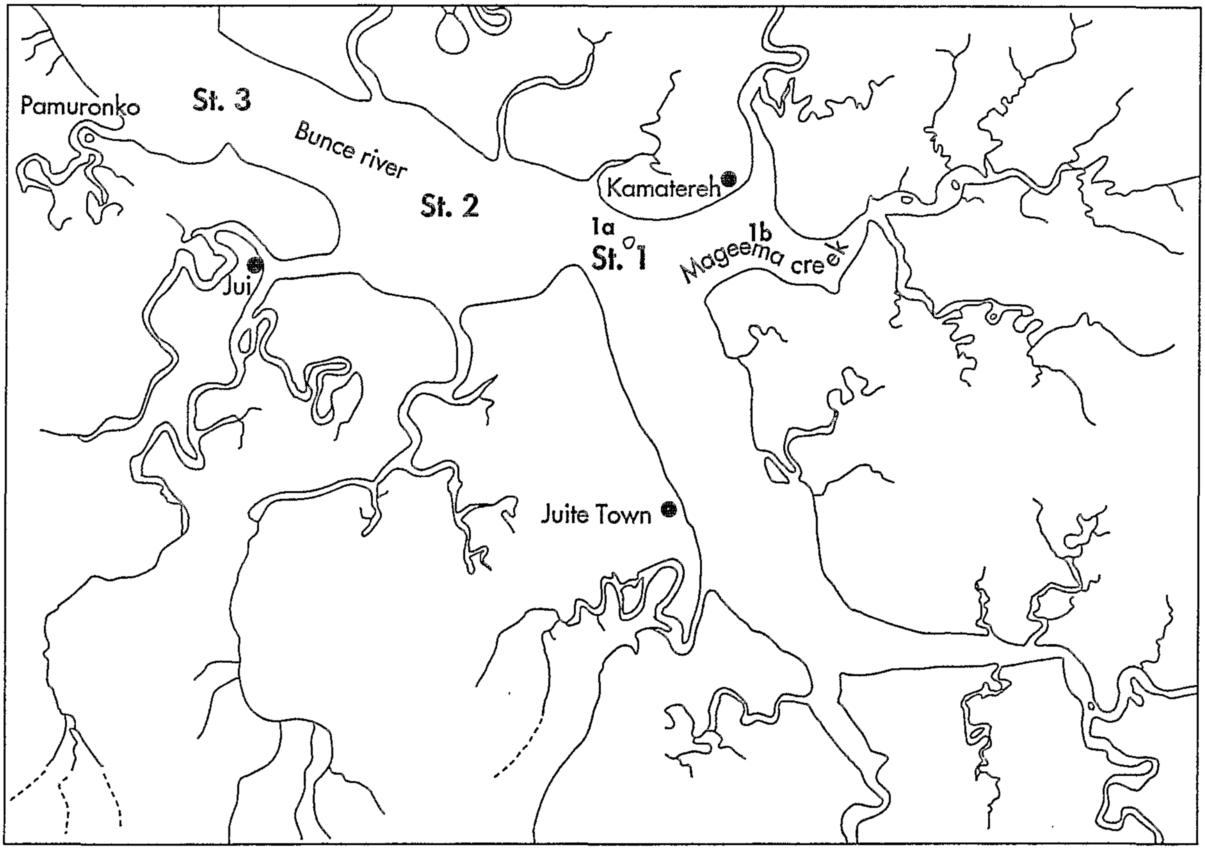

Fig. 1 : The Bunce river.

from the mouth, the depth does not exceed 8 meters. The depth however significantly varies with the tides. Areas with depth greater than 5 meters constitutes 60 % of the total area. Depths less than 5 meters are located near the banks and on the upper reaches. As a result of the tidal phenomenon, on the northern side of the river, sediments consist mainly of sand and silt. The deeper parts consist of mainly mud and silty sand, and towards the southern bank mud is mainly found.

The Bunce river is greatly influenced by the semi-diurnal tides of period around 12 hours 25 minutes. The fluctuation of the sea level due to the tides is further transmitted in the form of long waves in the river. The velocity of propagation of these waves which runs up to 2 m/sec. depends on the depths, and finally on the height of the tidal level at the mouth.

GEOMORPHOLOGICAL SETTING

The Bunce river is protected from the direct waves from the Atlantic Ocean and the south and southwest winds. It is however exposed to the north-west winds and waves from the Atlantic Ocean which reach the river via the Sierra Leone river estuary. The river is relatively wide which contrasts with the reduced size of its creeks.

The creeks are short, especially on the north-eastern side of the river compared to those on the southern side. The coastal plain is relatively narrow which permits some mangrove extension. The creeks located on the northern side of the river show almost no evolution as the river volume fluctuation is very low. The creeks located on the southern side of the river on the other hand are wider and more structured, thus they drain the largest area.

The river acts as a receptacle for sediments from parts of the peninsula south of the river thus controlling liquid flow. During the dry season the sedimentation is limited in the river by the proximity of the peninsula mountains which favour flushing. A major feature of the Bunce river is that of its mobile banks resulting from both tidal action and fresh water flow.

MATERIAL AND METHODS

At each station, a vessel was anchored and the depth recorded using line and weight as a depth recorder. Concurrently observations on temperature and salinity were carried at three stations located in the upper, middle and lower channels of the Bunce river (Fig.1). The distance between the stations was approximately 250 m.

A Peterson grab was used to collect sediment samples from the stations indicated (Fig.2). The samples were mainly made up of sand, mud and silt size particles.

Current measurements were done using an Ekman type current meter which was hung and operated from a small anchored vessel at one station only. The current velocities were measured over a whole tidal cycle of approximately 12 hrs. Some of the data is presented in Tables 2a et 2b respectively.

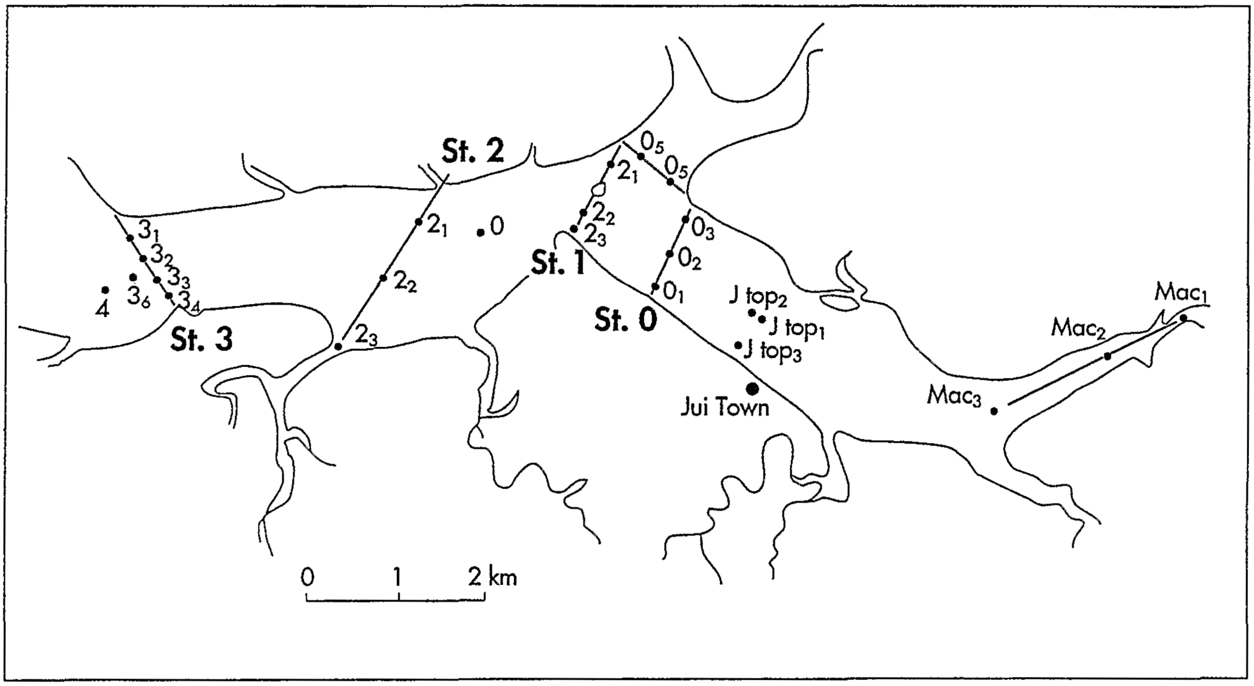

Fig.2 : Sediment sampling station.

RESULTS AND DISCUSSION

SEDIMENT DISTRIBUTION AND TYPES

The Bunce river can be divided into three main sectors with respect to sediment distribution patterns (Fig.3). Sector 1 is characterised by mainly pelitic sediments. Sector 2 comprises sediments of mixed type mainly sand and mud. The sand occupies the deeper areas with mud near the shores. These are normally

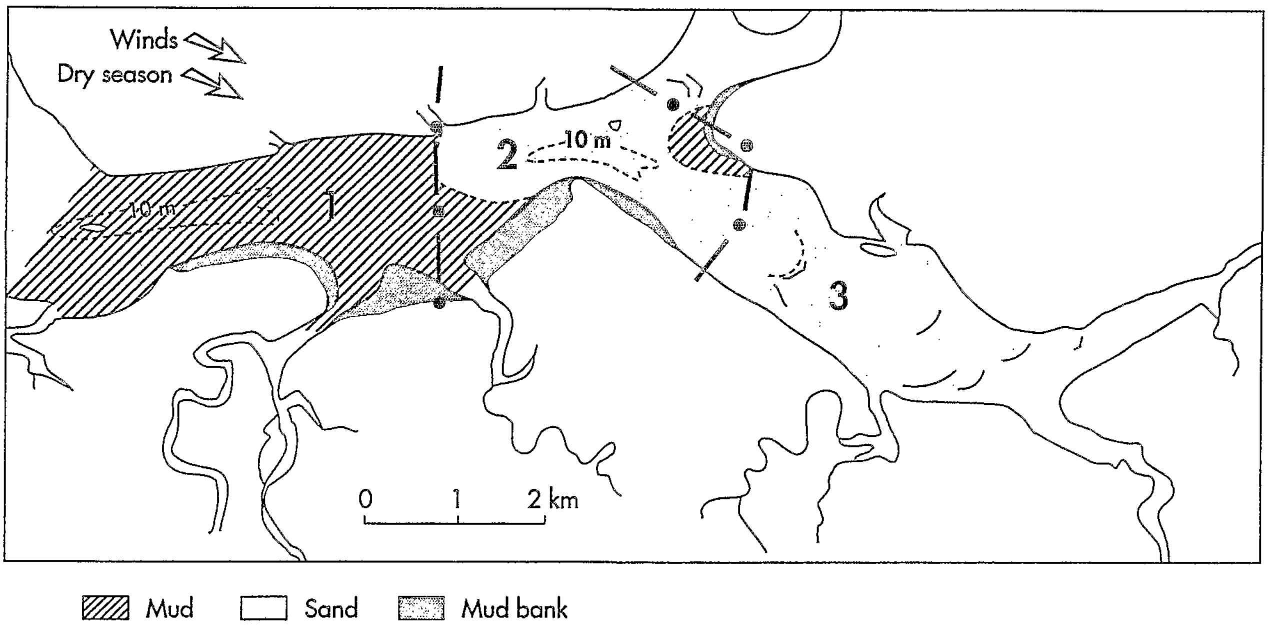

Fig. 3 : Sediment distributional pattern in the Bunce river.

exposed during low tide. Sector 3 upstream, where depths are shallower, the sediments are composed of exclusively sand with hydraulic dunes covered by ripple marks. (Table 1).

Station	Depth	(M)Sediment type
Mac	3.0	Sand
J Top	2.0	Sand
1	9.0	Sand & Mud
2	10.0	Sand & Mud
3	11.0	Sand

Table 1 - Sediment types in the Bunce river.

DYNAMICS

The Bunce river is characterised by strong semi-diurnal tidal currents intensity of which reduces from the mouth towards its upper reaches. The module of the tidal vector here is significantly dependent upon the phase of the spring and neap tides. The characteristic values at neaps and springs are 0.7 meter/sec. an 1.6 meters/sec. respectively (Table 2), although velocities may exceed 2 meters/sec. especially during the ebb.

The duration of the tidal cycle is not constant but changes from one period to another. The gradient current shows a seasonal variability. During the rainy season and also during the transition period from the wet season to the dry season, at the surface, very strong runoffs are observed, while at the bottom the residual flow is directed towards the river. During the dry season the flow changes into the opposite direction.

Time (hr)	Depth (m)	Velocity (m/s)
13.00	8	0.8
13.15	8	0.8
13.30	8	0.8
13.45	8	0.8
14.00	9	0.7
14.15	9	0.7
14.30	9	0.7
14.45	9	0.7
15.00	10	0.6
15.15	10	0.6
15.30	10	0.6
15.45	10	0.6

Table 2a : Surface current velocities during the flood tide at station II.

Time (hr)	Depth	Velocity (m/s)
15.00	8	1.3
15.15	8	1.4
15.30	8	1.4
15.45	8	1.4
16.00	7	1.4
16.15	7	1.6
16.30	7	1.6
16.45	7	1.6
17.00	6	1.6
17.15	6	1.7
17.30	6	1.7
17.45	6	1.8

Table 2b : Surface current velocities during the ebb tide at station II.

Visual observations of waves gave estimated heights of 0.5 meters at high tide to 0.25m at low level water, waves up to 1m height were observed during short lived storms along the mid-channel.

As the movement of bottom sediments are determined by the residual currents, then the flooding of the mangroves, probably takes place during the rainy season, and transport of bottom sediments into the Sierra Leone river estuary takes place during the dry season.

Analysis of data on seasonal variability of the residual current shows that during the rainy season the water of the Bunce river is partially stratified. During the dry season when the runoff is reduced a homogeneous structure of the water is established. The residual currents during this period throughout the water is directed towards the Sierra Leone river estuary.

Circulation Patterns in Mangrove Areas

The patterns of water circulation in mangrove fringed areas of the Bunce river is complex being dependent on a number of factors. These factors include topographic constraints on the current, resulting in most cases, in most of the water leaving the mangrove creeks at ebb tide to return to the mangrove creeks at the subsequent flood tide.

Investigations show that generally the waters are quite well-mixed as indicated by their salinity values. Though there are measurable horizontal gradients of salinity with fresher water being found in the creeks. Tidal flushing also play an important role in the dynamics of mangrove swamp area. Wolanski (1988) has shown that high salinity bay water intrudes into mangrove fringed creeks at flood and flushed out at ebb tides, and that it takes a shorter time for the water to be flushed out of the creeks than for it to return, because ebb currents are stronger than flood currents.

The presence of tidal asymmetry in the currents (ebb tidal current being larger than flood tidal currents) which is responsible for self-scouring of the channel would be much less pronounced in the absence of mangrove swamps, hence will lead to siltation (Table 2).

There are also significant horizontal variations in the water currents. Large lateral variations of velocity exist especially in the wide and shallow open tidal channels with uneven bathymetry even in the absence of mangrove swamps. In mangrove swamps, the high vegetation density prevent the occurrence of strong current there. The salinities of both flood and ebb tide waters are practically identical suggesting little mixing between river and mangrove water. Analyses of temperature data show similar pattern (Table 3).

Temperature and Salinity

Both temperature and salinity values (Table 3), show little difference at the surface and bottom indicating no vertical stratification. This is due to lack of fresh water supply into the Bunce river especially during the dry season. This situation is slightly altered during the rainy season when the rains serve as a source of fresh water supply. Due to the relative shallow depth of the Bunce river, stratification is not too well marked but surface salinities may differ from bottom salinities by as much as 1.0 ‰. In the horizontal, temperature may vary by as much as 0.3°c and salinity by as much as 0.6 ‰ (Table 3).

Station	Depth (m)	Temperature (°C)		S (‰)	
		Surf.	Bott.	Surf.	Bott.
1 A	12.0	30.7	30.6	33.81	34.47
1 B	4.0	30.7	30.5	34.16	34.83
1 C	1.5	30.4	30.2	32.21	32.96

Table 3 : Temperature and Salinity for the Bunce river (source: COMARAF, 1990).

The temperature field of the Bunce river shows a sharp seasonal variation. The water is practically homogeneous vertically. Average annual temperature of the water is 28.6° C .

The horizontal structure of the temperature is characterised by an alternation of relatively hot and cold areas. The occurrence of these thermal heterogeneity is connected with the unequal warming of the surface water at separate areas of the mangroves zones as a result of the different properties of the underlying surfaces (absorbing capability, albedo), different intensities of evaporation and horizontal heat exchanges (Fig.4).

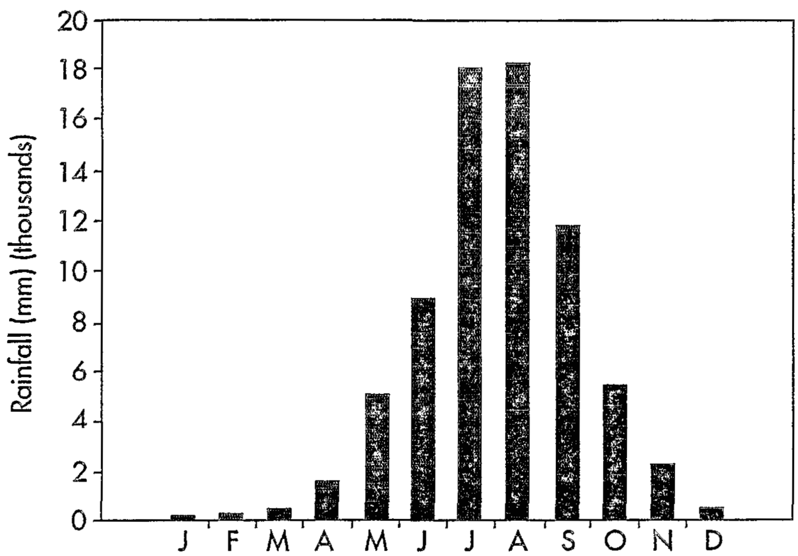

Fig. 4 : Mean monthly rainfall. Falcom Bridge (1958-1981).

The most significant factor responsible for the seasonal variability of the water temperature in the Bunce river is the fluctuation of the seasonal air. The thermal properties of the river are also influenced by tidal action.

The salinity regime of the Bunce river is significantly affected by flow characteristics at its upper reaches. At the beginning of the rainy season, a highly diluted water of salinity 31 - 33 ‰ is observed. Towards the end of the dry season at the head of the Bunce river and at its creeks, water of maximum salinity 34 ‰ (table 3) is observed. This is the result of intensive evaporation (saltation of mangroves). The salinity variation is supported by seasonal and synoptic variations.

CONCLUSIONS

The water of the Bunce river is nearly isothermal, well mixed and homogenous in the upper reaches and in the creeks. The seasonal influence of climate processes on the hydrological regime of the Bunce river is marked and the tidal regime appears to be the dominant factor responsible for short term variations in the regime. The mangrove area circulation tends to be constrained by topography, the tidal regime, and the presence or absence of mangroves.

The distribution of sediment types reflects the dynamics of the Bunce river indicating, that quieter waters are found towards the mouth of the River, that is, toward its meeting with the Sierra Leone river estuary and along the southern bank where such deposits predominate.

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