PRELIMINARY DETERMINATION OF THE SALINITY PROFILE DURING NEAP-SPRING TIDES OF THE SG. BARU ESTUARY, PERLIS

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ABSTRACT

This preliminary study was undertaken to examine the mixing dynamics during neap and spring tide at the Sg. Baru estuary, Perlis. Variation between temperature, depth and salinity were recorded to determine water column stability during the semi-diurnal tidal conditions. The results showed that vertical mixing occurred during spring tide and a salinity gradient persisted during neap tide. Although the water column is relatively shallow, salinity and temperature data indicate that lower salinity corresponds to higher temperature. Key words :salinity, estuary, neap tide, spring tide

1.0 INTRODUCTION

The major demands on water resources in the state of Perlis are for domestic supply and for industrial and commercial consumption, as well as to meet the irrigation needs of water deficit areas (JICA 1984). The Muda irrigation canal, which is managed by MADA (Muda Agricultural Development Authority), originates from the Pedu and the Muda dam in Kedah and covers about 20 304 ha of the southern part of Perlis (Information Malaysia Yearbook 2000). The canal is mainly used for paddy irrigation but it is also the source of raw water for the intake of the Arau treatment plant. The irrigation canal is interconnected into Sg. Baru and its estuary, which flows into the Straits of Malacca. The tidal regime in the area is typically a semi-diurnal tide. Tidal rangemeasured at the coast near Kuala Perlis, which is about 5 km away, has a mean high of about 3.0 m during spring tide and a mean of about 1.9 m duringneap tide (Hydrographic Department Royal Malaysia Navy 2003). Saltwater intrusion along the estuarine channel is about 3.5 km inland from the Sg. Baru estuary (Faridah Hanum *et al* 2003). The water flow is regulated by two canal lock gates situated upstream of the estuary.

Most estuaries are coastal plain estuaries which have unique salinity and flow characteristics. Estuaries can be classified as having a highly stratified, partially mixed or well mixed structure depending upon salinity difference between surface and bottom values (J. Sharples 2002). Water column stability in estuaries and coastal regions of freshwater influence is controlled by a competition between the tendency towards stratification, driven by the freshwater induced horizontal density gradient and local surface heating, and the vertical mixing produced by tide and wind-driven shear stresses within the water column (J. Sharples 1994).

The objective of this study is to observe the temperature, depth and salinity variation and to determine water column stability over one semi-diurnal tidal cycle, at neap and spring tides. This paper will examine the stratification-destratification pattern during the tidal cycles in order to determine the Sg. Baru estuary mixing dynamics as compared to known neap-spring hydrographic cycles.

2.0 METHODOLOGY

Two in-situ surveys were carried out at a single station, which is the Sg. Baru road bridge, located at the mouth of the estuary. The surveys were conducted on Nov 9 2003 (spring tide) and Dec 12 2003 (neap tide). Each survey consisted of vertical profiling of temperature, depth and salinity. The times of the survey were based on the heights of high and low waters for the Kuala Perlis coast as listed in Tide Tables provided by the Hydrographic Department of the Malaysian Royal Navy.

Each survey was timed to approximately coincide with the ebb and flood tide of one semi-diurnal spring-neap cycle. The surveys were undertaken at the beginning of flood tide and proceeded through high water until ebb tide occurs. Physical measurements of salinity, temperature and depth were made simultaneously using a Hydrolab DataSonde 4 water quality data logger. Calibration of the instrument was conducted prior to the designated survey dates.

3.0 RESULTS AND DISCUSSION

The results for both spring-neap semi-diurnal surveys are shown in Tables 1 and 2.

Table 1. Spring tide, 9/11/2003 (lock gate closed)

Time	Depth (m)	Temperature (ºC)	Salinity (ppt)	Comments
9.00 am	0.50	29.13	2.44	The estimated time for high water was at 12:25 pm
9.03 am	1.01	28.69	23.15	
9.06 am	1.53	28.55	24.48	
11.50 am	0.50	29.22	21.00	
11.54 am	1.01	29.15	24.66	
11.59 am	1.51	29.12	24.87	
1.00 pm	0.52	29.87	22.99	
1.03 pm	1.02	29.35	24.51	
1.08 pm	1.50	29.22	24.76	
3.45 pm	0.51	30.01	9.80	
3.49 am	1.01	30.10	11.66	
3.53 pm	1.50	29.96	15.54	

Table 2. Neap tide, 12/12/2003 (lock gate closed)

Time	Depth (m)	Temperature (ºC)	Salinity (ppt)	Comments
10.45 am	0.5	27.68	5.06	The estimated time for high water was at 2:17 pm
10.48 am	1.00	24.62	24.64	
10.51 am	1.50	26.35	25.27	
12.05 pm	0.50	28.07	5.60	
12.08 pm	1.01	27.01	20.80	
12.11 pm	1.50	26.74	25.02	
3.15 pm	0.50	28.63	14.15	
3.18 pm	1.00	27.46	24.50	
3.21 pm	1.51	27.75	25.62	
4.28 pm	0.50	28.71	12.71	
4.31 pm	1.02	27.63	24.53	
4.34 pm	1.50	27.76	25.50	

Figure 1. Sg. Baru road bridge where sampling was done.

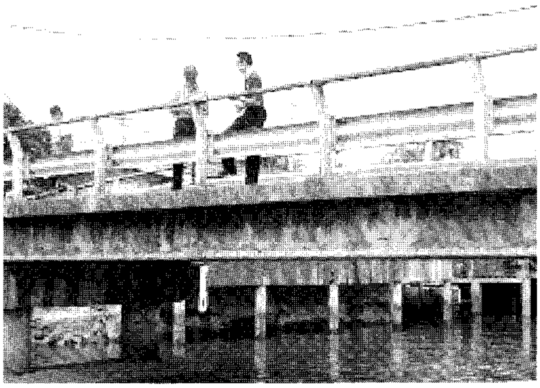

Figure 2. View from sg. baru road bridge showing mouth ofthe estuary.

Figure 3. Canal lock gate situated about 0.6 km from mouth estuary.

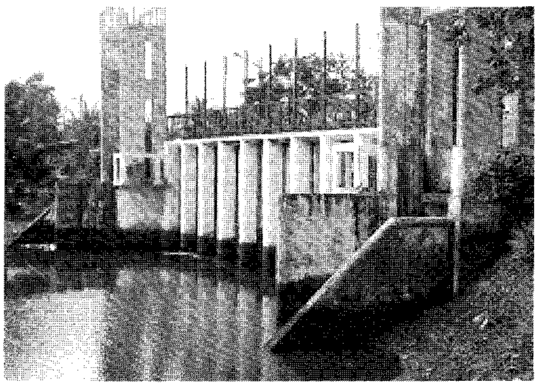

Figure 4. Data logging equipment DataSonde 4 and Surveyor.

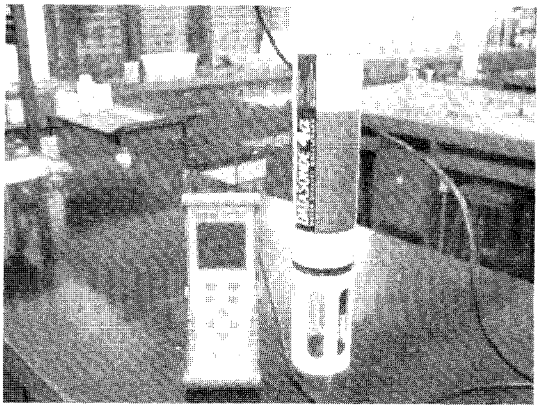

Figure. 5. DataSonde 4 being lowered into the water.

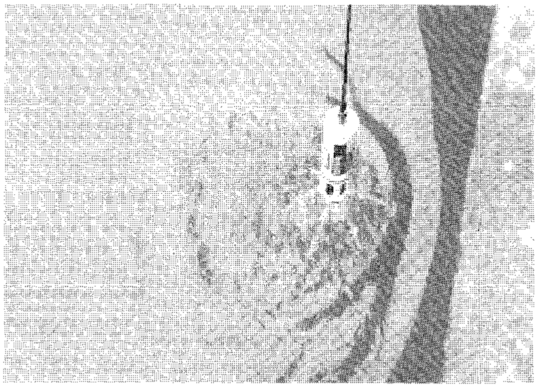

Figure. 6. Data logging activity in progress.

3.1 Salinity profile

Salinity recorded during the neap tide survey indicated significant stratification with depth of water column (Figure 7a).

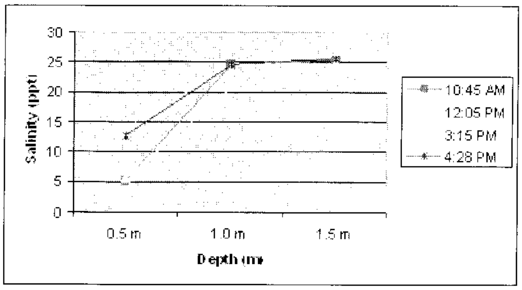

Figure 7a. Salinity and depth variation at neap tide

The most pronounced variation in salinity with depth of water column occurred during the progression of flood tide between 10 am to 12 pm. The difference between top and bottom salinity values became less pronounced after the occurrence of high water indicating some extent of vertical mixing. Thus the rising salinity occurred simultaneously with rising water level.

On the other hand, there was no obvious salinity stratification during the spring tide survey (Figure 7b).

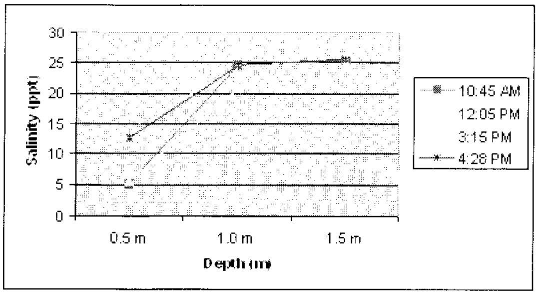

Figure 7b. Salinity and depth variation at spring tide

Salinity values recorded at 9:00 am showed the presence of a salinity gradient due to the sampling time. Sampling was done at the start of flood tide when seawater was just beginning to enter the estuary.

The data obtained for both diurnal neap and spring tide surveys show how salinity values kept increasing until high water and that salinity stratification was only observed during neap tide.

3.2 Temperature profile

The temperature profile of the estuarine channel is quite predictable. As expected the water at the surface is slightly warmer than the deeper channel water (Figures 8a and 8b).

Figure 8 (a)

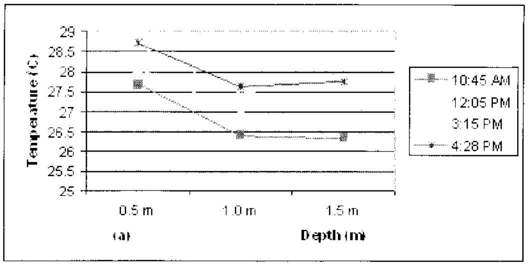

Figure 8 (b)

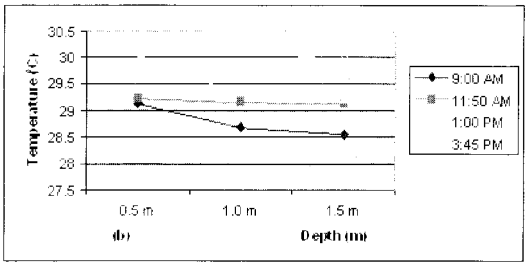

Figure 8. Temperature and depth variation at (a) neap tide and (b) spring tide

Since the waterway is quite shallow, its capacity to store heat over time is relatively small. Thus, no real temperature stratification is observed throughout both semi-diurnal surveys (Figures 9a and 9b).

Figure 9 (a)

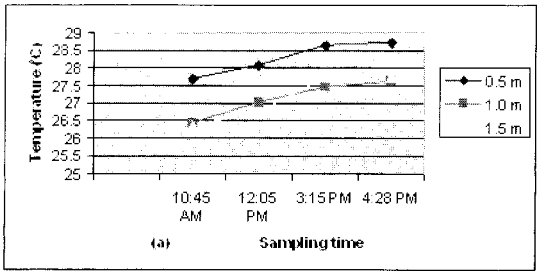

Figure 9 (b)

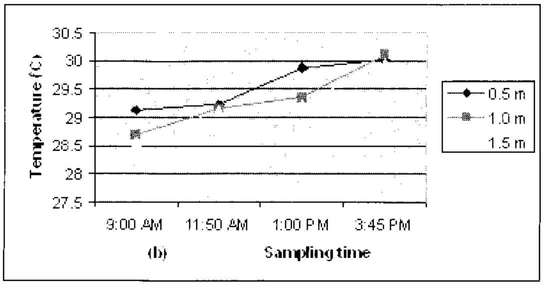

Figure 9. Temperature variation with sampling time at (a) neap tide and (b) spring tide

3.3 Tidal movements

The movement of water in and out of an estuary is predominantly influenced by the tides (NSW Department of Land and Water Conservation 2000). The effect of the neap-spring cycle is noticeable from these two diurnal surveys at Sg. Baru. In general, during weak neap tidal currents, bottom salinity increased.

It has been recognised that spring tidal currents are strong enough to prevent the development of density-driven stratification, but neap currents lower the available mixing energy enough for significant stability to develop (J. Sharples *et al* 1994). Salinity difference causes density difference. The density of seawater is greater than that of freshwater and varies with both salinity and temperature (NSW Department of Land and Water Conservation 2000). Near the mouth of the estuary, the lighter freshwater of the river will remain at the surface and flow right over the top of the denser saline water, which tends to remain near the river bottom (Figures 10a and 10b).

Figure 10 (a)

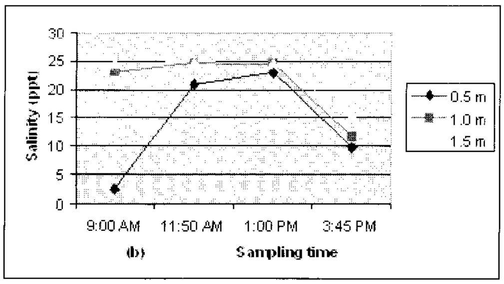

Figure 10 (b)

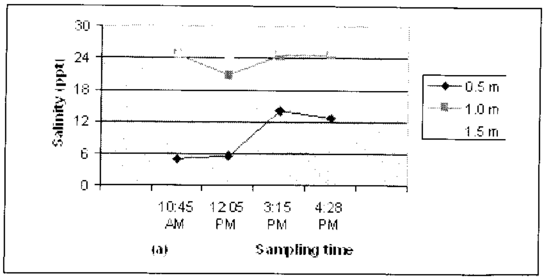

Figure 10 (b). Salinity variation with sampling time at (a) neap tide and (b) spring tide

These waters will ultimately mix, but where that mixing occurs will depend on tides, winds and the volume of freshwater flow. At high tide, the inflow of seawater dominates the salinity, thus vertical mixing occurred.

Salinity presently affects increasing areas of agricultural production and causes negative impacts on the growth of many crop species such as rice. The water used in the paddy fields contains many dissolved salts. Rice not being a halophyte, or plants which can tolerate high levels of salinity, accumulates toxic levels of salt in its leaves if grown in salty water. To limit saltwater intrusion into agricultural areas, saline water floodgates can be installed. In fact, the construction of structures such as dams, navigation channels and reclamation and dredging works in upstream catchment areas reduces both the volumes of freshwater run-off and the freshwater flushing of estuaries (NSW Department of Land and Water Conservation 2000). By virtue of their ability to significantly alter depths within the estuary, such developments can affect the tidal behaviour along the entire estuary.

It should also be noted that the propagation of tides along an estuary is affected by the geometry of its bed, especially water depths. Since the flow of water along the Sg. Baru estuary is regulated by lock gates situated about 0.6 km and 2.8 km upstream of the estuary, these man-made barriers may have significant effect with respect to mixing in times of drought and long-term sediment transport (NSW Department of Land and Water Conservation 2000).

4.0 CONCLUSIONS

The results of this preliminary study show that stronger spring tidal currents are capable of causing a destratification effect in the water column, causing vertical homogeneity at high water. Low tidal velocities at neap tide are insufficient to cause complete vertical mixing and stratified conditions were observed. Thus, bottom salinities are greater than surface salinities. Similar to Kuo-Chuin Wong (1995), a pattern for salinity and temperature variation is observed where lower salinity corresponds to higher temperature and vice versa.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of En. Mat bin Din during data gathering and the services of Tuan Syed Mohd. Hijan bin Syed Hamzah of ILQAM unit, UiTM Arau campus.

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