Influences of Nutrient Outwelling from the Mangrove Swamp on the Distribution of Phytoplankton in the Matang Mangrove Estuary, Malaysia

KATSUHISA TANAKA and POH-SZE CHO

1National Research Institute of Fisheries Science, 2-12-4, Fukuura, Kanazawa-ku, Yokohama 236-8648, Japan
2Fisheries Research Institute, Department of Fisheries, 11960 Batu Maung, Penang, Malaysia

(Received 16 October 1998; in revised form 10 March 1999; accepted 1 May 1999)

Distributions of dissolved nutrients and Chl. a were investigated in the Sangga Besar River Estuary in the well-managed Matang Mangrove Forest in West Malaysia. In the estuary, spring tide concentrations of ammonium, silicate and phosphate were higher than those in the neap tide, which suggests that these nutrients are flushed from the mangrove area by the inundation and tidal mixing of the spring tide. Ammonium comprised over 50% of the dissolved inorganic nitrogen in the spring tide, while nitrite tended to dominate in the neap tide, indicating the predominance of nitrification inside the estuary in neap tides. Nutrient concentrations in the creek water were higher than those of estuarine water, indicating the nutrient outwelling from the mangrove swamp and ammonium regeneration from mangrove litter in the creek sediments. The maximum concentration of Chl. a in spring tides reached 80 μg/l while it was below 20 μg/l in the neap tides. These variations in the phytoplankton biomass and nutrients probably reflect the greater nutrient availability in the spring tide due to outwelling from the mangrove swamp and creek.

1. Introduction

Little information is available on the distribution and dynamics of dissolved nutrients in tropical mangrove areas. Detailed studies on nutrient dynamics in tropical coastal areas are limited to coral reef areas (Boto and Wellington, 1988; Alongi et al., 1992) or pelagic shelf waters (Robertson et al., 1998). Two investigations which examined nutrients in Malaysian mangrove estuaries using mixing diagrams have been made (Nixon et al., 1984; Wong, 1984). Such studies have provided information on nutrient concentrations and their relationships with salinity. However, the distribution and behavior of nutrients are usually affected by tidal and weather conditions. Uncles et al. (1990) showed pronounced spring-neap variability in currents and salinity stratification in the Merbok River Estuary in Peninsular Malaysia. In the riverine forest type mangrove, the mangrove swamp is inundated by river runoff in the wet season and traps land-derived material, which is later outwelled by the tidal mixing and transportation during inundation. Thong et al. (1993) demonstrated that inorganic nitrogen increased after heavy rains or when tides inundated the forest floor in a mangrove creek in Peninsular Malaysia. Therefore, the nutrient mixing diagrams may give different results between spring and neap tides, and between the wet and dry seasons, which will affect the phytoplankton biomass in the estuary.

The major objectives of this study are to investigate tidal effects on the outwelling of inorganic nutrients in the wet season in the Sangga Besar River Estuary in the well-maintained Matang Mangrove Reserve, and to examine their relationships to the phytoplankton distribution in the estuary.

2. Materials and Methods

Matang Mangrove Forest Reserve in Perak is reputed to be the world’s best managed mangrove forest. The Reserve, situated on the northwestern coast of Peninsular Malaysia, consists of some 40,000 hectares of mainly Rhizophora apiculata mangroves (Khoo, 1989). It is the largest tract of mangrove forest in Peninsular Malaysia and has been under sustainable management since the early part of the 20th century.

Keywords:
- Mangrove estuary
- nutrient outwelling
- creek
- phytoplankton distribution
- chlorophyll a

Corresponding author e-mail: katuhi@nrifs.sfrrc.go.jp

Copyright © The Oceanographic Society of Japan.
Table 1. Tidal data for the sampling times.

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>1996</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oct. 29</td>
<td>Nov. 5</td>
<td>Oct. 31</td>
</tr>
<tr>
<td>Tidal range (m)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sp</td>
<td>2.5</td>
<td>0.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Spr (S) or Neap (N)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eb</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling stations</td>
<td>R1-R7</td>
<td>R1-R6</td>
<td>R1-R5</td>
</tr>
</tbody>
</table>

*Tidal data at Lumut (40 km south of Sangga Besar River Estuary) were obtained from the tide table published by the Royal Malaysian Navy.

Fig. 1. Maps of the Matang Mangrove Forest and Sangga Besar River Estuary with the location of sampling stations.

Fig. 2. Heights of high and low waters at Lumut (40 km south of Sangga Besar River Estuary) during the period from 27 Oct. to 6 Nov., 1996 (data from the tide table published by the Royal Malaysian Navy).

Sampling was conducted from October to December in 1996 and 1997 in the wet season within two days before or after, spring or neap tide. Sampling locations in the Sangga Besar River Estuary in the Matang Mangrove Forest and details of tidal data at the sampling times are shown in Fig. 1 and Table 1, respectively. Tides in Kuala Sepatang (Fig. 1) are typically semi-diurnal with mean high water springs of 2.65 m (Sasekumar et al., 1994). Figure 2 shows heights of high and low waters at Lumut (40 km south of Sangga Besar River Estuary) during the period from 27 Oct. to 6 Nov., 1996 (data from the tide table published by the Royal Malaysian Navy). Observations of time series of sea level at Stn. R3 in the periods of 22-23 Nov., 1997 (neap) and 1-2 Dec., 1997 (spring) were made by a self-recording tide gage (RIGO RMD-5225). The differences in the tidal range and high/low water time between from the tide table at Lumut and from the observations were within 20 cm and 90 min., respectively. The Matang Mangrove Forest is a Riverine Forest Type mangrove (Wolanski et al., 1992), which are inundated by most spring high tides. During a neap tide, almost all water is confined to the main channel. In con-