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ScienceDirect
Journal of Asian Earth Sciences 29 (2007) 576–584
Journal of Asian Earth Sciences
www.elsevier.com/locate/jaes

Wave attenuation in coastal mangroves in the Red River Delta, Vietnam

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Received 16 November 2004; received in revised form 19 September 2005; accepted 26 May 2006

Abstract

Wave attenuation was studied in a coastal mangrove system in the Red River Delta, Vietnam on the coast north of Do Son. From sea towards land the study area consisted of a bare mudflat, covered by a sandy layer with embryonic cheniers, abruptly changing into a muddy tidal flat overgrown with mangroves. Three instrumented tripods (A–C) placed in a cross-shore profile, were used to measure current velocity and water level, at the open tidal flat, at the beginning of the mangrove vegetation, and in the mangrove vegetation, respectively. Measurements were conducted in the wet season in July and August 2000. The elevation of the area was surveyed using a levelling instrument. Over the bare sandy surface of the mudflat, the incoming waves are reduced in height (and energy density) due to bottom friction. This reduction decreases with increasing water depth. In the mangrove vegetation, the bottom friction exerted by the clay particles is very low. However, the dense network of trunks, branches and above ground roots of the mangrove vegetation causes a much higher drag force. For the mangrove vegetation which mainly consists of *Kandelia candel*, the drag force can be approached by the function $C_D = 0.6e^{0.15A}$ (with A being the projected cross-sectional area of the under water obstacles at a certain water depth). For the same muddy surface without mangroves the function would be $C_D = 0.6$.

Keywords: Mangrove forest; Wave height reduction; Coastal defence

1. Introduction

Mangroves are tidal forest ecosystems on muddy soils in sheltered saline to brackish environments. They are considered as the low-latitude equivalent of salt marshes and mainly grow in tropical regimes. Mangrove forests are composed of bushes and trees with special root systems for both water and air supply. Because of these root systems, the trees are adapted to grow in anaerobic and unstable conditions of waterlogged muddy soils (Augustinus, 2004). The trunks and roots above the ground have a considerable influence on the hydrodynamics and sediment transport within the forests.

Mangrove forests play an important role in flood defense by dissipating incoming wave energy and reducing the erosion rates. Besides, the wave-driven, wind-driven, and tidal currents also reduce due to the dense network of trunks, branches and aboveground roots of the mangroves. This latter can be seen as an increased bed roughness.

Physical processes of wave dissipation across an intertidal surface with mangroves are not widely studied. Wu et al. (2001) described and modelled the tidal currents in the mangroves, focusing on the current velocity predictions in channels and tidal creeks. Mazda et al. (1997a) and Massel et al. (1999) measured and described the surface wave propagation in mangrove forests. Both studies focused on the wave energy dissipation by bottom friction and vegetation density, where the vegetation impact was incorporated by an extra component of the drag force (see also Mazda

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1367-9120/$ - see front matter
doi:10.1016/j.jseaes.2006.05.008

et al., 1997b). Wave dissipation across an intertidal flat with salt marshes has recently gained more attention (e.g. Brampton, 1992; Kobayashi et al., 1993; Möller et al., 1999; Möller and Spencer, 2002; Cooper, 2005).

This paper describes the wave reduction over a tidal flat and within a contiguous mangrove area in the Red River Delta, Vietnam. Field experiments are used to reach the main purpose: to quantify the wave reduction and wave energy dissipation in these two areas, incorporating the vegetation as an extra drag force.

2. Study area

The Red River Delta is one of the largest deltas in Vietnam and lies in the northern part of Vietnam where the Red River flows into the Bay of Tonkin (Fig. 1). The northern part of the Red River Delta is a tide-dominated system where waves are less important, due to the sheltering effect of Hainan Island and the Chinese mainland. The tides in the Bay of Tonkin are diurnal with a range of 2.6–3.2 m (mesotidal). Active intertidal mudflats, mangrove swamps and supratidal marshes in estuaries and along open coastlines characterize the coastal areas (Mathers and Zalasiewicz, 1999).

The study was conducted on a tidal flat and adjacent mangrove forest situated near Do Son on the Red River Delta (Fig. 1). The mudflat was characterized by sediments of <2 μm diameter (Fig. 2). The eastern part of the mudflat faced the open sea and was covered by a sandy layer with a mean grain size ranging between 100 and 250 μm. This sandy layer was between 2 and 40 cm thick. The western part of the mudflat was overgrown with mangroves and the westward located inland area was separated from the mangrove forest by a sea dyke.

Three instrumented tripods (A–C) were placed along a cross-shore profile (Fig. 2). The average slope of the profile between tripod A and B was 0.19%, which was typical for the whole sand-covered mudflat. The sandy surface on the mudflat extended further seaward of tripod A for several hundreds of meters. Ridges and runnels were observed on the beach plain and the ridges consisted of sand lying on top of the mudflat. These ridges were cheniers in an embryonic stage. The sand was probably derived by winnowing. The cheniers were 10–40 cm high and their crest were aligned north-south. The chenier surfaces were covered with two dimensional wave ripples (10 cm in length). Current ripples were sometimes present in the troughs. Chenier ridges were best developed at the landward site of the beach plain.

The mangrove forest was situated between the sand-covered part of the mudflat and the sea dyke (between tripod B and C in Fig. 2). The variation in bed level in the mangrove area was very small and there were no ripples present. Tripod C was positioned at a slightly lower elevation than tripod B. On the north-east side, the mangrove swamp was drained by a tidal channel, just outside the study area. The muddy soil was very soft and at least 3 m thick. The vegetation between tripod B and C consisted for 88.9% of *Kandelia candel*, 7.4% of *Sonneratia spec.* and 3.7% of *Avicennia marina*. The *Kandelia candel* occurred in bushes and small trees, and had hardly any roots above the ground. The soil between the mangrove trees was full of invertebrates.

3. Methods

3.1. Field methods

Hydrodynamic measurements were conducted using pressure sensors and electromagnetic flow devices. These instruments were attached to the three tripods. The three

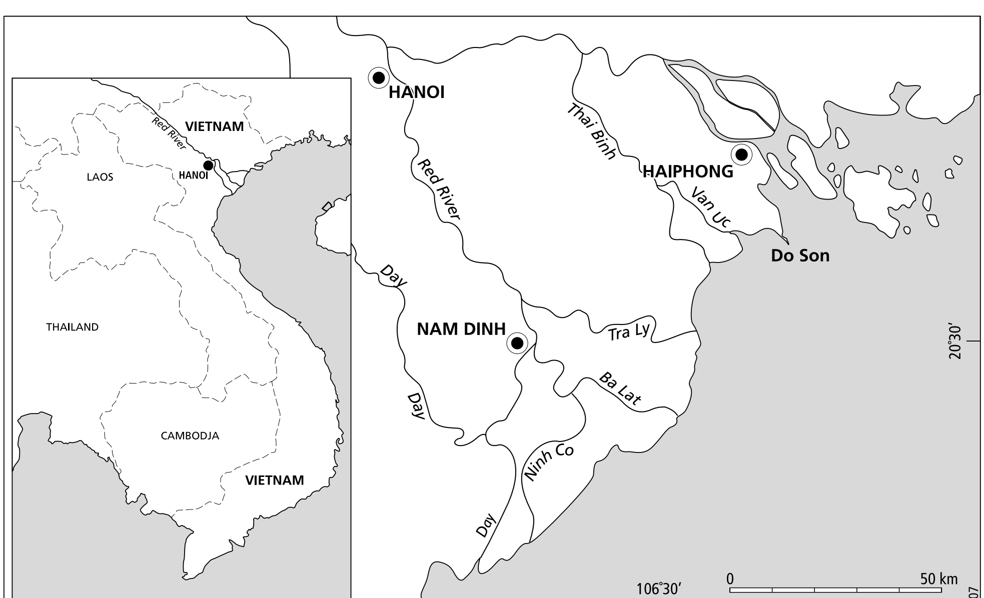

Fig. 1. Topographical map of Vietnam and the Red River Delta with Do Son south east of Haiphong.