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Effective management for acidic pollution in the canal network of the Mekong Delta of Vietnam: A modeling approach

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ABSTRACT

Acidic pollution can cause severe environmental consequences annually in coastal areas overlain with acid sulfate soils (ASS). A water quality model was used as an analytical tool for exploring the effects of water management options and other interventions on acidic pollution and salinity in Bac Lieu, a coastal province of the Mekong Delta. Fifty eight percent of the provincial area is covered by ASS, and more than three-fourths (approximately 175,000 ha) are used for brackish-water shrimp culture. Simulations of acid water propagation in the canal network indicate that the combination of opening the two main sluices along the East Sea of the study area at high tide for one day every week in May and June and widening the canals that connect these sluices to the West Sea allows for adequate saline water intake and minimizes the acidic pollution in the study area. On the other hand, canal dredging in the freshwater ASS area should be done properly as it can create severe acidic pollution.

1. Introduction

Millions of people living in tidal ecosystems of coastal zones, especially in South and Southeast Asia, are among the poorest and most food-insecure because agricultural production is hindered by seawater intrusion during the dry season. Many of these coastal zones are also overlain by acid sulfate soils (ASS). Worldwide, about 13 million ha of coastal ASS are located in Asia, Africa and Latin America (Brinkman, 1982). ASS occupy more than 40% (about 1.6 million ha) of the Mekong River Delta of Vietnam (Minh et al., 1997).

These ASS contain significant amount of pyrite material. Exposure of this material by excavation, lowering of groundwater or drainage results in its oxidation and produces high acidity, thus lowering the pH of the soil and releasing highly toxic elements such as iron and aluminum (Dent, 1986; Cook et al., 2000). Significant environmental damage due to changes in land use of coastal floodplains with ASS has occurred in Australia (White et al., 1997; Sammut et al., 1995, 1996a, 1996b); the Netherlands (Pons, 1973); the Mekong Delta of Vietnam (Tuong et al., 1993; Minh et al., 1997b); the Pearl River Delta of China (Lin and Melville, 1994); South Kalimantan, Indonesia (Hamming and van den Eelaart, 1993) and Finland (Palko and Yli-Halla, 1993).

Rainfall can leach acidic contaminants out of the soil, which in turn acidify and pollute the receiving waters (Minh et al., 1997). Acidic pollution of the water causes dramatic changes in the stream environment (Sammut et al., 1995, 1996b), including many adverse effects on plants (Dent, 1986; Xuan, 1993), fisheries, domestic water (White et al., 1997) and corrosion of engineering infrastructure (White et al., 1996). Surface runoff and sub-flow are the main routes for draining the acidity from ASS into canals (Minh et al., 2002). Macdonald et al. (2004) found that runoff from ASS affected the existing sulfide-rich sediments within an estuarine lake. On the other hand, Cook et al. (2000) found that acidity in the drains was mainly coming from agricultural land by groundwater discharge. They concluded that sub-flow is a more severe hazard than runoff for acid pollution. Other studies also claimed that the source of acid loads from agricultural fields entering canal water is groundwater, leaching from drain bank edges or seepage through drain walls

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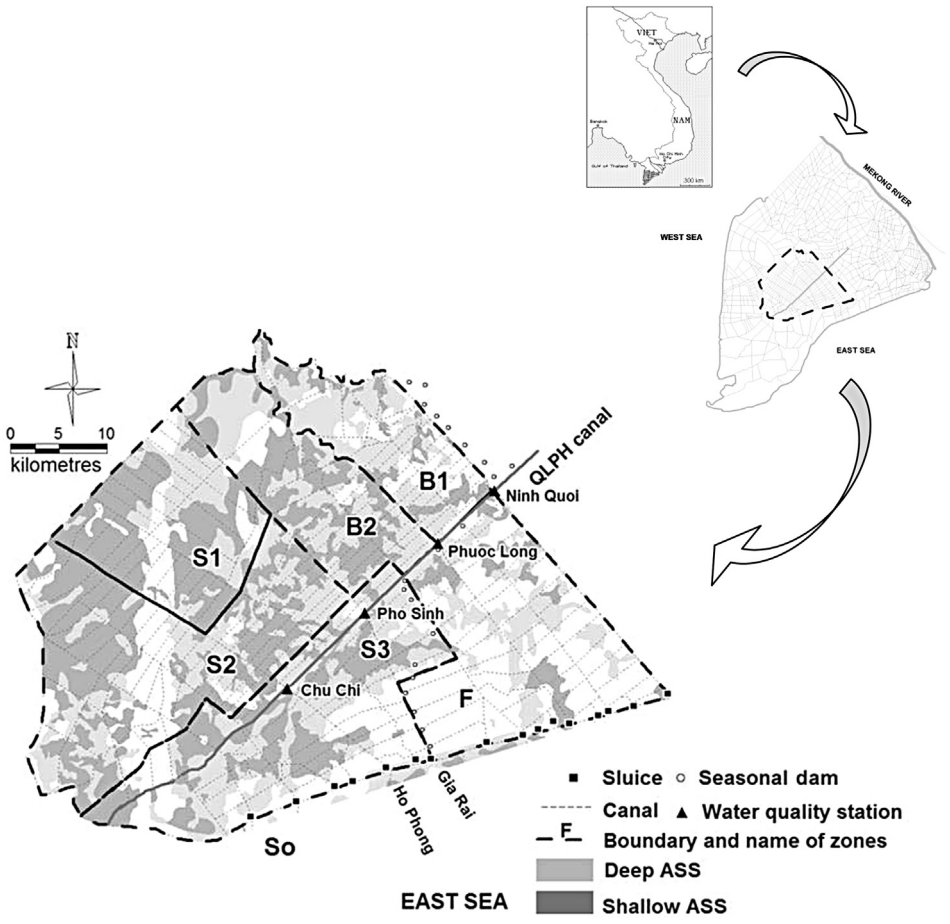

Fig. 1. Soil map of Bac Lieu province, Ca Mau peninsula, Vietnam, with dense canal network in freshwater zone (F) and saline-water zones (S1, S2, S3, B1 and B2).

with a low pH in the range of 3.2–4 (Blunden and Indraratna, 2000).

In the Mekong Delta of Vietnam, reclamation of ASS for agriculture and aquaculture has led to widespread acidic pollution of surface water in the freshwater zone (Tuong, 1993) as well as in the saline coastal zone (Hoanh et al., 2003; Gowing et al., 2006). Tuong et al. (2003) showed that inappropriate water management, land uses of ASS and acidic pollution have led to a 70% reduction in income of the farmers living in the ASS area of Ca Mau peninsula, a coastal area of the Mekong Delta of Vietnam. On ASS, spoils deposited on canal embankments during construction or dredging may be oxidized and form a source of acidic pollution (Tuong et al., 1998).

In this study, extensive modeling was used to explore alternative water management practices and other interventions such as canal widening to reduce acidic pollution in ASS areas. Such reduction will improve water quality and provide suitable water environment for both aquaculture and agriculture in the region.

1.1. The study area

The coastal plain of Bac Lieu province, Ca Mau peninsula is the study area located in the south of the Mekong Delta of Vietnam (Fig. 1). It is an area with a highly modified environment. The three most important soil groups in the study area are alluvial soils located in the northern and eastern parts near the Bassac River, ASS mainly located in the large depression in the central and western parts, and saline soils located in the southern and western parts along the East and West seas. Roughly 90% of the annual rainfall in Bac Lieu (1800 mm) is concentrated in the rainy season from May to mid-November. Rice crop is dominant in the north and shrimp raising is widespread in the south, where salinity is quite common in canal water (Hoanh et al., 2003). During the dry season from mid-November to April, freshwater availability for irrigation is a major constraint to rice production.

The canal network comprises a main canal, the Quan Lo Phung Hiep (QLPH), which connects the study area to the Bassac River, and series of canals of different capacity (BWRMBL, 2006, Fig. 1). The primary canals are perpendicular to the QLPH, at about 4–5 km apart. Their typical cross-section is 30–50 m wide and 4–10 m deep. The embankments of primary canals are about 10 m wide.

The secondary canals connect to the primary canals at 1 km spacing, and their typical cross section is 10–15 m wide and 1.5–2.0 m deep. The embankments of secondary canals are 7 m wide. The tertiary canals are spaced at 500 m and connect to secondary canals. Their typical cross section is 5–8 m wide and 1–2 m deep, with 5-m wide embankments.

The tide in the East Sea is semi-diurnal (two high waters and two low waters each day) with high amplitude from 3 to 4 m, compared with only 0.5–1 m amplitude of diurnal tide (one tidal cycle per day) in the West Sea.

A series of sluices along the East Sea side is operated for delivery of saline water taken from the East Sea for shrimp culture in the central part of Ca Mau peninsula or the western part of Bac Lieu province (Fig. 1). These sluices are also operated harmonically with the construction of temporary dams to restrict salinity intrusion into the agricultural zone in the eastern part of Bac Lieu. The only