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Suspended sediment in tidal currents: An often-neglected pollutant that aggravates mangrove degradation

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ABSTRACT

In this study, the influence of sediments deposited on the leaves of different mangrove species due to tidal movements on photosynthetic characteristics and chlorophyll fluorescence of the species was explored. The degree of accelerated degradation among different mangrove species was also obtained. Results show that the leaves of mangrove species have varying degrees of sediment deposition. Sediment deposition leads to photosynthetic reduction and physiological stress among *Kandelia candel*, *Aegiceras corniculatum*, and *Avicennia marina* in the Quanzhou Bay. Thus, the deposition of suspended sediments from tidal currents is an important environmental factor that accelerates the degradation of some mangrove species.

1. Introduction

Mangroves are assemblages of trees and shrubs that dominate the intertidal zone along coastlines, estuaries, and islands in tropical and subtropical regions worldwide and form biologically important and productive transitional coastal ecosystems (Middleton and Mckee, 2001; Alongi, 2002). However, more than one-third of the global human population lives along coastal areas, and the long-term sustainability of these populations depends on the coastal ecosystems (Barbier et al., 2008). The over-exploitation of mangroves and their consequent destruction vastly occur. Therefore, mangroves are one of the most threatened tropical ecosystems, with global loss exceeding 35% over the past 50 years (Alongi, 2002; Mumby et al., 2004). Mangroves are still disappearing worldwide by an annual rate of 1–2% primarily because of aquaculture, urbanization, coastal landfill, or pollution. Thus, the view that mangroves may vanish if the destruction of mangrove ecosystems continues has been repeatedly put forward (Duke et al., 2007).

For the conservation and sustainable utilization of mangrove ecosystems, numerous studies have focused on the different types of environmental stress to which mangroves are exposed. Some studies have paid attention to the adverse effects of some pollutants carried by tidal currents (e.g., different heavy metals, various petrochemicals, surrounding microorganisms, and anthropogenic sewage) on the germination, growth, photosynthesis rate, and enzymatic activity of mangroves. These pollutants even contributed to the degradation of mangrove ecosystems to some extent (Attri and Kerkar, 2011; Dos Santos et al., 2011; Herteman et al., 2011; Glassman and Casper, 2012). In recent years, soil erosion accelerated by intensified human activities led to elevated suspended sediment concentrations during tidal currents. Tidal ebb and flow result in the deposition of suspended sediments on the leaves of different mangrove species. In addition, the leaves of some mangrove species are covered with a thick layer of sediment, which could interfere with stomatal functioning and light energy absorption. Thus, suspended sediments from tidal currents have become actual pollutants. However, whether or not tides contribute to the degradation of mangroves to a certain extent remains uncertain. Previous studies related to suspended sediment carried by tidal currents mostly focused on the characteristics of sediment transport (Capo et al., 2006; Adame et al., 2010), input of organic nutrients (Kristensen et al., 2008), or the role of sediment microorganisms in mangrove ecosystems (Holguin et al., 2001). Less information is available on the effects of suspended sediment on the photosynthetic characteristics of mangrove leaves. Ellison (1999) pointed out that excessive sediment deposition on mangroves can cause death of the trees because of root smothering. In the present paper, the degrees of stress to which three mangrove species are exposed are determined by comparing the amount of sediment deposited on the leaves with the effects of these sediments on photosynthetic gas exchange and chlorophyll fluorescence. The hypothesis that suspended sediment in tidal currents

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contributes to the degradation of some mangrove species is proved. Moreover, the often-neglected pollutant that aggravates mangrove degradation is emphasized. This study may be beneficial to the conservation and sustainable utilization of similar mangrove ecosystems.

2. Materials and methods

2.1. Study site and study species

Quanzhou Bay (24°46′–58′N, 118°38′–47′E), which is located on the southeast coast of Fujiang Province, China, is a semi-enclosed bay with its mouth opening toward the Taiwan Strait (Fig. 1). The research site has a total area of 136.42 km^2, an annual average temperature of 19.2 °C, an annual average precipitation of 1120 mm, and an annual average evaporation of 2000 mm. The bay experiences semi-diurnal tides, and tidal current movement is primarily a stable back-and-forth current. The bay is also an important estuary of two main rivers, i.e., Luoyang and Jinjiang Rivers, which flow through the most active, fast growing, and most serious soil erosion regions in Southeast China. Moreover, these rivers transport a large amount of suspended sediment into Quanzhou Bay.

Three adult native mangrove species, namely, *Kandelia candel* with mean height of 2.5 m, *Aegiceras corniculatum* with mean height of 1.8 m, and *Avicennia marina* with a mean height of 2.0 m, constitute the mangrove communities in the Quanzhou Bay estuarine wetland. When the tide rises, the vast majority of adult mangrove plants are submerged under the tidal currents, with only the topmost part of *A. corniculatum*, and *A. marina* and the upper part of *K. candel* extending above the tidal range. Thus, much sediment was deposited on the leaves of these mangrove plants. Mangrove communities in Quanzhou Bay are also suffering from some degree of degradation in recent years. Of the three mangrove species, the *A. marina* population exhibits the most obvious symptoms of degradation, such as decreased growth and propagation rates, increased disease and individual death, and even disappearance of populations in some areas.

2.2. Measurement of tidal suspended sediment concentration and sediment deposited on leaves

Sampling plots were selected on the beach close to the bank of the Luoyang River and near the Yuguang Middle School of Huian Country. When the tide rose on September 8, 2013 (mean tidal

Fig. 1. Location of Quanzhou Bay.

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