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Trace metal partitioning in *Thalassia testudinum* and sediments in the Lower Laguna Madre, Texas

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Abstract

Seagrass communities dominate the Laguna Madre, which accounts for 25% of the coastal region of Texas. Seagrasses are essential to the health of the Laguna Madre (LM) and have experienced an overall decline in coverage in the Lower Laguna Madre (LLM) since 1967. Little is known on the existing environmental status of the LLM.

This study focuses on the trace metal chemistry of four micronutrient metals, Fe, Mn, Cu, and Zn, and two non-essential metals, Pb and As, in the globally important seagrass *Thalassia testudinum*. Seasonal trends show that concentrations of most essential trace metals increase in the tissue during the summer months. With the exception of (1) Cu in the vertical shoot and root, and (2) Mn in the roots, no significant positive correlation exists between the rhizosphere sediment and *T. testudinum* tissue. Iron indicates a negative correlation between the morphological units and the rhizosphere sediments. No other significant relationship was found between the sediments and the *T. testudinum* tissue. Mn was enriched up to 10-fold in the leaf tissue relative to the other morphological units and also enriched relative to the rhizosphere sediments. Both Cu and Mn appear to be enriched in leaf tissue compared to other morphological units and also enriched relative to the Cu and Mn in the rhizoshpere sediments.

Sediments cores taken in barren areas were slightly elevated in Zn relative to the rhizosphere sediments, whereas no other metals showed statistical differences between barren sediment cores and rhizosphere sediments. However, no correlation was measured in *T. testudinum* tissue and Zn in rhizosphere sediments. Previous studies suggested that Fe/Mn ratios could indicate differences between seagrass environments. Our results indicate that there is an influence from the Rio Grande in the Fe/Mn signature in sediments, and that ratio is not reflected in the *T. testudinum* tissue.

The results from this study show that the LLM contains trace metal concentrations less than or equal to values for uncontaminated locations worldwide. In addition, there appears to be a complex partitioning in the trace metals in the morphological units of *T. testudinum* tissue and that analysis only of the leaf may not be indicative of the trace metal levels in this important seagrass species.

Keywords: Trace metal partitioning; *Thalassia testudinum*; Sediments

1. Introduction

It is well known that seagrasses are critical to the structure and function of many marine ecosystems (Klumpp et al., 1989). Seagrasses provide habitat, sediment stability, nutrients, and a food source. In addition, annual production of carbon from seagrasses reaches 4×10^3 g C/m^2, ranking them as the most productive submerged habitats (McRoy and McMilan, 1977). Only salt marshes rank above seagrasses in annual carbon production (Maurinucci, 1982). Over 50% of the inshore finfish catch is supported by seagrass habitats (Hedgepeth, 1967). However, many of our seagrass ecosystems are declining. For example, Botany Bay Australia showed a 58% decline in coverage of *Posidonia australius* (Larkum and West, 1990). In Florida Bay, seagrass standing crop has declined up to 93% for *Syringodium filiforme* and 28% for *Thalassia testudinum* (Halk et al., 1999; Zieman et al., 1999). Quammen and Onuf (1993) and Onuf (2003, personal communication) report a 450% increase in the unvegetated bay bottom in LLM since 1965. These events are disturbing and dictate the need to better understand the causes of seagrass decline.

In Texas, over 25% of the coastal environment is dominated by seagrass based ecosystems (Onuf, 1995).

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Because of the enclosed nature of the entire LM, constituents are recycled in the form of detritus (Pulich et al., 1976). This makes the LM especially sensitive and vulnerable to input of pollutants since the tidal flushing and freshwater input, characteristic of traditional estuaries, is highly restricted. The residence time and exposure of pollutants, such as trace metals, to the estuary is consequently quite high.

Trace metals, unlike pesticides, petroleum hydrocarbons, and acid rain, occur naturally in organisms. In fact, selected trace metals are essential micronutrients and occur in soils and seawater as part of weathering of crustal rocks and marine sediments. High concentrations of certain essential trace metals can however be toxic (Ralph and Burchett, 1998; Prange and Dennison, 2000). Human activities such as maintenance dredging, transportation activities from the Brownsville Ship Channel and Gulf Intracoastal Waterway (GIWW), and runoff from the Rio Grande and the Arroyo Colorado are all potential sources for heavy metals. Up stream on the Arroyo Colorado new wastewater treatment plants have been built to keep up with the burgeoning population, causing potential increases in toxins and nutrients introduced into the enclosed LLM.

The Rio Grande Valley area bordering the LLM has been a major agricultural producer for the last 75 years. Agricultural chemicals, including arsenic, were used until 1970 on cotton to defoliate leaves prior to harvesting the cotton. Lead was widely used in fuels and other agricultural chemicals until 1990. Because of low rainfall and corresponding small volumes of freshwater runoff, chances of chronic contaminant input into the LLM are small. However, isolated values were reported for elevated metals in the Brownsville Ship Channel, the Port Isabel turning basin, and in sediments from the Port Mansfield harbor (Bowles, 1983, 1984; Webster, 1986). In addition, background levels of As, Pb, Zn, and Cu (among other metals), were reported in sediments from the mouth of the Arroyo Colorado (TNRCC, 1995). In the northern section of the Upper Laguna Madre (ULM), sediments showed enriched levels of Ba, V, Cu, Zn, Mn, and Fe (Sharma et al., 1999). Values decreased to background levels a few kilometers south.

The seagrass, *Posidonia oceanica*, has been studied as a biomarker of trace metal contamination in various parts of the world, especially the Mediterranean coast (Maserti et al., 1988; Sanchiz et al., 1990; Costantini et al., 1991; Catiski and Panayotidis, 1993). Along the US Florida coast, *T. testudinum* leaves were used to evaluate the As content in several estuaries (Fourqurean and Cia, 2001). In the ULM, several studies of the trace metal content in *T. testudinum* and *Halodule wrightti* have been reported (Pulich, 1980). *H. wrightti* is the most abundant seagrass in the LM system, however *T. testudinum* is increasing its northward coverage especially in the LLM (Kaldy and Dunton, 1999; Onuf, 1996a,b; Quammen and Onuf, 1993). In addition, there have been recent investigations on sunlight and hydrogen sulfide stress and the resulting physiological responses of *T. testudinum* in the LLM (Major and Dunton, 2002; Kaldy and Dunton, 1999; Cummings and Zimmerman, 2003; Lee and Dunton, 2000). *T. testudinum*'s subsediment biomass including the root/rhizome complex can account for over 50% of the total plant biomass (Powell et al., 1989; Fourqurean and Zieman, 1991). Hence, the trace metals in the sedimentary environment could be reflected in the extensive subsediment plant tissue. *T. testudinum* is a climax species (Zieman, 1982) and is an abundant seagrass in many tropical and subtropical environments worldwide. For these reasons, we have selected *T .testudinum* as an indicator seagrass species for trace metal determination in the LLM.

In this paper, we report concentrations of four important micronutrient metals (Fe, Mn, Cu and Zn) and two nonessential trace elements (As and Pb), in *T. testudinum* tissues, sediment cores, and rhizoshpere sediments from the LLM. We also evaluate the use of *T. testudinum* as a biomarker organism for trace metals and the relationship between these metals in sediments and *T. testudinum* tissue.

2. Methods

2.1. Geographic setting

The Laguna Madre of Texas (Fig. 1) is a 185-km shallow lagoon (average depth less than 1 m) that originated during the Holocene eustatic sea level rise. The coastal plain bordering the Gulf of Mexico was subsequently inundated concurrent with barrier island development, forming the Laguna Madre of Texas and Mexico (Morton et al., 1998). The Mexican and Texas sections of the LM make up the largest hypersaline lagoon in the world (Tunnell, 2002).

The Texas Laguna Madre is divided into two primary water bodies, the ULM and the LLM by a 20-km section of wind tidal flats, commonly known as "The Land Cut". Distinctive Rio Grande deltaic features such as oxbows lakes, distributary bars, and Chenier plains dominate the western shore of the LLM. The GIWW connects these two sections of the Laguna Madre. The LLM, by definition, begins south of the Land Cut extending 93 km to South Bay, which is the southern-most bay in the United States. It should be emphasized that the entire length of the Upper and Lower Laguna Madre is hypersaline averaging over 40 ppt during most of the year. However, during the last 30 years, hypersalinity has decreased from over 50 ppt by connection to the Gulf of Mexico via the jettied passes at the Mansfield Channel, the Brazos Santiago Pass at Port Isabel, and the GIWW (see Fig. 1). Salinity decrease is considered one of the primary reasons that coverage of *T. testudinum* is increasing in the LLM (Onuf, 1996a; Quammen and Onuf, 1993).

The LM of Texas extends 185 km south from Corpus Christi to the Rio Grande, and covers 25% of the Texas coast. Historically the land bordering the LLM has been primarily used for agriculture. The Arroyo Colorado is a