SULFIDE PHYTOTOXICITY IN TIDAL SALT MARSHES

A Thesis

Presented to the

Faculty of

San Diego State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in

Biology

---

by

John Franco Cantilli

Spring 1989

ABSTRACT

Pore water sulfide has frequently been cited as an important cause of reduced Spartina (cordgrass) growth in numerous Atlantic and Gulf coast salt marshes. Several factors prevent the confident identification of sulfide as a direct phytotoxin. Sediment characteristics that affect pore water sulfide concentrations, including aeration and drainage, can also exert considerable influence upon plant growth.

Little (or no) work on the cordgrass-sulfide toxicity question has been done on the Pacific coast. Moreover, sulfide may influence the growth and distribution of Salicornia virginica (pickleweed), the dominant California low marsh halophyte. A field survey was conducted along a contour of constant elevation, in order to clarify the relationship between salt marsh plants, sulfide, and soil. Three San Diego County marshes were employed: Paradise Creek marsh, Caltrans connector marsh (an adjacent man-made wetland), and the inland lagoon at Tijuana Estuary (TJE). The man-made marsh was exploited to investigate soil factors that affect sulfide accumulation.

Pore water sulfide concentrations (at depths of 5, 15, and 25 cm) redox potential (Eh, 5 and 15 cm), and pH (5 and 15 cm) were measured in winter (1987-1988) and summer (1988). Seasonal variation was generally not significant. Cordgrass total stem length (TSL)-sulfide patterns were essentially random in the Paradise Creek and connector marshes, but significant (and near-significant) positive correlations appeared at the TJE inland lagoon site, especially in summer. In both the Paradise Creek and TJE marshes, several correlations among the variables (sulfide, Eh, pH, TSL) were consistent with this positive trend.

Along the southwestern shore of the TJE inland lagoon, cordgrass zones had significantly higher sulfide concentrations (at 5 and 15 cm depths) than adjacent pickleweed zones. A possible causal mechanism for this zonation was examined in a 67-day hydroponic experiment with

S. virginica. The response of pickleweed to low (1 mM) sulfide levels did not differ from that of the control, but higher concentrations (3 mM) were clearly harmful. Sulfide levels reached nearly 3 mM in the Spartina zone at the Paradise Creek and TJE inland lagoon marshes.

The possibility that the cordgrass-sulfide relationship is a positive, autogenic one was supported by two additional observations. First, the natural Paradise Creek marsh had significantly higher sulfide concentrations than the man-made connector marsh. Second, the addition of organic matter (OM) to estuarine creek mud in an incubation experiment suggested that OM can limit sulfate reduction (and sulfide accumulation). On average, the artificial marsh has about half as much sedimentary OM (<2 mm fraction) as the natural marsh (0-10 cm depth). Spartina foliosa density and aerial biomass is also higher in the natural marsh. At a constant elevation, plant-derived OM is probably the main factor controlling sulfide production. Without sufficient OM, the man-made marsh does not function as a natural one.

Both Spartina and Salicornia undoubtedly possess metabolic adaptations that permit them to tolerate sulfide to some degree. Gradients in growth along elevation gradients may be better explained by the numerous problems that accompany anaerobiosis.

ACKNOWLEDGEMENTS

I thank Joy Zedler, Ross Virginia, Richard Gersberg, and Rene´ Langis for critically reading this manuscript. Joy Zedler read several versions, and, true to her title, offered useful advice during each stage of the study. Ross Virginia and Richard Gersberg kindly agreed to join my committee at a rather late date, and are hereby absolved of responsibility for any major flaws herein.

Kendra Swift pioneered the research upon the Paradise Creek-connector marsh system. She generously provided sampling sites, data, and maps (Figures 1 and 2). Rene´ Langis, Sue Rutherford, and Theresa Sinicrope cheerfully permitted me to "quote" them in the Discussion section.

Robert Berner and Don Rhoads introduced me to the wonders of sulfide, in several classes and seminars (New Haven, Conn.). They elegantly demonstrated that the biological and geological sciences are inseparable.

This work is a result of research sponsored in part by NOAA, National Sea Grant College Program, Department of Commerce, under grant number NA85AA-D-SG140, project number R/CZ-82, through the California Sea Grant College Program, and in part by the California State Resources Agency. The U.S. Government is authorized to reproduce and distribute for governmental purposes.