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Remediation of Sulfide Toxicity in Aquatic Sediments Impacted by Wood Waste Pollution: Laboratory, Modeling and Field Pilot Studies

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Historical logging and milling operations in Esquimalt Harbor, British Columbia, Canada resulted in the accumulation of more than 200 hectares of subaqueous wood waste (WW) deposits. Wood waste decomposition in the marine environment creates anoxic conditions and drives sulfate reduction and production of porewater sulfide (up to 200 mg/L) which is toxic to benthic organisms. Diver and video mapping of WW deposits, in conjunction with porewater sulfide (by DGT and microelectrode voltammetry) and sediment chemistry data (total and labile organic carbon, iron and sulfur) were used to delineate impacted areas. Laboratory mesocosms conducted over a 1-year period demonstrated the effectiveness of capping WW with sand (with and without various reactive amendments) by isolating the organic-rich WW from the sediment-water interface and thereby controlling sulfide production. The long-term effectiveness of sand cover was linked to its reactive iron content. Ferric iron can oxidize porewater sulfide diffusing upward and dissolved ferrous iron produced is available to further react with sulfide, thereby sequestering it in solid phases such as mackinawite and pyrite which were identified by bulk chemical and X-ray absorption methods. The laboratory study results led to a field pilot study including several test areas with both unamended and siderite ($FeCO_3$)-amended sand cover (30 cm thick) to evaluate placement methods, cover physical stability, and effectiveness at mitigating sulfide toxicity under dynamic field conditions. DGT profiles show no sulfide breakthrough in the upper 15 cm of sand cover over two years of monitoring whereas similar profiles in control areas (no cover) show seasonally variable but generally elevated sulfide concentrations with depth. A diagenetic model calibrated to DGT sulfide profiles of control areas was used to evaluate long-term performance of cover as a function of labile carbon content and thickness of WW deposits. Initial model results indicate that the sulfide attenuation capacity of sand is likely sufficient for long-term protection over thinner WW deposits (e.g., 30 cm or less) whereas thicker deposits may require addition of siderite to the sand to enhance long-term cover performance. The model will be used to evaluate cover thickness and amendment dosing for different WW areas during remedial design.