

Science, Technology and Social Value: Aquatic Ecosystem and Human Health Impacts of the Mercury Cell Chlor-Alkali Industry

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Social Value (n): the overall worth or importance of something to society as a whole, encompassing the collective benefits and contributions to public good, extending beyond economic or individual gain.

To be compensated, you must be valued. Developed in the 1890s and jointly patented in the United States and Austria, the Castner-Kellner chlor-alkali cell utilized elemental mercury in the electrochemical conversion of brine into chlorine gas and caustic soda. Over the span of the 20th century, ~300 mercury cell chlor-alkali facilities were built globally, generating Cl₂ for the production of bleach (for drinking water treatment and/or pulp and papermaking), PVC, and organochlorine pesticides, as well as NaOH for the catalytic cracking of petroleum and production of synthetic fibers. Across the Americas, mercury cell facilities were built in Canada (n = 15); the United States (n = 31); and in ten countries across Latin American (n = 24).

This paper summarizes the geographical distribution and eras of reliance on this technology across the Americas, including identification of national and international regulations that have closed or are in the process of eliminating the use of mercury in the chlor-alkali process. With specific focus on facilities that operated in Canada (Dryden, ON), the United States (McIntosh, AL) Nicaragua (Managua), and Venezuela (Maracaibo), this study also examines the ecological and human health impacts of facility operations as well as the aftermath of facility closures across a range of freshwater, estuarine and marine aquatic environments.

Teaching Ocean Science and Ocean Stewardship at a U.S. (Maine) Maritime Academy

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Many undergraduate students in STEM as well as vocational-technical training fields struggle with data literacy and quantitative reasoning skills, including the ability to integrate and apply learning across their academic programs. Studies in the pedagogy of STEM have increasingly demonstrated that approaches that are immersive and inquiry-based provide better learning outcomes for students than more passive pedagogical techniques. To this end, Maine Maritime Academy (MMA) is a career-oriented college in Castine, Maine (USA) that trains professional mariners via strong emphasis on hands-on learning. In addition to its core license-oriented programs, MMA also has a long and successful history of training physical and biological scientists with focus on interdisciplinary ocean research.

This project evaluates successes, challenges and innovations in the engagement of license-oriented students with ocean science. Teaching strategies explored include service learning courses taught by Ocean Studies (OS) faculty; interdisciplinary courses co-taught by faculty from across MMA; an on-going ArgoFloat collaboration between WHOI and the Training Ship State of Maine (TSSOM); environmental monitoring as a component of TSSOM training cruises; and OS Senior Capstone projects leveraging curiosity about ocean instrumentation into focus on community science and water quality. As framed, strategies explored herein are designed to innovate curriculum in pursuit of graduating skilled mariners with also an awareness of wise resource stewardship and the need for ocean ecosystem protections.

Silver Gelatin Photo Paper as a Tool for Characterizing Microbially-Mediated Redox Dynamics in Saturated Sediments

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At temperate latitudes, *Spartina*-dominated salt marshes exist as a dynamic balance between the rate of sea level rise; the availability of sediment for vertical marsh accretion; and the growth and predominance of botanical species with varying tolerances for salt exposure and rootzone saturation. For these coastal marshes, a limiting condition for healthy growth and sustained function may lie in the frequency, depth and duration of tidal inundation. Specifically, prolonged soil saturation following inundation results in water logging of the soil; biogeochemically, water logging in the presence of sulfate (SO_4^{2-}) results in shallowing (shoaling) of the depth of microbial sulfate reduction and resultant accumulation of sulfide with potential impacts on seed germination, plant root development and rhizome propagation. Ultimately, prolonged inundation of low topographic areas on a marsh platform results in the localized die-back of marsh vegetation and the elevated potential for overall marsh fragmentation.

Monitoring sulfide within the root zone of marsh soils is challenging for reasons including analytical costs, specificity of sample stabilization requirements and temporal limitations on the duration of field deployments. To address these limitations and based on the high affinity of silver (Ag) for free sulfide (S) ($K_{sp} \approx 10^{-50}$), strips of field-deployed photographic paper ("silver gelatin prints") have been tested as a sulfide monitoring medium over a sulfide concentration range (~ 5-50 mg/L) relevant for assessing botanical toxicity. Utilizing this approach and applying free ImageJ software to quantify and chemically characterize the results of stabilized (fixed) and subsequently digitally scanned test strips, short (< ½ hr) field deployments have been effected for fine-scale determination of ecologically relevant concentrations of porewater sulfide in coastal Maine salt pools. Results are presented here for deployment series in a range of coastal Maine salt marsh pools (5 min. deployment period) as well as in comparison to a porewater sulfide profile generated with a 30-day dialysis sampler deployment. The dialysis sampler deployment applied the standard method of sulfide determination following field stabilization of porewater aliquots with Zn-acetate and spectrophotometric analysis via the Cline method.