Mitigating the Risk of Bioaerosol Pollution from Ballast Tanks

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Introduction

Each time a ship dumps its ballast water, a mist effect takes place not unlike the phenomenon that occurs at the Niagara Falls. However, this mist carries biota from around the world and reaches sensitive on-shore populated areas. These "bioaerosols", which are composed of nuisance biota, are fueled by the re-suspension pf sediments and the seeding from ballast tank biofilms as the ballast water is emptied. "As global trade increases, pollution from large cargo ships is becoming a significant threat to public health ..Ships generate 15-30% of the world's smog-forming emissions. Earthjustice is now pushing strict pollution limits in order to reduce emissions from new and existing shipping fleets." (EarthJustice, 2010 Docket). Our Project is to minimize the related threat of unwanted microbes travelling with these pollutant plumes.

Figure 1: Ballast Organic Biofilm (BOB) sampler

Figure 2: Scanning electron micrograph of typical bacteria-dominated biofilms from ballast tank coupons carried around the world, as found using the Ballast Organic Biofilm sampler.

Methods

The reality of the persistence of world-wide ballast water-tank biofilms, and of re-suspended fine sediments carrying the same, was demonstrated with sampling devices (BOB's, Figure 1) carried by around-the-world and Great Lakes ships. The organic chemistry and fine particle compositions of such films were shown by spectroscopic and microscopic techniques (Figures 2, 3, 4). The presence of microbes in the aerosols generated by plunging-water-generated plumes from biota-containing waters was demonstrated experimentally(1). Aircraft-based and air-impactor fine particle plume tracing showed high concentration peaks of respirable particulates persisting 15 miles inland from point sources near the Port of Buffalo shore. (Figure 5) Work in progress seeks to periodically detach and remediate the microbe-rich slime layers of biofilms and sediments by application of a surface-active displacement solution (SADS) and a subsequent easy-release compliant paint layer to the ballast tank walls to minimize further buildup.

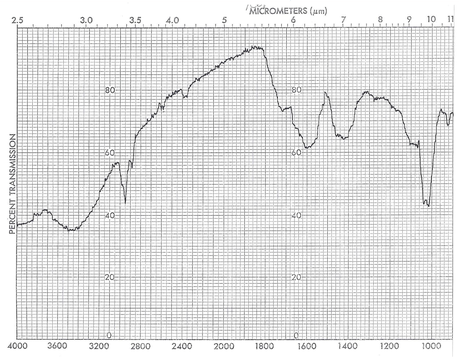

Figure 3: A typical infrared spectrum of collected ballast water biofilms.

Results

A laboratory model of a plunging ballast water plume, similar to a small breaking wave, showed efficient and concentrated water-to-air transfer of the marker microorganism *Serratia marinorubra* into respirable droplets less than 10 micrometers in diameter. Surface-active displacement solution (SADS)-sprayed biofilms, when replaced with easy-release coatings, were thinner and more patchy and easily detached than originally found.

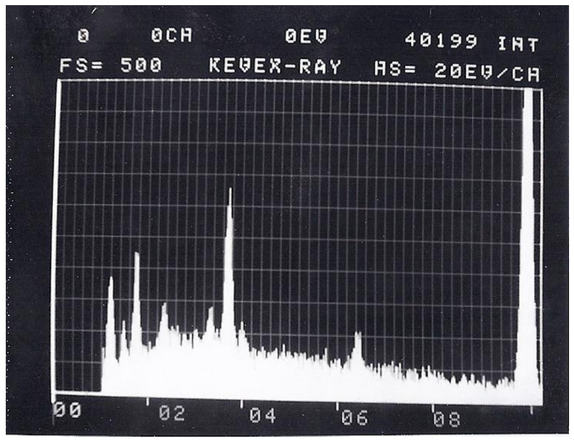

Figure 4. A typical Energy-Dispersive X-ray spectrum of the aerosolizabe particles from a plunging water plume in contact with ballast organic biofilms.

Conclusion

Since an inner ear infection {2} from an oceanic microbe has been apparently developed in Cleveland Harbor from such a protected and released biofilm organism, the health risk is consequential. Particle plumes of this size advect more than 15 miles inland as potential health-impacting pollutants (see Figure 5, below). Removal of the ballast tank biofilms at the Port of Buffalo and other coastal ports would be an environmental health measure of benefit to the reduction of air pollutants and health risks around port cities.

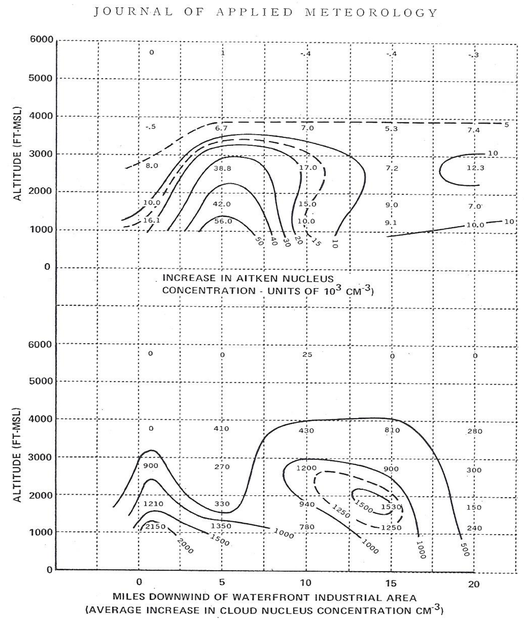

Figure 5: Contours of average increase in Aitken and cloud nucleus concentrations downwind of Lake Erie waterfront , Buffalo, N.Y.

References

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