



Hydrogen Sulfide Exposure on Rhode Island's Shoreline

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Recently, residents of the Conimicut Point neighborhood in Warwick, Rhode Island, were exposed to hydrogen sulfide gas produced by rotting seaweed and shellfish in shallow waters off a bayside neighborhood. The exposure was unusual because of its source, intermittence, intensity, and tenacity. Although health effects attributable to hydrogen sulfide exposure have not been reported to the Rhode Island Department of Health (HEALTH) by local physicians participating in a special surveillance effort, many local residents experienced considerable discomfort from hydrogen sulfide odors, and some experienced acute symptoms consistent with exposure to the gas. The event has received the attention of state and local officials, and is worthy of note by physicians who may encounter patients in future with acute symptoms of hydrogen sulfide exposure from environmental sources.

SOURCE

Nitrogen compounds ("nitrogen") flow into Narragansett Bay from various sources, including *raw sewage* (from combined sewers and storm drains in older cities, ships and boats, seepage from defective cesspools and septic systems), *effluent from sewage treatment plants* (from which nitrogen compounds are not totally removed), and nitrogen-rich *fertilizers*. The relative contribution of these sources to nitrogen levels in the bay has been hotly debated, and varies from place to place and time to time, but the overall effect of the combined contributions is nitrogen-rich bay water.

The nitrogen acts as a nutrient for algae, occasionally causing large "blooms," especially in small bays and coves in which the nitrogen lingers. When the blooms inevitably die, they are decomposed by micro-organisms that deplete oxygen in the immediate aquatic environment. Oxygen depletion may be lesser or greater depending on winds and tides. Winds oxygenate the water, while tides mix more-oxygenated water with less-oxygenated water. Occasionally, the winds and tides fail to re-oxygenate the water sufficiently to sustain most plant and animal life, causing plants, shellfish, and even fin-fish to die of oxygen deprivation.

A major "die-off" of aquatic plants and animals occurred in parts of eastern Narragansett Bay on August 20, 2003, ostensibly caused by a neap tide (a weak tide caused by the opposing action of sun and moon twice a month). Tons of dead plants and animals (shellfish and fin-fish) decomposed in the sheltered inlets, coves, and bays that once harbored

the algal blooms.¹

One of the affected coves is north of Conimicut Point in Warwick. The cove empties into Narragansett Bay directly in front of a seawall that protects suburban shoreline residences. Although the contour of the Bay in front of the seawall changes over time with the inevitable shifting of sand and silt, recent contour maps reveal a large shallow area directly east of the seawall. A large quantity of dead plants and animals was deposited in and around this shallow area in the days following August 20, assisted by winds from the south and east that slowed the movement of water from this area into Narragansett Bay. Some of this large "bio-mass" was deposited in areas exposed during low tide, while some "hung" in the shallow water directly beyond the usual low-water mark. This biomass quickly decomposed in the warm shallow water, creating large quantities of noxious by-products, including hydrogen sulfide.

INTERMITTENCE

The concentration of hydrogen sulfide in the residential neighborhood varied over time, depending on the tides, winds, and weather. The tides uncovered some rotting material twice a day, and generally churned the rest. The winds easily moved the hydrogen sulfide gas either out into the bay (if from the west) or up into the neighborhood (if from the east). Once in the neighborhood, the heavier-than-air gas tended to linger, trapped by natural barriers and invading homes open to the summer air. Sunny, calm days tended to warm the shallow water off the seawall, promoting decomposition.

Because wind and weather conditions varied considerably in the weeks following the die-off, it was difficult to gauge the intensity and tenacity of the problem. Sometimes the odor was unbearable, and sometimes it seemed as if the problem had abated. Officials dispatched by the state to investigate residents' complaints sometimes found no odor at all, even when walking the shoreline below the seawall at middle or low tide, and at other times found an intense odor at some distance into the neighborhood. Thus, "grab" measurements of hydrogen sulfide tended to be an unreliable indicator of the problem, necessitating continuous monitoring to reveal the true variability and periodic intensity of the problem.

INTENSITY

The intensity of hydrogen sulfide to which residents of Conimicut Point were exposed may be estimated from de-

scriptions of symptoms given by the residents themselves, and by the continuous monitoring of hydrogen sulfide (on the seawall) instituted by the Rhode Island Department of Environmental Management (DEM).

Beginning a week following die-off, residents of Conimicut Point telephoned complaints of a strong "sewage-like" odor pervading the neighborhood. Over the next three weeks (August 25 – September 12) some residents reported symptoms such as nausea, headache, runny eyes, runny nose, and burning in the throat. These symptoms, attributed by the residents to the intense odor in the neighborhood, are consistent with exposure to relatively low concentrations of hydrogen sulfide.

During the week of September 15 (a full three and a half weeks following die-off), DEM recorded several intermittent periods when hydrogen sulfide levels reached concentrations in excess of 90 ppb (more than three times the Minimum Risk Level established by the US Agency for Toxic Substances and Disease Registry – ATSDR – for "chronic" exposures of 14 days or more) at the seawall below Conimicut Point residences.

TENACITY

One of the worst aspects of this transient exposure was its tenacity. So great was the die-off of August 20 that the gentle cleansing action of the tides in Narragansett Bay apparently could not move decomposing material away from certain areas of its shoreline, most notably the shoreline north of Conimicut Point. Rotting seaweed and shellfish, for the most part, were so thick that they were deposited in large "mats" that apparently promoted the production of hydrogen sulfide in large quantities. As late as five weeks after the die-off, DEM was recording intermittent concentrations of hydrogen sulfide (at the seawall) that exceeded the federal Minimum Risk Level.

HEALTH EFFECTS OF COMMUNITY EXPOSURE TO HYDROGEN SULFIDE

From DEM: "Hydrogen sulfide is a gas with a foul odor of rotten eggs. Some individuals are sensitive to odors of hydrogen sulfide at levels of just a few parts per billion (ppb). Most people find hydrogen sulfide odors objectionable at 10 ppb, the DEM secondary standard. The odor of hydrogen sulfide can be nauseating, causing those exposed to feel sick to their stomachs. Communities impacted by hydrogen sulfide are primarily affected by its foul odor. Although high levels of hydrogen sulfide can be irritating and cause a variety of health effects, irritation and respiratory effects are not expected to occur at levels below 30 ppb, the Minimum Risk Level established by the US Agency for Toxic Substances and Disease Registry. Some individuals are extremely sensitive to the odors of hydrogen sulfide. Health effects associated with individual sensitivity to odors are relieved once the individuals leave the area affected by the odors. Occupational standards for hydrogen sulfide of 10,000 ppb are not appropriate for evaluating community exposures."²

OBSERVATIONS

1. *This incident caused acute health effects.* Although it is difficult to attribute symptoms to cause with absolute certainty, symptoms reported by residents were consistent with what one would expect from prolonged exposure to low levels of hydrogen sulfide. The intensity of symptoms reported by residents ranged from mild irritation of the eyes to severe nausea and splitting headache. Residents experienced transient physical discomfort over the course of one month, and some experienced physical dysfunction, primarily from nausea and headache.
2. *This incident was very frustrating to those it affected.* The noxious odor came and went at various tides, times of day, and temperature, with no apparent predictability. Sometimes it lingered for hours, apparently causing worrisome symptoms. The source was initially unknown, the health risk uncertain. Then, after hydrogen sulfide was identified as the culprit, its concentration in the neighborhood could not be measured with precision. Peak concentrations of hydrogen sulfide (as measured at the seawall) occasionally exceeded the upper limits of available continuous monitors (90 ppb). How high did the concentrations go? When? For how long? What are the associated health risks? No one knows for sure.
3. *This incident may occur again.* Nitrogen compounds continue to flow into Narragansett Bay, despite slow progress to abate the problem. The geography of the Bay changes little from year to year. Similar weather conditions may cause a die-off of similar proportions in the future. It will be near-impossible to remove the rotting leftovers soon enough and thoroughly enough to prevent the formation and dispersion of hydrogen sulfide gas.

REFERENCES

1. Rhode Island Department of Environmental Management. The Greenwich Bay Fish Kill – August 2003. September 3, 2003. <http://WWW.STATE.RI.US/DEM/pubs/fishkill.pdf>
2. Rhode Island Department of Environmental Management. Odors in Conimicut - H2S Background Information. 2003. <http://WWW.STATE.RI.US/DEM/news/h2s.htm>

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