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## Case Report: Two Cases of Keratoconjunctivitis Tied to *Sargassum* Algae Emanations

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**Abstract.** Since 2011, considerable amounts of *Sargassum* algae regularly end up on beaches in the Gulf of Mexico, the Caribbean, and in the French overseas departments. We report observations of two bilateral keratoconjunctivitis associated with important functional symptomatology. There was a conjunctival hyperemia and superficial punctate keratitis. The ocular impairment would repeat at every algae ashore landing. Clinical examination, history, and time line of symptomatology onset allowed us to eliminate the classic etiologies of bilateral keratoconjunctivitis and to suggest an irritant toxic origin tied to hydrogen sulfide. This is the first description of ocular impairment tied to *Sargassum* algae decomposition. Their decomposition, through H<sub>2</sub>S emission, can be at the origin of bilateral keratoconjunctivitis. Ocular impairment is often at the forefront of complaints made by individuals exposed to H<sub>2</sub>S.

### INTRODUCTION

The Gulf of Mexico, the Caribbean, and in particular the French overseas departments have been facing massive and recurring waves of *Sargassum* algae washing ashore since 2011.<sup>1–3</sup> The layer can be several meters thick, and the floating clusters can cover entire bay areas. In Martinique, the total washed-up biomass is estimated to be 58,000 tons. Contrary to what was originally believed, the algae are not from the Sargasso Sea but would most likely be from a new growth and accumulation zone located north of Brazil, a consequence of climate factors as well as increasing deforestation of Amazonia.<sup>4</sup> Removing the algae is very difficult, and they decompose on site. Their decomposition comes with highly elevated hydrogen sulfide (H<sub>2</sub>S) emissions in the ambient air.<sup>2</sup> Hydrogen sulfide is one of the most dangerous gases. Hydrogen sulfide is corrosive, explosive, and flammable.<sup>5</sup> Between January 2018 and August 2018, more than 8,000 people went to see their general practitioners, and many schools were closed for several months in Martinique because of the impairment felt by the population exposed to H<sub>2</sub>S. Among the people seeking medical consultations, about 50% described ocular irritation symptoms. The other signs were sneezing, runny nose, headache, insomnia, nausea, and difficulty breathing.<sup>6</sup> We report the first observations of keratoconjunctivitis linked to H<sub>2</sub>S toxicity from algae decomposition.

### CASE REPORT

A 58-year-old woman and a 59-year-old man presented themselves for a consultation at the University Hospital of Martinique to renew their optic correction as well as for a bilateral ocular redness that appeared 8 days earlier. They had no medical preconditions nor were they under medical treatments. They lived in a city on the south side of Martinique where *Sargassum* algae regularly landed ashore. Their house was located about 50 m from the beach, on which about 10 days ago, a significant quantity of algae had landed (Figure 1).

**Case 1.** Mrs M did not show visual acuity decrease but complained of a grain of sand sensation, of a foreign body, itching, and intermittent eye watering. Her visual acuity in both the eyes was 20/20, with the right glasses correction. The bulbar and palpebral conjunctiva showed signs of diffuse hyperemia without follicle, papilla, chemosis, limestone concretions, membrane, or hemorrhage (Figure 2). There were on both the eyes about 10 punctate erosions of the corneal epithelium, soaked by fluorescein and located in the inferior part of the eyelids' opening area (Figure 3). The overall cornea was clear; there was no stroma edema, opacities, or corneal neovessels. The anterior chamber was not inflammatory. Ocular tonus and funduscopy were normal.

**Case 2.** Mr M had a visual acuity of 20/20 with glasses correction. He also complained of the grain of sand sensation and itching in both the eyes. There was a bilateral diffuse conjunctival hyperemia, without any other impairment on the conjunctive. The right eye's cornea had keratitis with less than 10 punctate epithelial erosions colored by fluorescein. Examination of the left eye's cornea was normal. The rest of the ocular examination was normal.

In both cases, eyelid examination and ocular motility were normal, and there were no preauricular adenopathy. There were no secretions, or scabs in the eyelashes, nor cornea hypoesthesia. Schirmer 1 test and break-up time were normal. This ocular symptomatology was isolated and was not accompanied by otorhinolaryngological or bronchial signs. The treatment put in place was lubricants without preservatives and applied at least six times per day in both eyes. It significantly reduced the functional signs without reducing the hyperemia. The bilateral keratoconjunctivitis appeared 48 hours after the algae washed ashore and was present during the whole decomposition time of the algae, which the patients could pinpoint because of the typical rotten egg smell of H<sub>2</sub>S. Functional signs and ocular redness disappeared about 48 hours after the end of noticeable H<sub>2</sub>S smell. Questioning allowed us to find similar ocular irritation episodes which occurred every time there were massive amounts of algae washing ashore.

### DISCUSSION

This is the first description of ocular impairment tied to *Sargassum* algae decomposition. Superficial punctate

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FIGURE 1. *Sargassum* on a beach in Martinique.

keratitis and conjunctivitis are nonspecific lesions on the ocular surface that occur because of aggressions of a variety of toxins. Clinical examination, history, and onset time line of the symptomatology allowed us to eliminate classic etiologies of bilateral and synchronal keratoconjunctivitis (infectious, inflammatory, iatrogenic, mechanic, and allergic) and to suggest the toxic irritant origin linked to  $H_2S$ . Short onset time present during  $H_2S$  smell perception is in favor of direct and immediate toxic effects on the ocular surface capable of inducing a rapid inflammatory reaction.

*Sargassum* algae that wash ashore in the Caribbean belong to two different species: *Sargassum natans* and *Sargassum fluitans*. They are brown or yellow macroalgae without crampons that would allow them to attach to a substrate. They have lateral ramified and tangled branches, on which many floaters are located, and gas bladders.<sup>2</sup> No organic component of the fresh algae poses a health threat. When the algae are not regularly picked up, they amass, and, on the top, a scab layer forms, which prevents oxygen diffusion. During anaerobic decomposition, the sulfur present in the *Sargassum* leads to  $H_2S$  production. Hydrogen sulfide is a colorless gas, heavier than air, which has a characteristic smell of rotten eggs. Effects of acute exposure to  $H_2S$  on human with concentrations superior to 50 ppm (parts per million) are well known, of increasing gravity with concentration, and can lead to death (Table 1).<sup>5</sup> They are less documented for sub-chronic and chronic exposures ( $\leq 10$  ppm).<sup>7</sup> Studies of population living next to industrial sites which emit  $H_2S$  (paper factories, natural gas production, and intensive livestock farming) have shown the increase of nasal irritation, and respiratory and ocular symptoms.<sup>8-10</sup>

A few references describe the ocular impairment; as early as 1944, Larsen described keratitis among sewage workers exposed to  $H_2S$ . Besides the classical functional symptomatology

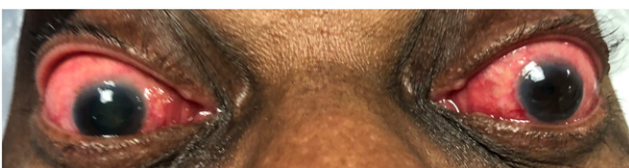


FIGURE 2. Case 1: bilateral keratoconjunctivitis. Important: bilateral and diffuse conjunctival hyperemia.

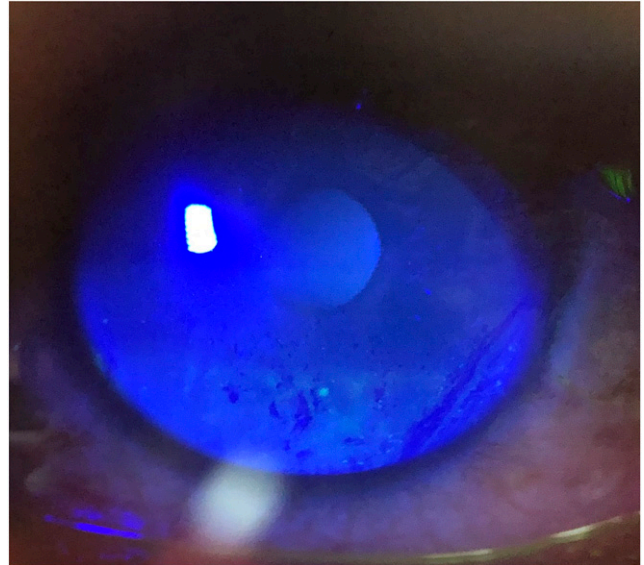


FIGURE 3. Case 1: right eye. Keratitis with less than 10 punctate epithelial erosions colored by fluorescein and located in the inferior part of the eyelids' opening area.

associated with exposure (disappearing when the workers would get back to the surface), corneal lesions manifested through superficial punctate keratitis holding fluorescein and located in the opening area of the eyelids.<sup>11</sup> Beasley reports three observations tied to  $H_2S$  exposure over 4 weeks after an accidental pipe burst. Victims had conjunctivitis associated with keratitis. They complained of ocular pain, photophobia, halo perception, and blurry and cloudy vision. The most severe case also had blepharospasm, severe and bilateral keratitis, as well as important conjunctival inflammation. Ocular signs

TABLE 1

Clinical signs of acute hydrogen sulfide intoxication as a function of concentration

Concentration (parts per million)	Clinical signs
0.00011–0.00033 0.0005	Normal concentration in the ambient air Smallest concentration detectable by the olfactory system
0.01–1.5 2–5	Perception of the rotten egg smell Watering, headache, insomnia, nausea, breathing, and difficulties in asthmatic patients
20	Irritability, tiredness, memory problems, dizziness, and decreased appetite
50–100	Irritation of the ocular mucosa, upper airway, and respiratory and digestive tracts
100	Conjunctivitis, keratitis, hyposmia, cough, respiratory difficulty, and drowsiness. Death after 48 hours of exposure
100–150 200–300	Anosmia Eye damage and respiratory problems (pulmonary edema) after 1 hour of exposure. Disorientation, severe asthenia, and nystagmus
500–700	Collapse, loss of consciousness. Death in 30 minutes
700–1,000 > 1,000	Death in minutes Death in seconds

were significantly less important on the remaining days and disappeared 48 hours after the end of exposure.<sup>12</sup> In a sheep intestine sausage factory, Luck and Kaye<sup>13</sup> describe six cases of isolated ocular impairment. They were bilateral keratoconjunctivitis tied to the H<sub>2</sub>S produced by putrefaction. Functional symptomatology consisted of blepharospasm, watering, and photophobia. The cornea showed multiple punctiform erosions and the conjunctiva, an important hyperemia. All the signs disappeared about 24 hours after the patients stopped working. Schinasi et al.<sup>14</sup> showed within a population living next to porcine industry that the smell and atmospheric H<sub>2</sub>S concentration were linked to the apparition of ocular and respiratory symptoms. There was also observation of increased frequency of cataracts.<sup>9</sup> Among animals, inhalation of small concentration of H<sub>2</sub>S lead to inflammation of the nasal mucous membrane and loss of olfactory neurons.<sup>15</sup> Chronic exposure to H<sub>2</sub>S also comes with neurobehavioral (headaches, vertigo, and memory loss) and cardiologic signs.<sup>16</sup>

### CONCLUSION

*Sargassum* algae decomposition represents not only an environmental and economic disaster but also a serious health threat. In more than half of the cases, ocular impairment is at the forefront of symptoms. It involves bilateral keratoconjunctivitis associated with variable functional symptomatology. Long-term impact on visual function is unknown. These observations justify the implementation of first preventative measures by informing the population of sanitary risks linked to H<sub>2</sub>S exposition, and also of prospective studies with the objective to define the effects of chronic exposure to lower H<sub>2</sub>S dose.

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