Hydrogen sulphide (H_2S)

October 2019

Hydrogen sulphide (**H_2S**), also called sewer gas or swamp gas, is a flammable, colourless gas with the characteristic odour of rotten eggs. H_2S gas is found naturally in geothermal areas and is also emitted from volcanoes, undersea vents, swamps and stagnant bodies of water. Bacteria found in your mouth and gastrointestinal tract produce H_2S during the digestion of food containing vegetable or animal proteins. H_2S is also produced in industrial processes such as pulp and paper manufacturing, oil refining, tanning of animal hides, and wastewater treatment. [1]

Whilst odorous at low concentrations (0.01 - 5 parts per million, **ppm**), H_2S can rapidly overwhelm the olfactometry system and not be perceptible at higher, dangerous concentrations. This is important because a person might falsely think that H_2S is no longer present; this may increase their exposure risk to air levels that may cause serious health effects. High-level exposure (> 50 - 100 ppm) to H_2S can cause unconsciousness and death.

Exposure pathways [2]

- Inhalation – most likely route of exposure because H_2S is a gas
- Oral – not a likely source of exposure
- Dermal (i.e. absorbed through the skin) – potential route of exposure, especially among workers handling H_2S-containing substances.

H_2S is heavier than air and collects in lower areas, for example down manholes but also near stagnant pools or wells.

Criteria and thresholds

H_2S in ambient air at concentrations around the odour threshold (0.00004 – 0.001 ppm) [3] has not been shown to have any significant biological activity in humans or animals. [4]

Air quality criteria (ppm)		Time average	Critical effect(s)
(Ca) OEHHA [a]	0.059	1-hr	Nervous system. Headache, nausea, physiological responses to odour
MfE [b]	0.01	1-hr	Set to protect against nuisance odour
AEGL-1 [c]	0.75	10-min	Notable discomfort, irritation
AEGL-2 [c]	41	10-min	Irreversible or other serious, long-lasting, adverse health effects or an impaired ability to escape
AEGL-3 [c]	76	10-min	Life threatening adverse health effects or death

[a] (California) Office of Environmental Health Hazard Assessment [5]
[c] Ministry for the Environment National Ambient Air Quality Guideline [1]
[c] (US) National Academies of Sciences Acute Exposure Guideline Levels [6]

Typical levels

In an active geothermal area, such as Rotorua, H_2S concentrations have been measured at 0.021 ppm (mean) in residences and 0.027 ppm (mean) in workplaces. [7] In non-geothermal areas, such as London, concentrations are typically around 0.0001 ppm.

Wastewater (sewer) gases

H_2S is the key odour contaminant from wastewater treatment and transport (sewers). Being heavier than air, it collects in lower areas (e.g. lower portions of manholes and pumping stations). H_2S can also severely corrode materials used in sewer and treatment plant construction. [8]

In addition to H_2S, anaerobic decomposition of organic matter containing sulphur and nitrogen in sewers can also produce ammonia, carbon dioxide, methane and a variety of inorganic sulphates and sulphides (such as mercaptans, thioethers and sulphides). These sulphur compounds can be very odorous as shown in the table below.

Odorous sulphur compounds in wastewater [8]

Compound	Formula	Characteristic odour	Odour threshold (ppm)	Molecular weight (g/mol)
Allyl mercaptan	CH_2=CH-CH_2-SH	Strong garlic-coffee	0.00005	74.15
Amyl mercaptan	CH_3-$(CH_2)_3$-CH_2-SH	Unpleasant-putrid	0.0003	104.22
Benzyl mercaptan	$C_6H_5CH_2$-SH	Unpleasant-strong	0.00019	124.21
Crotyl mercaptan	CH_3-CH=CH=CH_2-SH	Skunk-like	0.000029	90.19
Dimethyl sulphide	CH_3-S-CH_3	Decayed vegetables	0.0001 [a]	62.13
Ethyl mercaptan	CH_3CH_2-SH	Decayed cabbage	0.0000087 [a]	62.10
Hydrogen sulphide	H_2S	Rotten eggs	0.00004 [a]	34.10
Methyl mercaptan	CH_3SH	Decayed cabbage	5.1 x 10^{-13} [a]	48.10
Propyl mercaptan	CH_3-CH_2-CH_2-SH	Unpleasant	0.075	76.16
Sulphur dioxide	SO_2	Pungent, irritating	0.34[a]	64.07
Tert-butyl mercaptan	$(CH_3)_3C$-SH	Skunk, unpleasant	0.08	90.10
Thiocresol	CH_3-C_6H_4SH	Skunk, rancid	0.062	124.21
Thiophenol	C_6H_6SH	Putrid, garlic-like	0.062	110.18

[a] (AIHA, 2013) [3]

Potential exposure

H_2S is a gas therefore it is most likely to be breathed in. Skin and eye contact may also occur. The nervous system and cardiovascular system are most affected by H_2S, leading to a range of symptoms such as nausea, headache and dizziness. The physiological response is rapid, even one or two breaths at elevated concentrations can cause 'knock down'. Single exposures to very high concentrations may rapidly cause breathing difficulties and death. [9]

In New Zealand, sanitation workers are most at risk from exposure to H_2S, especially when working in or near confined spaces such as sewers, septic tanks and sump holes. Geothermal areas, such as Rotorua, also pose risks to the general public. There have been 11 deaths linked with H_2S exposure in spa pools and confined spaces (hotels) in New Zealand between 1946 and 2008. [10]

Vulnerable populations

Vulnerable populations include asthmatics, the elderly and young children with compromised respiratory function since the respiratory tract is the major target organ of H_2S toxicity. [11]

Managing health risks

If H_2S is suspected or detected (distinctive rotten eggs smell):

- Use an H_2S monitor to determine concentrations. Do not enter a confined space, or descend to a lower area, without first checking levels;
- Use personal protective equipment (eye wear, gas mask) if concentrations > 1 ppm;
- Eliminate the source of H_2S wherever possible. If flushing with fresh air, ensure venting to open space where other people will not be exposed;
- Keep the general public away.

Do not rely on the sense of smell to indicate the presence of H_2S or to warn of harmful levels.

References

[1] MfE (2002). *Ambient air quality guidelines – 2002 update*. Ministry for the Environment, Wellington.
[2] ATSDR (2016). *ToxGuide for Hydrogen Sulfide H_2S*. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services Public Health Service, Atlanta, Georgia.
[3] AIHA (2013). *Odor Thresholds for Chemicals with Established Health Standards*. 2nd Edition. American Industrial Hygiene Association, Fairfax, Virginia.
[4] IPCS (1981). *International Peer Reviewed Chemical Safety Information – Hydrogen Sulfide*. International Programme on Chemical Safety, World Health Organisation, Geneva.
[5] OEHHA (2016). *OEHHA Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary*. California Office of Environmental Health Hazard Assessment [Website accessed: 16 September 2019]
[6] National Academies of Science (2010). *Acute Exposure Guideline Levels for Selected Airborne Chemicals, Vol 9*. Washington. DC.
[7] Cakmak, Y (2017). Rotorua, hydrogen sulphide and Parkinson's disease—A possible beneficial link? The New Zealand Medical Journal, Vol 130 No 1455: 12 May 2017.
[8] US EPA (1985*). Odour and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants*. Design Manual. Office of Research and Development. Cincinnati, Ohio.
[9] Public Health England (2014). *Hydrogen Sulphide General Information*. July.
[10] Rotorua Daily Post (2008). *The Death Toll*. 13 June 2008.

Health effects on humans at various H_2S concentrations [12]

Concentration (ppm)	Symptoms/effects
0.00011-0.00033	- Typical background concentrations
0.01-1.5	- Odour threshold (rotten egg smell is noticeable)
2-5	- Odour becomes more offensive at 3-5 ppm. - Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. - Airway problems (bronchial constriction) in some asthma patients.
20	- Possible fatigue - Loss of appetite - Headache - Irritability - Poor memory - Dizziness - Above 30 ppm, odour described as sweet or sickeningly sweet.
50-100	- Slight conjunctivitis ("gas eye" or aka pink eye) and respiratory tract irritation after 1 hour. - May cause digestive upset and loss of appetite.
100	- Coughing, eye irritation, loss of smell after 2-15 minutes (olfactory fatigue). - Altered breathing, drowsiness after 15-30 minutes - Throat irritation after 1 hour. - Gradual increase in severity of symptoms over several hours. - Death may occur after 48 hours.
100-150	**- Loss of smell (olfactory fatigue or paralysis)**
200-300	- Marked conjunctivitis and respiratory tract irritation after 1 hour. - Pulmonary oedema may occur from prolonged exposure.
500-700	- Staggering, collapse in 5 minutes. - Serious damage to the eyes in 30 minutes. - Death after 30-60 minutes.
700-1,000	- Rapid unconsciousness - "Knockdown" or immediate collapse within 1 to 2 breaths - Breathing stops - Death within minutes.
1,000-2,000	- Nearly instant death

References

[11] WHO (2003). *Hydrogen Sulphide: Human Health Aspects*. Concise International Chemical Assessment Document 53, World Health Organisation, Geneva.
[12] OSHA (2019). *Hydrogen Sulfide.* US Department of Labor, Occupational Safety & Health Administration