Review Article

Sewer Gas Toxicity: A Literature Review

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Abstract

Sewer gas toxicity is still a major concern even today, and we still have deaths reported from sewer gas toxicity especially among the people who work within sewers. These gases are highly toxic when inhaled in large amount or when inhaled for prolonged period of time. Sewer gas is a combination of Hydrogen Sulphide, Ammonia, Carbon-dioxide, Sulphur dioxide, Nitrogen dioxide, and carbon monoxide. Hydrogen sulphide, in combination with CO2 and Methane, formed in sewers, is known as 'sewer gas.' Sulphuretted hydrogen is the principal and dangerous component in sewer gas. It produces multi organ involvement and it is crucial to timely diagnose and provide high quality resuscitation and care to prevent complications including deaths. Therefore, clinicians must be aware about this toxicity.Though manual scavenging has been prohibited by Indian law, still a lot number of lives are lost while cleaning sewage and in manholes. This is due to the toxic gases formed within the sewage due to decomposition, collectively known as sewer gases. The clinical presentation is wide and varied and has high mortality rate, if not treated in time. The treatment includes timely identification. decontamination, specific antidotes including amyl nitrite, sodium nitrite, bronchodilators and even hyperbaric oxygen therapy would be helpful in severe cases. But as always prevention is better than cure. Hence people involved in manual scavenging should be given all safety equipments and adequate protective gears because 'all lives matter'. This is a narrative literature review on sewer gas toxicity to create awareness among clinicians that this toxicological emergency exists, though not widely discussed. According to the National Commission for SafaiKaramcharis (NCSK), 1298 deaths were reported from 1993 to 28thFebruary 2025.

Keywords: sewer gas, hydrogen sulphide, manual scavengers, amyl nitrite

Introduction

Sewers posenumerous dangers for those who work within them. They containa variety of gases that can be extremely toxic when inhaled and result inseveral complications, including death. Exposure to toxic gas is aneminent hazard for sewer workers who work in a closed space; the significant hazard is hypoxia due to the accumulation of methane, carbon dioxide, or hydrogen sulphide and explosive risk as a result of flammable gases. These gases can be

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extremely toxic if inhaled in high concentrations or for a prolonged period. Sewer gas toxicity and related deaths occur still, since manual scavenging system is still prevalent.

Epidemiology and Prevalence

Septic tanks are relatively standard in residential and industrial areas to cater to sewage wastes. Septic tanks are enclosed areas made for the accumulation of decomposed domestic wastes, sewerage, and its resultant gases(1).Natural putrefaction and the mixture of sewage lead to the production of sewage gases. Sewer gas is a combination of Hydrogen Sulphide, Ammonia, Carbon-dioxide, Sulphur dioxide, Nitrogen dioxide, and carbon monoxide. Hydrogen sulphide, in combination with CO2 and Methane, formed in sewers, is known as 'sewer gas.' Sulphuretted hydrogen is the principal and dangerous component in sewer gas.Figure-1 shows the graph of total number of sewer gas or septic tank deaths, state-wise from 1993 till 28th February 2025 in India. According to the National Commission for SafaiKaramcharis (NCSK), 1298 deaths were reported from 1993 to 28th February, 2025.

Toxicity and Exposure

Hydrogen sulphide:

Persons exposed to hydrogen sulphide pose no risks of secondary contamination to a person outside the hot zone (area having highest potential of contamination), though, fatalities have occurred to the rescuers entering the hot zone. Hydrogen sulphide is a colourless, highly flammable and explosive gas produced naturally by decaying organic matter and by specific industrial processes. Hydrogen sulphide has adistinctive rotten-egg odour; yet, olfactory fatigue may occur, and therefore, it may not provide adequate warning of dangerous concentrations. Hydrogen sulphide is primarily absorbed through the lungs; skin absorption is minimal. Exposure by any route can have systemic effects.

Routes of Exposure: (2)

Inhalation:

1. Inhalation is the primary route of sewer gas exposure. The lungs rapidly absorb the gas. Although its strong odour is readily identified, olfactoryfatigue occurs at high concentrations and continuous low concentrations. Hence, the odour is not a reliable indicator of sewer gas's presence, and it may not provide adequate warning of hazardous concentrations.

Skin/eye contact:

Prolonged exposure to sewer gas, even at relatively low levels, can result in painful dermatitis and burning eyes. Frostbite can occur from direct contact with liquid gas. Absorption through intact skin is negligible.

Clinical features

Methane and carbon dioxide act as physical asphyxiants, producing anoxia by displacing oxygen in an enclosed space. Clinical symptoms are thus related to decreased oxygen tension in the blood and include tachycardia, hyperventilation, headache in low-level exposures, proceeding to confusion, loss of consciousness, and death at higher concentrations due to hypoxia(3).

In contrast, H2S and CO are classified as chemical asphyxiants; while CO interferes with oxygen delivery via formation of carboxyhaemoglobin, H2S interferes with cytochrome oxidase and aerobic metabolism, similar to hydrogen cyanide. Symptoms of CO poisoning range from headache, nausea, and dizziness at lower levels (10%–30% carboxyhaemoglobin) to visual disturbance, syncope, and eventually death when carboxyhaemoglobin levels reach 50%. It can produce severe symptoms at much lower concentration if associated with medical conditions that make individuals susceptible tohypoxia(3). H_2S acts as a tissue irritant at lower concentrations (up to 100–150 ppm), causing kerato conjunctivitis, respiratory irritation, lacrimation, and cough. At even this low level, olfactory fatigue/ paralysis occurs, and the warning "rotten egg" smell is lost. Relatively acute pulmonary edema occurs at levels of 300 ppm and higher. Acute exposure to very high concentrations (1000 ppm) causes instantaneous loss of consciousness, rapid apnea, and death if the victim is not immediately moved to fresh air; in these cases, the local irritant effects may not have time to develop (3). Toxic effects of sewer gas on various organ system are described in table 1

Table 1: Clinical Features of Sewer Gas Toxicity

Organ affected	Clinical features
Central Nervous System (CNS)	Loss of consciousness Coma Respiratory paralysis Seizures Death
Respiratory System (RS)	Irritation of the nose, throat Cough, shortness of breath Bronchitis Pulmonary oedema
Cardiovascular System (CVS)	Hypotension Arrhythmias Conduction defects
Gastrointestinal symptoms	Nausea Vomiting
Ocular	Kerato conjuctivitis
Dermal	Burning sensation Itching Painful inflammation

Mechanism of Action of sewer gas:

The hydrogen sulphide toxicity has been proposed mainly due to inhibition of cytochrome oxidase, which plays acrucial role in cellular mitochondrial respiration. In mitochondria, cytochrome oxidase is the final enzyme in respiratory chain, which is inhibited by hydrogen sulphide because of oxidative reduction of one of the enzymatic haems. Consequently, the electron transport chain is interrupted by stopping oxygen to act as final electron acceptor and leading to blockage of oxidative metabolism, which causes anaerobic metabolism and production of lactic acid [4]. The characteristic rotten egg odour is detectable at levels as low as 0.025 ppm. At levels between 100 and 150 ppm, the olfactory nerve becomes paralyzed, and the characteristic scent is no longer recognized, which allows for toxic exposures to occur. Levels of 10- 500 ppm cause various respiratory symptoms and fatal at 500- 1000 ppm. [5]

Case reports from literature: Several reports of rapid H2S intoxication by the pulmonary route in humans have been published.

A review of toxic inhalation fatalities among US construction workers during the 1990s by Dorevitch et al[6]. determined that 1.3% of all construction-related fatalities were due to acute toxic inhalation or oxygen exclusion. Just under 20% of these cases were due to H2S, and 26% occurred in sewers or sewer maintenance holes. The non-H2S sewer deaths were due to CO or oxygen exclusion. Water and sewer workers were among those occupations listed as the highest risk for occupational death due to poisoning—additionally, workers who were attempting to rescue their incapacitated co-workers composed 10% of the fatalities.

While classically associated with H2S exposure, the differential diagnosis for deaths occurring in sewers, like those presented here, includes oxygen exclusion due to high concentrations of Methane or carbon dioxide. Sulphur dioxide and ammonia are also possible agents as by-products of organic decomposition but are less commonly seen as causes of fatalities. Finally, carbon monoxide (CO) is a well-known hazard in confined spaces but is less likely in sewer gas as it is produced by combustion rather than decomposition. However, occasional deaths in sewers/maintenance holes have been attributed to carbon monoxide, which may have accumulated due to the use of gasoline-powered tools in the unventilatedsewer[6]. Memchoubi et al. reported two case reports of sewer gas toxicity; both the patients died before they reached the hospital[7]. Hariharan at al. reported a case of a 24-year-old male who died after five days of in-hospital treatment[8].

Available reports of death in India due to sewer gas toxicity is just the tip of the iceberg. Most of the deaths are reported either as accidental deaths due to some other reason or not reported at all. According to the data of the National Commission for SafaiKaramcharisunder the Ministry of Social Justice and Empowerment, Government of India, a total of 1298 workers lost their lives from 1993 till 28th February 2025 [16]. (Figure-1)

Laboratory Tests

All symptomatic exposed patients will require tests which include CBC, blood glucose, and electrolytes. Additional studies for patients exposed to hydrogen sulphide include ECG and renal-function tests. Pulse oximetry or ABG and chest radiography can be helpful in cases of inhalation exposure. If nitrites are used, check methemoglobin levels. (9)

Emergency Department Management

Treatment of massive inhalation of hydrogen sulphide toxicity is mainly supportive. The initial goal of treatment should be attention to the airway, breathing, and circulation. Currently, the treatment approach is not evidence-based (as in most toxicological hazards) and shares some features with the approach to cyanogenpoisoning.[9]

Hospital staff who are away from the scene are not at risk of secondary contamination from patients exposed only to sewer gas; however, staff can bese condarily contaminated by contacting orbreathing vapours from clothing heavilysoaked with sewer gas

Basic Decontamination

Conscious and able patients may assist with their decontamination. Remove and put the contaminated clothing and personal belongings in a double bag. Wash the hair and exposed skin with water for 5 minutes. Be cautious to avoid hypothermia while decontaminating children or the elderly. Use warmers or blankets when appropriate, irrigate the eyes for at least 5 minutes. Remove contact lenses if removable without causing additional trauma to the eye. An ophthalmic anaesthetic may be necessary to ease blepharospasm, and lid retractors may be required to allow adequate irrigation under the eyelids.

Critical Care Area

Shift the patient to a critical care area. Assess and support airway, breathing, and circulation. Children are more susceptible to corrosive agents than adults due to the smaller diameter of their airways. Establish intravenous access in all symptomatic patients. Monitor the cardiac rhythm continuously. Patients who are hypotensive, comatose or have seizures or cardiac arrhythmias should be treated conservatively. Give oxygen by mask to patients who have respiratory symptoms. Treat patients who have bronchospasm with bronchodilators.

Antidotes

Specific treatments for hydrogen sulphide toxicity include administration of amyl nitrite, sodium nitrite. Salbutamol and Ipratropium Bromide nebulizer treatments may be given for associated bronchospasm. Hydrogen sulphide has a higher affinity for methemoglobin than cellular cytochrome oxidases. Nitrite administration results in theformation of methemoglobin and thereby helps to reduce the metabolic toxicity of hydrogen sulphide by allowing for the conversion of hydrogen sulphide to the less toxic sulfmethemoglobin. Nitrites, nonetheless, can also result in hypotension, and methemoglobinemia will further decrease oxygen saturation. Furthermore, there is limited evidence supporting the use of nitrite therapy in hydrogensulphide poisoning. It should be used with caution. Amyl nitrite ampules (0.3 ml) may be inhaled by patients and can be repeated every 3-5 mins. Sodium nitrite is administered 0.33 mL/kg of 3% solution by a slow intravenous push to a maximum of 10 ml. It is important to note that thiosulfate should not be used in the treatment of hydrogen sulphide poisoning.

Nitrite therapy of cyanide antidote kit has been suggested as a therapy for hydrogen sulphide exposure. Amyl nitrite is given by inhalation route for 30 seconds every minute till an intravenous line is established, which is followed by intravenous sodium nitrite 300 mg over 5 minutes—this aid in recovery by forming sulfmethemoglobin, thus removing sulphide from the tissue. The antidotal efficacy of nitrite therapy is debatable. There is only circumstantial evidence that nitrite therapy is effective, and the victims of hydrogen sulphidetoxicity have survived without any sequelae after supportive care alone. Nitrite therapy should not interfere with the establishment of adequate ventilation and oxygenation.

Hyperbaric oxygen therapy may act by a competitive mechanism against H2S at the level of cytochrome oxidase [10,11] and may have a role in the prevention of both short and long-term neurological sequelae[12].

Disposition and Follow-up

Patients who are hypotensive or unconscious should be observed closely for any complication, like hypoxic encephalopathy. As pulmonary edemacan be delayed in onset, patients severely exposed to sewer gas inhalation should be monitored for atleast 24 hours. Moreover, if pulmonary edema is suspected, admit patients to an intensive care unit.

Asymptomatic patients without any signs of pulmonary edema or respiratory or CNS depression and no signs of eye irritation can be discharged after 4 to 6 hours of observation in Emergency Department (ED) with instructions to return to ED immediately if any symptoms develop.

Guidelines for Sewer Cleaning

The employer must take following safety measures when cleaning a septic tank or sewer:[13]

1. Before cleaning: Employers must ensure safety precautions before manual cleaning of a sewer.

    - Having a minimum of three employees present all time and one of whom shall be a supervisor.
    - Cleaning of a sewer to be done only in daylight and for a duration not exceeding 90 minutes at a time, with a compulsory break of 30 minutes between two shifts.
    - Before cleaning, the atmosphere within the confined space is to be tested for oxygen deficiency and the absence of poisonous and combustible gases.
    - To prevent injuries, the employer has to ensure that all the employees who are present on-site during cleaning work are trained and are acquainted with the knowledge to operate all the equipment which are involved in cleaning work and that they use protective gear and safety devices before entering a sewer line.
    - Regular medical check-up of workers, and regular vaccination against respiratory, skin and other occupational diseases to which they are prone, due to exposure to harmful substances and gases in sewers.

    The employer is also required to ensure that every worker engaged in cleaning has a life insurance of at least ten lakh rupees, the premium for which shall be paid by the employer.

2. During and after cleaning: The employer is required to ensure that sufficient safety precautions are taken at the time when workers are cleaning a sewer line.

    - Include the presence of rescue equipment such as a tripod and harness system for maneuvering an injured worker to the surface, a basket stretcher or similar device for moving the injured worker to emergency transportation, first aid equipment, or an ambulance nearby.
    - Sewer gas detectors like portable multi gas detector can be used by people entering closed spaces.
    - The smallest gas detection instrument for upto five gases, the Drager X-am 5000 is a new generation detector.

3. Post-cleaning safety precautions have to be ensured by the employer when the worker comes out of the sewer after a session of cleaning. These include the facility for removal of contaminated clothing and wash-up as well as cleaning, dry clothing, and immediate treatment for any cuts/bruises on the skin or problems with a respiratory system suffered during cleaning.

National guidelines against direct manual handling of human excreta: [14]

The direct manual handling of human waste by sanitation workers has been banned in India since 1993 under the Employment of Manual Scavenging and Construction of Dry Latrines (Prohibition) Act, which has also banned the construction and maintenance of dry latrines. The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act went into effect on December 6, 2013, making manual scavenging illegal in India. The barring of Employment as Manual Scavengers and their Rehabilitation Act was notified by Central Government. This Act is a Parliamentary law, binding on all the states. While the earlier 1993 law forbid the employment of manual scavengers and construction of dry latrines, the strong point of the new Act is that it brings unsafe cleaning of sewers and septic tanks under its domain. Ministry of Social Justice and Empowerment is planning to table "Prohibition of manual scavenger work and their rehabilitation amendment bill in 2020. This bill will ensure sewer cleaning completely machine operated, will also ensure better safety and compensation to the sewer workers.

Conclusion

Sewer lines continue to be health hazards as they produce sewer gases, which can be toxic to human beings. Sewer gas poisoning can be fatal if inhaled in high concentrations or for prolonged periods. H2S direct toxicity and subsequent cellular hypoxic induction may rapidly lead to multi-organic dysfunction and death, depending on the level of gas exposure. Management includes nitrites, hyperbaric oxygen therapy, and hydroxocobalamin. Preventive measures are crucial in preventing lethal exposure to hydrogen sulphide toxicity. Implementation of H2S detection equipment, air-supplied respirators in toxic or oxygen-deficient atmospheres, and confined space safety training could help to prevent most H2Srelated fatalities[15]. However, the mainstay of care relies on early supportive measures. Hypoxic injury to the vital organs can be challenging to treat, and a good outcome may not be possible in severe poisoning cases. Sewer gas toxicity should be kept in mind in any case of sudden death occurring in a confined space, especially in or around a sewer. Several people lose their lives annually while cleaning septic tanks and sewers, even though the Prohibition of Employment as Manual Scavengers and their Rehabilitation (PEMSR) Act, 2013 forbids the practice.

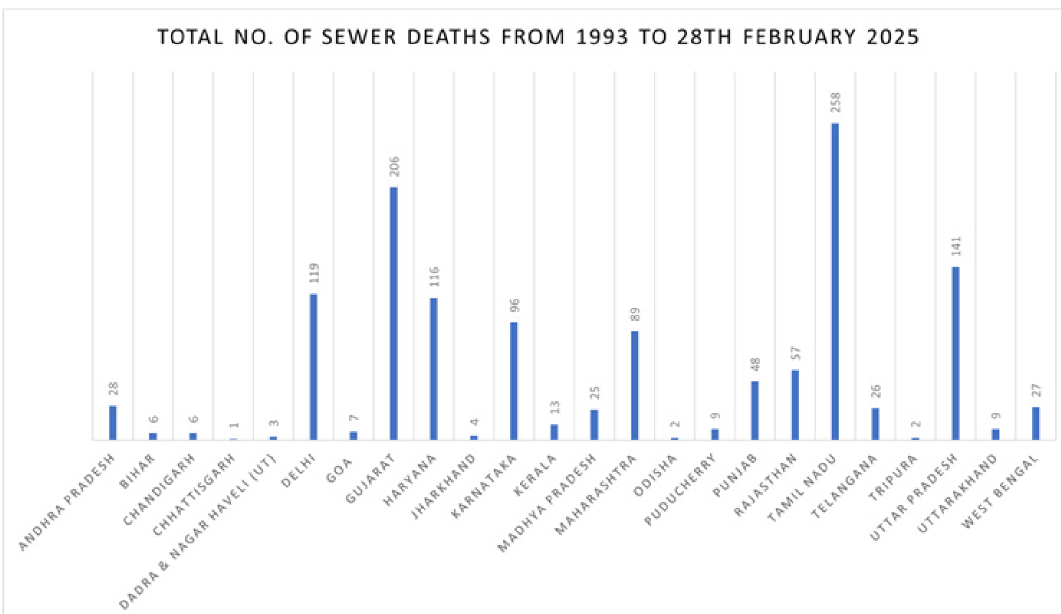

Figure 1: According to the data of the National Commission for SafaiKaramcharis under the Ministry of Social Justice and Empowerment, Government of India, a total of 1298 workers lost their lives from 1993 till 28th February 2025

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