International Journal of Research in Medical Sciences
*Rangu SC et al. Int J Res Med Sci. 2016 May;4(5):1775-1777*
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20161271

**Case Report**

# Suffocation due to irrespirable gases in confined spaces: accidental deaths of rescuers

**Sridhara Chary Rangu[1], Suraj Sundaragiri[2]*, Saritha Rangu[3]**

[1]Department of Forensic Medicine and Toxicology, Government Medical College, Nizamabad, Telangana, India
[2]Department of Forensic Medicine and Toxicology, Jawaharlal Institute of Postgraduate Medical Education & Research, (JIPMER) Puducherry, India
[3]Department of Pedodontics, Meghna Institute of Dental Sciences, Nizamabad, Telangana, India

**Received:** 11 March 2016
**Accepted:** 07 April 2016

***Correspondence:**
Dr. Suraj Sundaragiri,
E-mail: drsurajfm@gmail.com



## ABSTRACT

Oxygen-reduced atmosphere or irrespirable gases in confined spaces causes a loss of consciousness and immediate death. Some cases of suffocation in confined spaces due to a reduction of oxygen in the respired atmosphere have occurred, for example an advertising balloon filled with pure helium gas, underground drainage system with hydrogen sulfide, large reactor vessel in pharmaceutical plant with nitrogen etc. This paper reports here a rare case wherein four persons died of suffocation due to irrespirable gases in a water sump, and further it also recommends some measures to prevent such tragedies.

**Keywords:** Asphyxia, Suffocation, Water sump, Irrespirable gases, Rescuers

## INTRODUCTION

Confined space means a space in which because of its construction, location or contents, the accommodation of a hazardous gas, vapour, dust or fume or the creation of an oxygen deficient atmosphere may occur.[1]

Confined spaces include water and sewer pipes, pumping stations, manholes, boilers, vats, kilns, vaults, silos, storage bins, meter vaults, tunnels, tanks, wastewater wetwells, grit chambers, utility tunnels, crawl spaces under floors, water reservoirs, holding tanks, pits, and sumps.[1-4]

Confined spaces has the potential for a hazardous atmosphere that may include the lack of or too much oxygen, and/or the presence of toxic or explosive vapors or gases such as carbon monoxide, sulfide and methane and/or has physical safety hazards such as machinery, sources of electrical shocks, liquids (drowning or fires), steam (burn hazard), or loose, unstable materials that can cause employees to be trapped, crushed, or buried.[5,6]

In this paper, we report a rare case of death caused in water sump caused as a result of irrespirable gases. Key autopsy findings of the deceased are described, and the chemical analysis and cause of death are discussed. Additionally, this paper stresses on awareness and recommendations for the employees working at such places.

## CASE REPORT

### *Case history*

Four male persons aged about 22, 29, 30 and 44 years old were found dead in a water sump at a residential apartment under construction. According to police

inquest reports, centring work had already completed in the sump that was about nine feet deep. Tragedy struck when one workman collapsed on descending the water sump to take off the centring plates. A second workman went down to assist the first, then the third and fourth followed before they could be prevented, but all in turn, fell over almost immediately on reaching the bottom of the sump. The sudden drift in atmosphere was irrespirable. This inhalation of vitiated air, associated with inadequate ventilation contributed to death.

***Autopsy findings***

All deceased shown similar findings on post-mortem examination. On external examination, fluidly blood oozing out from nostrils, marked cyanosis and suffusion of the eyes were noted. Rigor mortis was present in the limbs. Post-mortem staining seen on the back of the body. All organs were congested. No antemortem external or internal injuries were present on the dead bodies. In the stomach, about 150 - 250 grams of partially digested food particles is present with no suspicious smell and mucosa was normal.

Time of death was given as 14 -18 hours prior to post-mortem examination. Viscera were preserved in sealed condition and hand over to escort police constable of police station for chemical analysis.

***Viscera preserved for chemical analysis***

The following specimens of stomach with its contents, a piece of intestine, 500 grams of liver, 500 grams of kidney and 10 ml of blood were collected and preserved in saturated solution of sodium chloride for chemical analysis in forensic science laboratory (FSL).

***Forensic science laboratory report***

On physical examination, pH was determined as acidic. On chemical examination for volatile substance, corrosive poison, metallic poison, drugs and insecticides, no poisonous substance was found.

***Cause of the death***

Cause of death was opined as basing on the post-mortem findings, FSL report and circumstantial evidence as - the cause of death as to best of my knowledge and belief was due to 'suffocation as a result of irrespirable gases'. However, as the vitiated air sample was not preserved, the exact nature of the gases could not be determined.

## DISCUSSION

Suffocation is a type of asphyxia which is caused by deprivation of oxygen either due to lack of oxygen in the environment or inhalation of irrespirable gases or from obstruction of air passages at the level of mouth or nostrils.[3,7,8]

This vitiated atmosphere is deficient in oxygen which causes reduction of oxygen in the atmosphere by physical replacements by irrespirable gases i.e. inert gases or other gases generated in the atmosphere.[3,8]

Most cases are accidental resulting from inadvertent build-up of gases like carbon monoxide, carbon dioxide, methane, sulphureted hydrogen, ammonia and sulphur dioxide in a confined space.[3,9,10] Some such incidents due to irrespirable gases such as an advertising balloon filled with pure helium gas, underground drainage system with hydrogen sulfide, large reactor vessel in pharmaceutical plant with nitrogen[12] etc. have been reported.[11,12]

Simple asphyxiants displace oxygen from ambient air, thereby reducing the fraction of inspired oxygen ($FiO_2$) in air to below 21%, and result in a decrease in the partial pressure of oxygen. Clinical findings associated with reduction of inspired oxygen below 10% being incoordination, coma and below 6%, immediate unconsciousness, gasping respiration, seizure and death.[13]

Asphyxiation typically occurs in confined spaces or with rapid release of concentrated simple asphyxiants.[13] These clinical findings are directly related to the reduction in the partial pressure of oxygen in ambient air, which leads to hypoxemia, or low oxygen content of the blood.[14]

Tragedies due to irrespirable gases in the confined spaces involving the death of the rescuers as seen in the present study have also been reported by others.[15-17] These accidents evolve due to lack of awareness of the employees and no proper training of the rescuers.[12,15] Although safety precautions demand venting of confined spaces before the men enter, it is not been followed due to lack of awareness and ultimately causing their death on encountering such atmosphere.[8]

In deaths due to suffocation as a result of irrespirable gases, postmortem findings are generally minimal, hampering the cause of death determination without historical evidence or advanced laboratory testing.[18]

The following are the recommendations from this study;

- All employees who work in confined spaces should be aware of potential hazards.
- Vault manhole covers should have holes for ventilation.
- Air quality testing must be done to assure adequate oxygen supply, adequate ventilation, and the absence of all toxic air contaminants.
- Specific procedures to be followed like the wearing of breathing apparatus and other safety equipment, prior to entering a confined space.
- Emergency rescue training of the workers.
- Effective rescue procedures which are immediately available on site.
- Rescue of any person from a confined space where dangerous fumes, or an oxygen-deficient atmosphere

may be present is prohibited without wearing appropriate safety equipment.
- Procedures to prevent unauthorized entries with provision of an attendant outside the space at all times.
- Confined Spaces Regulations Act must be passed and adopted by every country to protect people against risks to health or safety arising out of work activities.
- Further, the rescuers/firefighters must also be advised for collecting and preserving the air from the scene for analysis for specific treatment of survivors and accurate cause of death.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: Not required*

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**Cite this article as:** Rangu SC, Sundaragiri S, Rangu S. Suffocation due to irrespirable gases in confined spaces: accidental deaths of rescuers. Int J Res Med Sci 2016;4:1775-7.