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Safeguarding Environments: A Review Paper on Study and Detection of Hazardous Gases in Septic Tank

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A B S T R A C T

The research focuses on developing a cost-effective Hydrogen Sulfide (H2S) detection kit, aiming to improve safety in septic tank environments. The kit employs lead acetate paper, which offers a simple, reliable, and accessible method for detecting H2S gas. This development provides a practical solution for monitoring H2S levels, facilitating timely interventions to mitigate the health and safety risks associated with this highly toxic and flammable gas.

The resulting kit empowers individuals working in or near septic tanks with a practical means to monitor their environment safely and maintain the well-being of all involved.

Keywords: Cost Effective, h2s detection kit, h2s gas hazards in septic tank prevention, environmental safety.

1. Introduction

One of the greatest challenges facing humanity is to fulfill the increasing demand for energy with a growing population, while also sustaining economic growth without causing irreversible harm to the environment. The continuous emissions of various chemical pollutants such as NOx, NH3, CH4, SOx, CO, H2S, and fluorocarbons from industrial sources, vehicle exhaust, wastewater, septic tanks, and household waste pose multiple problems including acid rain, global warming, sick building syndrome, and ozone layer depletion. To mitigate or minimize the environmental damage caused by air pollution, it is crucial to have monitoring and control units that can quickly detect these factors and identify pollutants within acceptable limits. While standard analytical techniques like electrochemical, optical spectroscopy, and gas chromatography/mass spectrometry can be employed to detect these gases, they are time-consuming, expensive, and not suitable for real-time and field applications. Therefore, ensuring environmental safety from pollutants has become a paramount concern for the scientific, public, and political communities in the 21st century. Some have even referred to the first decade of this century as the "Sensor Decade."

Furthermore, Landrigan et al. have reported that environmental toxic gases are responsible for more than one in four deaths and have adverse effects on children's health. In 2016 alone, approximately 7 million deaths were attributed to household and outdoor pollution, making it the fourth leading cause of global mortality. Consequently, modern buildings, industries, offices, and institutions are now equipped with efficient and accurate toxic gas sensors. As a result, the sensors market has experienced a significant growth surge in recent years. The projected global value of the sensor market is estimated to be $190 billion by 2021 and is expected to exceed 1 trillion by 2025. The industry and research community's objective is to develop state-of-the-art environmental gas sensors utilizing advanced electronic nose technology that is affordable and energy-efficient. Additionally, scientists are actively exploring and producing sensor alternatives that do not rely on electronic components to meet current demand.

PHYSICAL AND CHEMICAL PROPERTIES OF H2S.

H2S, a gas with no color and a pungent smell resembling rotten eggs, is both flammable and toxic. It occurs naturally in certain environments such as swamps and volcanic areas. The subsequent information outlines the physical and chemical properties of H2S.

A) Physical properties:

Hydrogen sulfide appears as a gas under standard temperature and pressure conditions (STP). Below -60.35 OC (-76.63 degrees Fahrenheit), it undergoes a change in state, transforming into a liquid. The odor, akin to the scent of rotten eggs, is both distinct and disagreeable. At STP, the density of H2S gas reaches approximately 1.363 grams per liter. The solubility of hydrogen sulfide in water increases as the temperature decreases, resulting in the formation of an acidic solution known as sulfhydryl acid (H2S(aq)). When subjected to heat, hydrogen sulfide reaches a boiling point of -60.35 degrees Celsius (-76.63 degrees Fahrenheit). Its solid state, or melting point, is measured at -82.9 degrees Celsius (-117.2 degrees Fahrenheit).

B) Chemical properties:

The flammability of hydrogen sulfide allows it to ignite when exposed to a spark or flame. This combustion process generates sulfur dioxide (SO2) as a byproduct when it reacts with air. Reactivity wise, hydrogen sulfide acts as a reducing agent and readily interacts with oxidizing agents. It also forms metal sulfides when it reacts with metals such as copper and lead. In terms of acidic properties, when dissolved in water, hydrogen sulfide dissociates to create sulfide ions (S2-) and hydronium ions (H3O+), resulting in an acidic solution. Furthermore, it is important to note that hydrogen sulfide is highly toxic and can be lethal in high concentrations. Its toxicity acts as a respiratory depressant and inhibits cellular respiration. It is crucial to avoid exposure to high concentrations of hydrogen sulfide due to its hazardous nature, as it can lead to death.

The structural formula of hydrogen sulfide (H2S) consists of two hydrogen (H) atoms covalently bonded to one sulfur (S) atom. The compound adopts a bent molecular shape due to a bond angle of 92.1 degrees, and the sulfur atom possesses two lone pairs of electrons. The Lewis structure of hydrogen sulfide is best represented by a bent H2S molecule, with two lone pairs of electrons on the S atom depicted as two pairs of dots (or two bars).

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2. Literature Review

A) Uma Hariharan, Nikhil Basin, Vishakha Mitthal, Rajesh Sood "A Fatal Case of Septic Tank Gas Poisoning: Critical Care Challenges" Septic tanks continue to be health hazards as they produce sewer gases which can be toxic to human beings and also cause greenhouse effect :

In this article, the medical community continues to face the challenges of deaths caused by poisoning. Poisoning can occur accidentally, intentionally, or through acts of violence. Certain poisons do not have antidotes and can lead to rapid fatality. The victims typically succumb to the harmful effects of the toxic substance itself or suffer from secondary complications and multi-organ failure. Septic tanks pose significant dangers due to the presence of various toxic sewer gases, which, when inhaled, can result in severe complications, including death. Here, we present a case study of a young patient who experienced fatal accidental poisoning due to septic tank gases, along with the critical care challenges associated with it.

B) Manish Tripti Singh, manual cleaning of sewers and septic tanks: what does the law say:

According to the 2011 Census, about 46.9% of households in India have access to toilets. Among these households, approximately 9.8% of individual household latrines (IHHLs) in urban areas are connected to sewers, while 10% are connected to septic tanks. In rural areas, only 2.2% of IHHLs are connected to sewers, 12.2% are connected to septic tanks, and 10.3% are connected to other on-site sanitation systems. The distribution of households with septic tanks and sewer connections across urban and rural areas can be seen in Figure a. Interestingly, there are nearly twice as many septic tanks as sewer connections. Although septic tanks are more prevalent in rural areas, accounting for 85% of connections, they still make up more than half of the connections in urban areas, mainly in small and mid-size towns. Among urban areas, larger million-plus cities, which have more developed sewer networks, account for less than one in five septic tanks (and 65% of sewer connections). It is important to note that the responsibility of cleaning septic tanks falls upon the individual households, which can be quite challenging in rural and smaller urban areas where there is a high prevalence of septic tanks. This task is often undertaken by small and informal service providers who are contracted by the households.

C) CWAS, CEPT University Standard Operating Procedures for Desludging of Septic Tanks Operating Procedure for Desludging of Septic Tank:

In this Paper, it is acknowledged that addressing open defecation is only half the battle. In order to improve sanitation, it is necessary to safely manage faecal sludge and wastewater as well. Therefore, the Government of India, Ministry of Housing and Urban Affairs (MoHUA), has issued a National Faecal Sludge and Septage Management (FSSM) Policy, recognizing the importance of regular desludging of septic tanks. This systematic extraction and collection procedure is essential in preventing environmental pollution. In accordance with the recommendations from CPHEEO, septic tanks should be cleaned at least once every two to three years.

D) klima Begum, Md. Abdullah Al Mamun, Md. Atiar Rahman, Sabiha Sattar1, Mist Toma Khatun, Hasina Akhter, and Mohaimina Begum Toxic and Non-Toxic Gas Detection System for Septic Tank A microcontroller-based gas detection system has been presented:

In this paper, the main cause of worker fatalities in industries that primarily utilize chemicals is gas leakage accidents. To address this issue and enhance safety measures, the implementation of the latest advancements in information technology, particularly the Internet of Things (IoT), can play a crucial role. This project aims to prevent industrial accidents by monitoring harmful gases and promptly notifying the safety control board of the industry using Arduino Uno R3 and IoT. The central microcontroller, Arduino Uno R3, is interconnected with various sensors such as temperature, gas, and alcohol sensors, enabling continuous monitoring of relevant environmental parameters. Consequently, this device can serve as a multi-gas detection apparatus with a rapid response rate. Whenever the gas levels exceed the normal range, an alarm is immediately triggered, alerting the designated receiver section via the internet. The sensor-collected data is then stored on the internet, facilitating further analysis to enhance safety regulations. The scalability of this model provides the potential to create a pollution-controlled environment, improving the living conditions for individuals residing in close proximity to industrial areas.

E) Galstyan, V., N. Poli, et al. (2019). "Highly Sensitive and Selective H2S Chemical Sensor Based on ZnO Nanomaterial." Applied Sciences 9(6): 1167:

ZnO demonstrates remarkable physical and chemical properties, making it a valuable candidate for chemical sensing applications. This study focuses on the fabrication and analysis of ZnO nanomaterial for the detection of hydrogen sulfide (H2S) gas. The prepared material exhibited an impressive gas

sensing response of 7400 when exposed to 30 ppm of H2S in the surrounding air. Moreover, the structure demonstrated a high selectivity specifically towards H2S, surpassing its sensitivity to other reducing gases.

F) "A Fatal Case of Septic Tank Gas Poisoning: Critical Care Challenges." (2016). Journal of Anesthesia & Critical Care: Open Access 6(3):

Deaths due to poisoning continue to be an issue in medical practise. Poisonings may be due to accidents, suicide, or homicide. Certain poisons have no antidote and can be rapidly fatal. Victims usually succumb either to the harmful effects of the toxic substance itself or to a secondary phenomenon or multiorgan failure. Holding tanks are dangerous because they contain a variety of exhaust gases that can be highly toxic when inhaled and lead to various complications, including death. We report here a fatal case of accidental septic tank gas poisoning in a young patient and the associated challenges for critical care medicine.

3. Methodology

Most available gas sensors for hydrogen sulfide are very expensive and suffer from several problems such as high power consumption, detection at high gas concentrations, poor stability, and inflexibility. Therefore, H2S gas sensors are constantly being developed to meet the requirements of highly efficient sensors and minimize the harmful effects of this toxic gas.15,16 However, it has always been a great challenge to measure H2S accurately due to the difficulty in manufacturing H2S sensors from prototype to final product. In addition, there are a variety of techniques in the field of science and engineering to detect H2Sg.

Design and development of a kit for the detection of H2S gas using lead acetate paper:

*1.**Lead acetate paper selection:** a suitable lead acetate paper specifically designed for the detection of H2S was selected. Factors such as sensitivity, selectivity, and compatibility with the expected H2S concentration range were considered.*

*2.**Sample collection:** a mechanism was developed to collect air or gas samples from the environment. This involved using a pump or other means to draw the air over the lead acetate paper.*

*3.**Enclosure and protection:** an enclosure was designed to protect the lead acetate paper from external influences such as moisture, dust, and light. This can be a simple holder or a more complex enclosure with a clear viewing window to observe the colour change.*

*4.**Calibration:** A calibration procedure has been established to determine the threshold for colour change at a given H2S concentration. This involved exposing the lead acetate paper to known concentrations of H2S gas and observing the colour change.*

*5.**Sensitivity and detection limit:** The sensitivity and detection limit of the lead acetate paper were determined by testing it with different concentrations of H2S gas. This information was used to determine the range of H2S concentrations that the kit can reliably detect.*

*6.**Instructions for Use:** Clear and concise instructions were provided for users on the proper use of the H2S gas detection kit with lead acetate paper. This included guidelines for sample collection, exposure time, and interpretation of colour change.*

*7.**Safety aspects:** Guidelines and safety precautions for handling H2S gas and the limitations and precautions associated with the use of lead acetate paper were provided to users.*

4. Conclusions

- In summary, lead acetate strips can be used as a simple and convenient method for the detection of hydrogen sulphide (H2S).

- The present technique is very useful for rapid detection of H2S gas in the environment. The technique is cost effective, durable and portable etc.

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