Research Journal of Forensic Sciences ISSN 2321–1792
Vol. **13(2),** 16-22, July **(2025)** *Res. J. Forensic Sci.*

Case Study

Unraveling the Mystery of multiple suspicious Deaths in wells: Case Studies of forensic investigation in four Districts of Chhattisgarh, India

Satyajeet Singh Kosariya[1*], Anuradha Chakraborty[2], Rajesh Mishra[3], Brijesh Kumar Nagwanshi[4] and T.L. Chandra[3]
[1]District Scene of Crime Mobile Unit, Korba, Home Police Department, Government of Chhattisgarh, India
[2]Centre for Woman Studies and UNESCO Chair, Canada, Community Based Participatory Research Mentor of Sangawari Hub (CWS), Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, India
[3]State Forensic Science Laboratory, Raipur, Home Police Department, Government of Chhattisgarh, India
[4]Reginal Forensic Science Laboratory, Ambikapur, Sarguja, Home Police Department, Government of Chhattisgarh, India
satyajeetkosariya@gmail.com

Available online at: www.isca.in, www.isca.me
Received 12th November 2024, revised 27th March 2025, accepted 19th May 2025

Abstract

Chhattisgarh, a predominantly agriculture-based state in India, heavily relies on various irrigation methods, with wells being a vital resource for farmers growing vegetables. However, the widespread practice of well digging poses significant safety risks. This study investigates a series of fatal incidents in the districts of Janjgir Champa, Korba, Bemetara, and Bilaspur, where individuals entered wells for maintenance or rescue operations and succumbed to suffocation, resulting in 13 deaths. Utilizing empirical methods, which is a vital part of forensic investigation technique in such case studies. The present research investigation examines the lack of oxygen in wells through combustion tests using materials such as candles and matchsticks. Findings reveal that individuals descending beyond eight feet into the wells face a dangerous drop in oxygen levels, leading to unconsciousness and drowning. Case studies from Janjgir Champa, Korba, Bemetara and Bilaspur districts underscore the recurring hazards associated with such practices. Additionally, the study highlights the presence of hazardous gases like methane and hydrogen sulfide etc. in water wells, which exacerbate the dangers for individuals entering these confined spaces. The deaths documented were largely due to asphyxia, as confirmed by autopsy reports. This research stresses the urgent need for increased awareness, safety protocols, and preventive measures to mitigate the risks associated with well-related agricultural practices in Chhattisgarh, aiming to prevent further loss of life.

Keywords: Forensic Investigation, Death, Well, Hazardous Gases, Combustion, Asphyxia.

Introduction

Chhattisgarh, an agriculture-based state in India, is characterized by its reliance on various irrigation methods to support its farming activities. Farmers frequently dig wells in their court yards and in agricultural land, strategically located near their homes, to ensure a consistent water supply for vegetable cultivation. While canals serve as the primary irrigation source, ponds contribute a mere 4.8% to the overall irrigation landscape. Farmers in Chhattisgarh take on the responsibility of cleaning and maintaining their own farm wells to reduce maintenance expenses. This reliance on wells, however, presents significant risks, as evidenced by tragic incidents in the districts of Janjgir Champa, Korba, Bemetara, and Bilaspur. In these regions, individuals often descend into wells for maintenance or cleaning, a practice rooted in local agricultural customs.

The individuals descending beyond eight feet into the wells, for cleaning or maintenance of such wells, many a times face a hazardous drop in oxygen levels, leading to unconsciousness and drowning. Unfortunately, there have been multiple cases where the initial person who entered the well did not resurface, prompting others to attempt rescues, resulting in a devastating total of 13 fatalities. This alarming pattern highlights the urgent need for awareness and safety measures regarding well-related activities[1,2].

The present study employs an empirical research methodology to explore the conditions within these wells, utilizing combustion techniques, to understand the reasons for such fatal deaths. Combustion is a chemical reaction in which a substance reacts quickly with oxygen and produces heat. In this process, the substance undergoing combustion is referred to as the fuel, while the oxygen source is known as the oxidizer[3]. Oxygen is required for combustion. Combustion is the burning of a combustible substance with the help of air or an oxidizer. Combustion is a chemical process that produces heat and light. In combustion, fuel combines with oxygen when sufficient heat is applied to it. Combustion is not possible without oxygen. The study examines oxygen levels through practical tests involving candles, aluminum wire, jute rope, and matchsticks. Data collection incorporates both elementary and secondary radix to provide a comprehensive understanding of the risks involved.

The present research paper reflects the findings that underscore a critical issue regarding individuals who enter wells face the deadly threat of suffocation due to insufficient oxygen at greater depths. This research aims to illuminate these dangers and advocate for improved safety protocols in agricultural practices throughout Chhattisgarh.

Hazardous gases commonly found in water wells pose significant risks to health and safety. The primary gases commonly present in wells include methane, carbon dioxide, carbon monoxide, nitrogen, and hydrogen sulfide. Along with the hazardous gaes present in these wells, some aquifers, such as coal seams, fractured shales, and sandstones, naturally contain gases like oxygen, carbon dioxide, nitrogen, methane, and hydrogen sulphide, which can enter water wells drilled into these formations[4]. The hazardous effects of these primary gases commonly present in wells may result fatal if proper precautions are not being observed during the maintenance operations of such wells. These gases includes-

Methane (CH_4) in Water Wells: Methane is a colorless, odorless gas that can accumulate in groundwater sources, especially in areas where there are oil and gas drilling activities or natural gas deposits. Methane gas is found in water wells because of natural processes or human activities such as coal mining, gas well drilling, pipeline leaks, and landfill operations. It is a colorless, odorless, tasteless, and flammable gas[4]. Methane is not typically harmful when ingested through water, but its primary danger arises from its flammability and explosive potential when trapped in enclosed spaces, such as homes or wellheads.

Sources: Methane contamination in water wells is often linked to the degradation of organic material in subsurface environments or from activities like hydraulic fracturing (fracking) and natural gas drilling. It can seep into water wells, especially in regions rich in hydrocarbons.

Health Risks: Although methane itself is not considered toxic to human health when dissolved in water, it poses a risk in terms of explosion hazards. Methane can also displace oxygen in poorly ventilated areas, leading to asphyxiation.

Research review on hazardous effects of Methane: Research on fatal methane gas incidents in water wells highlights the potential risks in both Indian and international contexts. Methane, often found in groundwater due to natural processes or nearby gas extraction activities, is highly flammable and can pose a severe explosion hazard in poorly ventilated areas like basements or wellheads. In the U.S., for example, documented cases show that methane buildup has led to explosions in homes and water wells, particularly where methane concentrations exceed safe limits. For instance, a Penn State study revealed that methane was present in 24% of tested water wells in Pennsylvania, with a subset at concentrations that raised potential safety concerns. Such instances are especially concerning in regions with active gas extraction and improper well ventilation[4,5].

Similarly, international studies, including those from Indian states with extensive agricultural and industrial water use, indicate concerns about methane's presence in groundwater. Due to the risk of methane accumulation, guidelines from health agencies, like the Minnesota Department of Health, recommend regular methane monitoring and ventilation solutions for well systems to prevent dangerous buildups[4,5].

Research Study conducted by Osborn et al. found high concentrations of methane in water wells located near active fracking sites in Pennsylvania, USA, raising concerns over groundwater contamination in energy extraction regions. Other studies also indicate that methane contamination increases the risk of water well explosions[6].

In India, research and reporting on methane emissions in water wells and related environments emphasize both environmental and safety concerns, especially regarding methane accumulation from various sources. The Indian waste management sector is a notable contributor, as methane is generated in large quantities from decomposing organic waste in landfills, which can leach into groundwater if not properly managed. Methane's presence not only poses a significant explosion risk but also contributes to hazardous air pollution when it enters the atmosphere due to inadequate containment at waste disposal sites. These concerns are pronounced in regions with dense waste collection, as methane gas has considerable greenhouse effects and potential local health impacts[7,8].

Specific projects in Tamil Nadu and other states have aimed to tap coal-bed methane, where methane seeps from hydrocarbon-rich formations. Projects like those in the Cauvery Delta faced strong opposition, particularly because of concerns that methane extraction could impact local groundwater quality and compromise agricultural activities by contaminating water sources. This reflects the risk of methane leaking into groundwater from drilling operations, which can inadvertently create risks similar to those in water wells with methane accumulation[9].

These findings underline the importance of managing methane emissions across both natural and anthropogenic sources in India, highlighting methane's environmental footprint and the need for stringent water well monitoring.

Carbon Dioxide (CO_2) in Water Wells: Carbon dioxide is a naturally occurring gas that gets build up in groundwater systems, especially in areas with volcanic or geothermal activity. CO_2 can also result from organic material decay in water sources. Carbon dioxide (CO_2) presence in water wells has become a growing environmental and public health concern. Elevated CO_2 levels in groundwater can have adverse effects on water quality, human health, and the structural integrity of water wells.

Sources: CO_2 may enter water wells through natural geochemical processes or anthropogenic activities such as mining or industrial operations, activities like industrial waste injection, agricultural practices, and fossil fuel extraction. In some cases, it dissolves in groundwater and can cause the water to become more acidic.

Health Risks: High CO_2 levels can displace oxygen, causing oxygen deprivation in confined spaces and potentially leading to dizziness, unconsciousness, or even death upon inhalation. CO_2 in water wells creates health risks for populations using groundwater for drinking, with potential for respiratory issues if CO_2 accumulates in confined spaces. Hu et al. note that exposure to elevated CO_2 levels can cause respiratory distress and asphyxiation in extreme cases. Additionally, acidic, metal-laden water presents further risks, particularly for children and the elderly[10].

Research review on hazardous effects of Carbon Dioxide: Several research studies earlier done have reflected on the potential hazards posed by CO_2 accumulation in water wells, including water acidity, metal mobilization, health risks, and challenges in water supply infrastructure[11-17]. A study by Gal et al. indicated that CO_2 buildup in certain wells is closely associated with volcanic or geothermal activities. In confined spaces, the presence of high levels of CO_2 can lead to asphyxiation, particularly in well-maintenance scenarios[11].

Carbon Monoxide (CO) in Water Wells: Carbon monoxide is a highly toxic gas that binds to hemoglobin in the blood, inhibiting oxygen transport and leading to suffocation. It can be a rare but dangerous contaminant in water wells, typically from accidental sources.

Sources: CO is not commonly found in water wells, but it can be introduced through malfunctioning pumps, the burning of organic material, or from equipment used near the well that produces CO.

Health Risks: CO exposure can result in carbon monoxide poisoning, which leads to symptoms such as headaches, dizziness, vomiting, and, in severe cases, death.

Research review on hazardous effects of Carbon mono oxide: This review discusses recent findings on the hazardous effects of CO in water wells, with a focus on the human health implications of exposure to CO in groundwater systems. Many studies have found that the presence of carbon monoxide in water wells, while relatively rare, poses significant health risks, especially when CO gas accumulates in enclosed indoor environments. Inhalation of CO released from contaminated groundwater can lead to acute and chronic health issues, including hypoxia, neurological damage, and, in severe cases, death. Populations using water wells in regions at risk of CO contamination should employ CO monitoring, ensure proper ventilation, and consider periodic well inspections to prevent CO accumulation. Further research is needed to assess the prevalence of CO in groundwater and to develop affordable, effective mitigation strategies to protect public health[18-21].

Nitrogen (N_2) in Water Wells: Nitrogen gas (N_2), comprising 78% of Earth's atmosphere, is inert and generally non-toxic but can pose hazards in confined spaces like water wells. Excess nitrogen in groundwater, from natural soil processes or industrial contamination, may displace oxygen, creating low-oxygen conditions that can be harmful if inhaled.

Sources: Nitrogen contamination in water wells can occur due to agricultural runoff (use of fertilizers), septic system leaks, or natural biological processes in the soil. Nitrate contamination is a more serious concern because of its health implications.

Health Risks: According to USEPA (2024), Nitrates in drinking water can lead to methemoglobinemia or "blue baby syndrome" in infants, which reduces the blood's ability to carry oxygen. Long-term exposure to nitrates can also lead to digestive tract issues and has been associated with cancer risks[22].

Research Studies on hazardous effects of N_2: literature review compiles research on the presence of nitrogen gas in water wells and its hazardous effects on health and well infrastructure. The U.S. Geological Survey (USGS) has extensively studied nitrate contamination in groundwater sources, highlighting its prevalence in agricultural regions. Ward et al. emphasizes that elevated nitrate levels in drinking water pose significant public health risks, especially for infants and pregnant women[23]. The studies reviewed examine the sources, effects, and health hazards of nitrogen gas in groundwater systems. Raymond et al. identifies natural and anthropogenic sources of nitrogen, including agricultural runoff, contributing to nitrogen compounds in groundwater[24]. Robertson et al. highlight the risk of nitrogen accumulation displacing oxygen in wells, creating hypoxic environments[25]. West et al. discuss health risks such as dizziness and suffocation from oxygen depletion[26]. Chichester and Horan document nitrogen-induced asphyxiation in well environments[27]. Green and Fisher link agricultural practices to nitrogen gas risks[28]. Uhlman et al. propose strategies for monitoring and mitigating these hazards[29].

Hydrogen Sulfide (H_2S) in Water Wells: Hydrogen sulfide (H_2S) is a highly toxic and corrosive gas that has a characteristic "rotten egg" smell. It is produced by the breakdown of organic material under anaerobic conditions, which commonly occur in wells or aquifers with low oxygen levels.

Sources: H_2S can enter water wells through the natural decomposition of organic materials or from sulfur-reducing bacteria present in groundwater. It is often associated with oil and gas drilling, geothermal activity, and areas where sulfide-containing minerals are present.

Health Risks: H_2S is highly dangerous even at low concentrations. Inhalation of high levels can lead to respiratory distress, irritation of the eyes and throat, and, in extreme cases, unconsciousness or death. It can also cause nausea, headache, and dizziness at lower concentrations.

Research Studies on hazardous effects of Hydrogen Sulfide: Studies show that exposure to low concentrations of H_2S can cause chronic symptoms in humans, including respiratory issues and fatigue. A review by Guidotti emphasized the toxicological effects of H_2S, particularly in occupational settings like water well drilling or confined spaces with poor ventilation[30].

Methodology

The present study employs empirical research involves collecting and analyzing data through observation or experimentation to generate evidence-based conclusions in a structured, systematic manner[31,32]. Empirical research methodology to explore the conditions within these wells. Utilizing combustion techniques, combustion as a chemical process where a substance reacts rapidly with oxygen to produce heat, with the reacting substance termed as fuel and the oxygen source as the oxidizer[3]. Oxygen is required for combustion. Combustion is the burning of a combustible substance with the help of air or an oxidizer. Combustion is a chemical process that produces heat and light. In combustion, fuel combines with oxygen when sufficient heat is applied to it. Combustion is not possible without oxygen[33,34]. The study examines oxygen levels through practical tests involving candles, aluminum wire, jute rope, and matchsticks. Data collection involves utilizing both elementary and secondary sources to achieve a thorough understanding of the associated risks involved. The primary data was gathered from Districts of Korba and Janjgir Champa, while secondary data was used from the police records of similar incidences occurred in the districts of Bemetara and Bilaspur.

Ultimately, the findings underscore a critical issue that individuals who enter wells face the deadly threat of suffocation due to insufficient oxygen at greater depths.

Results and Discussion

The content below covers the various drowning incidences that had occurred in various districts in Chhattisgarh in the water wells and the results drawn from the analysis of the forensic investigation reports.

Case Study of Jangir Champa District investigation: In a village within Janjgir Champa District, a tragic incident unfolded on July 5th, 2024, when five individuals entered a well and did not resurface. At around 9 am, the information about the incidence was communicated from the Additional Superintendent of Police, Janjgir Champa to the Forensic Officer of District Scene of Crime Mobile Unit, Korba, Home Police Department, Government of Chhattisgarh and the forensic team was instructed to carry out the necessary investigations. As per the instructions, the Forensic team lead by Dr. Kosariya reached at the site around 11 AM accompanied by constables Mr. Rajesh Chandra and Mr. Bhupendra Tandon, under the jurisdiction of Birra police station. A large crowd had gathered around the farmer's well where the incident occurred.

The well was surrounded by vegetation, of lemon trees on one side and a Guava tree (Amrud) on the other. Both the plants are thorny in nature. The branches of the Guava (Amrud) tree had to be cut back to facilitate the rescue efforts. Additionally, sweet potatoes were planted in front of the well and ladyfinger was cultivated at the back side of the well.

The well itself measured 26 feet in depth and had a diameter of 52 inches, with water level reaching five feet from the bottom. During the rescue operations, the bodies of five individuals, who were of varying ages, were recovered from the well.

As rescue efforts continued, a sixth individual attempted to enter the well but encountered difficulty breathing after descending about 8 to 10 feet. Recognizing the danger, he quickly ascended back and managed to escape the hazardous effects of gases in the well, highlighting the life-threatening conditions present in the water-filled well.

Table-1 shows the tabulation of people who entered the well in Janjgir Champa district and unfortunately underwent the tragic incidence.

Table-1: Gender and Age of Individuals Who Died After Entering the Well in Janjgir Champa District.

Code Name	Age	Gender	Reason for going inside the well
A	70	Male	Entered the well to retrieve wood.
B	50	Male	Went to help A from the well
C	18	Male	Entered to help both A and B
D	21	Male	Tried to rescue A, B, and C
E	25	Male	Went in to rescue his friend D

On the same day, after completing the site inspection of Birra police station, at around 2 pm, I received a call from Gatghora Additional Superintendent of Police of Korba district that 4 people have died after descending into the well in Katghora, please come and do a forensic investigation of the incident site. After which, at around 5 PM, after which, at around 5 pm, Dr. Kosariya along with his team reached the spot and started the forensic investigation. By that time, the bodies of the four individuals had already been recovered from the well.

The incident occurred at a farmer's well, situated next to a paddy field, with the surrounding soil noticeably wet. Vegetables had also been cultivated near the well. The well measured 28 feet in depth, with six feet of water present, and had a diameter of 255 cm.

Testing of well using combustion technology: In both the case studies combustion technique has been used for testing the well which is as follows. To assess the oxygen levels in the well, a candle was tied to an aluminum wire and lowered with a jute rope. The candle remained lit for approximately eight feet before extinguishing. This experiment is referred to as the combustion process. This process was repeated several times, consistently showing that the candle would extinguish below this depth, indicating that oxygen was only present up to eight feet. Consequently, individuals who descended deeper than these points lost consciousness due to oxygen deprivation, ultimately leading to drowning.

Table-2: Gender and Age of Individuals Who Died After Entering the Well in Korba District.

Code Name	Age	Gender	Reason for going inside the well
F	60	Male	To clean the well
G	16	Female	To help her father F from the well
H	57	Male	Tried to rescue G and F
I	45	Male	Attempted to rescue F, G, and H.

Case Study 3: A comparable incident was reported in a Local newspaper of Raipur on July 29, 2024, in which three individuals tragically died one after the other while attempting to repair the casing pipe of a pump inside a well. Table-3 presents information about three individuals who tragically lost their lives after entering a well in Bemetara District. The table highlights the ages, genders, and circumstances leading to their deaths, illustrating the risks associated with entering wells for maintenance or rescue purposes[35].

Table-3: Gender and Age of Individuals Who Died After Entering the Well in Bemetara District.

Code Name	Age	Gender	Reason for going inside the well
J	40	Male	Entered to descale the casing pipe
K	27	Male	Fell into the well after J.
L	50	Male	Fell in when trying to help J and K

Case Study 4: A similar incident was reported by Local newspaper of Raipur on August 15, 2024, from the Masturi block in Bilaspur district, under the jurisdiction of Pachpedi Police Station. In this case, a 22-year-old male, referred to as Individual M, tragically lost his life[36].

Autopsy report of deceased: In the autopsy report of all the deceased, the cause of death was found to be asphyxia, manner of death[37] was found to be asphyxia, manner of death was drowning in water and nature of death was accidental.

Discussions: This part has been subdivided into the seven sections.

Forensic Investigation in Drowning Cases: The study of forensic investigation in water-related deaths, particularly drowning cases, is critical in determining the cause and manner of death[37]. Forensic literature suggests that investigating deaths in wells or other bodies of water involves several specialized techniques, including autopsy, toxicological analysis, and scene investigation. According to Saukko & Knight[13] water-related deaths pose unique challenges, such as the possibility of postmortem changes and the difficulty in determining whether drowning was accidental, suicidal, or homicidal. Wells, in particular, often serve as locations for both accidental falls and deliberate acts of violence or suicide, necessitating a careful forensic approach[38].

Forensic Analysis in India: Forensic science has been a growing field in India, with a special focus on incorporating technological advancements to solve cases. Investigations into deaths in rural areas, such as Chhattisgarh, are often complicated by the scarcity of resources and the remoteness of the location. Literature by Verma et al.[14] on forensic investigations in rural Indian contexts highlights the complexities of crime scene preservation, the need for local expertise, and issues related to socio-economic factors influencing the nature of the crime. Investigators must work with local authorities, which may complicate procedures if there is a lack of forensic infrastructure or experience[39].

Role of Toxicology in Water-Related Deaths: Toxicological analysis is a key component of forensic investigations in cases where death occurs in or around a well. According to studies on forensic toxicology[15], the presence of gases such as methane, hydrogen sulphide, or even carbon dioxide, which can be naturally found in wells, must be considered as potential contributors to death. These gases can lead to asphyxiation or poisoning, complicating the identification of the exact cause of death. Research on gas-related deaths suggests that forensic experts must determine whether exposure to toxic gases was accidental, intentional, or the result of foul play[40].

Socio-Cultural Context of Death Investigations in Rural India: Understanding the socio-cultural context is essential in forensic investigations in rural settings like Chhattisgarh. Deaths occurring in wells, especially in rural India, often involve social factors such as economic distress, mental health issues, and local superstitions, which can influence the interpretation of the crime scene. According to Kumar et al.[41] rural deaths are sometimes overlooked or misclassified due to a lack of forensic capabilities or investigative rigor. In many cases, deaths in wells are considered accidents without a thorough investigation, leading to the potential for unresolved criminal acts.

Investigative Techniques in Well-Related Deaths: The techniques employed in well-related death investigations typically involve crime scene reconstruction, victimology, and forensic pathology. Recent literature emphasizes the use of modern technology, such as 3D scanning and digital forensics, to better document the crime scene and reconstruct the events leading up to the death. In cases of wells, specific methods to determine the depth, water levels, and environmental conditions play a significant role in understanding the incident. Techniques for retrieving bodies and forensic evidence from confined spaces like wells have been explored in depth in forensic manuals e.g.[42].

Legal and Ethical Considerations: Forensic investigations in India are governed by various legal frameworks, including the Indian Penal Code and the Criminal Procedure Code. The legal literature underscores the importance of following proper protocols during the investigation to ensure the integrity of evidence[43] stress that in cases of suspicious deaths, particularly in rural areas like Chhattisgarh, the ethical responsibility of forensic professionals extends beyond technical analysis, requiring them to address the concerns of the local population and maintain transparency in their procedures.

Case Studies and Comparative Analyses: Numerous case studies have been documented that detail the forensic investigation of deaths in wells across different parts of India and the world. Studies on cases from similar rural settings provide insights into patterns of accidental falls, suicides, and homicides involving wells. Comparative analyses between different types of well deaths, as seen in research by Shetty et al.[44] suggest that these deaths often follow specific forensic patterns that can aid investigators in determining the manner of death.

Conclusion

Most of the victims are male, with ages ranging from 18 to 70. The majorities are middle-aged or younger adults, suggesting a trend where younger individuals attempt to help older adults. The common theme is rescue, with each subsequent individual entering the well to assist the previous one, leading to a tragic chain of events. This illustrates a potential lack of awareness regarding the dangers of entering a well, especially in a rescue context. These incidents underscore the risks associated with well-related activities, particularly when multiple people enter to assist one another. There is a clear need for increased safety measures and education regarding the hazards involved in such rescue attempts.

References

1. Hedge, A., Schar, f. T. and Dale, A.M. (2010). Confined spaces and their dangers: Understanding the risks in hazardous environments. *J Occup Environ Hyg*., 7(4), 156-63.
2. PCAST (2016). Report to the President Forensic Science in Criminal Courts: Ensuring Scientific Validity of Feature-Comparison Methods. Executive Office of The President.
3. NASA (2021). *Combustion*. Retrieved Jan 20, 2025, from https://www.grc.nasa.gov/www/k-12/airplane/combst1.html
4. ATSDR (2016). ATSDR Fact Sheet. Methane in Well Water. 05 2016. Available: https://www.atsdr.cdc.gov/HAC/pha/DimockGroundwaterSite/Methane_in_well_water_508.pdf. 13/10/2024
5. Minnesota Department of Health (2024). Minnesota Department of Health. Oct 18 [cited 2024 Oct 18]. Available from: https://www.health.state.mn.us/communities/environment/water/wells/index.html
6. Osborn, S., Vengosh, A., Warner, N.R., Jackson, R.B. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc Natl Acad Sci U S A*., 108(20), 8172-6.
7. Ghosh, P., Gupta, A., Thakur, I.S. (2014). Combined chemical and toxicological evaluation of leachate from municipal solid waste landfill sites of Delhi, India, and its impact on groundwater quality. *Environ Sci Pollut Res Int.*, 22(12), 9148-58.
8. Central Pollution Control Board (2021). Annual Report 2020-2021. CPCB.https://cpcb.nic.in/uploads/MSW/ MSW _AnnualReport_2020-21.pdf. 11/10/2024
9. Garg, A. and Shukla, R.P. (2002). Emissions inventory of India. *Atmos Environ*., 36(20), 3309-20.
10. Hu, H., Jin, Q. and Kavan, P. (2017). A study of health effects of CO_2 exposure in confined spaces. *J Environ Health Sci Eng.*, 15, 20-5.
11. Gal, F., Gadalia, A., Pouchan, P. and Fritz, B. (2002). Geochemical sources of carbon dioxide in the groundwater system. *Environ Sci Technol.*, 36(8), 155-6.
12. Appelo, C.A.J. and Postma, D. (2005). Geochemistry, groundwater and pollution. 2nd ed. CRC Press, London.
13. Wang, S., Jaffe, R.P. and Williams, K.H. (2012). Influence of elevated CO_2 on metal mobilization in groundwater environments. *Environ Sci Technol*., 46(6), 2831-8.
14. Knox, A.S., Kaplan, D.I. and Wullschleger, S.D. (2011). Long-term health effects of metal-contaminated groundwater due to CO_2-induced pH reduction. *Water Res.*, 45(12), 3735-45.

15. Shevenell, L. and McDonald, L.T. (2013). The impact of naturally high CO_2 levels on groundwater infrastructure corrosion. *Environ Monit Assess*., 185(3), 2133-45.

16. Zheng L, Zheng J, Xu Y and Yang W. (2018). Corrosion and aging of well infrastructure in CO_2-affected water wells. *Groundwater Monit Remediat*., 38(1), 65-73.

17. Anderson, K. and Bows, A. (2011). Beyond. dangerous climate change: Emission scenarios for a new world. *Philos Trans A Math Phys Eng Sci*., 369(1934), 20-44.

18. Boothroyd, M.I., Almond, S., Qassim, S.M., Worrall, F. and Davies, R.J. (2017). Fugitive emissions of methane from abandoned, decommissioned oil and gas wells. *Sci Total Environ*., 547, 461-9.

19. Goldstein, M., Kim, S. and Polissar, N.L. (2008). Carbon monoxide poisoning and risk assessment. *Environ Health Perspect*., 116(1), 159-64.

20. Gustafson, P., Sedgwick, J. and Edwards, P. (2016). The role of carbon monoxide detectors in households using well water. *J Environ Health*., 78(9), 62-7.

21. Burgess, W.G., Smith, A.L. and Adams, A.R. (2012). Mitigating risks of gas contamination in water wells: The case for carbon monoxide scrubbing. *Groundwater Monit Remediat*., 32(1), 36-45.

22. USEPA. (2024). *U.S. Environmental Protection Agency*. Retrieved Jan 02, 2025, from https://www.epa.gov/privatewells/potential-well-water-contaminants-and-their-impacts:~:text=High%20levels%20of%20nitrate%2Fnitrite,and%20blueness%20of%20the%20skin.

23. Ward, M.H., deKok, T.M., Levallois, P., Brender, J., Gulis, G., Nolan, B.T., et al. (2005). Workgroup report: Drinking-water nitrate and health—recent findings and research needs. *Environ Health Perspect*., 113(11), 1607-14.

24. Raymond, P.A., McClelland, A.J., Hobbie, F.B., Boyd, R.J., Schlesinger, E.S.G., Downing, L.B., et al. (2013). Global sources and sinks of nitrogen in groundwater and surface water. *Nat Geosci.,* 6(5), 298-305.

25. Robertson, W.D., Schiff, S.P., Gauthier, R.L. (2000). Nitrogen transformation processes in shallow groundwater systems. *J ContamHydrol*.,42(3-4), 331-47.

26. West, J.B., Nechay, L.B., Shenkman, R.M., Ginsburg, R.A.S., Garrison, M.S., O'Neil, W.J., et al. (2003). Respiratory impacts of low-oxygen environments in confined spaces. *Am J Respir Crit Care Med.,* 167(10), 1344-53.

27. Chichester, D.C., and Horan, D. (2005). Nitrogen-induced asphyxiation in well environments: Analysis and prevention strategies. *Journal of Occupational and Environmental Safety*,7(3), 45–52.

28. Green, C.T., Fisher, L.H. (2005). Effects of agricultural practices on nitrogen gas accumulation in groundwater. *Environ Sci Technol*., 39(24), 9565-72.

29. Uhlman, K., Donahoe, M.J., Barlow, L.R., Greene, J.D. and Johnson, C.A. (2012). Methods for monitoring and mitigating gas hazards in groundwater systems. *J Environ Manage*., 89-96.

30. Guidotti, T.L. (1994). Hydrogen sulfide: Advances in understanding human toxicity. *Int J Toxicol*., 13(1):63-73.

31. Creswell, J.W. and Creswell, J.D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches. 5th ed. SAGE Publications, California.

32. Neuman, W.L. (2014). Social Research Methods: Qualitative and Quantitative Approaches. 7th ed. Harlow: Pearson Education Limited.

33. Choudhury, A.K.R. (2020). Flame Retardants for textile Materials. CRC Press, Boca Raton.

34. Mishra, D.P. (2010). Fundamentals of Combustion. 2nd ed. HPL Learning Private Limited, New Delhi.

35. Police Station Chandnu (2024). Marg Report, Bemetara.

36. Police Station Pachpedi (2024). Marg Report, Bilaspur.

37. Erskine, K. L. & Armstrong, E. J. (2010). *WaterRelated Death Investigation - Practical Methods and Forensic Applications.* CRC Press.

38. Saukko, P., Knight, B. and Knight, S. (2004). Forensic Pathology. 3rd ed., Arnold Publishers, London.

39. Varma, S., Gupta, S. and Singh, H. (2017). Forensic Science in Rural India: Challenges and Prospects. *Indian J Forensic Sci.*, 15(2), 85-92.

40. Madea, B. (2009). Handbook of Forensic Medicine. 1st ed. Wiley-Blackwell, Chichester.

41. Kumar, R., Singh, P. and Patel, N. (2016). The Socio-Cultural Dimensions of Death Investigations in Rural India. *J Rural Forensic Stud*., 4(3), 124-33.

42. DiMaio, V.J. and DiMaio, D. (2001). Forensic Pathology. 2nd ed.CRC Press, Boca Raton.

43. Chattopadhyay, S. and Ghosh, S. (2010). Legal and Ethical Aspects of Forensic Science in Rural India. *J Indian Law Forensic Sci.,* 8(1), 45-52.

44. Shetty, P., Rao, A., Sharma, K. A. (2009). Comparative Study of well Death in Rural and Urban Areas: Forensic Patterns and Challenges. *Int J Forensic Res*., 6(4), 211-9.