

AI Based E-Textile for Chemical Exposure Monitoring for Industrial Worker's Safety

Shanthi K.¹; K. Praveenkumar²; Rajaram Mani³; Shanthi V.⁴; Preethibha C.⁵;
Suganthi N.⁶; Sugumar M.⁷; Aswhin A.⁸; Drisyia S.⁹; Sruthika V.¹⁰

¹Department of IT Srikrishna College of Technology Coimbatore
^{2,3,4,5,6,7,8,9,10}Department of ECE Park College of Engineering and Technology Coimbatore, India

Publication Date: 2026/05/28

Abstract: The PAPER addresses safety concerns in industries where workers face potential exposure to hazardous chemicals. Utilizing e-textile technology, the method develops a wearable smart system that incorporates chemical sensors into the fabric of industrial workers' protective clothes. A secure cloud-based architecture for effective data processing and storage, real-time notifications to warn employees of dangerous exposure levels, and ongoing chemical concentration monitoring are some of the key objectives. Transmitting exposure data to a centralized cloud platform, the e-textile operates as an Internet of Things (IoT) device. Implementing e-textile technologies, carefully choosing and integrating chemical sensors, using microcontrollers for efficient data management, putting communication modules in place for real-time data transmission, and creating user-friendly interfaces for mobile or web applications are all crucial project components. The report also highlights data analytics, which evaluates and forecasts possible long-term health effects using cumulative exposure data. The project's expected results include developing a working mobile or web application for real-time monitoring, creating a smart e-textile system prototype, and demonstrating how the system seamlessly tracks chemical exposure and sends data to the cloud. Analysing preliminary data will highlight the project's importance in enhancing occupational health by assessing the possible long-term impacts of chemical exposure in industrial settings.

Keywords: E-Textiles, IoT, Chemical Exposure, Industry Worker, Chemical Worker, Chemical Exposure Monitor, Health Monitoring, Hazardous Gas.

How to Cite: Shanthi K.; K. Praveenkumar; Rajaram Mani; Shanthi V.; Preethibha C.; Suganthi N.; Sugumar M.; Aswhin A.; Drisyia S.; Sruthika V. (2026) AI Based E-Textile for Chemical Exposure Monitoring for Industrial Worker's Safety.

International Journal of Innovative Science and Research Technology, 11(5), 2020-2026.

<https://doi.org/10.38124/ijisrt/26may1301>

I. INTRODUCTION

In numerous industries, workers are exposed to considerable risks to their health and safety due to frequent contact with hazardous chemicals. Extensive research has underscored the detrimental effects of such exposures, emphasizing the need for innovative approaches to protect employees in hazardous environments. Utilizing smart fabrics, safety equipment has been developed to enhance workplace safety, incorporating statistical insights to inform decision-making.

One study focused on the respiratory health of textile workers involved in dyeing cotton and wool fibres. Findings revealed a higher prevalence of chronic respiratory symptoms and lung function abnormalities among exposed workers. Interestingly, the overall mortality rate among dye industry workers was significantly lower than that of the

general population (SMR=0.40, 95% CI 0.24–0.63), but asthma-related mortality was notably higher (SMR=9.03, 95% CI 1.86–26.39). While deaths from non-malignant respiratory diseases were elevated in dye industry workers compared to other sectors, the disparity was not statistically significant (SMR=2.0, 95% CI 0.41–5.86). The construction sector exhibited the highest exposure rate (75%, 73 to 76%), followed by manufacturing (59%, 57 to 60%), social and human health services (39%, 38 to 41%), motor vehicle trade and repair (35%, 34 to 36%), and public administration, transportation, and storage (25%, 23 to 28%). Construction and manufacturing sectors significantly differed from all other sectors ($p < 0.001$, ES ranging from 0.15 to 0.50). Additionally, a survey conducted in textile facilities identified specific allergies to reactive dyes, leading to respiratory and nasal complaints among workers associated with their job duties.






MAIN SECTORS OF EXPOSURE	PRIMARY HEALTH IMPACTS	GLOBAL BURDEN OF OCCUPATIONAL EXPOSURES	WORK-RELATED HEALTH IMPACT
 Mining  Construction  Agriculture; plantations; other rural sectors  Automotive industry  Protective textiles	Cancer (mesothelioma, cancer of the lung, larynx, ovary) Asbestosis and pleural disease	>125,000,000 (WHO 2018)*	>233,000 deaths annually (GBD 2019)

Fig 1 Main Sectors of Chemical Exposure [3].

Research examining the historical perspective of chemical workers exposed to benzene investigated the enduring health impacts of occupational exposure. The findings revealed elevated mortality rates for haematological and lymphatic malignancies, emphasizing the necessity for continual surveillance and preventative measures.

Further insights were gleaned from studies assessing the respiratory health of individuals engaged in welding, painting, and auto repair. These investigations demonstrated that recurrent exposure to fuels, fumes, exhaust emissions, and dust could impair lung function. Recommendations included implementing control measures to mitigate vapor concentration and enhance respiratory well-being among workers. Addressing these concerns is the Smart E-Textile for Chemical Exposure Monitoring in Industrial Worker's Safety initiative. Its objective is to develop a wearable smart system integrating chemical sensors with protective clothing. Leveraging e-textile technology, this system would deliver prompt notifications upon hazardous chemical exposure, enable real-time monitoring, and facilitate data transmission to a secure cloud infrastructure.

Ultimately, the aim is to empower industrial workers with continuous monitoring tools to navigate hazardous environments safely. In addition to developing a functional prototype, the project endeavours to contribute significant insights to the broader discourse on occupational health and safety. By leveraging findings from these investigations, the initiative seeks to enhance the well-being of workers routinely exposed to chemicals during their daily tasks.

➤ *Existing Chemical Exposure Monitoring Systems*

Existing systems for monitoring chemical exposure primarily concentrate on ensuring the safety of workers by swiftly detecting and responding to potential hazards. One approach involves installing fixed gas detection devices in industrial environments. Utilizing IoT technology and an Arduino Uno R3, these systems are designed to identify and manage hazardous gas leaks within industrial settings. MQ-6 sensors are employed to detect flammable gases, triggering alarms and notifications when gas levels surpass acceptable thresholds. Data is analysed and stored for future reference, aiming to minimize environmental gas pollution

and enhance industrial safety through real-time monitoring and smartphone integration.

Another method to mitigate industrial accidents caused by harmful gas leaks utilizes IoT and Arduino Uno R3 technology. Sensors continuously monitor environmental parameters, detecting hazardous gases like carbon monoxide and ammonia. Upon detection of elevated gas levels, alarms are activated, and alerts are dispatched to the industry's safety control board via SMS. Online data storage facilitates analysis and potential expansion to improve living conditions around industrial areas.

In addressing health hazards associated with working with hazardous gases, an IoT-based Toxic Gas Sensor and Temperature Monitoring Device is employed. This device is particularly relevant for workers in industries such as mining and textiles, who are frequently exposed to toxic vapours that can adversely affect their health and productivity. By measuring external temperature and detecting gases such as carbon monoxide and methane, the instrument promptly alerts individuals in proximity to potential hazards. Data is accessible globally through mobile applications and online servers, facilitating rapid responses to safety concerns.

Another IoT device is utilized to track ambient conditions and identify hazardous gases, thereby safeguarding workers' safety. Real-time data collection during gas leaks, facilitated by central microcontrollers and sensors such as heat, gas, and smoke sensors, triggers immediate alarms. Alerts are communicated to users via an Android app and online platform, while online data storage enhances industrial safety and facilitates future analysis.

Furthermore, portable gas detectors and chemical exposure badges function as wearable dosimeters, continuously monitoring cumulative exposure levels over time. Real-time air quality monitoring systems assess particulate matter and volatile organic compounds, contributing to improved worker safety. These technologies collectively enable prompt responses to dangerous situations and immediate dangers, promoting a safer work environment.

➤ *Proposed Smart E-Textile System*

The Smart AI E-Textile System represents a novel approach to chemical exposure monitoring tailored to the needs of industrial workers, aiming to enhance workplace safety. This innovative device guarantees real-time monitoring of chemical exposure levels by seamlessly incorporating electronic components into protective

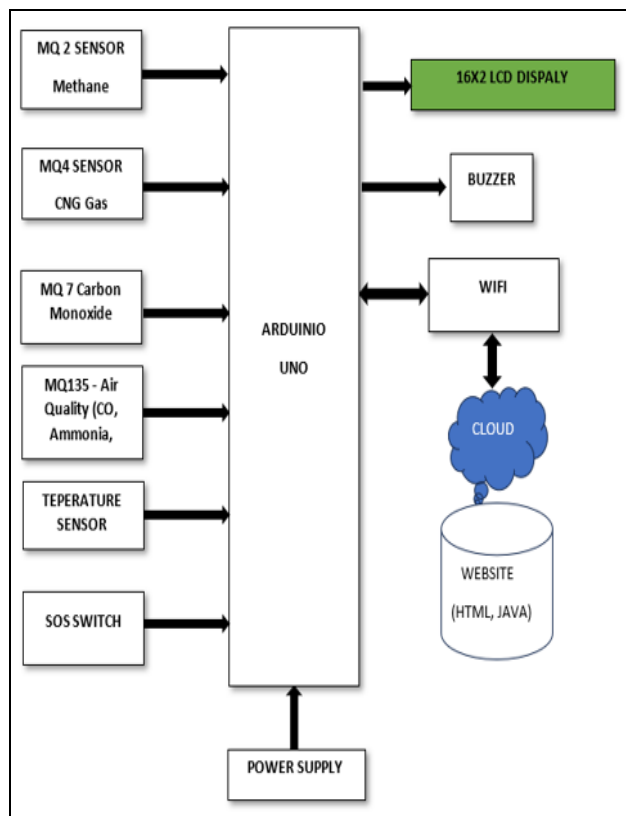


Fig 2 Block Diagram of Chemical Exposure Monitoring System

➤ *Protective Clothing Material*

Careful consideration in selecting materials for protective apparel is paramount. The integration of e-textile technology into the fabric ensures an optimal balance between functionality and comfort. It's crucial to choose materials that are breathable, durable, and suitable for diverse industrial settings. Employing a fabric designed to repel water ensures wearer comfort and dryness, further enhanced by a PU coating for additional liquid protection. The inclusion of a ripstop weave enhances durability by preventing minor tears from expanding. Moreover, the incorporation of air mesh fabric promotes breathability, keeping workers cool while providing protection.

➤ *Sensors*

Incorporating chemical sensors into the fabric is crucial for detecting and quantifying harmful compounds in real time, providing workers with proactive protection against chemical exposure. This section underscores the pivotal role of sensor technology in delivering fast and accurate data on exposure levels. The inclusion of MQ 135 sensors in the system is essential for identifying various hazardous substances, serving as the "nose" of the system to

garments via e-textile technology. Beyond immediate safety enhancements, this method offers insights into the long-term health effects of chemical exposure. Let's delve into the three core components of this groundbreaking system: the cloud-based infrastructure, the embedded sensors, and the protective garment material.

detect potential threats in the environment. Upon detecting increased levels of chemicals, these sensors trigger a buzzer emitting a 2300 Hz frequency, ensuring clear and prompt notification. Acting as the system's central processing unit, the microcontroller interprets sensor data and activates the alarm if necessary. Together, these components enable timely alerts and real-time monitoring, enhancing worker safety.

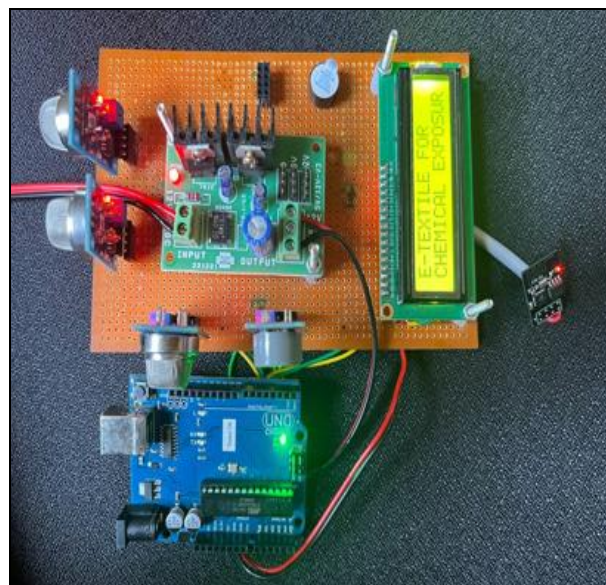


Fig 3 Hardware Setup of Smart E-Textile for Chemical Exposure Monitoring System.

➤ *Cloud-Based Infrastructure*

A robust cloud-based infrastructure serves as the central hub for processing, analysing, and storing data, significantly enhancing the effectiveness of the proposed system. Real-time data collected by sensors is securely transmitted to the cloud for swift processing and organization. Beyond providing workers with immediate notifications of harmful exposure levels, this cloud-based architecture facilitates comprehensive data analytics. This section underscores the critical role of the cloud-based infrastructure in maintaining the system's scalability, reliability, and ability to deliver insightful information about the long-term health effects of chemical exposure.

In practical terms, our fabric is designed to repel water, withstand tears, and promote air circulation, making it suitable for everyday wear. The sensors serve as vigilant monitors, continuously detecting any traces of harmful chemicals. Upon detection, the buzzer sounds the alarm, prompting the wearer to take necessary precautions. Coordinating this entire process, the microcontroller ensures that our Smart E-Textile System is a dependable and user-friendly solution for enhancing workplace safety.

II. DATA ANALYSIS

Data analysis plays a pivotal role in harnessing collected information to glean insights into the long-term health ramifications of chemical exposure. By scrutinizing both historical and current data, patterns and trends can be identified, enabling pre-emptive measures to mitigate health risks. Furthermore, data analysis facilitates the creation of predictive models that anticipate future health outcomes based on exposure levels and other relevant variables.

➤ *Algorithms Such as:*

- *Statistical Analysis:*

Utilize descriptive statistics to summarize and explore the distribution of worker health outcomes and chemical exposure levels. Compute metrics like mean, median, standard deviation, and correlation coefficients to ascertain the relationship between exposure and health outcomes.

- *Machine Learning Models:*

Employ supervised learning algorithms, like logistic regression, random forest, and support vector machines, to forecast future health outcomes based on past data. Additionally, utilize survival analysis methods such as the Cox proportional hazards model and Kaplan-Meier estimate to analyse time-to-event data, considering censorship and providing insights into the cumulative impact of chemical exposure on health.

- *Time-Series Analysis:*

Conduct time-series analysis to examine temporal trends in chemical exposure levels and health effects over time. Predict future trends and seasonal fluctuations using techniques like exponential smoothing and autoregressive integrated moving average (ARIMA) models.

- *Feature Selection and Dimensionality Reduction:*

Employ methods such as principal component analysis (PCA), t-distributed stochastic neighbour embedding (t-SNE), or recursive feature elimination to identify relevant features and reduce dataset dimensionality. These techniques enhance predictive model performance.

By leveraging these data analysis techniques and algorithms, the Smart E-Textile System can enhance workplace safety and well-being by providing insightful information on the long-term health impacts of chemical exposure among industrial workers.

➤ *Emergency SOS Button*

The Emergency SOS button serves as a critical component of the system, allowing workers to swiftly summon assistance during crises or urgent situations. Activating the SOS button triggers a distress signal, initiating a rapid response protocol to safeguard the worker's safety and well-being. Instant Alert functionality ensures that upon pressing the SOS button, designated individuals or emergency responders receive immediate notification of the urgent need for assistance. Location Identification

capabilities enhance response times by enabling rescue teams to pinpoint the exact location of the distressed worker. Integration with GPS or position tracking technology ensures precise location tracking in real-time. By incorporating an Emergency SOS button into the Smart E-Textile System, the overall safety and well-being of industrial workers are further fortified, providing them with a lifeline in times of peril.

The hazardous gas detected by Smart E-Textile for chemical exposure monitoring system are shown in the below given figures.

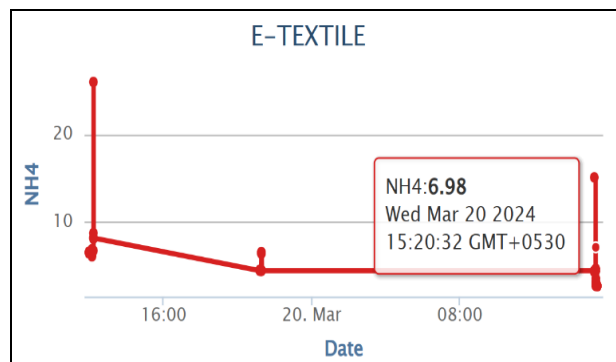


Fig 4 Ammonia Detection

The above Figure 4 is a graph that depicts the Ammonia exposure levels, measured in parts per million (ppm), plotted against date and time on the y-axis.

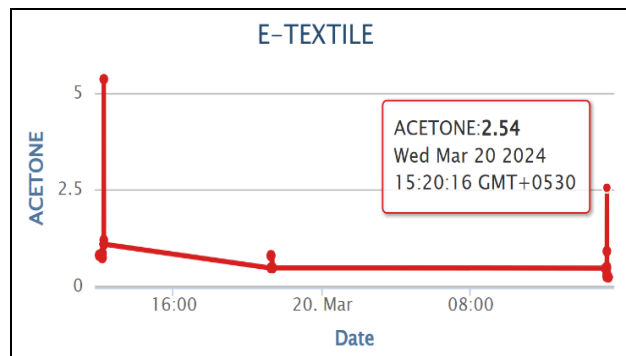


Fig 5 Acetone Detection

The above Figure 5.6 is a graph that depicts the Acetone exposure levels, measured in parts per million (ppm), plotted against date and time on the y-axis.

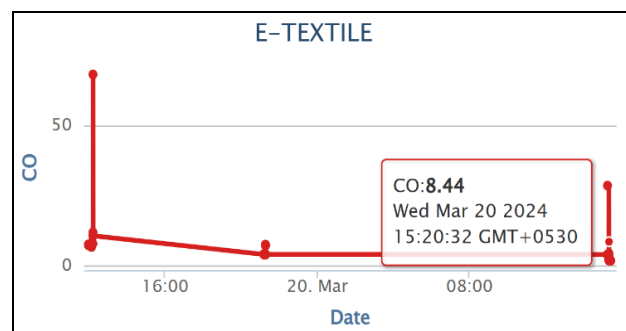


Fig 6 Result from Things Speak – Carbon Monoxide Detection

The above Figure 6 is a graph that depicts the carbon Monoxide exposure levels, measured in parts per million (ppm), plotted against date and time on the y-axis.

➤ *Dataset*

At gas stations, the mean concentration of BTEX (benzene, toluene, ethylbenzene, and xylene) was slightly higher compared to roadside levels, with no significant variance between inner and outer areas. For workers exposed to benzene and ethylbenzene over 30 years, the estimated mean lifetime cancer risks were 1.75×10^{-4} and 9.55×10^{-7} respectively. Hazard quotients for BTEX compounds were estimated at 0.600, 0.008, 0.007, and 0.002 respectively. Common symptoms among workers included headache (61%), fatigue (29%), and throat irritation (11%), with significant associations between benzene and toluene exposure and fatigue.

Another study examined the health impacts of non-invasive carbon monoxide (CO) saturation in workers at Hattar Industrial Estate and Sultan Purr. Using a Rad-57 Pulse CO-Oximeter, the highest CO saturation level recorded was 17% in the steel industry, while the lowest was 4.2%. Prevalence rates for respiratory inflammation, dermatosis, and asthma were assessed. In Indonesia's Combined Cycle Power Plant (CCPP) Indralaya unit, the impact of sulphur dioxide (SO₂) exposure on workers' health was evaluated. The average SO₂ concentration measured was 0.085 mg/m³ over an 11.88-year period, or

an average exposure of 8.44 hours per day. Risk Quotients (RQ) for lifetime and real-time exposures were both less than 1, indicating no significant non-carcinogenic dangers to workers despite detectable concentrations.

III. RESULTS

The Smart E-Textile System introduces an innovative approach to addressing the critical challenge of safeguarding industrial workers from hazardous chemical exposure. This solution ensures that workers operating in potentially risky environments benefit from real-time monitoring and alarm systems, achieved through a combination of advanced sensors and cutting-edge fabric technology. The fabric itself is engineered for everyday wear in diverse industrial settings, boasting water-repellent properties, tear resistance, and optimal airflow for wearer comfort. Integrated sensors, including a microcontroller and MQ 135 sensors, continuously scan the surrounding air for hazardous chemicals. Upon detection, the wearer is promptly alerted via a buzzer alarm. Beyond providing immediate warnings, this proactive approach facilitates ongoing data collection and analysis, enabling the identification and mitigation of potential long-term health effects. In summary, the Smart E-Textile System offers a practical and user-friendly solution to enhance workplace safety, with the potential to significantly improve occupational health outcomes in modern work environments.

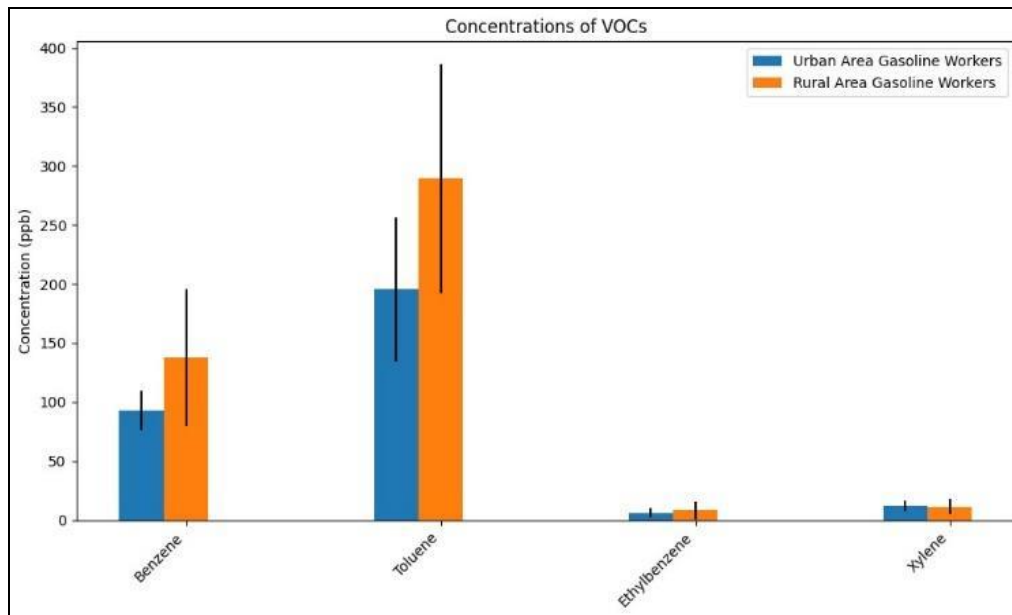


Fig 7 VOC Concentrations between Urban and Rural Gasoline Workers

The above Figure Depicts the concentration of Voltaic Organic Compound Gases which gasoline station workers are exposed to in urban and rural gas station. From these data we can conclude that exposure to BTEX compounds

would increase the risk of cancer in gasoline station workers. Exposure to benzene and toluene may cause fatigue.

Table 1 Types Gases Present in Various Industries with Potential Health Risks for Workers.

Gas	Industries	Potential Risk
CO	Food Industry	Respiratory issues, skin allergies, asthma, eye inflammation, and gastrointestinal

	Processing Industry (Vegetable, Ghee).	Face respiratory diseases, skin issues, asthma, eye inflammation, hypertension, and gastrointestinal
	Steel Industry	severe respiratory issues, skin allergies, asthma, eye inflammation, hypertension, and gastrointestinal infections
SO ₂	Power plants (coal-fired, gas-fired), refineries, metal processing, paper production	Asthma, bronchitis, chronic obstructive pulmonary disease (COPD), cardiovascular diseases
NO ₂	Combustion processes (vehicle engines, power plants), industrial manufacturing.	Respiratory irritation, exacerbation of asthma, lung function impairment, increased susceptibility to respiratory infections, bronchitis, respiratory infections, decreased lung function.
H ₂ S	Oil and gas extraction, wastewater treatment, pulp and paper manufacturing.	Eye and respiratory irritation, headache, dizziness, nausea, olfactory fatigue (loss of sense of smell), neurological effects, cardiovascular effects.

IV. DISCUSSION

The Smart E-Textile System represents a significant advancement in occupational safety technology, offering real-time monitoring and alarms for chemical exposure to enhance worker safety and well-being in industrial environments.

Firstly, the system's incorporation of electrical components into protective apparel marks a notable departure from conventional approaches to chemical exposure monitoring, which often rely on periodic evaluations or fixed detection equipment. By providing real-time alarms and continuous monitoring, the Smart E-Textile System enables employees to swiftly respond to changing environmental conditions, thereby reducing the risks associated with chemical exposure. Furthermore, the system's cloud-based architecture facilitates seamless data collection, analysis, and storage, empowering organizations to gain valuable insights into exposure patterns and trends. By leveraging a data-driven approach, companies can enhance workplace safety procedures, implement targeted interventions, and improve situational awareness. Additionally, the technology holds promise in addressing the long-term health effects of chemical exposure through continuous observation and data gathering. Despite its potential advantages, the Smart E-Textile System also presents several challenges that warrant further investigation and development. These include the need for continuous calibration and validation of the system's sensors to ensure accuracy and reliability, as well as practical considerations such as comfort, maintenance, and longevity of the protective apparel. Organizational buy-in, along with investments in training and education, may also be necessary for successful adoption and implementation. Moreover, concerns regarding data security and privacy must be addressed to safeguard sensitive information collected by the system.

In conclusion, while the Smart E-Textile System offers significant potential to improve workplace safety and well-being through real-time monitoring and alarms for chemical exposure, ongoing research and development are necessary to address challenges related to sensor validity, integration, and data privacy. By proactively managing chemical exposure hazards through technology, companies can create safer and healthier work environments for their employees.

V. CONCLUSION

In conclusion, the Smart E-Textile System presents a new approach for handling the critical issue of industrial workers' chemical exposure monitoring. The water-repellent fabric, ripstop weave, PU coating, and air mesh fabric combine to form a framework that is both comfortable and protective. With the use of sophisticated sensors including five MQ 135 sensors, a microprocessor, and a buzzer that beeps at a frequency of 2300 Hz, the system creates a dynamic and adaptable monitoring system. This idea considers the practical aspects of daily wear in addition to providing workers with real-time notifications when hazardous chemicals are present. The fabric is a practical option for a variety of industrial settings due to its breathability, tear resilience, and water repellence. The integration of these components establishes the Smart E-Textile System as a proactive, dependable, and user-friendly instrument for guaranteeing worker safety. With a focus on both short-term alerts and long-term ease, the system is prepared to significantly impact the larger field of occupational health and safety. In the modern workplace, where employee welfare is prioritized, the Smart E-Textile System shows promise as a workable and viable way to foster a safer and healthier atmosphere.

REFERENCES

- [1]. Dogbla L, Gouvenelle C, Thorin F, Lesage FX, Zak M, Ugbolue UC, Charbotel B, Baker JS, Pereira B, Dutheil F. "Occupational Risk Factors by Sectors: An Observational Study of 20,000 Workers." *Int J Environ Res Public Health*. 2023.
- [2]. Shree, E. Nithya, PJ Vinusri, and AV Sharni. "Development of personal protective apparel for sanitation and hygiene workers." (2021).
- [3]. "Exposure to hazardous chemicals at work and resulting health impacts: A global review." International Labour Organisation - Geneva, ILO 2021.
- [4]. S. I. Nahid and M. M. Khan "Toxic Gas Sensor and Temperature Monitoring in Industries using Internet of Things (IoT)" 24th International Journal on Computer and Information Technology (ICCIT), Dhaka, Bangladesh, 2021.
- [5]. Dr. Savita Sonoli, Akash H, Bhargavi Y, Gudiputi Dharani, Avinashgouda A Hiregoudar. "Harmful Gas

- Detection and Monitoring System in Industries using IoT” International Journal of Creative Research and Thoughts (IJCRT), 2022.
- [6]. Srinivas, Chalasani & Chandol, Mohan. “Toxic gas detection and monitoring utilizing internet of things”. International Journal of Civil Engineering and Technology. 2017.
- [7]. S. Balasundaram, S. Prabhu, G. S. Kumar R and S. D “Integrating IoT and Sensor Technology for Improved Industrial Safety Measures in the Textile Industry” 3rd International Journal on Pervasive Computing and Social Networking, 2023.
- [8]. Varma, M. S., Leelavathi, N., Sangamitra, Sirisha, Kiran, Venkateswara. “Toxic Gases Identifying in Industries with Alert System using IoT”. Indian Journal of Public Health Research & Development, 2018
- [9]. Johnston, Jill, and Lara Cushing. "Chemical exposures, health, and environmental justice in communities living on the fenceline of industry." *Current Environmental Health Reports* (2020): 48-57.
- [10]. Suneela Jadoon, Shamyala Nawazish, Qaisar Mahmood, Asif Rafique, Summar Sohail and Asma Zaidi “Exploring Health Impacts of Occupational Exposure to Carbon Monoxide in the Labour Community of Hattar Industrial Estate” Atmosphere 2022.
- [11]. Shofi Nurhisana, Hamzah Hasyim “Environmental health risk assessment of sulfur dioxide (SO₂) at workers around in combined cycle power plant (CCPP)” International Journal of Civil Engineering and Technology · December 2017
- [12]. Koh, Dong-Hee, et al. "Asthma mortality in male workers of the dye industry in Korea." *Journal of occupational health* 50.2 (2008): 130-135.
- [13]. Ahmad, Ijaz, and Mansour A. Balkhyour. "Occupational exposure and respiratory health of workers at small scale industries." *Saudi Journal of Biological Sciences* 27.3 (2020): 985-990.
- [14]. Wong O. "An industry wide mortality study of chemical workers occupationally exposed to benzene." I. General results. *Br J Ind Med*. 1987.
- [15]. Khamis, Jamal, et al. "Smart textiles for occupational safety health at oil stations and offshore platforms in the Black Sea." *Industria Textila* 73.1 (2022): 84-88.
- [16]. Pranvera Kortoçi, Naser Hossein Motlagh, Martha Arbayani Zaidan, Pak Lun Fung, Samu Varjonen, Andrew Rebeiro-Hargrave, Jarkko V. Niemi, Petteri Nurmi, Tareq Hussein, Tuukka Petäjä, Markku Kulmala, Sasu Tarkoma, “Air pollution exposure monitoring using portable low-cost air quality sensors” *Smart Health*, Volume 23, 2022, 100241, ISSN 2352-6483.
- [17]. Parvin, Forida, et al. "A study on the solutions of environment pollutions and worker’s health problems caused by textile manufacturing operations." *Biomed. J. Sci. Tech. Res* 28 (2020): 21831-21844.
- [18]. Zeba Idrees, Lirong Zheng “Low-cost air pollution monitoring systems: A review of protocols and enabling technologies” *Journal of Industrial Information Integration*, Volume 17, 2020, 100123, ISSN 2452-414X.
- [19]. Sara Zolghadri, Elham Rahimpour, Mohammad Reza Rahimpour “11 - Short-term and long-term health problems in exposure to chemicals” Editor(s): Mohammad Reza Rahimpour, Babak Omidvar, Nazanin Abrishami Shirazi, Mohammad Amin Makarem, *Crises in Oil, Gas and Petrochemical Industries*, Elsevier, 2023.
- [20]. Chizubem Benson, Christos Dimopoulos, Christos D. Argyropoulos, Cleo Varianou Mikellidou, Georgios Boustras, “Assessing the common occupational health hazards and their health risks among oil and gas workers” *Safety Science*, Volume 140, 2021
- [21]. Atanu Bag, Nae-Eung Lee “Recent Advancements in Development of Wearable Gas Sensors” *Advanced materials technology*, 2021.
- [22]. Minnesota Safety Council. "Falls Prevention." Minnesota Safety Council, n.d., <https://www.minnesotasafetycouncil.org/facts/factsheet.cfm?qs=CF901EBF63EA66BC88E9F0D6BA1DE734>.
- [23]. U.S. Department of Labor, Mine Safety and Health Administration. "Carbon Monoxide and Mining: Health Hazard Information Card HH-28." May 2007.
- [24]. Tunsaringkarn T, Siriwong W, Rungsiyothin A, Nopparatbundit S. Occupational Exposure of Gasoline Station Workers to BTEX Compounds in Bangkok, Thailand. *The International Journal of Occupational and Environmental Medicine* 2012; 3:117-25.