Literature Review for Factory Realtime Air Condition Monitoring for Improved Health

Introduction

The Factory Realtime Air Condition Monitoring for Improved Health project aims to address the critical issue of indoor air quality in industrial environments. Poor air quality in factories, caused by harmful pollutants such as carbon monoxide (CO), volatile organic compounds (VOCs), and nitrogen dioxide (NO2), can lead to serious health risks and reduced productivity. This literature review evaluates recent studies on IoT-based air quality monitoring solutions, focusing on their applicability to industrial settings and identifying gaps in existing solutions.

Existing Solutions in Air Quality Monitoring

Indoor air quality monitoring has become a key area of research, particularly as concerns about volatile contaminants grow. One study developed an indoor air monitoring system using chemical gas sensors based on polymer/functionalized single-walled carbon nanotubes (SWNT). This system, although consumer-friendly and compact, faces challenges in its application in Uganda due to the high cost and limited availability of these sensors (Thepudom et al., 2014). This highlights the need for more accessible and affordable solutions.

In another study, an IoT-based real-time environment monitoring system for factories was proposed, integrating sensors for temperature, humidity, air quality, and noise. While this system is effective in providing emergency alerts for incidents such as gas leaks, it lacks a focus on long-term air quality management and health impacts, which are crucial in industrial environments (Suryawanshi et al., 2024).

Similarly, Andarini and Widjaja (2022) developed an IoT system focused on monitoring indoor air quality through parameters like temperature, humidity, and CO_2 levels. However, this system overlooks more hazardous pollutants found in factories, such as VOCs and nitrogen oxides, highlighting a gap in its application to industrial settings. The study also emphasizes thermal comfort over critical health-related air quality concerns.

IoT-Based Systems for Factories

Research by Islam et al. (2020) presents an IoT-based HVAC monitoring system for smart factories, integrating sensors for energy efficiency optimization. While relevant to environmental control, the system's focus on energy efficiency limits its utility in addressing harmful air pollutants that directly affect worker health. A more comprehensive approach, including air quality sensors, would improve its applicability in industrial health and safety.

A more relevant solution is explored by Kuncoro (2023), who developed a sensor fusion system that integrates seven sensors to monitor gases such as CO, sulfur dioxide, ammonia, and VOCs. This system provides a detailed overview of indoor air quality, though it lacks predictive models, limiting its proactive management capabilities. Moreover, its focus is more general, and it does not yet cater to the complex and diverse air quality issues in industrial settings.

Finally, Samal et al. (2023) integrate stationary and portable IoT sensors to monitor and predict air quality using machine learning algorithms. This hybrid approach is effective for outdoor environments and smart cities, but it lacks application in industrial indoor settings. The absence of detailed strategies for managing air quality in specific industries limits its relevance to factory environments.

Gaps and Opportunities

Most existing solutions either focus on household or general indoor environments, overlooking the complex and hazardous air pollutants prevalent in factories. Additionally, systems that monitor air quality in factories emphasize emergency situations rather than continuous monitoring and predictive health management. Many studies also fail to address the need for accessible and cost-effective solutions in regions like Uganda.

Summary

Project/Study	**Focus Area**	**Core Technology**	**Key Gaps**	**Our Added Value**
Integrated IoT-Based Air Quality Monitoring	Outdoor air pollution monitoring	IoT sensors & ML for trend forecasting	Focus on **outdoor** pollution; lacks indoor, industry-specific solutions	**Indoor** & **factory-focused** monitoring with **predictive** insights for industrial pollutants
Sensor Fusion for Indoor Air Monitoring	General indoor air quality	7 sensors (CO, VOCs, SO2, NO2, temp, humidity)	No **predictive models**; not tailored for industrial pollutants	Adds **forecasting** for complex **factory** pollutants and worker health improvements
IoT-Based Environment Monitoring & Safety	Factory safety & emergencies	IoT for real-time alerts on gas leaks & fires	Focus on **emergencies**, not long-term health or continuous improvement	Provides **continuous** monitoring and focuses on **health risks** beyond emergencies
IoT-Based HVAC Monitoring	Energy efficiency in factories	IoT & Big Data for HVAC control	Focus on **energy**, minimal attention to **air pollutants** & worker health	Expands to **air quality** control for **CO, VOCs, NO2**, ensuring regulatory compliance
Monitoring Indoor Air for Thermal Comfort	Indoor comfort (temp, humidity)	IoT to track temperature, CO_2	Focus on **comfort**, not harmful factory pollutants	Focuses on hazardous **industrial pollutants** with **real-time alerts** for worker safety
AirQo (Uganda)	Outdoor air pollution in Uganda	Low-cost PM2.5 & PM10 sensors with AI	Focuses on **outdoor** urban air, not indoor factory pollutants	Targets **indoor factory** air issues (CO, VOCs, NO2) with scalable, affordable IoT

Key Insights:

- **Indoor vs Outdoor Focus**: Our project stands out by focusing on **indoor factory environments**, addressing gaps in both **predictive** models and **industry-specific** air pollutants.
- **Proactive Health Management**: Most existing projects emphasize **emergencies** or **comfort**—Our delivers **continuous monitoring** and **long-term health improvements** for workers.
- **Affordability & Scalability**: While **AirQo** excels in affordability, it lacks indoor industrial applications. Our project brings low-cost, **scalable** solutions to **factories**, improving worker health and safety.

Conclusion

This literature review demonstrates that while significant progress has been made in air quality monitoring using IoT, there remain critical gaps in the monitoring of industrial environments. Existing solutions either focus on household pollutants or emergency response but fall short in providing continuous, real-time monitoring of hazardous gases that are common in factories. The proposed **Factory Realtime Air Condition Monitoring for Improved Health** project addresses these gaps by integrating affordable, IoT-enabled sensors to detect harmful pollutants in real-time and provide predictive analytics for proactive health management in industrial settings. This solution will enhance worker safety, ensure regulatory compliance, and offer a scalable system adaptable to various industrial environments.

References

1. Andarini, R., & Widjaja, M. (2022). Monitoring indoor air quality for thermal comfort using Internet of Things. 2022 Seventh International Conference on Informatics and Computing (ICIC), Denpasar, Bali, Indonesia, 1-6. https://doi.org/10.1109/ICIC56845.2022.10006955
2. Islam, F. B., Nwakanma, C. I., Kim, D.-S., & Lee, J.-M. (2020). IoT-based HVAC monitoring system for smart factory. 2020 International Conference on Information and Communication Technology Convergence (ICTC), Jeju, Korea, 701-704. https://doi.org/10.1109/ICTC49870.2020.9289249
3. Suryawanshi, R., Garje, R., Ghodake, S., Nadar, H., Ingle, P., & Shaikh, I. (2024). IoT-based real-time environment monitoring and safety for factory workplace. 2024 1st International Conference on Cognitive, Green and Ubiquitous Computing (IC-CGU), Bhubaneswar, India, 1-6. https://doi.org/10.1109/IC-CGU58078.2024.10530721
4. Thepudom, T., Siyang, S., Seesaard, T., & Kerdcharoen, T. (2014). Indoor air quality monitoring system based on polymer/functionalized-SWNT gas sensors. 2014 IEEE 3rd Global Conference on Consumer Electronics (GCCE), Tokyo, Japan, 190-191. https://doi.org/10.1109/GCCE.2014.7031331
   Hikmah, A. N., & Kuncoro, C. B. D. (2023). Sensor fusion with seven parameters for indoor air quality monitoring system. 2023 10th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), Palembang, Indonesia, 2023, pp. 110-115. https://doi.org/10.1109/EECSI59885.2023.10295770
5. Samal, A., Samal, L., Swain, A. K., & Mahapatra, K. (2023). Integrated IoT-based air quality monitoring and prediction system: A hybrid approach. 2023 IEEE International Symposium on Smart Electronic Systems (iSES), Ahmedabad, India, 2023, pp. 441-444. https://doi.org/10.1109/iSES58672.2023.00099