GJR Publication
OPEN ACCESS

Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 04| Issue 04 | July-Aug. | 2024
Journal homepage: https://gjrpublication.com/gjrecs/

Research Article

Implementing an intelligent air quality monitoring device for the intensive care units in hospitals

*Auda Raheemah

Department of Electronic and Communication Engineering, College of Engineering, Al-Muthanna University.

DOI: 10.5281/zenodo.13300650 **Submission Date:** 26 June 2024 | **Published Date:** 12 Aug. 2024

***Corresponding author:** Auda Raheemah
Department of Electronic and Communication Engineering, College of Engineering, Al-Muthanna University.

Abstract
Patients in intensive care units need constant monitoring to monitor their health condition, and they also need to be in a safe, clean, and breathable environment. Due to the difficulty of the continuous presence of nurses and doctors in these units on an ongoing basis, the use of air monitoring devices is resorted to. Indoor air quality monitoring devices in intensive care units examine the concentration of gases inside these units using gas sensors that collect, analyze and process data, and then send alert messages to users in central control rooms in the event that these gases exceed the permissible limit by the mobile phone via the GSM network. Everyone can easily use this tool in hospitals, homes, or anywhere else.

Keywords: healthcare, monitoring system, Sensor systems, AQI, integrated sensorized platform.

1. Introduction
For the health of medical professionals and patients alike, hospitals' indoor air quality (IAQ) has emerged as an essential component of hospital management practices. Therefore, establishing an effective IAQ monitoring program is a central issue in protecting patients, doctors and hospital staff. The quality of air is mainly related to the following pollutants; physical (such as particulate matter, humidity, and temperature), chemical (such as carbon dioxide, carbon monoxide, formaldehyde, nitrogen dioxide, and ozone), biological (such as fungi and bacteria), and radioactive (such as radon) [1,2,3]. Depending on the reports of environmental protection agencies, human exposure to indoor air pollutants can sometimes be more than 100 times higher than exposure to outdoor air pollutants [4]. Physical indoor air pollutants, chemical, and biological pollutants are considered potential risks to patients, visitors, and medical staff. Therefore, it has become necessary to rely on an effective and flexible monitoring system to monitor and sense the air quality inside these units. Monitoring air quality inside hospitals is essential to maintaining high standards of hospital operations and reducing the amount of hazardous pollutants and other environmental elements that may harm the health of patients [5].

Yang, Chao-Tong, et al. [6] studied the air quality in a hospital and built a smart monitoring device that combines an information platform and wireless sensing technology. The study aims to demonstrate the applicability of this prototype for sensing carbon dioxide as an air quality indicator in hospital settings, through which the air quality inside the hospital can be monitored in real-time and the medical staff notified if the level of air quality declines below a certain threshold.

The Transparent Robot (TR), an integrated sensor platform created by researchers in [7] with the purpose of sensing the indoor environment in hospitals, introduced the concept of a smart hospital. The (TR) system can be mounted on automated movable platforms that allow it to move throughout the hospital or be fixed in a specific place, thus enabling it to be used for static and dynamic monitoring. By integrating this system with the hospital's software environment, a secure database containing information about monitoring hospitals' internal environments can be created. This would allow hospital administration or specialists to be alerted as soon as parameters deviate from permissible ranges.

Baqer, Noor S et al. in [8] developed a technique to assess various indoor contaminants and offer an updated air pollution dataset. The system that has been built offers real-time monitoring of air quality, feeds pollutant data to a cloud

platform such as ThingSpeak, and has the ability to initiate and send early notifications if an air quality indicator malfunctions.

Researchers in [9] developed a low-cost indoor air quality assessment tool that uses the BME680 and CCS811 as its two primary sensors. The device's continuous measurement and recording capabilities allowed it to track the volatile organic compounds (TVOC) in the air, humidity and temperature. The suggested tool has been utilized in a sizable hospital for monitoring the indoor air quality.

In [10] an Internet of Things (IoT) system for real-time monitoring of fine particles in dust called iDust is demonstrated. The iDust tool used a microcontroller type (WEMOS D1) and the PMS5003 PM sensor to measure the values of airborne particles (PM10, PM2.5, and PM1.0). Based on the notifications that appear on the building manager's dashboard, the building manager can intervene to improve indoor air quality (IAQ). The iDust system is an open-source technology and represents a useful tool to contribute to internal quality and occupational health in hospitals and medical centers.

The authors of [11] presented a study analyzing the effect of diverse HVAC systems on IAQ (in terms of carbon dioxide) and thermal indicators. Indoor air quality data were monitored in three different building types in relation to the HVAC system; And in working hours and outside working hours to examine the effect of all these factors on carbon dioxide concentrations and comfort standards in buildings.

This work proposed a smart, low-cost, easy-to-install, and easy-to-use tool for monitoring air quality inside intensive care units and can perform other functions such as detection and notification using SMS technology via the GSM network.

2. Methodology

The IAQ device monitors the air quality inside the ICUs and alerts the officials if the concentration of CO2 or dust particles exceeds the normal permissible limit by sending an alert to the officials in the central control rooms via SMS or call using the network (GSM). Fig.1 shows the main dimension of the air quality monitoring system proposed in this paper.

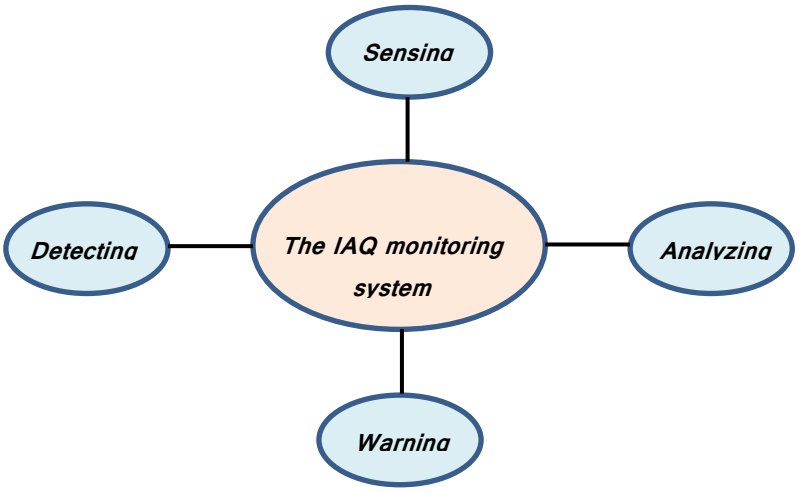


Fig.1. The dimension of the monitoring system

The dimensions of the IAQ monitoring system in (ICU) consist of sensors that sense the concentration of CO2 and PM (PM2.5 and PM10) in the air, the sensor signals are applied to the algorithm to analyze these data and compared with the permissible limit for the concentration of carbon dioxide and suspended particles (which was previously determined) to determine Indoor air quality. Suppose the concentration of gas and suspended particles exceeds the permissible threshold, in that case, an alert signal will be sent to the administration to alert it to take the necessary measures.

Fig.2 shows the steps for data collection and analysis, while Fig.3 illustrates the flowchart of the suggested air quality monitoring system.

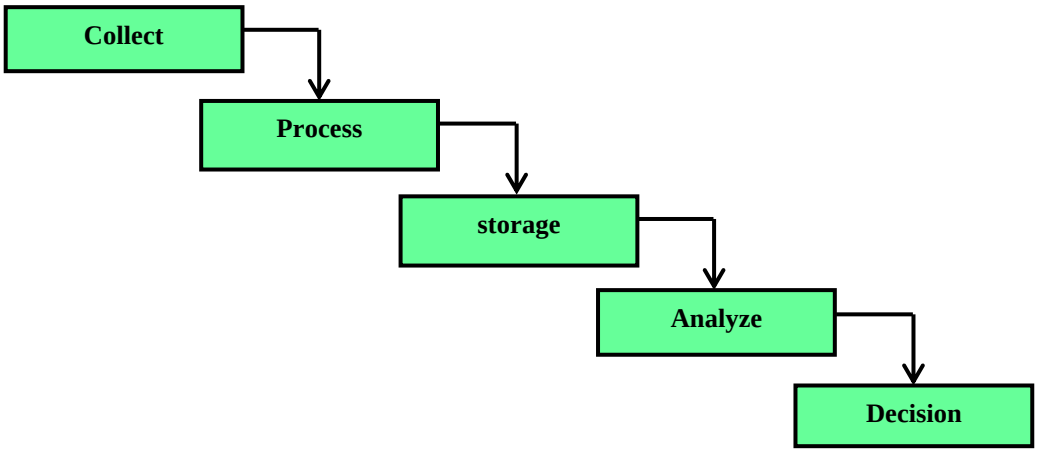
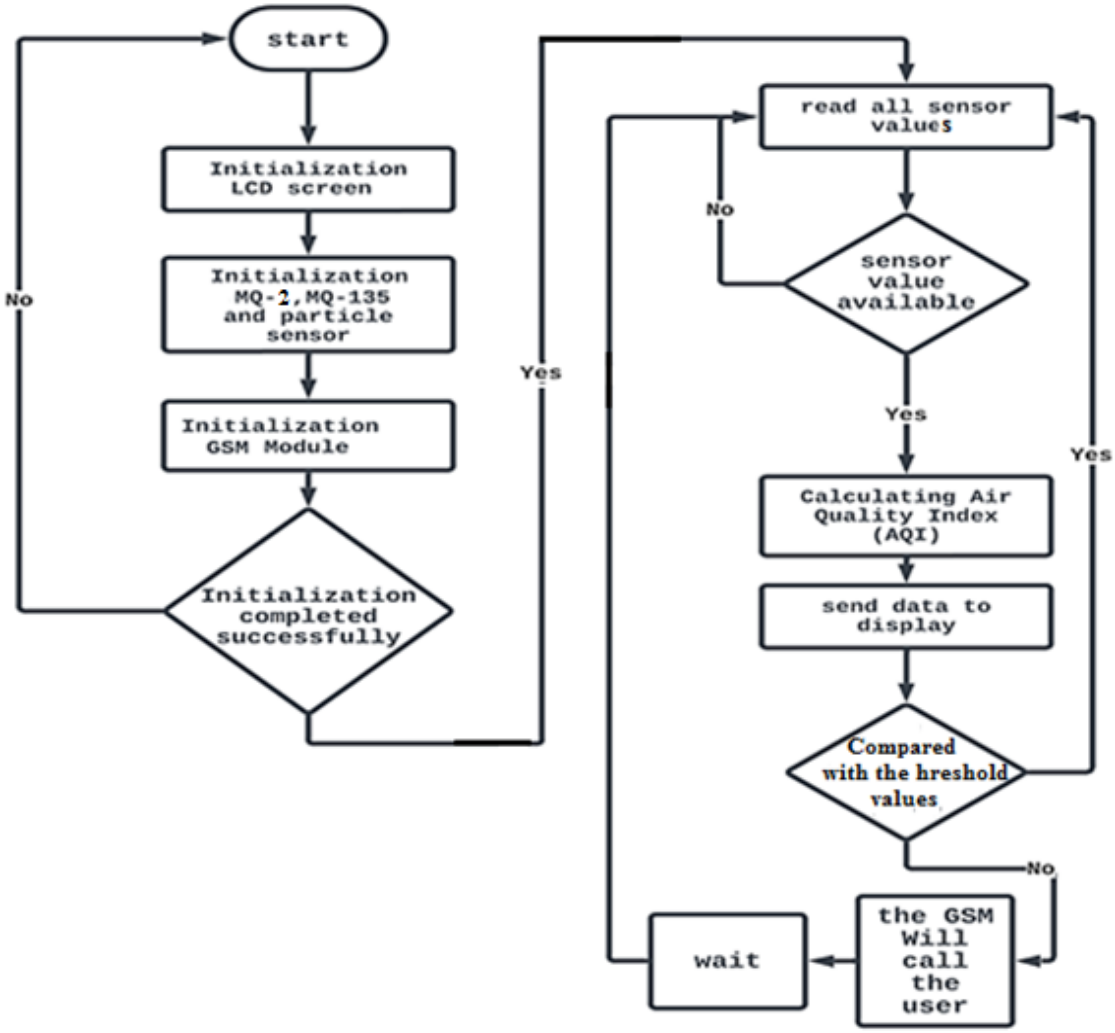


Fig.2. The process of collecting and analyzing data



b. Initialization Stage **a. Decision Stage**

Fig.3. The Flowchart for the Air Quality monitoring system

3. The Experimental Setup

The proposed device for measuring air quality in (ICU) consists of the following components:

- **The Microcontroller chip**: The processing unit of the suggested device is a microcontroller, namely an ATMEGA328p. Because of its many capabilities and peripherals, the ATmega328P can be used in many embedded systems and electronic applications. The monitoring device in this work requires two (ATMEGA328p) connected in a master-slave method (I2C). This method works especially well when the complexity of the project demands more than one Arduino can handle. Each Arduino can concentrate on a particular task by sharing the burden among several devices, which improves performance and makes better use of the resources available.

- **The Sensors:** different types of sensors are used in the proposed device such as the MQ-9 for measuring the concentration of CO and combustible gas in the air, MQ-135 for detecting the CO_2 and smoke and dust sensor for determining the levels of (PM 2.5 and PM10) in the air.

- **The GSM module:** the SIM808L is a flexible GSM module that empowers portable communication capabilities in a tremendous assortment of gadgets and applications. It is commonly utilized in IoT (Web of Things) ventures, security frameworks, and further checking applications due to its little measure, moo control utilization, and dependable execution [12].

- **The display Unit:** the 128x64 LCD is the display unit for displaying data in this device. This type of screen has a resolution of 128 pixels wide by 64 pixels high, giving plenty of space to display text, graphics and other visual elements. Fig.4 shows the block diagram of proposed monitoring device.

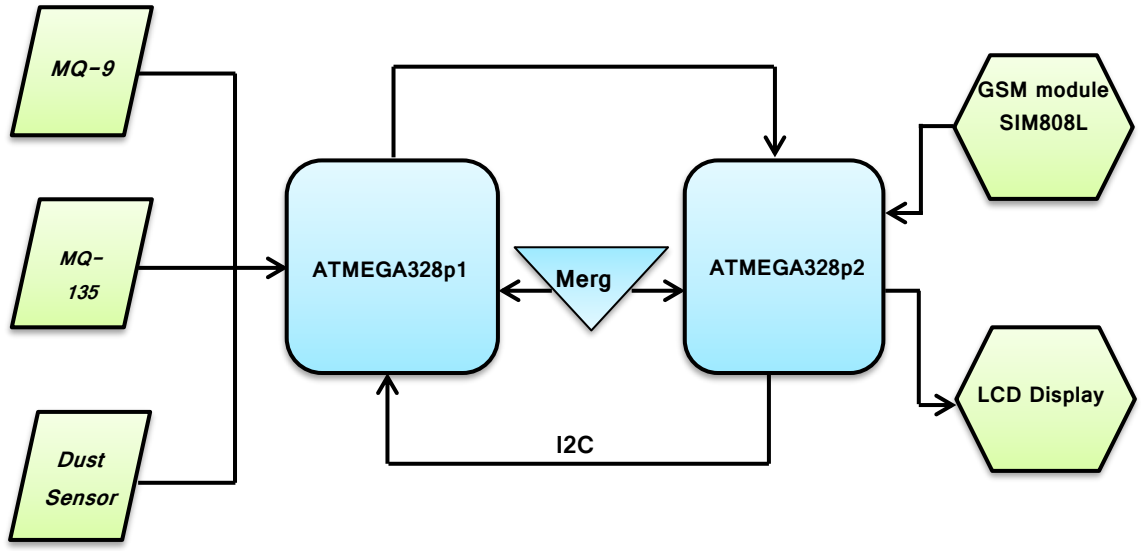


Fig.4. The block diagram of proposed monitoring device.

4. Discussions

The process of designing and implementing the air pollution monitoring system in the intensive care unit (ICU) suggested in this work consists of the following stages:

a. The hardware collection stage: This stage includes the following sub-stages:

- Connecting two of the Microcontroller chips (ATMEGA328p) in a master-slave manner to distribute work between the processors.
- Connecting gas sensors (MQ-2), (MQ-135) and dust sensors.
- Connecting the GSM module (SIM808L) for portable communication to send SMS messages or calls.
- Connecting the screen to display information about air quality (128x64 LCD).

Fig.5 shows the construction of the hardware collection stage.

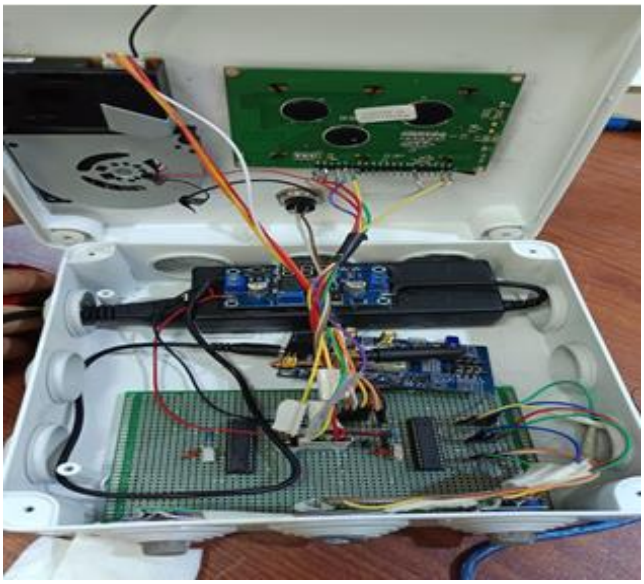


Fig.5. The construction of the hardware collection

b. The device calibration stage: In this stage, calibration is performed for gas sensors to measure the concentration of CO, CO2, smoke, and the dust sensor for suspended particles in the air (PM2.5 and PM10), the GSM module is also prepared and added phone card (SIM card) to it for enabling it to send messages to the administration.

c. The software stage: In this stage, programs for the operating system of the proposed system are written, and all hardware components are prepared for work.

d. The decision-making stage: This stage is designed to work as follows:

- Receiving readings of gas concentration levels in the indoor air of (ICU) from sensors.
- Compare these readings with the previously specified values (permissible threshold limit) previously defined in the device's memory.
- Display the values that were read to the user through the screen (LCD display).
- If the values entered are normal values and within the permissible limit, the device continues to read new values from the sensors. However, if the values exceed the permissible limit (which causes harm to the patient), an alert message is issued to the administration to take appropriate action.
- The alarm message regarding gas levels exceeding the permissible limit is sent via the (GSM) network to call a mobile device located in the administration rooms.

Fig.6 shows the readings of the LCD display in the event of an increase in the concentration of Co_2 gas as a result of burning a sheet of paper as an example of the device's operation.

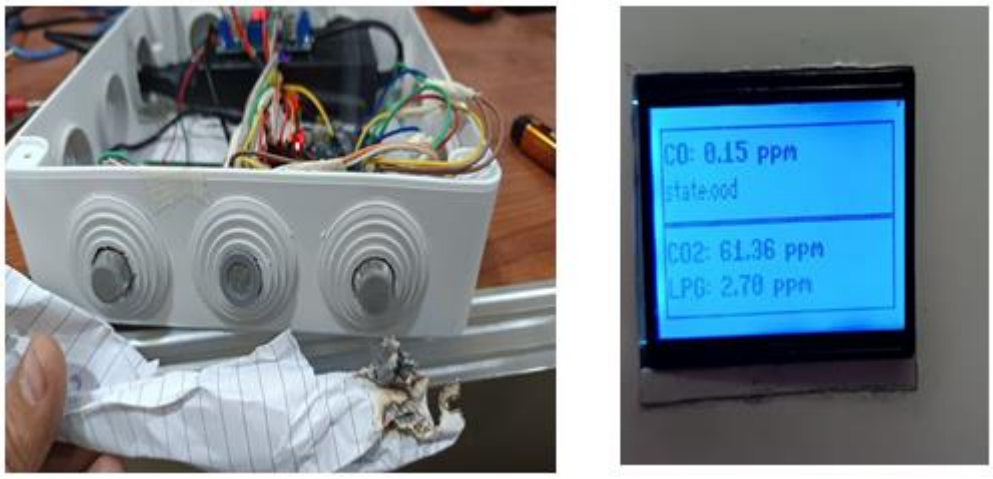


Fig.6. The actual operation of the proposed device

5. Conclusions

Patients hospitalized in intensive care units (ICUs) need continuous monitoring of their health condition, and the environment surrounding them must be completely healthy and provide appropriate health conditions, especially the high quality of the air they breathe, which must be free of pollutants. In this work, a prototype of an air pollution monitoring device in intensive care units was built. The proposed device senses harmful gases such as (co2) and suspended particles in the air (PM2.5 and PM10) records these readings and compares them with the percentages allowed in health standards. In the event of air pollution and high concentrations of harmful gases, this device will send a text message in real-time to a mobile device located in the administration room via the (GSM) network to alert the administration to take appropriate action to preserve the health of patients. The proposed device is easy to operate so that anyone can operate and deal with it, and it is also suitable for working in hospitals, homes, or any other place. The proposed device can be connected in the future to a ventilation system or an air purification system to automate the work and build a system for monitoring and purifying the air inside intensive care units in hospitals.

6. References

1. Wang, X., Bi, X., Chen, D., Sheng, G., & Fu, J. (2006). Hospital indoor respirable particles and carbonaceous composition. *Building and Environment*, *41*(8), 992-1000.
2. Wang, X., Bi, X., Sheng, G., & Fu, J. (2006). Hospital indoor PM10/PM2. 5 and associated trace elements in Guangzhou, China. *Science of the Total Environment*, *366*(1), 124-135.
3. Scaltriti, S., Cencetti, S., Rovesti, S., Marchesi, I., Bargellini, A., & Borella, P. (2007). Risk factors for particulate and microbial contamination of air in operating theatres. *Journal of Hospital Infection*, *66*(4), 320-326.
4. Pitarma, R., Marques, G., & Ferreira, B. R. (2017). Monitoring indoor air quality for enhanced occupational health. *Journal of medical systems*, *41*(2), 23.
5. Chen, H. W., Chuang, C. Y., & Lin, H. T. (2009). Indoor air distribution of nitrogen dioxide and ozone in urban hospitals. *Bulletin of environmental contamination and toxicology*, *83*, 147-150.
6. Yang, C. T., Liao, C. J., Liu, J. C., Den, W., Chou, Y. C., & Tsai, J. J. (2014). Construction and application of an intelligent air quality monitoring system for healthcare environment. *Journal of medical systems*, *38*, 1-10.
7. Gandah, S., Chiurazzi, M., Domina, I., Dei, N. N., Spreafico, G., di Luzio, F. S., ... & Ciuti, G. (2023). An Integrated Sensorized Platform for Environmental Monitoring in Healthcare. *IEEE Sensors Letters*.
8. Baqer, N. S., Mohammed, H., & Albahri, A. S. (2023). Development of a real-time monitoring and detection indoor air quality system for intensive care unit and emergency department. *Signa Vitae*, *19*(1).
9. Lasomsri, P., Yanbuaban, P., Kerdpoca, O., & Ouypornkochagorn, T. (2018, July). A development of low-cost devices for monitoring indoor air quality in a large-scale hospital. In *2018 15th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON)* (pp. 282-285). IEEE.
10. Marques, G., Roque Ferreira, C., & Pitarma, R. (2018). A system based on the internet of things for real-time particle monitoring in buildings. *International journal of environmental research and public health*, *15*(4), 821.
11. Asif, A., Zeeshan, M., & Jahanzaib, M. (2018). Indoor temperature, relative humidity and CO2 levels assessment in academic buildings with different heating, ventilation and air-conditioning systems. *Building and Environment*, *133*, 83-90.
12. Islam, R. U., Andersson, K., & Hossain, M. S. (2017, May). Heterogeneous wireless sensor networks using CoAP and SMS to predict natural disasters. In *2017 IEEE Conference on Computer Communications Workshops (INFOCOM)*.

Citation
Auda Raheemah. (2024). Implementing an intelligent air quality monitoring device for the intensive care units in hospitals. In Global Journal of Research in Engineering & Computer Sciences (Vol. 4, Number 4, pp. 108–113). https://doi.org/10.5281/zenodo.13300650