Indoor Air Quality Monitoring Systems: The Impact of using Intelligent Communication System in Living Environments

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ABSTRACT

With the advancement of communication system over the last 10 years, indoor air quality (IAQ) monitoring technology has advanced significantly, improving the monitoring system's real-time performance and lowering the possible effects of pollutants linked to health. "Incorporating the Internet of Things into these cutting-edge developing technologies therefore offers a great opportunity for the development of air quality systems, which require new networking models, strategies, and processes for multiple constraints with sophisticated sensing and communication abilities. A thorough analysis of the hardware requirements, communication methods, and architectures is necessary to handle reasonable data related to building inhabitants' daily activities. Research and understanding of the existing air quality systems serve in making choices by assisting in the matching of appropriate intelligent, adaptive, and reasoning technologies with data flow management. This article will include further details and a detailed examination of new communications protocols, networking systems, sensors, topologies, and technologies related to indoor and outdoor air quality systems. This article uses an intelligent communication system in the living environments to examine and evaluate the advancements in IAQ monitoring technology and the usage of communication technology in this area. The issues and difficulties with the IAQ monitoring system are also covered in this paper, which serves as a resource for researchers and encourages the quick and comprehensive advancement of IAQ monitoring.

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1. INTRODUCTION

Indoor air pollution (IAP) is a significant environmental problem that is closely related to the peace, good health, and well-being of building inhabitants. People spend around 90% of their time inside; therefore frequent exposure to indoor air pollution has an impact on their jobs and production. According to the Air Quality Index (AQI), the air quality in a particular location is determined by the daily reported concentration of pollutants. The US Environmental Protection Agency (EPA) reports that indoor air pollution consumption can occasionally surpass outside pollution levels by more than 100. Air pollution levels, residential habits, sources, and environmental infrastructure all affect indoor air quality (IAQ). IAQ is a tool for assessing the purity of the air by examining volatile compounds, such as those found in paint, furniture, office supplies, trash, exhaled breath, and/or perspiration [1]. One of the top five environmental issues affecting world health is air quality. To improve regulations, inspections, and the creation of automated real-time monitoring systems for human health, IAQ research is badly needed. To improve the building's construction rules, such methods have to be used in both private and public settings, including educational institutions and hospitals [2].

The World Health Organization (WHO) has produced a number of IAQ reports. Approximately three billion of the world's lowest-income individuals rely on solid fuels for their everyday cooking and heating requirements, including coal, wood, charcoal, animal dung, and agricultural wastes, according to these data. These solid fuels release a lot of harmful gases and increase the amount of particulate matter in the atmosphere. Frequent exposure to these contaminants can negatively impact a person's health. Due to the extensive use of oil-based paints, chemical-rich cleaning products, scented decorations, and other hazardous building materials and consumer goods, indoor air pollution (IAP) has an equally significant impact on metropolitan structures [3]. A key component of measuring indoor air quality (IAQ) is ventilation. Building constructions with inadequate ventilation arrangements have lower indoor air quality (IAQ) and are unfit for habitation. According to studies, one of the main reasons why health problems linked to inadequate ventilation are becoming more prevalent is IAP. In contrast to the minimum rate recommended by the American Society of Heating, Refrigeration, and Air Conditioning Engineers, research carried out in a few isolated villages in the Palpa area in western Nepal found that the proportion of ventilation deficiencies was 80% [4].

The Internet of Things, or IoT, is a concept in which devices with sensory capabilities are linked to the Internet. The Internet of Things is based on the widespread existence of a wide range of products or devices that may be accessible via special addressing methods with interaction and collaboration characteristics. Intelligent manufacturing is greatly impacted by IoT as it streamlines and expedites administrative procedures like arrival and departure certification. On the one hand, the Internet of Things may help with product trackability during the production process, allowing for remote administration and cost reductions. However, the Internet of Things offers a significant contribution to statistical analysis and process automation through the use of AI algorithms for improved performance [5]. When it comes to individual exposure to pollutants, indoor air quality (IAQ) is crucial since many populations, including the elderly, kids in schools, and individuals with disabilities, may spend the majority of their time inside. IAQ monitoring is therefore a crucial tactic for enhancing living circumstances and occupational health.

An IAQ sensor or multiple IAQ sensors make up the IAQ system. Their purpose is to gather and move environmental elements from the many rooms in which they are placed. After receiving data from the IAQ Sensors, the IAQ Gateway connects to the Internet via Wi-Fi 2.4 GHz. Real-time data is recorded and stored in an organized database. Thus, it may be possible to build a modular system that can monitor many locations at once. An Atmel AVR microprocessor is incorporated into the open-source Arduino Mega system, which is used to build the IAQ Sensor [6]. ZigBee technology was implemented using Xbee modules, allowing the IAQ Sensor and IAQ Gateway to communicate with each other. In this fascinating combination of IoT and AAL, a ZigBee wireless network is used to provide a unified platform for household surveillance and administration. Figure 1 depicts the overall design of the IAQ system.

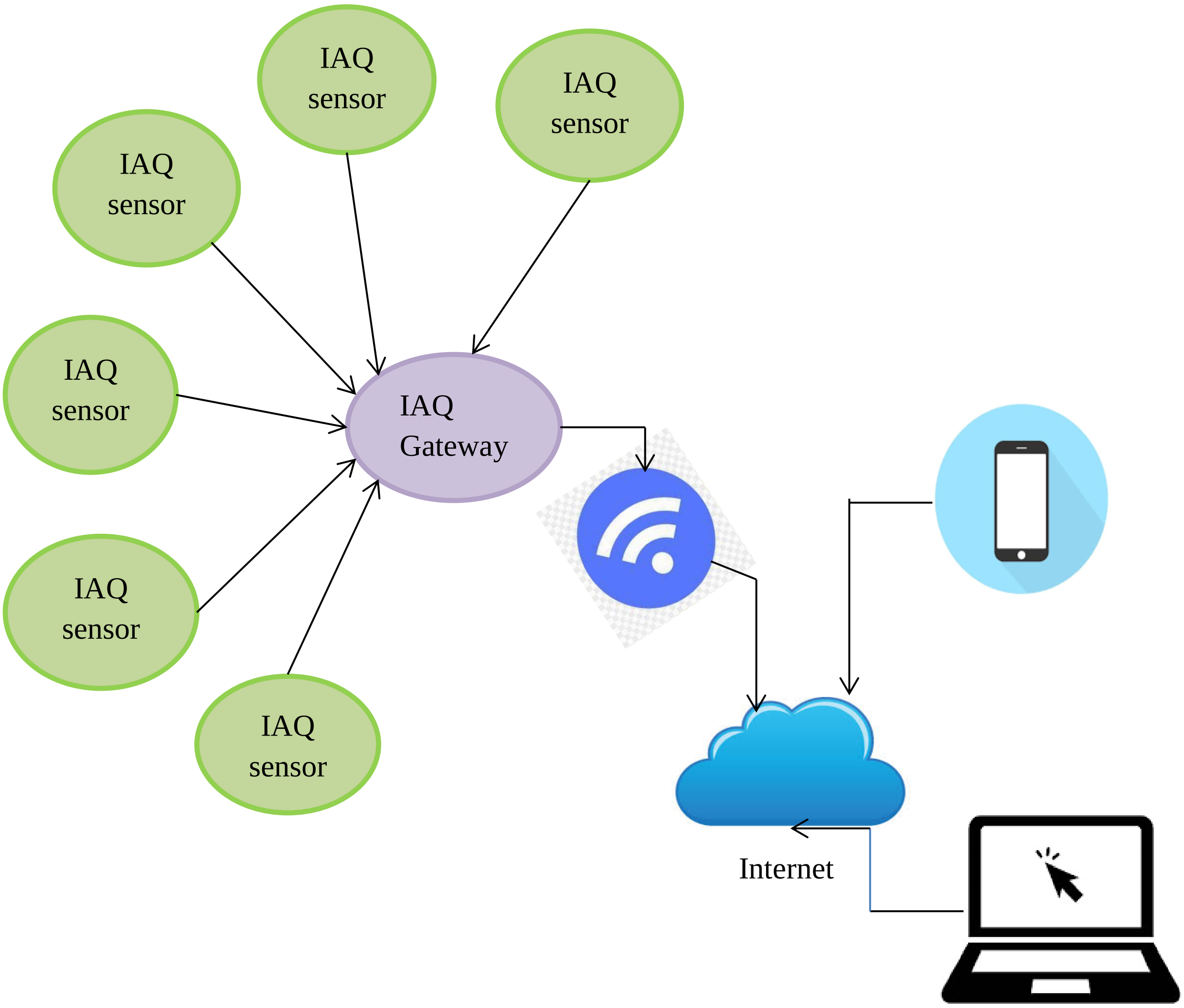

Figure 1. Architecture of Indoor Air Quality (IAQ)

IAQ control has to be expanded to include public service centers, hospitals, offices, libraries, schools, recreational areas, and car cabins. Monitoring of the IAQ must be concentrated on schools. Factors like as population density and the amount of time spent indoors should be taken into account in addition to the availability of pollutants. By using this information in the creation of more efficient automatic monitoring systems, educators, pupils, and other school personnel may experience a productive and healthy work environment. Smoking inside may be avoided by individuals, and when needed, natural ventilation can be used. Individuals can take precautions against smoking indoors or use natural ventilation when necessary. However, the first step in creating enhanced living environments is to install real-time monitoring systems [7]. This investigation's primary focus is air quality. Showing that higher air pollution levels have a more detrimental effect on human health is the primary goal of the Air Quality measure (AQI), a nonlinear metric that quantitatively characterizes air quality. Main pollutants, fine particles, and particle matter are the primary measurements of the "real-time air quality" concentration data index, which was released by the Administration of the Environmental Protection Agency [8]. Monitoring the real-time concentration data while air quality is being assessed makes more sense from a practical standpoint.

2. RELATED WORKS

Kumar et.al [9] introduced From Conservation to Regeneration: Enhancing the Quality of the Indoor Environment with Creative Design. Regenerative design, a novel field that goes beyond sustainability to enhance and repair natural and human systems, is examined in this research. This study evaluates the impact of applying regenerative principles to indoor environments on indoor environmental quality (IEQ). Regenerative design offers a revolutionary method for enhancing the built environment's indoor environmental quality (IEQ). To guarantee that regenerative solutions continue to be successful while adjusting to changing demands and environmental circumstances, ongoing monitoring and adaptive techniques are crucial. Encouraging multidisciplinary cooperation between architects, engineers, legislators, and building inhabitants is essential for successful implementation. By following these guidelines, we may design interior spaces that improve everyone's quality of life by being healthier, more robust, and sustainable.

Osa-Sanchez et.al [10] proposed An Intelligent Internet of Things System Using 3-D Printing and Low-Cost Sensors for Actual Time Indoor Air Quality Monitoring. A portable air quality station with a 3D-printed shell was created for this project with the goal of reducing material use and expediting data collection in lab settings. This innovation has a great deal of potential to improve public health because of the health risks associated with certain gasses and particles, particularly for vulnerable groups like children and asthmatics. Since COVID-19 is mostly spread by airborne particles, the significance of interior ventilation has been emphasized, underscoring the necessity of effective monitoring and risk reduction measures. The device's modular architecture enables users to target certain contaminants and personalize measurements. The portable configuration provides an affordable way to create air quality networks that cater to the requirements of populations that are more susceptible.

Alsamrai et.al [11] proposed an extensive analysis of Internet of Things-based air pollution monitoring devices for both indoor and outdoor environments. An estimated 1.6 million avoidable deaths are caused by indoor air pollution each year. Although lots of systems are built around the Arduino and ESP series, the ESP8266 is the suggested microcontroller. Moreover, favored interfaces centered on creating an Internet of Things cloud, server, or webpage that can show air quality attributes. Overall, most research employed Wi-Fi for systems that monitor air quality levels. The areas that were indoors received the most attention. The most common connections were IoT cloud and web services (53.28%), while the most popular connection mechanism was Wi-Fi (67.37%). The majority of research (39.60%) focused on indoor surroundings, whilst 20.79% of studies focused on outdoor situations. This suggests that pollution directly affects the quality of life in enclosed spaces. Broadly speaking, IoT-based apps might be regarded as dependable and affordable substitutes for both interior and outdoor pollution monitoring.

Higgins et.al [12] developed using inexpensive sensors to monitor indoor air quality and assign sources. Examining recent research on LCS for IAQ measurements and determining whether any techniques were used to detect or measure indoor air pollution sources are the goals of this study. The interior environment is diverse, exhibiting notable variations both inside the space and among various places and microenvironments. Measurements in several microenvironments and locales, occupancy and activity reports, and sensor placement can all help to explain this heterogeneity. Although outside contaminants may enter the area through the building envelope, external contributions can be allocated with the aid of measurements of environmental factors and external pollution, as well as documentation of the building fabric and ventilation conditions.

Islam et.al [13] proposed Improving the Quality of Indoor Air by Ventilating Smoke in Structures. Effective smoke control systems have several goals, such as preventing fatalities, creating less dangerous escape routes, preventing smoke from spreading to parts of the building that are not affected, protecting property, assisting with firefighting, and making post-fire cleanup easier. This study explains the basic requirements and working principles of incorporating smoke ventilation systems into all-encompassing fire protection measures. Hence, "smoke management," which frequently includes both active and passive strategies for "smoke control," is the deliberate use of ways to restrict and guide the flow of smoke within a structure in the event of a fire. Modern times demand that producers in the ready-made garment industry, which is particularly susceptible to fire incidents, improve their fire protection procedures.

Rathnayaka et.al [14] introduced a Comprehensive Review of the Literature on IoT-Powered Environmental Intelligence for Sustainable Futures Using Advanced Machine Learning. The proposed method examines the state of the art in IoT-driven environmental intelligence system research, emphasizing the use of machine learning methods for projection and real-time data processing. IoT sensor technologies, data transmission protocols, machine learning techniques, and their use for environmental monitoring systems were among the important areas we looked at in order to determine the state of research and any gaps in this field.

Neoaz et.al [15] developed Intelligent Cities and the Internet of Things and Examined the potential benefits of IoT technology for improving urban living and infrastructure management. Intelligent cities include addressing significant urban issues including waste, energy use, transportation, and security using the Internet of Things (IoT). Additionally, IoT applications in trash management promote sustainability since the bins themselves notify users when they are full, which facilitates route planning and pickup scheduling. In terms of security, security networks improve prompt response to incidents and provide valuable data for urban planning. Lastly, IoT continuity in smart cities results in more citizen involvement, information utilization in urban planning, and smart sustainable development, which makes smart cities sustainable and changes urban hard systems.

3. METHODOLOGY

The Internet of Things' incorporation into these cutting-edge technologies substantially facilitates the development of air quality systems, which need new networking models, techniques, and procedures because of numerous limitations. By integrating suitable intelligent, adaptive, and reasoning technologies with data flow management, knowledge of and research into the current air quality systems facilitates decision-making. For indoor as well as outdoor air-quality systems, this article will offer further details and a detailed examination of new network designs, sensors, communication channels, designs, and techniques. The issues and difficulties with the IAQ monitoring system are also covered in this paper, which serves as a resource for researchers and encourages the quick and comprehensive advancement of IAQ monitoring.

3.1 IAQ monitoring systems based on the Internet of Things (IoT)

The general architecture of IAQ monitoring systems based on the Internet of Things (IoT) is shown in Figure 2.

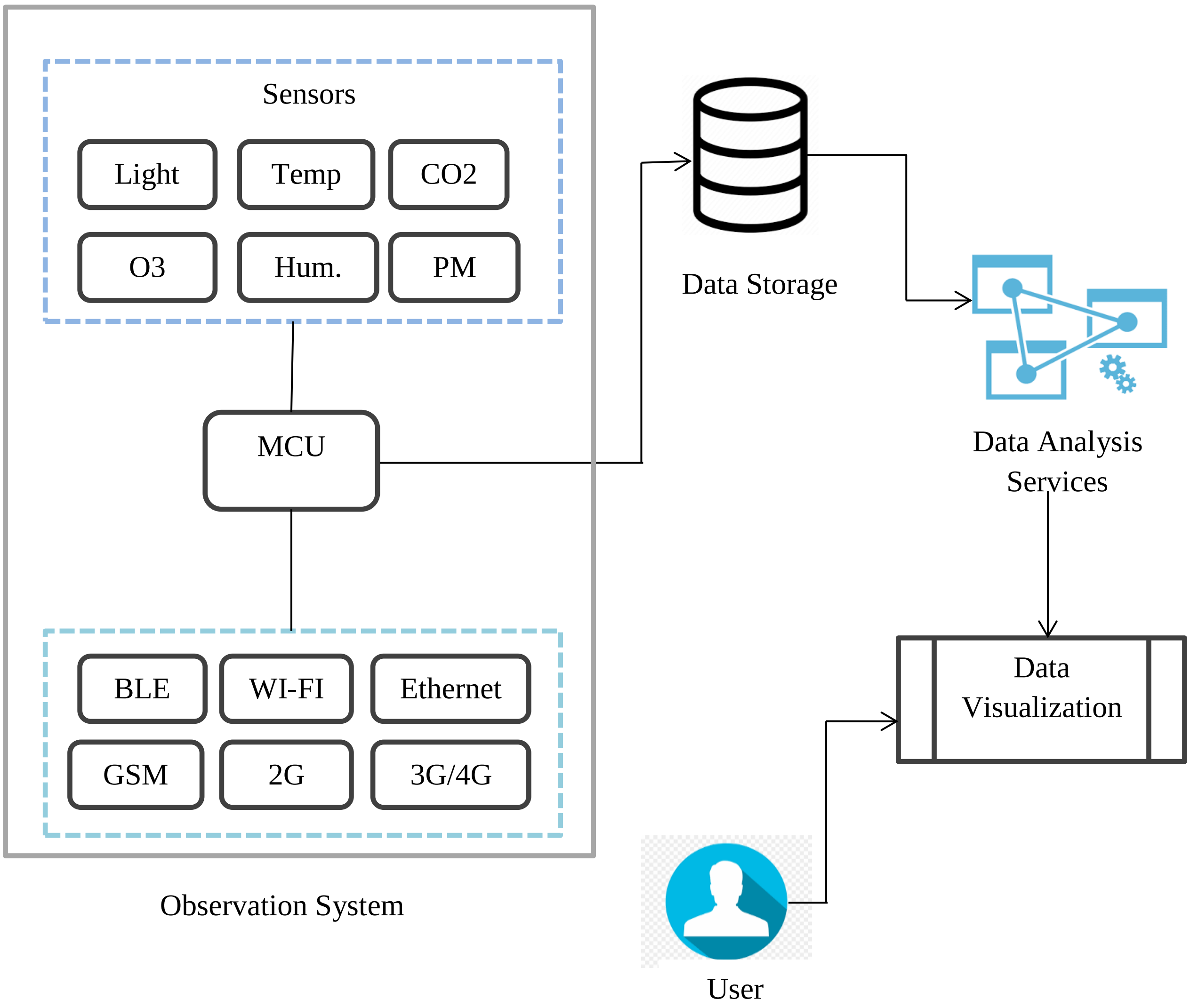

Figure 2. Systems for monitoring IAQ based on IoT

Indoor air pollution (IAP) is a significant environmental problem that has a direct impact on the relaxation, wellness, and well-being of building inhabitants. When consistently exposed to indoor air pollution, those who spend 90% of their time indoors are more effective and productive at work. IAP may have an impact that is up to 100 times larger than outdoor pollution levels. Incomplete burning of biomass fuels in traditional stoves, especially in homes with poor ventilation, results in higher concentrations of carbon monoxide (CO), particulate matter (PM), formaldehyde, nitrogen oxides (NOx), polycyclic aromatic hydrocarbons, benzene, and other toxic organic compounds. This exacerbates long-term health problems [16].

Two promising technologies that might provide a strong basis for the expansion of IAQ monitoring systems in the future are the Internet of Things (IoT) and wireless sensor networks (WSN). Given that current government programs are promoting the development of smart cities and smart villages through the usage of IoT-based infrastructures, it is vital to investigate the Internet of Things' potential for real-time IAQ monitoring applications. The Internet of Things (IoT) provides reliable solutions for enhanced environmental health and well-being when combined with contemporary information and communication technology [17]. Software and hardware are the two primary elements of these monitoring systems. When combined, these domains offer up-to-date pollution statistics. Researchers in the future must choose the right sensors, microcontrollers (MCUs), and gateways. Real-time data on pollution levels is nevertheless provided by communication technologies such as Ethernet, Bluetooth, ZigBee, and Wi-Fi. A detailed examination of the architecture, communication channels, and hardware requirements is required in order to handle meaningful data about the everyday activities of building inhabitants. The four primary parts of the framework include tracking systems, information analysis services, data presentation systems, and data storage. Several MCUs, IAQ sensors, and communication systems comprise the monitoring system. Sensing devices gather data, which is then stored in a physical or digital data storage system [18]. The impact of contaminants at the target premises may also be examined with the help of data analytics services. Additionally, the visualization system facilitates end users' access to real-time information on IAQ levels.

This study aids in the analysis and synthesis of crucial information on current systems, as well as the hardware and software elements that contribute to improved living conditions. Its main objective is to give an overview of the most widely used sensor units, MCUs, system architectures, connection options, and communication protocols. The material that has been aggregated highlights possible difficulties and limits of current systems while describing gaps in the corpus of knowledge. Furthermore, this report provides ideas and recommendations for further research targeted at enhancing general health and wellness. The broad acceptance of the smart building concept, which provides improved IAQ tracking and assessment, is influenced by this study.

Table 1. Systems for monitoring IAQ communication technologies.

Communication Technology	**Number of studies**
Wi-Fi	29
Bluetooth	12
ZigBee	6
GSM	2
GPS	1
GPRS	1
Ethernet	1

Sensor networks, artificial intelligence-based software, and advanced information and communication systems have created new opportunities for improved environmental management and monitoring [19,20]. Based on the data in Table 1, without a doubt, the most widely used communication system for IAQ monitoring systems is Wi-Fi. On the other hand, ZigBee and Bluetooth rank third and second, respectively, in terms of popularity. For IAQ surveillance systems, 29 researchers (70%) used Wi-Fi. However, Wi-max and Bluetooth connectivity were selected based on six and twelve surveys, respectively. For systems requiring continuous monitoring, Wi-Fi's primary drawback is its high power consumption. Additionally, 13 (33.5%) Wi-Fi-enabled monitoring systems were built using the ESP8266 MCU. However, several Raspberry Pi models were used to manage nine monitoring systems (21.5%). IEEE 802.11b/n/g is the most widely used protocol for Wi-Fi connectivity, whereas IEEE 802.15.4 is the protocol for ZigBee communications. Comparing the MQTT protocol to IEEE 802.11, some researchers also favored it because of its simple implementation and low power requirements.

Wi-Fi

In a CPN, Wi-Fi is the most often utilized wireless technology. It uses unregistered ISM (Industry, Scientific, and Medical) bandwidths between 5 and 60 GHz and is based on IEEE 802.11 conventions. Schools, households, and other networks make extensive use of its 100 m coverage area. Numerous electronic gadgets, including gaming consoles, personal computers, and cell phones, have Wi-Fi network connections. Wi-Fi wireless communication system was used in the IAQ tracking systems of more than half of the projects evaluated in this study, mostly for connection between gateways and IoT servers. This was due to the technology's advantages, which include the cheap cost of marketing and high speed, safety, and dependability. There have been several initiatives utilizing Wi-Fi to mitigate or lessen the effects of short-term transmissions and the comparatively expensive costs and power consumption of short-range wireless technology [21].

ZigBee

Another popular wireless communication technique is ZigBee, which is employed in over one-third of all research. The IEEE802.15.4 standard serves as the foundation for ZigBee, a wireless personal area network (WPAN) that operates on the 2.4 GHz ISM spectrum and has a low 250 kbps data transmission rate. Despite this, its low price, low electricity usage, support for numerous nodes in networks, and range of topologies make it popular. Up to ten years is the extended service life of ZigBee. ZigBee's short transmission range allows for the use of the low-power XBee module, which allows transmission distances of up to 305 meters inside [22]. Indoor systems may be efficiently served by XBee's coverage. Additionally, data-gathering circuits can include XBee modules instead of external microcontrollers, saving weight and onboard space—a benefit in interior settings with constrained space.

Bluetooth

Bluetooth is a widely used wireless technology for short-range communication. Wireless Bluetooth is a low-cost, low-power application mobility communications system based on the IEEE 802.15.1 standard. It takes advantage of the 2.4 GHz unlicensed ISM band. Approximately 10% of the systems in the reviewed articles make use of it, and portable personal devices commonly employ it. Through Bluetooth, sensors and gateways, as well as mobile phones and other electronic devices, may connect. The classroom's carbon dioxide sensor data was sent via Bluetooth to the smartphone app for further data processing. In three out of nine Bluetooth-enabled apps, BLE—the ultralow power, a cheap variant of Bluetooth—was specifically utilized. Nevertheless, Bluetooth does not satisfy the strict security standards of other wireless protocols for communication as it lacks a robust safety layer to stop monitoring. Second, the use of Bluetooth is extremely restricted due to its poor transmission coverage and various 802.11 interference problems.

Visible Light Communication

Electromagnetic interference (EMI), which is produced by radio frequency (RF) communications that are wireless for internal atmosphere monitoring, can disrupt electronic device functioning and be harmful to human health, particularly in the elderly, sick, and newborns. The indoor environment monitoring system may be used in more unique situations by successfully resolving this issue through the use of bidirectional VLC technology free from electronic interference. The average-voltage tracking method that was suggested makes it possible to employ LEDs for both distant wireless communication and illumination. VLC can cover up to 6 meters of interior illumination for short-distance communication devices.

3.2 Sensor Calibration and Accuracy Considerations

Sensor calibration is a fundamental necessary component for indoor air quality (IAQ) monitoring systems to produce reliable and actionable information. Calibration connects sensor outputs with actual pollutant concentrations and environmental variables while using inexpensive pieces of hardware like low-cost electrochemical or metal oxide sensors in IoT-based, IAQ systems [23].

Calibration generally consists of comparing the sensor output against a reference standard in controlled environments. Calibration may be performed using standard gas mixtures, which simulate a condition similar to the ambient atmosphere, or in environmental chambers where you can control the humidity, temperature, and concentration of the gas(s). In sophisticated instrumentation systems, machine learning models may even be used to allow for dynamic, and real time, recalibration of low-cost sensor outputs from the feedback of a reference-grade instrument.

Sensor drift is a significant challenge in long-term IAQ monitoring. Sensor drift refers to the gradual decrease in sensor measurement accuracy over time. Environmental factors such as dust accumulation, chemical changes, and temperature ranges have caused sensors to drift. Sensors most affected by drift are most often low-cost sensors. Periodic sensor recalibration, or using adaptive correction algorithms to adjust for this drift, will help retain measurement accuracy [24].

A trade-off exists between cost and accuracy. Industrial-grade sensors have greater sensitivity, are built to last longer, and experience less drift, but are considerably more expensive and less energy efficient. Low-cost sensors represent a practical choice for large-scale, distributed monitoring networks (i.e., smart homes or smart campuses), but require verification more often to avoid supporting and propagating reduced data quality. Table 2 represents the comparisons of IAQ sensors that are being commonly referenced in the literature to show this trade-off.

Table 2. Comparison of commonly used IAQ sensors

Pollutant Type	Sensor Type	Typical Accuracy	Calibration Frequency	Remarks
PM2.5	Optical Laser Scattering	±10–15%	Monthly	Affected by humidity and dust accumulation
CO_2	NDIR (Non-Dispersive Infrared)	±50 ppm or ±3%	Biannually	Stable, but expensive
VOCs	Metal Oxide Semiconductor	±20–30%	Weekly to Monthly	Sensitive to temperature/humidity variations

As can be seen, there is a large range of accuracy and maintenance requirements by sensor type. Designers of the IAQ system then have to balance the scale of deployment, budgetary constraints, and data confidence when choosing sensor types and calibration procedures. Regarding future systems, self-calibrating sensors and cloud-based adjustment models may continue to reduce maintenance, and enhance the trustworthiness of the data.

4 EXPERIMENTAL RESULT AND ANALYSIS

The implementation of IoT technology frees IAQ monitoring systems from the need for human monitoring and opens up new avenues for system growth. A WSN has been utilized in the majority of the projects included in this assessment. By using this technique, it is possible to measure multiple contaminants simultaneously, eliminating the need for a single indoor air monitoring parameter. Additionally, the field of IAQ monitoring may incorporate various forms of sophisticated communication technology, enhancing data timeliness and efficiency, and thereby expanding the system's functionality beyond pollution monitoring [25]. The fuzzy rule base is created by gathering environmental data from both indoor and outdoor sources, processing large amounts of data, and working with reference data. There is the best fuzzy control technique for environmental data that is not linear. The designers' acquaintance with the environment is also tested by the fuzzy judgments for various contexts, which necessitates the analysis of vast amounts of trial data. Figure 3 illustrates the connection between window, interior, and outdoor PM2.5.

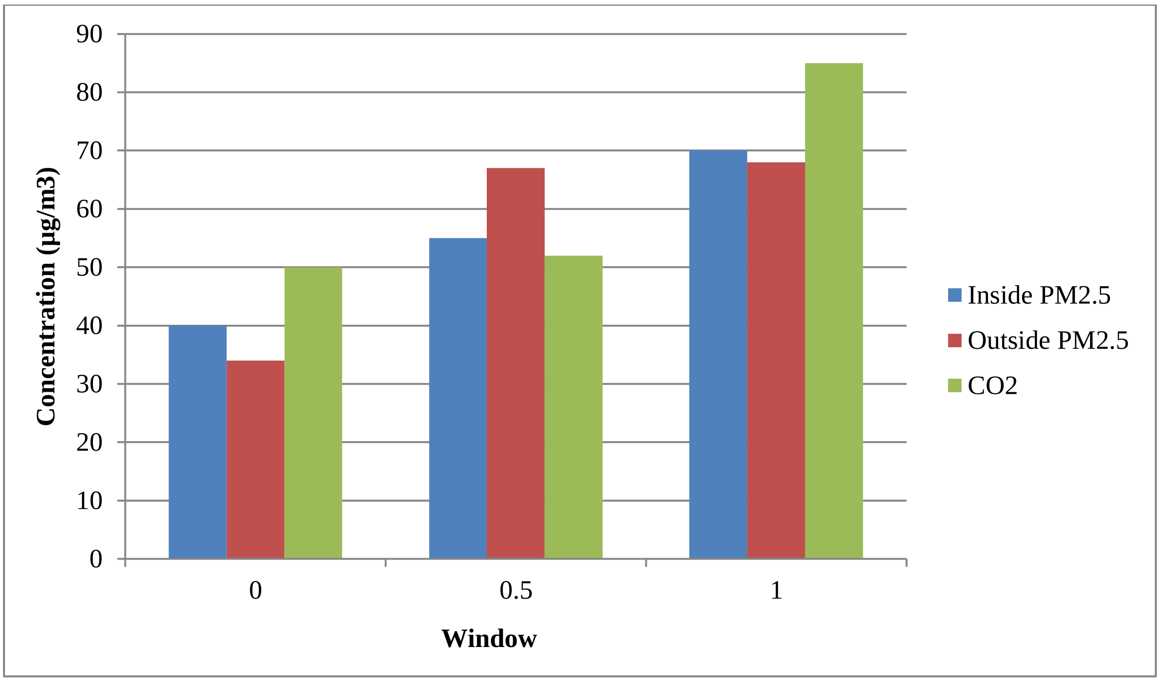

Figure 3. Relationship diagram of window

4.1 Comparison of Indoor Air Quality environmental monitoring

The aforementioned flexible control approaches for air quality are described in terms of three scenarios: absence of control, continuous control, and variable control. Because the ambient data fluctuated so rapidly, the experiments' indoor and outdoor sensor data were captured every 30 seconds.

Table 3. Illustration of the mode without control

No control	**CO2 concentration (ppm)**	**Indoor Air Quality Index (IAQ)**
Minimum	405	2
Mean	1345.87	8
Maximum	2109	69

The majority of indoor air pollution sources originate outdoors; the optimum air quality may also be attained without any regulated load. To do this, close the windows and doors. However, the CO2 concentration will be the highest of the three if the room is closed for an extended period of time owing to inadequate ventilation; hence, finding a balance between the two is crucial for this study. Table 3 presents a comprehensive Illustration of the mode without control.

Table 4. Illustration between the constant control modes

Constant control	**CO2 concentration (ppm)**	**Indoor Air Quality Index (IAQ)**
Minimum	352	8
Mean	744.67	29
Maximum	1568	105

Under continuous management, the CO2 concentration is clearly greatly decreased because the window and entrance are open, allowing for efficient air circulation both within and outside; yet, the room also absorbs the contaminated outside air. The inadequate ventilation system and air purifier in the space would indirectly result in poor inside air quality. A comprehensive examination of the continuous control mode is given in Table 4.

Table 5. Illustration of the flexible control mode

Fuzzy control	**CO2 concentration (ppm)**	**Indoor Air Quality Index (IAQ)**
Minimum	254	6
Mean	395.76	15
Maximum	643	38

The AQI and CO2 concentration can stay constant under flexible management, provided that the fuzzy rule basis is set up properly and that energy is not wasted by turning off the always load. Table 5 displays the fuzzy control mode's thorough comparison. The flexible rule base is created by gathering environmental data from both indoor and outdoor sources, processing large amounts of data, and working with reference data.

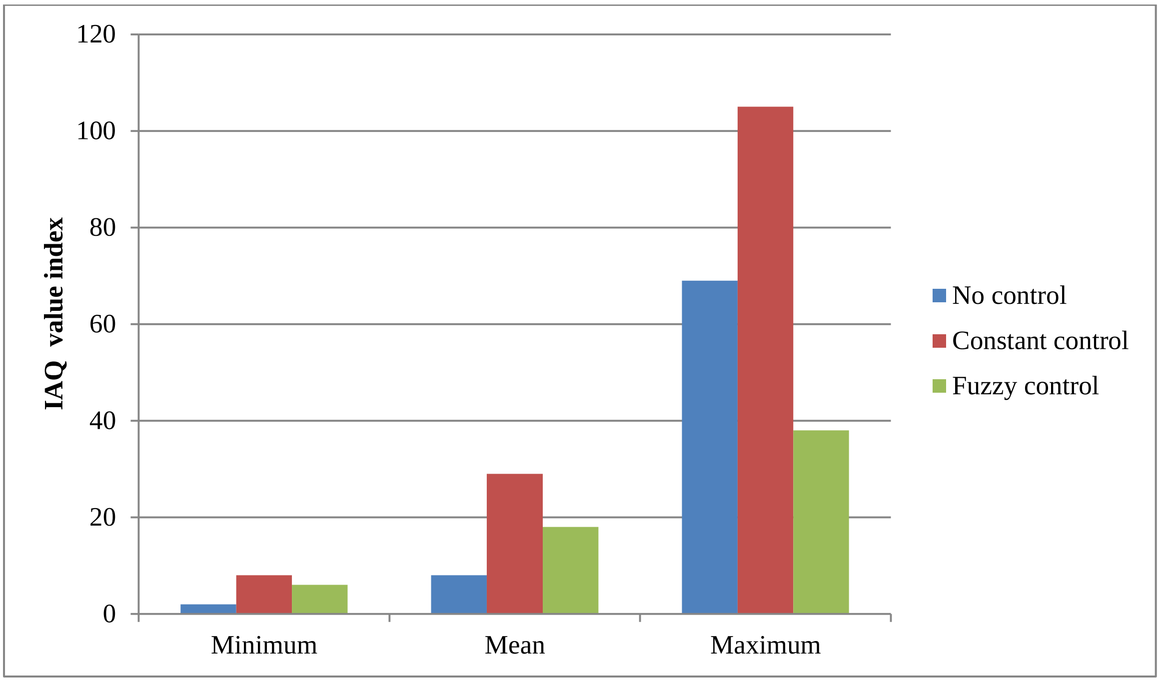

Figure 4. Comparison of Indoor Air Quality

Figure 4 compares the air quality under continuous management, flexible control, and no control in detail. The no-control mode produces the best air quality when the window is kept closed for a long time. Long periods are spent with the door and window open under continuous management, however even with a high ventilation rate, the load's cleaning pace cannot keep up with environmental changes, hence the air quality is subpar. As a result, the relationship between interior and outdoor air quality may be ascertained. Below following extensive measurement and observation, fuzzy control rules are developed. Therefore, indoor air quality and CO2 can reach the ideal environment standard when wise decisions are made based on the existing environment.

According to the aforementioned experiment, the concentration of fine particulate matter is least under unloaded control, followed by unstable control and constant control, out of the three control modes. When it comes to CO2 concentration, fuzzier control works best, followed by consistent control and no control. This suggests that both interior and outdoor air circulation are crucial for CO2 concentration and that it is important to prevent air quality degradation during air circulation. The suggested approach is successful since every fuzzy theory experiment in this study fell within the optimal range.

5 CONCLUSION

This study introduces the Internet of Things-based ambient-aided settings air quality monitoring system, or IAQ. It was developed using open-source technology and inexpensive sensors. There are five sensors in this system, but additional sensors might be added to monitor particular traits. Based on the findings, indoor air quality may differ significantly from what is thought to be typical of a high-quality home. The load was controlled by using fuzzy logic concepts after the experimental results were analyzed about the data from the interior environment. The goal of this research was to enhance the standard of life in every home and preserve a healthy level of indoor air quality, so that Poor air quality is less likely to cause respiratory issues and asthma in children and allergy sufferers, and adults are less likely to have decreased office efficiency and fall asleep due to elevated CO2 levels, hence establishing favorable air quality conditions for the general population.

The IAQ nodes for sensors and IAQ Gateway can connect thanks to the system's wireless technology. It also provides a wireless Internet connection through the ESP8266's built-in WiFi and an Android mobile app that lets users view relevant data and get notifications from anywhere at any time. The smartphone application offers the benefit of remote real-time notifications, which might assist the user in maintaining a home's indoor air quality to improve the health, well-being, and productivity of its occupants. The results show that the condition of indoor air may vary greatly from what is usual for an excellent living environment, but it also significantly advances indoor environmental investigation because it positions itself as a modular, simple-to-install solution that offers instant access to indoor air quality data through a smartphone or web portal. It also alerts users to critical instances of poor air quality.

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