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DEVELOPMENT OF AN IOT-BASED HUMIDITY, TEMPERATURE, AND AIR QUALITY MONITORING SYSTEM

Ukadike, I.D[1], Okpako, A.E[2], Isitor, N.D[3]
Central Academic Records Processing Unit, University of Delta, Agbor, Delta State, Nigeria[1].
Department of Information and Communication Technology, University of Delta, Agbor, Delta State, Nigeria[2].
Department of Cyber Security, University of Delta, Agbor, Delta State, Nigeria[3].
Email: Ifeanyi.ukadike@unidel.edu.ng[1], ejaita.okpako@unidel.edu.ng[2], nkechi.isitor123@gmail.com[3]

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ABSTRACT

Monitoring the environment has become of great importance as it helps individuals keep tabs on their environment. Air pollution is very dangerous to human health and it is known to cause deadly health conditions. This research presents an IoT-based design that will effectively monitor the humidity, temperature, and air quality of a given environment. NodeMCU humidity, temperature, and gas sensors were deployed in the design of the system. The output interface was designed using the Blynk IoT platform. The system was tested in two stages using application of gas pollutants and heat on one hand, whilereadings were taken from a cool evening and sunny afternoon on the other hand. After testing all the functions of the system under various conditions, it revealed 76% humidity, 26.8^{o}C temperature, and 461ppm on the application of gaseous air pollutants, 43.1% humidity, 45.6^{O}C temperature, and 199ppm of air quality on the application of heat, 51.1 humidity, 20.4% temperature, 198ppm of air quality on a cool evening and 70.7% humidity, 29.5^{O}C of temperature and 206ppm of air quality on a sunny afternoon. The system showed improved performance in terms of monitoring of humidity, temperature and air quality and can be deployed suitably in homes, schools, and industries.

Keywords: Air Quality, Blynk, Internet of things, and Sensor

INTRODUCTION

One of our generation's greatest scourges is air pollution, on account not only of its impact on climate change but also its effect on public and personal health because of increased morbidity and mortality, (Ioannis*et al.*, 2020). Poor air quality, as we know leads to respiratory problems. The main cause of this poor air quality can be attributed to the hotness or stuffiness of a given place or environment, the presence of pollutants such as gaseous substances in the air, and high humidity levels which involves the increase of airborne pollutants such as dust mites and mold. Air is a very essential need of humans and animals, so more effort should be put to ensure that the environment is air pollution free and habitable. Air pollution causes damage to the health of humans and animals. When a person breathes in polluted air, it causes the penetration of invisible particles into the cell and organs, which in turn causes persistentdiseases inclusive of dementia and heart attacks, which can cause strokes.

IoT-based technology has been used to proffer solutions to problems encountered by humans and to make their life easier. Interesting research has been carried out on the use of the Internet of Things in solvingproblems of human health and way of life.

An IoT-Based Smart Framework for a human heartbeat rate monitoring and control system was designed and the research showed the comprehensive study of IoT techniques and technologies that are used in controlling the rate of heartbeat, (Sani & Abubakar, 2019).

An IoT-based health monitoring system, with the use of the MySignals development shield and a low power long range (LoRa) wireless technology was produced. In the design, multiple IoT sensor components were used in the development of this system (Mohammad*et al.,* 2019). A research on an increase in the scope of the Internet of Things (IoT) to the Internet of Domestic Things by comparing the interlink between Radio frequency identification (RFID) of things and the Internet of Domestic Things was carried out. This research was done with the view of safeguarding the personal belongings of individuals with the Internet of Things (IoT), (Akazue *et al.,* 2017).

Internet of Vehicle Speed Detection and Reporting System Based on RFID was designed. The system uses the Internet of Things (IoT) technology in detecting speed, (Akazue & Ighoyota, 2016).

These and many other problems relating to human health and ways of life have been solved using IoT technology.

The Internet of Things (IoT) era proves pretty effective to mitigate environment-associated issues. IoT is a significant subject that involves better use of resources, sensor-based functionalities, and techniques to ensure environments are safe and uplift businesses.

Environmental monitoring is known to be the most useful IoT utility. It uses superior sensor gadgets to pick out the presence of pollutants within the air and water and promotes better sustainability. Premises can be kept safer and purified by using a smart environmental tracking solution, (Sanjeev, 2021).

In closed-area places of work, which include underground mines, workplace premises, schools, or rooms, it is essential to hold positive surroundings. Air information is captured through sensors and is dispatched on a cloud platform through gateways. Organizations can easily collect the information in a person-friendly format through a related dashboard and analyze it for higher outcomes (Sanjeev, 2021).

The health of humans is a very important factor to consider in the development and growth of any nation.

RELATED LITERATURES

Ukadike *et al*. (2023) developed an IoT-Based air quality monitoring system using IoT technology. The designed system monitored humidity and air quality. From the test conducted, the system was found to be accurate and efficient in reporting the presence of harmful substances in the air to users. The designed system monitored only humidity and air quality without regard to temperature, which is important in maintaining healthy living.

Dhingra *et al.* (2019) designed an Internet of Things mobile-air pollution monitoring system (IoT-Mobair) which is an Air pollution-monitoring system using gas sensor for prediction but the findings from the system analysis showed that the system monitored for only gaseous substances in the air without regard to humidity and temperature.

Odikwa *et al.* (2021) designed a fuzzy-based chat-bot messenger for home intelligent system with multiple sensors. They design and implemented a low cost fuzzy-based system which converts fuzzy values to crisps values that uses weather conditions of a particular environment to function as an intelligent system in a smart home. They integrated multiple sensors of Pewatron Zirconia in a

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circuit in conjunction with fuzzy values in a chatbot messenger nvironment with the aid of telegram BOt service to control the state of electrical devices in the nouse based on atmospheric weather conditions.

Arco *et al.* (2016) proposed an integrated approach for Pollution Monitoring, Smart Acquirement, and Smart Information using Geometric sensors and IoT. This design was an Air monitoring system, used in monitoring large areas. The problem with this design is that it hasnoisy data, and it is costly to implement.

Shinde & Siddiqui (2018) designed Environmental Monitoring System which monitored for dust and humidity using IoT-based technology. The advantages of the design are that it was efficient, of low cost, portable, and had wide coverage. However, the system monitored for dust and humidity but it did not monitor the presence of gaseous pollutants in the air.

Gaglio *et al.* (2014) designed an IoT-based Environmental Monitoring Application with a novel middleware for resource-constrained devices using a mobile sensor network and Wireless Sensor Network (WSN). It was found to be scalable and of high-density air quality monitoring with the interconnection of heterogeneous sensors. The problem of the system was its computational complexity because of the huge data gotten and processed.

Tadejko (2017) developed and implemented an environmental monitoring system using the Internet of things-standards and protocols using heterogeneous sensors. It used the world wide web consortium(W3C) standard for interoperability but had issues relating to heterogeneous sensors.

These and other research too numerous to mention have been done on IoT-based environmental monitoring to bring to the barest minimum, air pollution and its effect on humans and animals.

Research Motivation

This work was motivated by the need to design and implement a system that deals in totality with the menace of air pollution by adequately monitoring the three very essential parameters of the environment, which are temperature, humidity, and air quality, in other to ensure the environment is very safe for human inhabitation. This will help reduce respiratory problems to the barest minimum by alerting the users of the level of conduciveness of their immediate environment.

MATERIALS AND METHODS

Materials

For the design of this system, the following components were used:

i. NodeMCU

NodeMCU is an open-source IoT platform. It includes firmware that runs on the ESP8266 Wi-Fi system on chips(SoC) from Espressif Systems, and hardware that is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The NodeMCU provides access to general purpose Input/Output. Figure 1 shows the image of nodeMCU.

Figure 1: NodeMCU [20]

ii. Temperature and Humidity Sensor

A thermocouple or Resistance Temperature Detector (RTD) provides for temperature measurement through an electronic signal. It detects the temperature and humidity of an environment..

Figure 2 shows the figure of temperature and humidity sensor.

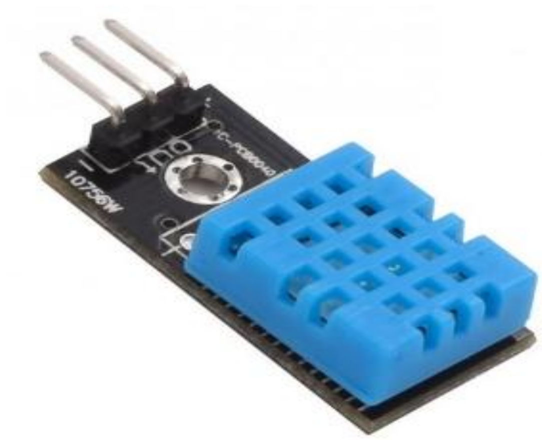

Figure 2: Temperature and Humidity sensor [20]

iii. Gas Sensor

The gas sensor MQ 5 will detect the presence of smoke and gas in the atmosphere. This sensor has good sensitivity to harmful gases in various concentrations for long active periods and it is not costly. Figure 3 shows the figure of gas sensor.

Figure 3: Gas Sensor [21]

Methodology

IoT methodology was used in the development of the system. IoT methodology is outlined in ten (10) steps:

a. Purpose and Requirements Specification
b. Process Specification
c. Domain Model Specification
d. Information Model Specification
e. Service Specifications
f. IoT Level Specification
g. Functional View Specification
h. Operational View Specification

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i. Device and Component Integration
j. Application Development

Figure 4 shows the graphical representation of the IoT methodology

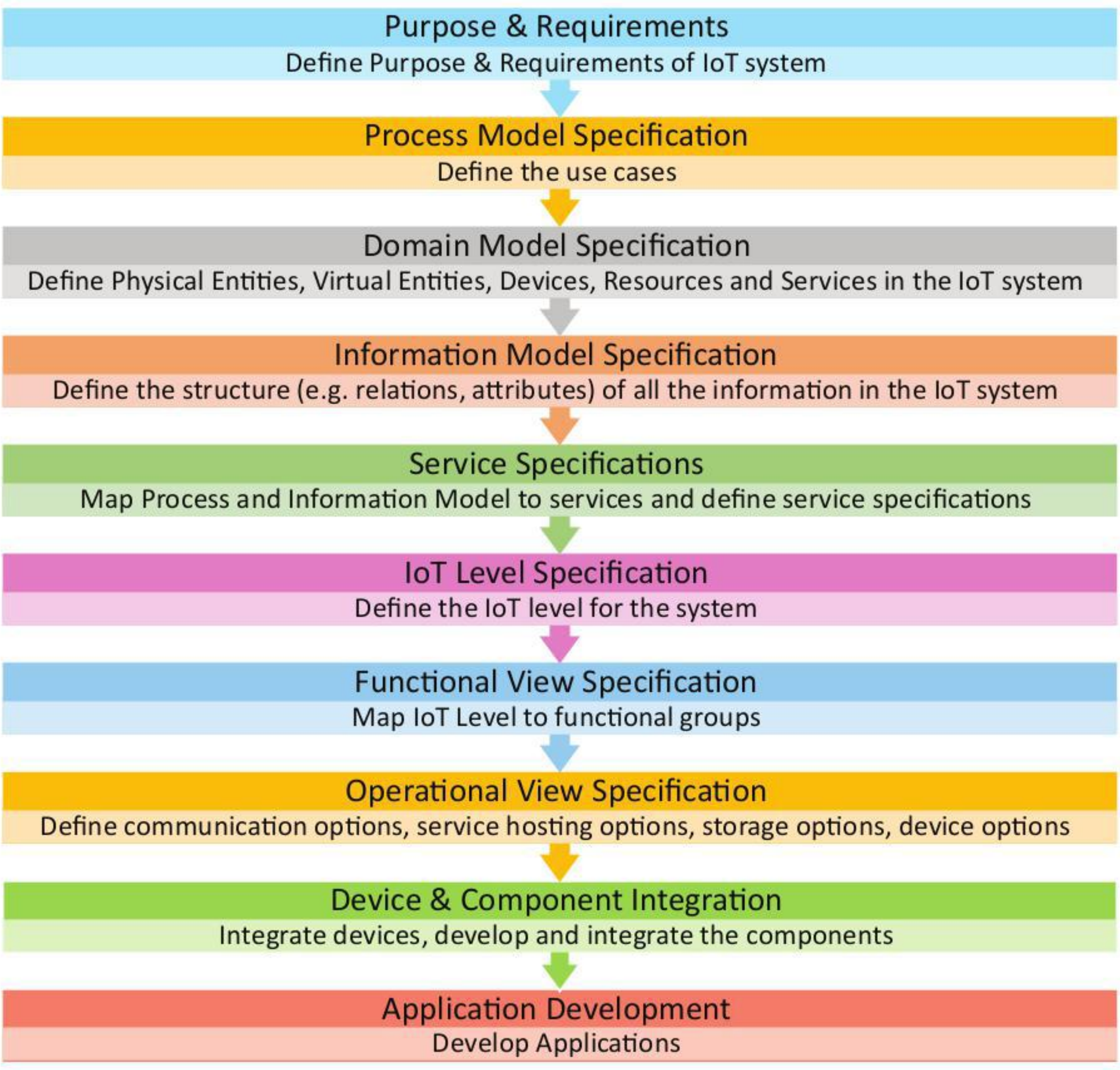

Figure 4: IoT Design Methodology [22]

The system monitored the humidity, temperature, and air quality of an environment using IoT-based technology. The sensors (gas, humidity, and temperature sensors) got the input (data) from the environment and sent the same to the nodeMCU, which worked as the brainbox of the system and houses the connection of the sensors. The IoT was integrated using the Blynk platform. A user-friendly Blynk application was created for the output of the system. The designed application could run on PC and mobile platforms. The system could monitor the adjustments in a surrounding using sensors, microcontrollers, and IoT-based technology. Users can observe temperature, and humidity, and detect the presence of harmful gases both in the indoor andoutdoor environment through the usage of the proposed module. The information was saved in a web server and the consumer could get access to the data anywhere in the world through an internet connection.The values gotten from the sensors were viewed on the gauge and chart controls, which enabled the readings of data from sensors. Its mobile platform could alert the user of air pollution when the system senses pollutants in the air and notifies the user when the humidity and temperature rise above normal. The system performance was measured in two stages, which were sunny day, rainy day, and the application of heat and air pollutants. Figure 5 shows the block diagram of the system, while figure 6 shows the output interface of the system.

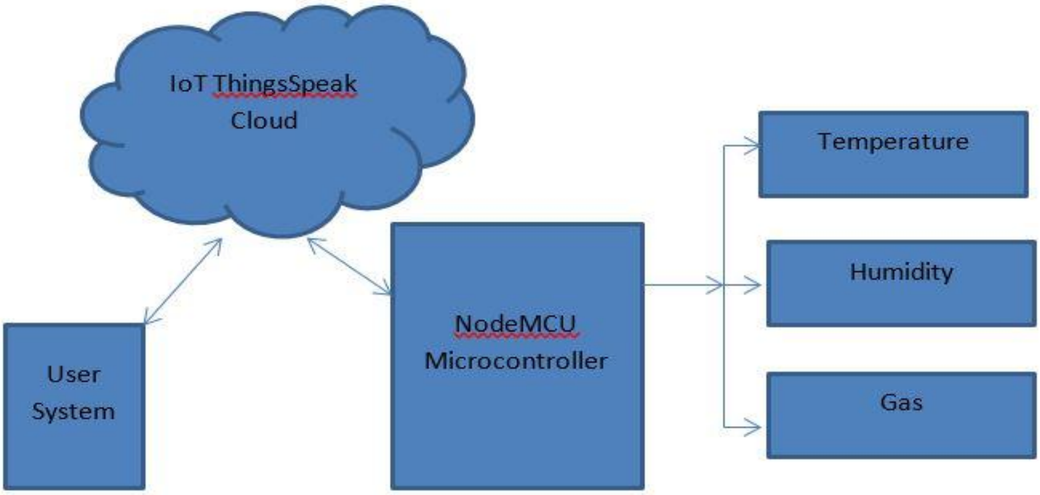

Figure 5: Block diagram of the proposed system

HUMTAQ Algorithm)

Algorithm: The Humidity, Temperature, and Air Quality Monitoring Algorithm **(HUMTAQ Algorithm)**

Start

Step 1: The system reads the air quality through the gas sensor

Step 2: The system reads the humidity through the humidity sensor

Step 3: The system reads the temperature through the temperature sensor

Step 4: The system displays the value of the readings on the user interface via Blynk (Smartphone or PC)

Step 5: If air quality is above 300 ppm, then display "Air Pollution Detected"

Else, take readings

End if

End

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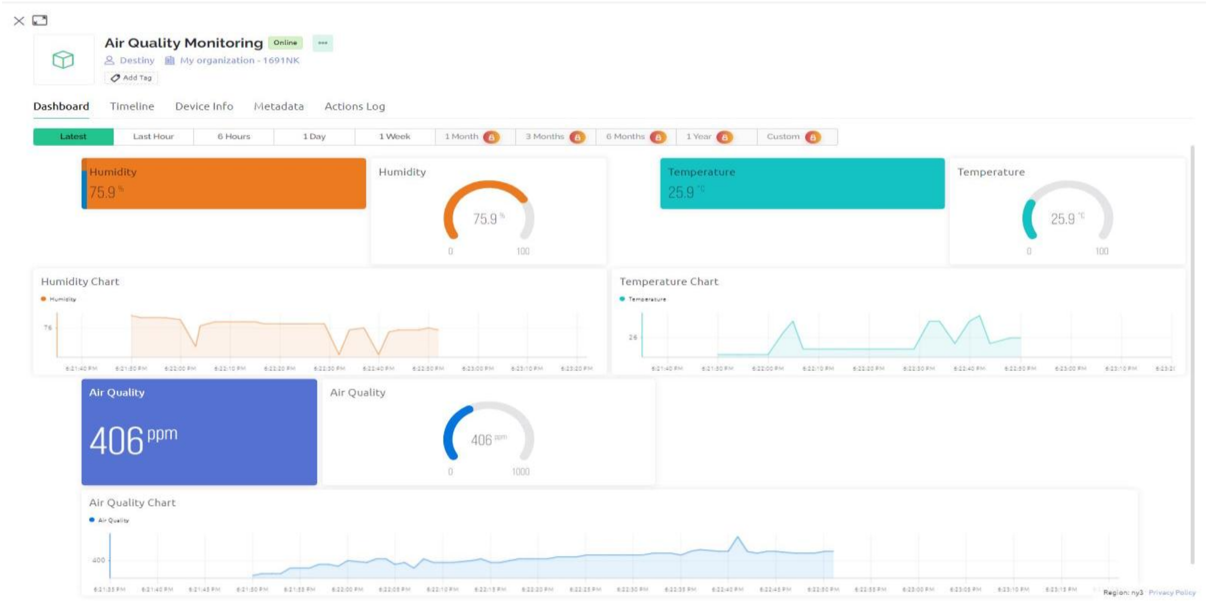

Figure 6: Main Output of the system (System output interface)

RESULT AND FINDINGS

A review of the earlier works done by Ukadike et al. (2023) showed that an air monitoring system was designed using IoT technology. The system could take readings of the air quality and humidity of a given environment accurately and timely. The output interface was designed with Blynk. IoT isuser-friendly and comprises gauges and charts used in displaying the readings gotten from the sensors. The system produced by Ukadike et al. (2023) took readings of humidity and air quality only while the proposed system took readings of humidity, temperature, and air quality at the same time.

Figure 7 The output interface of the system designed by Ukadike et al (2023).

Figure 7: output interface of air quality monitoring system [15]

Measurement of Performance

To measure the performance of the system, tests were carried out in two stages. Stage 1 measurement for sensitivity and stage 2 measurement for precision. Readings for measurement of sensitivity were taken by applying a gas pollutant in the air and heat using a heater to see if the system can sense it, while readings formeasurement of precision were taken on a cool evening and a sunny afternoon. Tables 1 and 2 show the readings gotten from the two conditions respectively. The output interface of the conditions is also shown in Figures 8, 9, 10, and 11 respectively.

Stage 1: Measurement for Sensitivity (applying gas pollutant heat)

Table 1: Test Reading I

	HUMIDITY (%)	TEMPERATURE	AIR QUALITY (PPM)
POLLUTANT (GAS)	*76*	*26.8*	*461*
HEAT	*43.1*	45.6	199

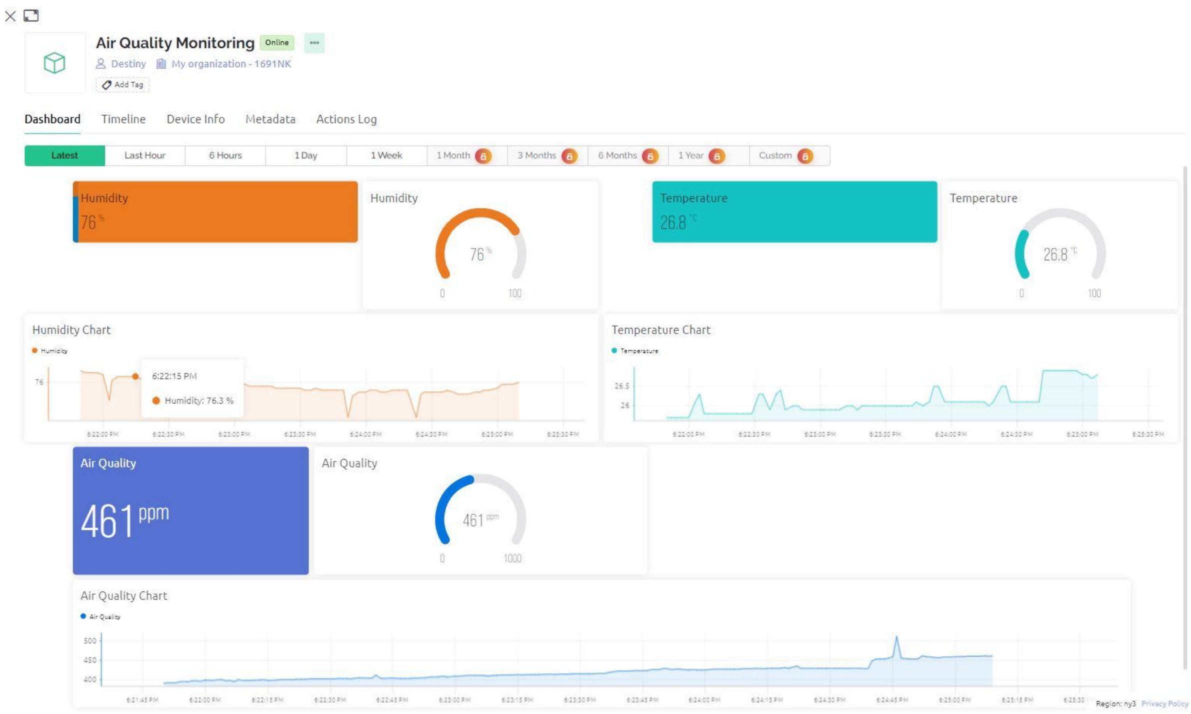

Figure 8: Output on Application of Gas

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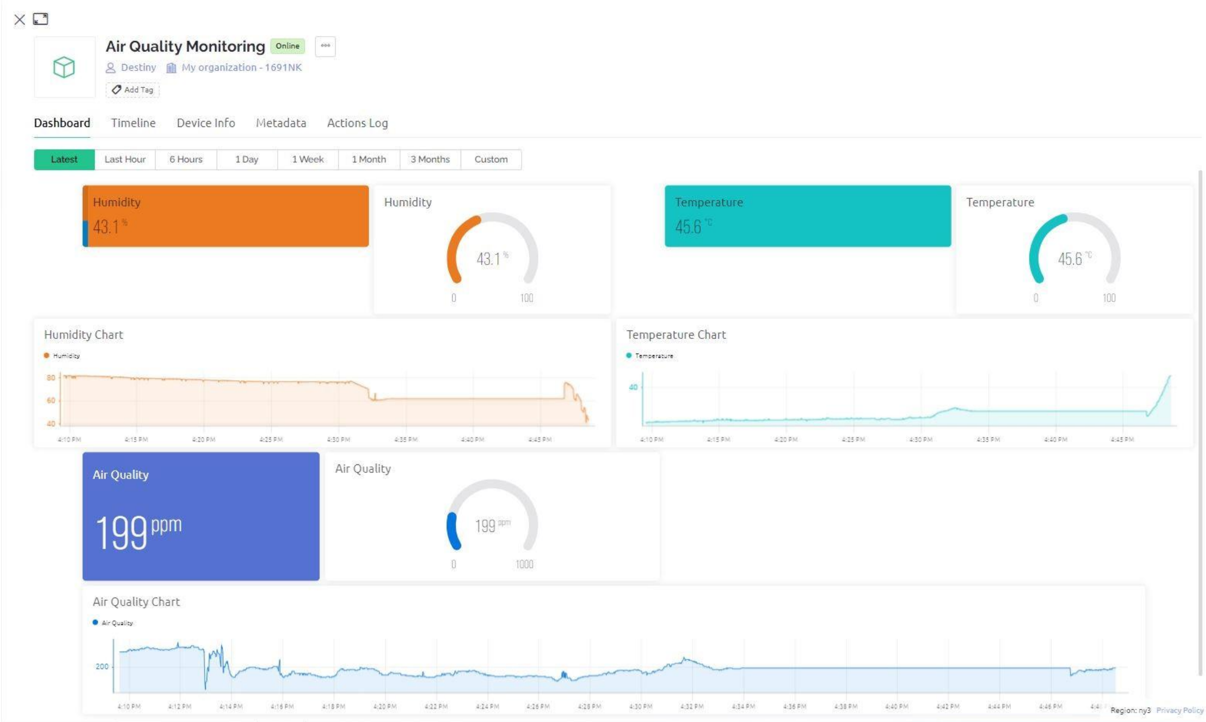

Figure 9: Output on Application of Heat

Stage 2: Measurement for Precision (Taken on a cold evening and a sunny afternoon)

Table 2: Test Reading II

	HUMIDITY (%)	TEMPERATURE	AIR QUALITY (PPM)
COOL EVENING	*51.1*	*20.4*	*198*
SUNNY AFTERNOON	*70.7*	*29.5*	206

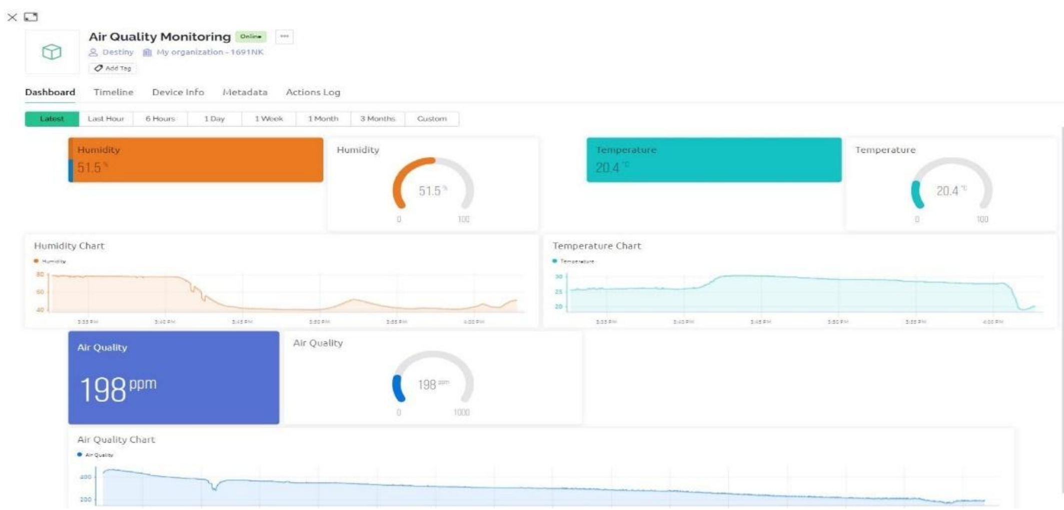

Figure 10: Output on a Cool Evening

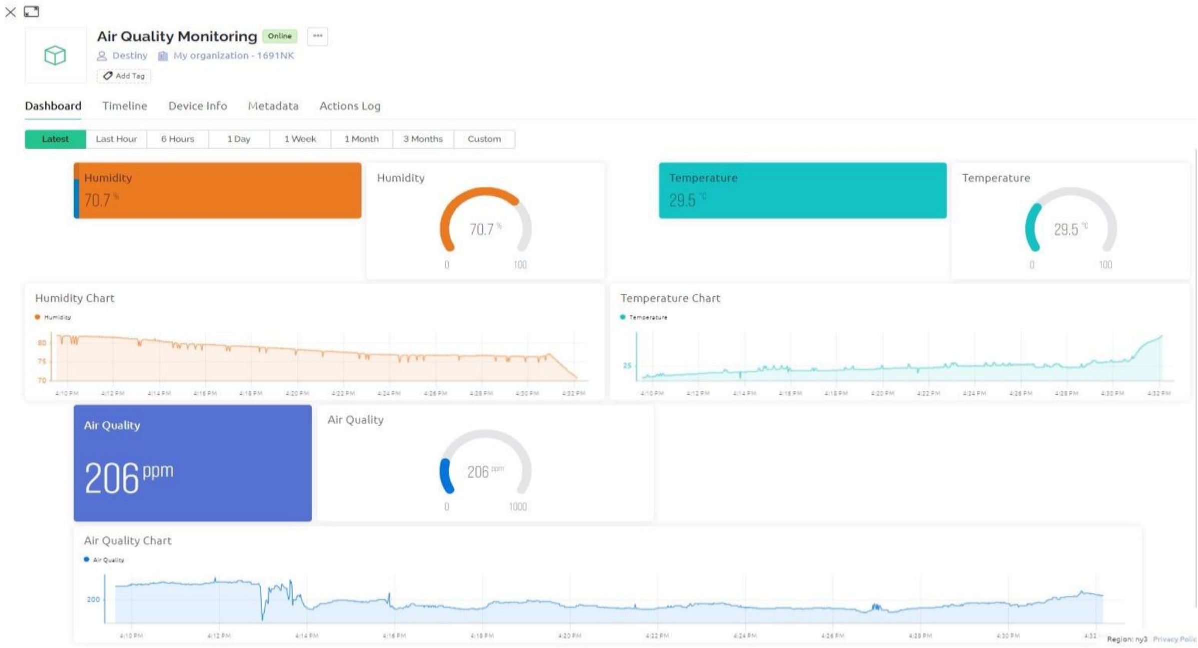

Figure 11: Output on a Sunny Afternoon

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From the tests carried out using the two stages, the system was found to take the readings timely and accurately. The humidity, temperature, and air quality readings were seen on the gauges and charts of the output interface.

CONCLUSION

In conclusion, this work designed and implemented an IOT based system for monitoring and alerting the system users of the quality of air in their immediate environment. This could ensure that users are adequately aware of the needto have clean and safe environmental factors like temperature, humidity, and quality of air to ensure healthy living condition. The designed system is safe, affordable, and easy to use.

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REFERENCES

Akazue, M., Agwi, C. U., & Ighoyota, B.A. (2017**).** The interlink between RFID of things and the Internet of domestic things.*SAU Science-Tech Journal*, 2(1), 92-101.

Akazue, M.I., & Ighoyota, B.A. (2016). Internet of Vehicle Speed Detection and Reporting System Based on RFID.*Journal of the Nigerian Association of Mathematical Physics* Volume 34 219-226. University of Benin, Nigeria

Akpoyibo T.P., Akazue M.I., & Ukadike I.D,. (2022). Development of a Floating Surface Water Robotic Oil Spillage Surveillance (SWROSS) System.*GSJ: Volume* 10, Issue 11, Online: ISSN 2320 9186 www.globalscientificjournal.com

Arco E., Boccardo P., Gandino F., Lingua A., Noardo F., & Rebaudengo M. (2016). An Integrated Approach for Pollution Monitoring: Smart Acquirement and Smart Information. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci*; 4:67–74.

Bahga A., and Madisetti V., (2015). IoT Design Methodology.*Book website:* *http://www.internet-of-things-book.com*

Beebi F. (2018).Environmental Monitoring System Using IoT.*India Res. Tech. Organiz*.; 5:64–68.

Dhingra S., Madda R.B., Gandomi A.H., Patan R., Daneshmand M. (2019). Internet of Things mobile-air pollution monitoring system (IoT Mobair). *IEEE Internet Things* .; 6:5577–5584.

Gaglio S., Re G.L., Martorella G., Peri D., & Vassallo S.D. (2014). Development of an IoT Environmental Monitoring Application with a Novel Middleware for Resource Constrained Devices. *Proceedings of the 2nd Conference on Mobile and Information Technologies in Medicine (MobileMed 2014)*; Prague, Czech Republic. 20–21 October 2014.

Ihama E.I., Akazue M.I., Omede E., Ojie D., (2023). A Framework for Smart City Model Enabled by Internet of Things (IoT).*International Journal of Computer Applications* (0975 – 8887) Volume 185 – No. 6.

Ioannis M., Elisavet S., Agathangelos S., & Eugenia B. (2020). Environmental and Health Impacts of Air Pollution:*A Review. Frontier in Public Health Article*.

Kamal R. (2020). Lesson 11 Internet Connected Environment (Weather, Air Pollution and Forest Fire) Monitoring. (Accessed on 6 April 2020); 2017, 1–41. Available online: *https://www.dauniv.ac.in/public/frntassets/coursematerial/Internetof things/IoTCh1*L11EnvironmentMonitoring.pdf.

Kulkarni P.H., Kute P.D. (2016), Internet of Things Based System for Remote Monitoring of Weather Parameters and Applications.*Int. J. Adv. Electron*. Comput. Sci..

Mohammad, S.I.; Mohammad, T.I.; Ali, F.A.; Gan, K.B.; Norbahiah, M.; & Amin, N. (2019). Monitoring of the Human Body Signal through the Internet of Things (IoT) Based LoRa Wireless Network System..

Odikwa H.N, Ekong P.A, Okpako E. A (2021). A fuzzy-based chat-bot messenger for home intelligent system with multiple sensors. *International Journal of Advanced Trends in Computer Science and Engineering. 10(2)*

Sani, A. & Abubakar, M.G. (2019). An IoT-Based Smart Framework for a Human Heartbeat Rate Monitoring and Control System.*International Electronic Conference on Sensors and Applications.* Basel: Switzerland.

Sanjeev, V. (2021).Integrating IoT technology for effective environmental monitoring. *IoT Agenda.*

Sharma J., John S. (2017). Real-Time Ambient Air Quality Monitoring System Using Sensor Technology.*Int. J. Adv. Mech. Civ. Eng*. 2017; 4:72– 73.

Shete R and Agrawal S. (2016.) "IoT-basedurban climate monitoring using Raspberry Pi, "*2016International Conference on Communication and Signal Processing.* (ICCSP). Melmaruvathur,. 2008-2012.

Shinde D., Siddiqui N. (2018). IoT Based Environment Change Monitoring Controlling in Greenhouse usingWSN; *Proceedings of the 2018 International Conference on Information, Communication, Engineering, and Technology* (ICICET 2018); Pune, India. 29–31 August 2018; pp. 1–5.

Tadejko P. (2017). Environmental Monitoring Systems Using Internet OfThings Standards And Protocols.*Pawel Tadejko Environmental policy and management.* Ekon. I Środowisko: https://www.indiamart.com/proddetail/nodemcu-esp8266-wifi-development-board 22452149088. html.

Ukadike I.D., Akazue M., Edith O., Akpoyibo T.P. (2023). Development of an IoT-based Air Quality Monitoring System. *FUPRE Journal of Scientific and Industrial Research (FJSIR).*