

Smart IoT based Bathroom Monitoring System to assess the Humidity Levels for Human Comfort

Dzikri Hadi Pratama¹, Muhammad Iqbal¹, Siti Marwangi Muhammad Maharum², Ghulam Fizza² & Radial Anwar¹

¹School of Applied Science, Telkom University, Bandung, Indonesia

²Electronics Technology Section,
Universiti Kuala Lumpur British Malaysian Institute

Corresponding email: radialanwar@tass.telkomuniversity.ac.id

Abstract: Humidity is the amount of moisture in the air. It significantly influences indoor environmental quality, affecting human health and comfort. This research investigates the impact of humidity on the human body within diverse bathroom environments. Low humidity can lead to skin dryness, nasal irritation, and eye discomfort, while high humidity fosters bacterial growth and discomfort. In this study the BME280 sensor and ESP32 microcontroller employed using Favoriot platform to measure and analyze humidity levels in staff, student, and boarding house bathrooms. The findings reveal that average humidity in staff bathrooms ranged between 63% and 68%, while student bathrooms exhibited levels between 63% and 72%. Notably, boarding house bathrooms maintained higher humidity, varying from 70% to 77%. This study underscores the importance of maintaining appropriate humidity levels in bathrooms for human well-being and suggests tailored interventions for maintaining good indoor environmental quality.

Keywords: *IoT, Monitoring System, Microcontroller, Sensors, Favoriot*

1.0 INTRODUCTION

Humidity, the invisible yet essential part of our daily lives, plays a vital role in our health and comfort. Humidity is the amount of moisture in the air. Ideally, the humidity in our home should be between 30% to 50%. Low humidity can cause dry skin, irritation of the nasal passages and throat, and itchy eyes. High humidity can make your home feel stuffy and cause condensation on walls, floors, and other surfaces, which promotes the growth of harmful bacteria, dust mites, and mold [1]. In [2] A condition caused by an enterovirus, hand, foot, and mouth disease (HFMD) primarily affects children under the age of five. The tendency of outbreaks to reach its height during the humid summer months suggests a link between HFMD and weather trends. They investigated the English-language literature for research describing a relationship between climatic conditions and HFMD. There were 72 studies found, and all of them satisfied the criteria. In 61 of 67 studies, or 91.0%, a positive link between HFMD cases and the temperature was found [CI 81.8-95.8%, P=0.0001]; in 41 of 54 studies, or 75.9%, a positive relationship between HFMD cases and relative humidity [CI 63.1-85.4%, P=0.0001].

The Internet of Things (IoT) is a phenomenon that is permeating many facets of our daily life. The market is seeing an increase in the number of gadgets that can communicate with one another. IoT technology education is becoming a requirement in schools. Researchers offer a

demonstration in this article that employs use cases to demonstrate the basic IoT concepts as they apply to smart homes. The general public may more readily comprehend the working principles of these new applications from fundamental use cases executed in a model building, which encourages the creation of new applications as in [3]

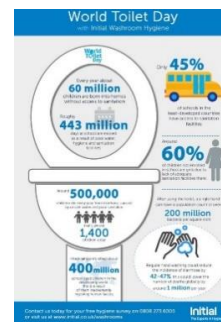


Fig.1.0: World Bathroom Hygiene Statistics [4]

The spread of germs may be a result of humidity, as seen in Fig 1.0 Even after washing hands, 200 million bacteria can still be found on a single hand used in the bathroom. Additionally, having lots of people coming in and out can hasten the spread of bacteria. Many works are being conducted on humidity to see its effect on the human body with sensors. In [5], Piecuch A et. al discussed the quantitative and qualitative assessment of mycological air pollution in a

dormitory bathroom with high humidity and fungal stains on the ceiling a case study. To stop the current fungal outbreak, the diversity and concentrations of fungal pollution in the ceiling and air of the Polish University dorm bathroom were evaluated. The results stated that *aspergillus flavus*, *aspergillus niger*, *cladosporium cladosporioides*, *fusarium poae*, *penicillium chrysogenum*, and *rhizopus nigricans* were all the species of fungus present in the air, however, only *cladosporium cladosporioides* was present on the dark stains on the ceiling.

Therefore, indoor air quality is a subject that requires attention. It is required to routinely check several factors that can affect indoor air quality in order to maintain it. Additionally, IoT-based sensor and monitoring technology development has greatly aided in the construction of autonomous and recurring monitoring systems. This encourages us to carry out research on creating a tool that can periodically check the state of indoor air quality. In [6], an air quality monitoring system was developed using the ESP32 as a controller and several sensors to gauge the quality of the air. As a result, a system that can track air quality, dust particles, and harmful gases has been created (H₂S, NH₃, CO, NO₂, and SO₂).

A room humidity levels could be affected by minimal air circulation, which, of course, could impair people's comfort and convenience. According to [7] The upkeep of a healthy indoor air quality (IAQ) has been shown to be crucial for ensuring that residents of homes are comfortable and have respectable health conditions. Currently, it is believed that both indoor and outdoor sources, such as gases and/or particles, are to blame for the deterioration of indoor air quality in homes. The health effects of these sources are particularly dangerous in environments with poor ventilation, high temperatures, and high humidity.

Beside of that in [8]. The top two symptoms in office surroundings, together with the sensation of "dry air," are typically complaints of sensory irritation in the eyes and upper airways. The effects of indoor air humidity on ocular and airway health must be examined holistically in light of this. Increased indoor air humidity may have a favorable effect on how well the indoor air quality is perceived, ocular symptomatology, and perhaps work performance. Increased humidified air appears to reduce nasal symptoms in patients with obstructive apnea syndrome, while no clear improvement in voice production was found, except in patients with voice fatigue.

Both low and high RH and perhaps even better absolute humidity (water vapor) have been shown in many studies to favor influenza virus transmission and survival. The perception of dry and humid air continues to be reported in offices and homes. This IAQ parameter appears to reflect different perceptions, including odors and dustiness and may be exacerbated by the drying effect of low humidity. It is important to distinguish between indoor humidity (relative or absolute) near the breathing and eye areas and phenomena caused by moisture damage in building construction and resulting emissions.

Numerous studies are being done on bathroom surveillance systems, using common Wi-Fi devices, offer a danger-pose detection system that may be used to monitor bathrooms while maintaining anonymity. Due to high range resolution and Doppler-range resolution, minimal privacy, and anti-humidity capabilities, the high-resolution radar will be useful in solving the bathroom problem. However, every system still has flaws and difficulties. In [9], The author has trouble using traditional healthcare methods based on cameras and wearable sensors to monitor inside a bathroom because of the high privacy and humidity. Data collection in target settings is typically necessary for machine learning-based detection techniques, which makes it challenging in instances where danger is being detected. While in [10], A bathroom surveillance system has several issues, including privacy, multipath, and humidity.

According to the comments above, there is still potential for development in terms of having a reliable monitoring system. In this paper, a monitoring system prototype is proposed to provide a usage bathroom monitoring system.

This paper makes the following objectives:

1. To investigate the indoor environmental quality parameter (temperature, humidity and pressure) in staff, student, and boarding house bathrooms.
2. To propose IoT based bathroom monitoring system for measuring the indoor environmental quality for bathroom in staff, student, and boarding house bathrooms
3. To analyze the measurement results of indoor environmental parameter for bathroom and their effects on human health.

The outline of the paper is organized as follows. The introduction, facts, statistics, and related work from previous studies of this study are presented in Section 1 which motivates this paper. Section II clarifies the methodology and parameters used in this paper. In Section III, the results and analysis are presented. Finally, conclusions are drawn in Section IV.

2.0 METHODOLOGY

Fig 2 shows the block diagram of the proposed proof of concept development of the Monitoring device for the humidity, pressure, and temperature in the bathroom. The bathroom's temperature, humidity, and pressure will be measured using the BME280 as an input. ESP32, which was programmed using uPyCraft v1.1, will receive the data by using the I2C protocol, an integrated mechanism for receiving and transferring data. To connect to Favoriot as a cloud service provider and send this data, an internet connection is needed. Additionally, the LED will show the BME280's measurement results so that the humidity level in the room can be decided whether to be raised or lowered in order to use the solutions. The software, hardware, cloud, and connection of this device all fulfill the IoT requirements.

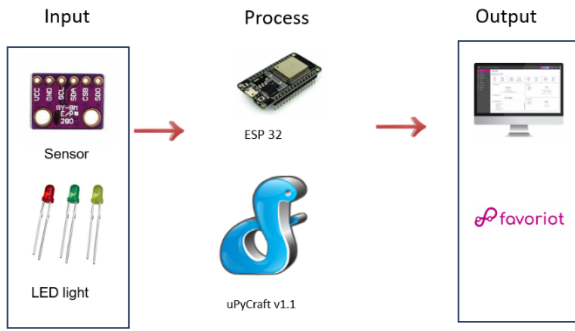


Fig 2. Block diagram of Indoor Bathroom Environmental Monitoring System

As shown in the operational flowchart for the system in Fig 3, the system begins with the ESP32 calling the four uploaded Python programs main, boot, urequests, and the BME280 library. According to programming in the boot files that specify where the ESP32 should look for connections, the initialization of the Wi-Fi will go off without a hitch. Then, to make ESP32 familiar to sensors, integration between ESP32 and BME280 has also been set up using the BME280 library. The following step is for BME to attempt to measure three parameters: temperature, humidity, and pressure; the results will then be sent to Favoriot along with the number 201 designating a successful data transmission. The debug code is where it will go if it fails.

The requests application, which is integrated with Hypertext Markup Language, will facilitate the process of sending data to Favoriot if it is successful. The device can explain its measurement results with LEDs that are set to light up at a given humidity level, notably White for less than 35%, Green for the range of 35% to 50%, and Red for more than 50%, without having to glance at the serial monitor from uPyCraft v1.1 or the Favoriot IoT platform. The device needs a delay since Favoriot sets daily API restrictions, thus it must be properly controlled. If no forced termination occurs after that, the program will keep running in a loop. Forced termination can result from several circumstances, including the cutting off of the ESP32's power source and the internet connection.

A schematic circuit diagram for the device is shown in Fig 4 for an explanation. With the aid of the project board, the positive LEDs are linked to D12, D13, and D5, while the negative LEDs are connected to GND. A second connection between BME280 and ESP32 is made with the VCC linked to 3.3V, GND to GND, SCL to D22, and SDA to D21. Together, these tools will measure the three characteristics that the BME280 could measure.

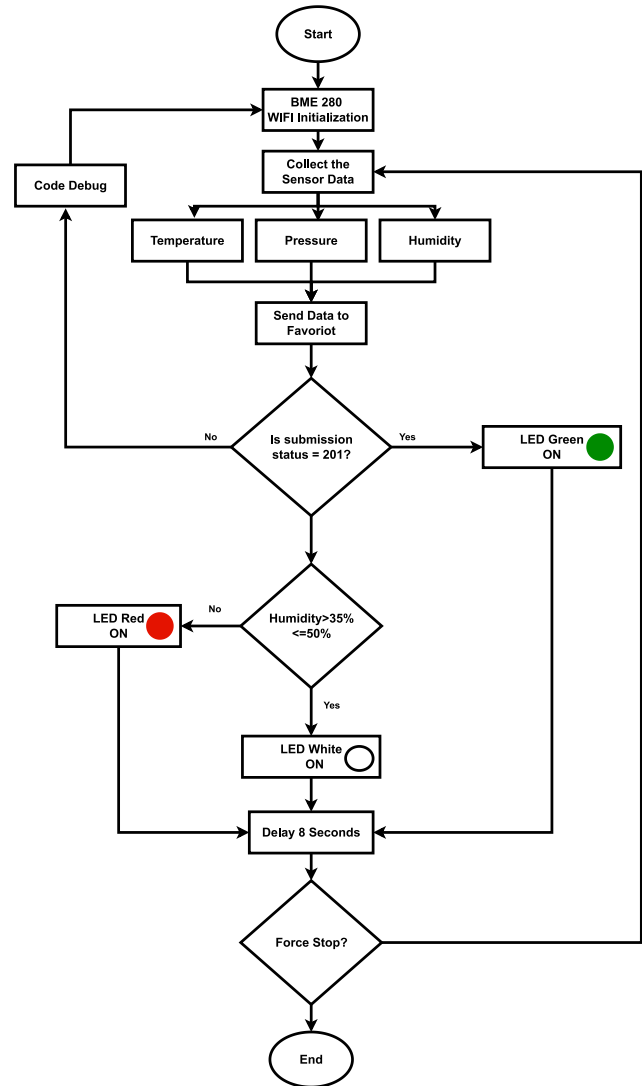


Fig.3 Flowchart of Indoor Bathroom Environmental Monitoring System

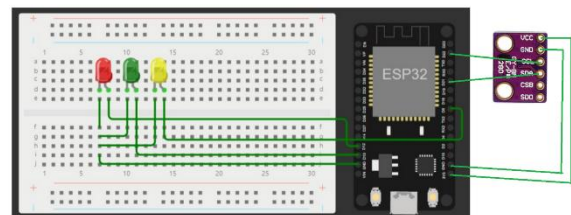


Fig. 4. Circuit diagram of Indoor Bathroom Environmental Monitoring System

3.0 RESULTS & DISCUSSION

The Favoriot IoT platform was used to obtain detailed results for this project's temperature, humidity, and pressure

measurements in the bathroom, along with LED indicators for quick value determination. Fig 5 depicts the project prototype under development. To take measurements, the device has to be constantly linked to both Wi-Fi and electricity.

Fig. 6 shows the actual proof of concept circuit developed in this project. To start the system evaluation, the respective micro python file codes were downloaded and run on the ESP32 microcontroller via uPyCraft IDE. The BME280 sensor is placed on the user's sink counter

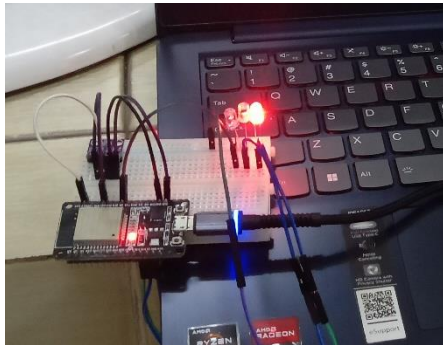


Fig. 5. Prototype of Indoor Bathroom Environmental Monitoring System

It should be noted that if one of the anomalous circumstances shown in Fig 6 is detected, the LED will blink as a warning message. For instance, the red LED will light to indicate a high humidity condition if the room humidity level surpasses 50%. The Green LED will turn on to show that the ideal humidity range is between 30% and 50%. A white light will turn on to indicate that the humidity is too low if it is lower than 35%.

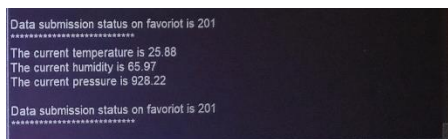


Fig. 6. uPyCraft v1.1 displayed the measurement of BME280

The results of the measurements are depicted in Fig 7 to Fig 9 for three locations, including the student's boarding house bathroom and two bathrooms used by faculty, staff, and students at the Telkom University, Bandung, Indonesia. The data is quite fascinating because, although there is not much of a difference between the humidity levels in the staff and student restrooms, entering the two creates a totally distinct sensation. However, the staff restroom gives off a fresher, cozier impression than the student restroom.

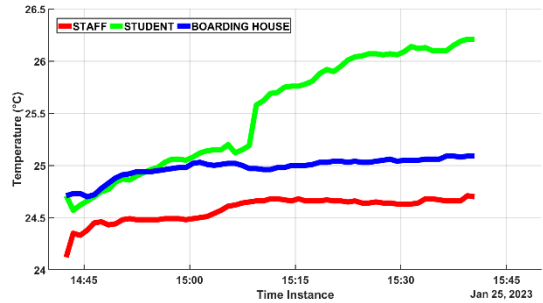


Fig. 7: Temperature of different Bathrooms Environment

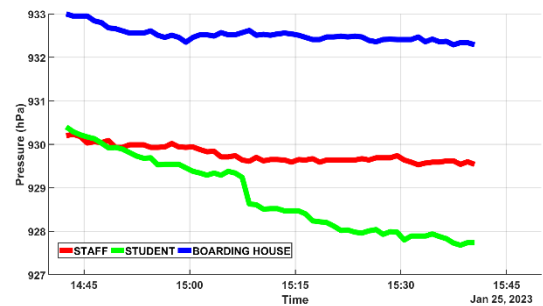


Fig. 8. Pressure of different Bathrooms Environment

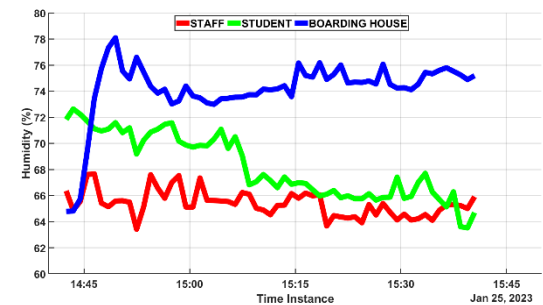


Fig 9: Humidity Ratio of different Bathroom Environment

When compared to the student's bathroom, the value is significantly higher in terms of humidity. When entering a room with no air freshener but a very high and constant level of humidity of 70%, it also provides a different atmosphere. A summary measurement outcome is shown below in Table 1.

Table 1. Measurement data recorded from three different bathrooms

Environmental Parameter	Staff	Student	Boarding House
Temperature(°C)	24-25	24-26.5	24.5-25
Pressure (hPa)	929-930	927-930	932-933
Humidity (%)	63-68	63-72	70-77

It is obvious from the measured values, which are shown in Fig 9a, 9b, and 9c, that the humidity is too high and needs to be reduced to a range between 30% and 50%. There is no

requirement to take this into consideration as it is still at room temperature and there is no observable change in either the pressure or temperature.

4.0 CONCLUSION & RECOMMENDATION

This study investigated indoor environmental quality within varied bathroom environments. The prototype humidity, temperature, and pressure monitoring system, utilizing the BME280 sensor and ESP32 microcontroller via Favoriot have been implemented in staff, student, and boarding house bathrooms. Using the proposed monitoring system, temperature 24-25°C in staff bathroom, 24-26.5 °C in student bathroom, and for boarding house is 24.5-25 °C have been achieved where is pressure 929-930 hPa in staff bathroom, 927-930 hPa in student bathroom, and 932-933 hPa in boarding house bathroom have been observed. However, higher humidity level 70-77% in boarding house, compared to student (63-72%) and staff (63-68%) have been observed. This is achieved by maintaining real-time data in a cloud database and relying on the internet of things (IoT) idea for device-to-device interaction.

The research substantiates the compelling need for maintaining optimal humidity levels in bathrooms to ensure human well-being. The proposed tailored interventions further accentuate the commitment to elevating indoor environmental quality. In culmination, the study underscores the convergence of innovative technology and human-centric comfort, projecting a future where smart monitoring systems harmonize with human spaces for an elevated indoor environment quality.

ACKNOWLEDGMENT

This project was conducted by students and staff of Telkom University and its publication is financially supported by Universiti Kuala Lumpur British Malaysian Institute (UniKL BMI). Therefore, the authors would like to thank Telkom University and UniKL BMI for the provision of laboratory facilities and financial support.

REFERENCES

- [1] Mayo Clinic Staff, "Humidifiers: Ease skin, breathing symptoms - Mayo Clinic," Jun. 08, 2021. <https://www.mayoclinic.org/diseases-conditions/common-cold/in-depth/humidifiers/art-20048021> (accessed Jan. 30, 2023).
- [2] S. J. Coates, M. D. P. Davis, and L. K. Andersen, "Temperature and humidity affect the incidence of hand, foot, and mouth disease: a systematic review of the literature – a report from the International Society of Dermatology Climate Change Committee," *International Journal of Dermatology*, vol. 58, no. 4. Blackwell Publishing Ltd, pp. 388–399, Apr. 01, 2019. doi: 10.1111/ijd.14188.
- [3] O. Debauche, S. Mahmoudi, and Y. Moussaoui, "Internet of Things Learning: A Practical Case for Smart Building automation," in *Proceedings of 2020 5th International Conference on Cloud Computing and Artificial Intelligence: Technologies and Applications, CloudTech 2020*, Institute of Electrical and Electronics Engineers Inc., Nov. 2020. doi: 10.1109/CloudTech49835.2020.9365920.
- [4] W. Rudy, "24 Toilet fact ideas | toilet, infographic, world toilet day." <https://id.pinterest.com/pin/386324474287979729/> (accessed Feb. 01, 2023).
- [5] A. Piecuch and R. Ogórek, "Quantitative and qualitative assessment of mycological air pollution in a dormitory bathroom with high humidity and fungal stains on the ceiling a case study," *Pol J Environ Stud*, vol. 30, no. 2, pp. 1955–1960, 2021, doi: 10.15244/pjoes/125006.
- [6] T. H. Nasution, A. Hizriadi, K. Tanjung, and F. Nurmayadi, "Design of indoor air quality monitoring systems," in *2020 4th International Conference on Electrical, Telecommunication and Computer Engineering, ELTICOM 2020 - Proceedings*, Institute of Electrical and Electronics Engineers Inc., Sep. 2020, pp. 238–241. doi: 10.1109/ELTICOM50775.2020.9230511.
- [7] M. F. Bani Mfarrej, N. A. Qafisheh, and M. M. Bahloul, "Investigation of Indoor Air Quality inside Houses From UAE," *Air, Soil and Water Research*, vol. 13, 2020, doi: 10.1177/1178622120928912.
- [8] P. Wolkoff, "Indoor air humidity, air quality, and health – An overview," *International Journal of Hygiene and Environmental Health*, vol. 221, no. 3. Elsevier GmbH, pp. 376–390, Apr. 01, 2018. doi: 10.1016/j.ijheh.2018.01.015.
- [9] Z. Zhang, S. Ishida, S. Tagashira, and A. Fukuda, "Danger-pose detection system using commodity wi-fi for bathroom monitoring," *Sensors (Switzerland)*, vol. 19, no. 4, Feb. 2019, doi: 10.3390/s19040884.
- [10] IEEE Microwave Theory and Techniques Society, IEEE Aerospace and Electronic Systems Society, IEEE Antennas and Propagation Society, Institute of Electrical and Electronics Engineers, and Tex.) *IEEE Radio and Wireless Week (2020 : San Antonio, 2020 IEEE Radio and Wireless Symposium : 26-29 January 2020, Grand Hyatt San Antonio, San Antonio, Texas, USA. 2020.*