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Development of an Inhaler Tag-Based Air Quality Monitoring Device for Asthmatic Patients With Heart Disease

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ABSTRACT

The development of an inhaler tag-based air quality monitoring device for asthmatic patients with heart disease began by connecting the MQ7's pins GND, VCC, and A0 to the ESP32's pins GND, 3V3, and VP. The DHT11's pins VCC, DATA, and GND are connected to the ESP32's pins 3V3, GPIO4, and GND, respectively. The push button's two pins are connected to the ESP32's GPIO13 and GND. The MCU is powered by a 3.3-V, 2-A supply. When the inhaler tag is powered on, it performs an intro buzzer sequence to indicate startup, followed by a beep indicating a packet from the air quality monitor. The sensor detects carbon monoxide and other pollutants in the air and transmits the data to a smartphone app via Wi-Fi. The user's heart rate was monitored using an attached monitor to ensure a healthy rhythmic beat and to prevent any irregularities in heart rate. The companion device, a tag-based sensor attached to an inhaler, is intended to help patients locate their inhaler (in their hand or purse) in the event of a respiratory emergency. In the event of an attack, the inhaler tag, which was attached to the inhaler, would set off the alarm and pinpoint its exact location. The audible beep allowed the inhaler tag to be found from wherever it had been hidden, proving that the device (an air quality monitoring device) was working properly and making the results easily accessible via the mobile app. The developed device could detect airborne contaminants and issue an immediate warning to the user. In the event of an asthma attack, the user was able to quickly administer relief by using the inhaler, thanks to the inhaler tag's ability to pinpoint its exact location. The developed heart rate monitoring system also tracks blood oxygenation and the user's respiratory rate.

Keywords: *Inhaler-Tag, buzzer,blood-oxygenation, Rhythmic beat, sensor,ESP32*

1. INTRODUCTION

Asthma is a chronic inflammatory lung disease that causes wheezing, coughing, and shortness of breath. It can cause life-threatening breathing difficulties in severe cases. According to the Centers for Disease Control and Prevention, approximately 17 million Americans have asthma, and it is one of the leading causes of hospitalization in children under the age of 18.

Airborne irritants such as dust, pollen, or smoke can cause asthma attacks. Asthmatics should be aware of their surroundings and avoid irritants to the greatest extent possible. However, traditional methods of assessing air quality can be difficult because they only provide information on a few specific pollutants over a short period of time. Long-term exposure levels to specific pollutants are difficult to quantify. This makes determining whether the air quality in a given area is safe for people with asthma difficult. A device that monitors air quality and includes an inhaler tag for asthmatic patients could improve their health and reduce the risk of frequent asthma attacks. The device could be used in the homes of asthma patients to provide real-time information about the quality of the air in their environment. It would be attached to a smartphone or other mobile device and worn on the person's inhaler.

Many asthmatics keep a personal journal to track when they have symptoms and whether they are caused by environmental factors. This assists them in identifying patterns in their symptoms and directing their treatment options. It also allows them to communicate with their doctor if they have any questions about their treatment. Unfortunately, because the majority of people do not have regular access to a doctor's office, they have no way of knowing if the air quality in their environment is affecting their health. An app that connects to an air quality monitor worn by a person wearing an inhaler tag would provide a continuous stream of data about the air quality in their surroundings. This information would be saved on the device and reviewed by their doctor. Furthermore, it could notify them if pollution levels in their area are dangerously high, allowing them to take appropriate precautions to avoid further exposure.

High levels of air pollution can irritate the lungs and exacerbate asthma symptoms. Severe cases may necessitate medical attention and may be fatal. Air pollution has been linked to a variety of health issues, including heart disease, stroke, respiratory diseases, and even cancer. An air quality monitoring device could provide important information about air quality levels in their immediate surroundings to people with asthma and their families, allowing them to take the necessary precautions to protect themselves from harmful pollutants. This device could assist people in tracking changes in their environment over time and identifying new asthma triggers. The device could connect via bluetooth or wifi to a smartphone app that analyzes real-time data on ozone, nitrogen dioxide, and carbon monoxide.

The importance of air quality monitoring in public health is becoming more widely recognized. One of the most effective tools for assessing air quality and understanding its impact on public health is air quality monitoring. Poor air quality has an impact on both respiratory and cardiovascular health, and it is estimated that nearly 200,000 people die each year in the United States alone from illnesses caused by air pollution. There is also mounting evidence that poor air quality may have an impact on fetal development. Recent research has found a link between maternal air pollution exposure during pregnancy and an increased risk of low birth weight and low gestational age babies. Air pollution can cause respiratory diseases, cardiovascular conditions, and neurological effects in both children and adults.

Most studies on the relationship between air quality and health have focused on adults, but there is now growing evidence that suggests that exposure to air pollutants may be harmful to children's health as well. Children with asthma are especially vulnerable to the effects of air pollution, according to studies, and even low levels of pollution can aggravate their symptoms. A recent study published in the journal Pediatrics looked at the link between fine particulate matter (PM2.5) in the home and acute lower respiratory infections in children. Children living in households with higher levels of PM2.5 were found to be more likely to develop an acute lower respiratory tract infection during the study period.

The study also discovered that each 10 g/m3 increase in PM2.5 concentration increased the risk of hospitalization due to acute lower respiratory infections by 1.9%. High PM2.5 concentrations are also linked to an increased risk of pneumonia and bronchitis in children. Other studies have found that when children with asthma are exposed to high levels of PM2.5 or ozone, they are significantly more likely to develop a respiratory infection. Children with underlying respiratory issues are particularly vulnerable to the effects of air pollution because they inhale more air than adults and have a larger surface area to inhale pollutants from their surroundings. It has also been discovered that young children have a decreased ability to clear pollutants from their lungs, which puts them at a higher risk of contracting an airborne infection. This increased risk is especially noticeable during the summer months, when the temperature rises and children spend more time outside. Because of high levels of ambient air pollution, pregnant women are also at an increased risk of developing an acute respiratory infection. Several studies have found that pollution levels in certain neighborhoods are high enough to endanger pregnant women's health.

This risk has been linked to a number of factors, including exposure to exhaust fumes from cars and other diesel-powered vehicles, as well as exposure to particulate matter emitted by coal-fired power plants. According to a 2013 World Health Organization study, air pollution is responsible for one out of every eight deaths worldwide. Children, on the other hand, account for more than 20%.

The develop device itself could connect by bluetooth or wifi to a smartphone app that analyzes real time data on the ozone, nitrogen dioxide, carbon monoxide and other contaminants in the air. It could also be paired with a heart-rate monitor to help monitor the user's pulse rate while they're using the device to ensure that their heart isn't beating too fast or too slow. The inhaler tag-based sensor is a twin device designed to help patients determine where their inhaler is (in their hand or purse) when their breathing becomes difficult. This is especially useful for people who struggle with physical dexterity, such as the elderly or those with disabilities. make the inhaler available to the end user without clicking it in order for the user to locate it quickly on the user's body and optimize the patient's chances of accessing the medication on time by generating an alert to the user via a mobile app When the inhaler is out of reach of the user, the chances of the patient missing a dose decrease significantly, improving treatment compliance. This is especially important for asthma patients who frequently forget to take their medication. The inhaler tag keeps the inhaler accessible to patients at all times, reducing unnecessary trips to the emergency room and improving the community's overall health. This tool also contributes to significant cost savings in healthcare by ensuring that patients receive the correct medication on time and are more likely to adhere to their treatment plans.

The study's goal was to look over the existing literature on air quality monitoring methodology and come up with a better approach. There is no single accepted methodology for monitoring air quality, according to a review of the literature. Existing methods are classified into several groups, including measurement techniques and equipment, sample collection procedures, data analysis techniques, reporting methodologies, and so on. According to the review of literature, there is no consensus on measurement techniques or reporting methodologies. The development of an air quality monitoring device with an inhaler tag for easy inhaler location during an asthma attack could be a possible solution to making it easier for those suffering from the disease to breathe. As a result, developing appropriate methods and tools for monitoring air quality is critical in order to reduce the negative effects of air pollutants on human health and the environment.

This can be accomplished by developing a comprehensive monitoring system that incorporates all of the components that contribute to air quality. The proposed system will include the development of a portable sensor network consisting of an air quality monitor and a wireless sensor node. Temperature, humidity, sound level, air pressure, light intensity, and gas concentration will all be monitored using both hardware and software components in the system.

2. LITERATURE REVIEW

In order to forecast asthma attacks based on environmental and local parameters, (Khasha et al., 2018) created a mobile GIS2-based tool with maps of asthma attacks. Patients with asthma could benefit from daily monitoring maps of asthma episodes depending on environmental conditions, thus the team set out to create a program that would provide such information. The patient can access the tool wherever they are, and it can help them become more cognizant of any relevant hazards. Continuous self-management of asthma benefits greatly from a methodical and interdisciplinary approach to the development of this tool. According to a study (Sung et al., 2019), the researchers have created a high-tech instrument for measuring temperature, humidity, carbon monoxide, volatile organic compounds, carbon dioxide, particulate matter (PM), and more. With the help of both short- and long-range communication modules, the smart air quality monitoring system can talk to a custom smartphone app. The smart app mainly focuses on delivering data on air quality (daily, monthly, and yearly), air management techniques, and new environmental concerns. Further, they used additional, trusted measurement tools to verify the accuracy of the established air quality monitoring system.

A platform for measuring a wide range of indoor pollutants was proposed by Juniper et al. (2002), and it is based on the most up-to-date IoT sensors and machine learning capabilities. As such, we've created a multi-sensor IoT node that can measure a wide variety of indoor pollutants, including NH3, CO, NO2, CH4, CO2, and PM2.5, as well as temperature and humidity. To achieve this goal, we create an Internet of Things (IoT) node that incorporates sensors for eight pollutants—among them, NH3, CO, NO2, CH4, CO2, and PM 2.5—along with environmental conditions like temperature and humidity. The IoT node is installed in a lab for proof-of-concept and research purposes, where it will collect data on the quality of the air inside the building. The suggested system utilizes GSM and WiFi to send real-time air quality reports to a web portal and mobile app, and it may send out notifications once the air quality reaches dangerous levels.

An alert system was developed (Alzoubi et al., 2021) to notify parents of changes in air quality that may affect their children's susceptibility to asthma episodes. Two primary wireless components make up their prototype system. A sensor for gauging air quality is the initial component, followed by a smartphone app. The Air-Quality Sensing Subsystem (AQSS) is a network of sensors that monitors environmental conditions that contribute to asthma attacks in our area, such as temperature, humidity, dust, and carbon monoxide (CO). This component processes the collected information to conclude whether or not the air quality is appropriate for children with asthma. The filtered information and warning systems. In order to reduce the health effects of poor indoor air quality, (Chojer et al., 2020) developed inexpensive devices to monitor air quality in buildings. This overview was conducted by searching three scientific databases (ScienceDirect, IEEE, and Scopus) extensively. There was a total of 891 books published after 2012 that were retrieved and checked for applicability. A total of 41 research articles covering 35 separate device development projects were reviewed, with a focus on device development aspects such as sensor calibration and performance, processor type, data storage and communication, and the availability of remote, real-time access to sensor data.

Only 16 of the 35 projects included in the analysis calibrated or validated their sensors, making this a prominent finding. For this reason, it is suggested that future studies include calibration, credible validation, and standardization of sensor performance and assessment.

3. METHODOLOGY:

Air Quality Monitor

The device used in this study was the ESP-WROOM-32 air quality monitor, which was capable of measuring carbon dioxide (CO2), temperature, humidity, pressure, and indoor air quality in real time using WiFi technology. All measurements can be displayed on a smartphone or tablet via the free ESP-NOW mobile app, or on the connected computer. Temperature and humidity sensors in the monitored space can record daily fluctuations as well as long-term trends. The MQ-7 Sensor Module is a low-cost, high-precision Air Quality and Temperature Sensor designed specifically for the DIY market. When the developed device is powered on, the MCU transforms into a transmitter for the inhaler tag, causing the inhaler tag to beep when the push button is pressed. The MCU sends data packets to the inhaler tag to indicate the push-button state.

The MCU also functions as a web server, hosting a sensor webpage that displays the read sensor values. In this state, it serves as an access point to which the user can connect, obviating the need for a router. The circuitry connection was made by first connecting the MQ7's pins GND, VCC, and A0 to the ESP32's pins GND, 3V3, and VP. The DHT11's pins VCC, DATA, and GND are connected to the ESP32's pins 3V3, GPIO4, and GND, respectively fig1.0a. The push button's two pins are connected to the ESP32's GPIO13 and GND. The MCU is powered by a 3.3-V, 2-A supply.

When the inhaler tag is powered on, it performs an intro buzzer sequence to indicate startup, followed by a beep indicating a packet from the air quality monitor fig 1.0b. Once the required packet indicating a beep is received, the beep sequence begins to indicate that the inhaler tag is being sought.
The buzzer's positive and negative pins are connected to the MCU's VCC and GPIO2 (ESP8266). The MCU is powered by a 3.3-V, 2-A supply.

Components

A. Air Quality Monitor:

1. ESP-WROOM-32
2. MQ-7
3. DHT11
4. Push Button

B. Inhaler Tag:

1. ESP-01S
2. Active Buzzer

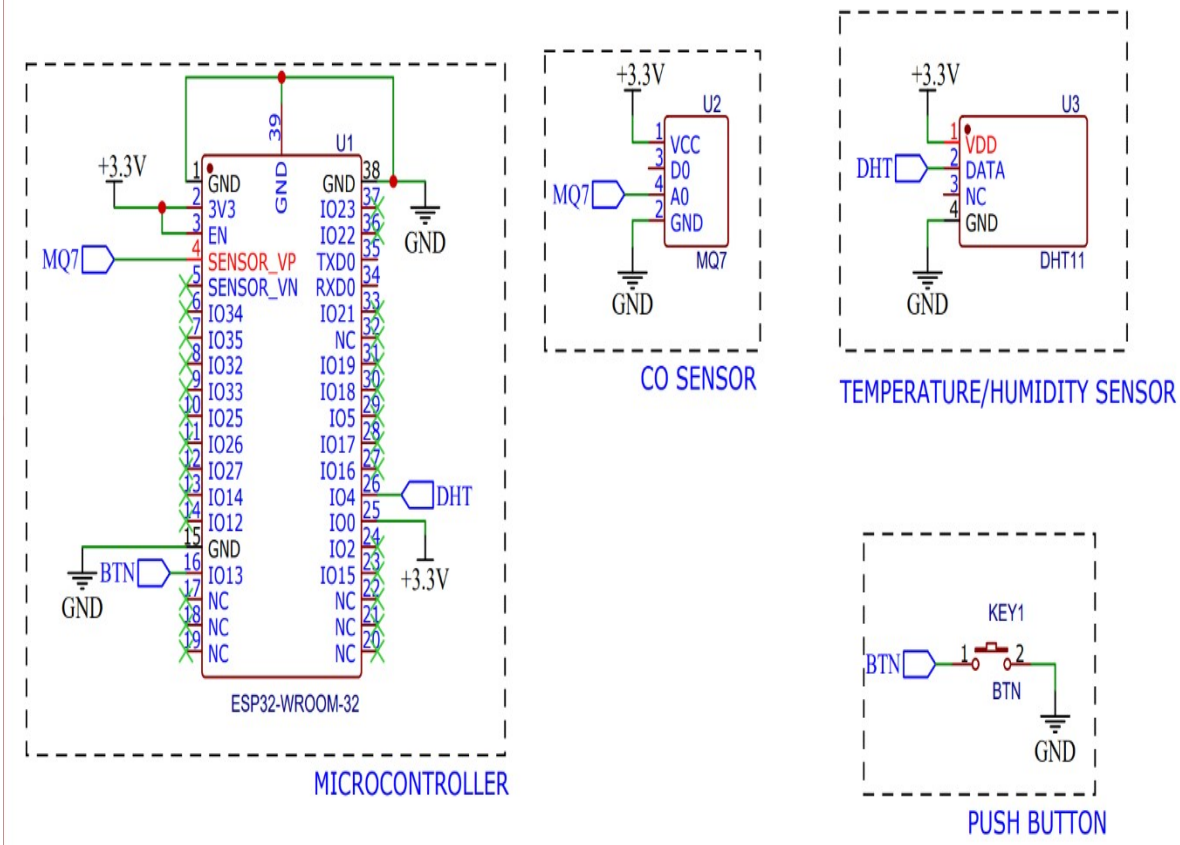

Figure 1.0aCircuit diagram for Air quality monitoring device

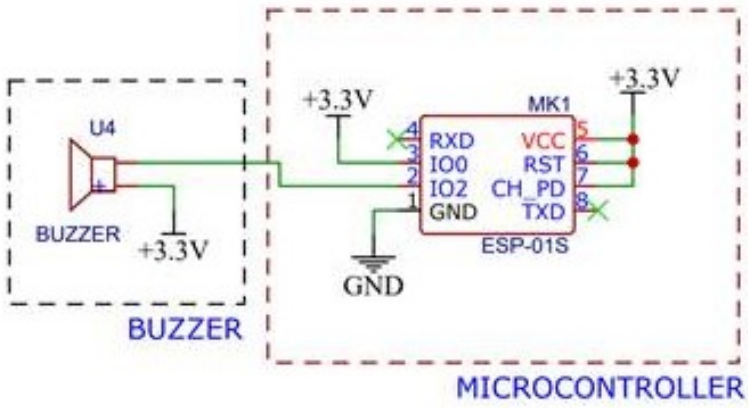

Figure 1.0b Circuit diagram for the inhaler Tag

4. RESULTS AND DISCUSSION

The sensor detects carbon monoxide and other pollutants in the air and sends that information via wifi to a smartphone app fig 2.0c. The user's heart rate was monitored via an attached(fig.2.0d)monitor to ensure a healthy rhythmic beat and prevent any irregularities in heart rate. The companion device, a tag-based sensor attached to an inhaler, is meant to assist patients in locating their inhaler (in their hand or purse) in the event of a respiratory emergency. The inhaler tag fig.2.0b, which was attached to the inhaler in case of an attack, would cause the alarm to go off and pinpoint its exact location. The inhaler tag could be located from wherever it had been concealed thanks to the audible beep, proving that the device (Air quality monitoring device)figure 2.0a was functioning properly and making the result readily available via the mobile app.

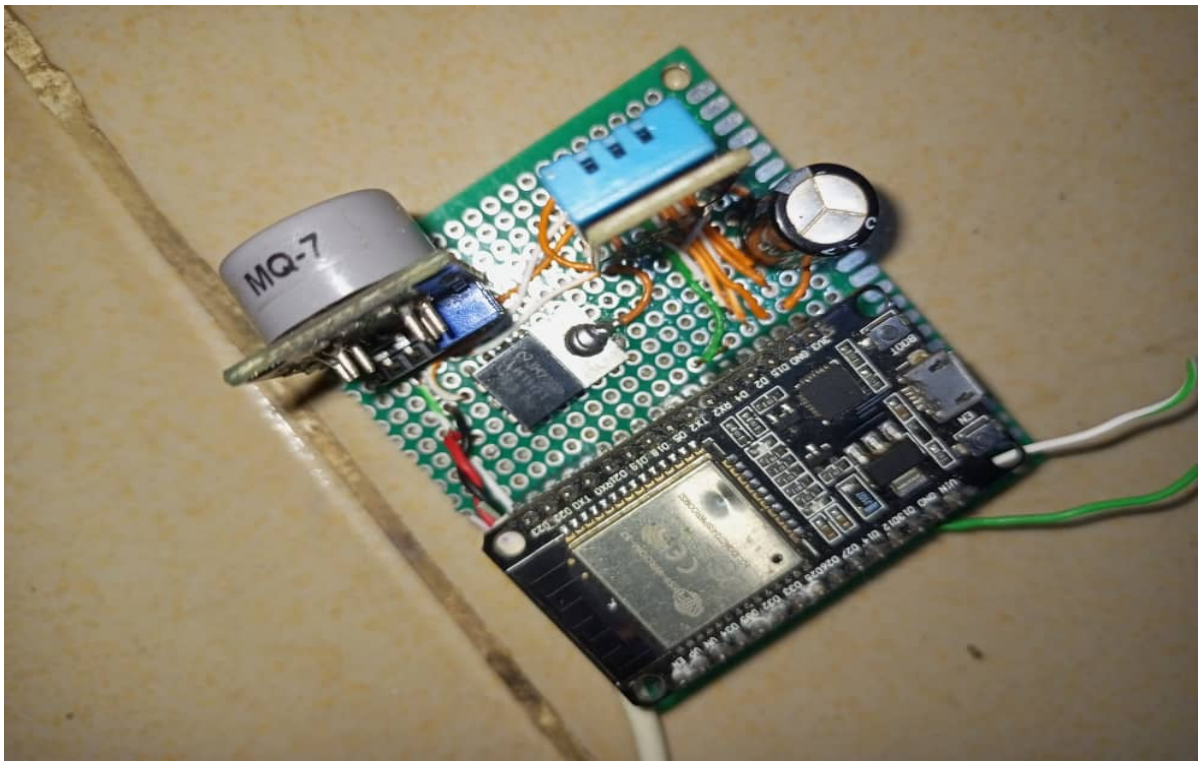

Figure 2.0a the developed Air quality monitoring device

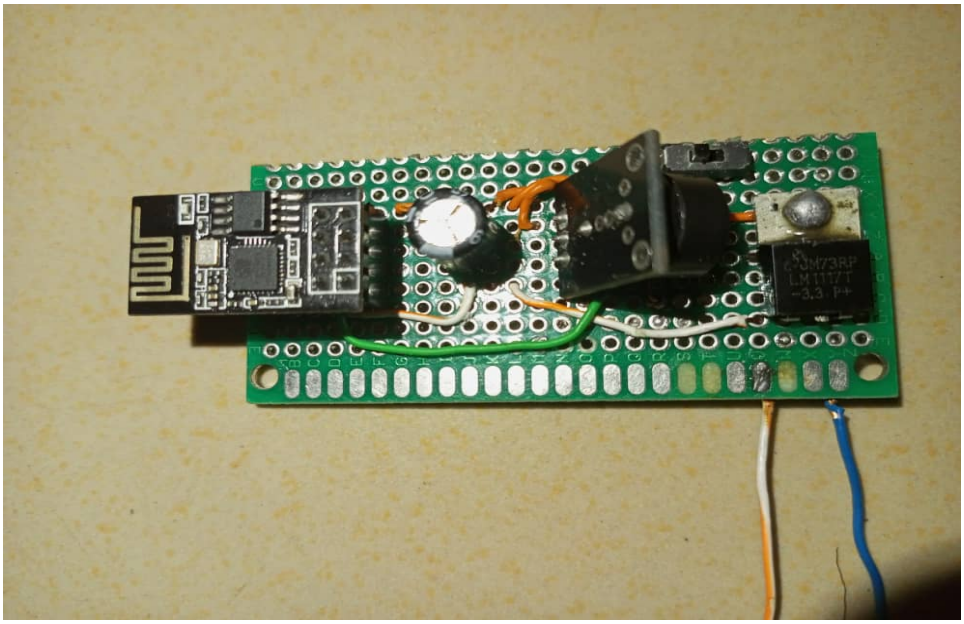

Figure 2.0b The developed Inhaler-Tag

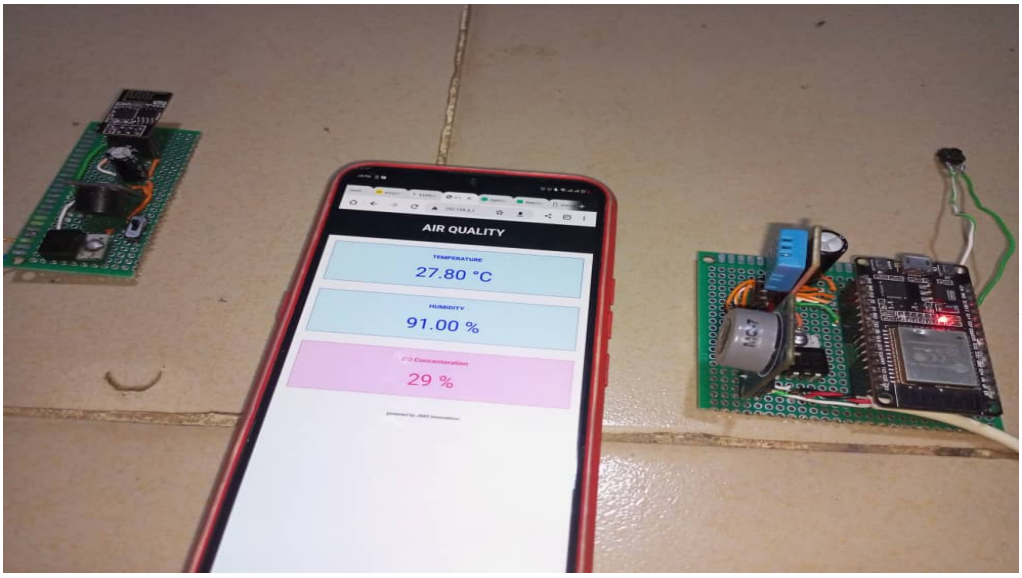

Figure 2.0c The monitoring device setup during testing

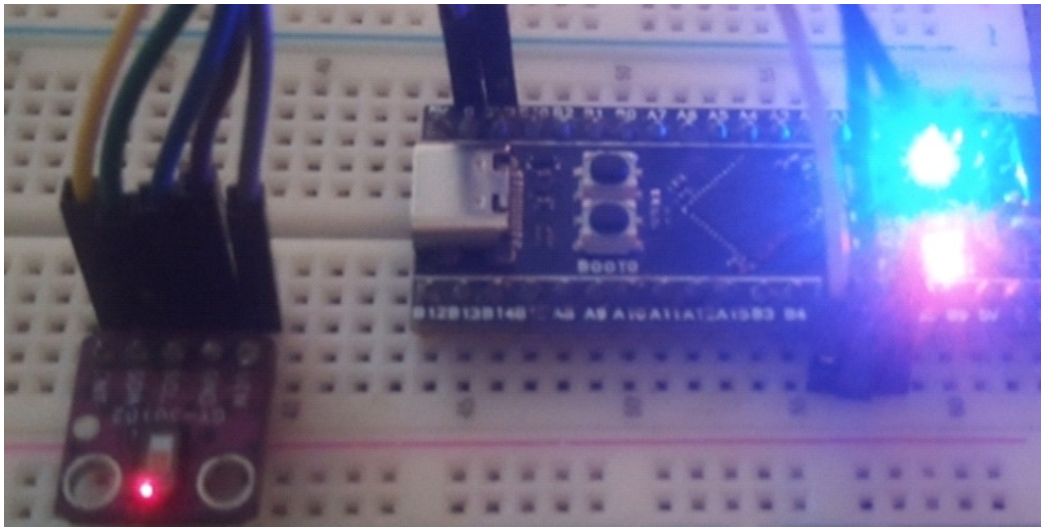

Figure 2.0d Heart rate and blood oxygen monitoring device

5. CONCLUSION AND RECOMMENDATIONS

Conclusion

The developed device could detect airborne contaminants and sound an immediate warning to the user. In the event of an asthma attack, the user was able to quickly administer relief by using the inhaler, thanks to the inhaler tag's ability to pinpoint its exact location. The oxygenation of the blood and the user's respiratory rate are also tracked by the developed heart rate monitoring system.

Recommendations

Based on the findings of this study, the following recommendations are made:

(i) Inclusion of Artificial intelligence for the prediction of the possible asthma attack based on the trained dataset

(ii) Comparing this device with another using ESP32 microcontroller to know which will perform better.

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