Air quality monitoring System

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fuels, deforestation, and transportation emissions, not only create air pollution but also contribute to global climate change.

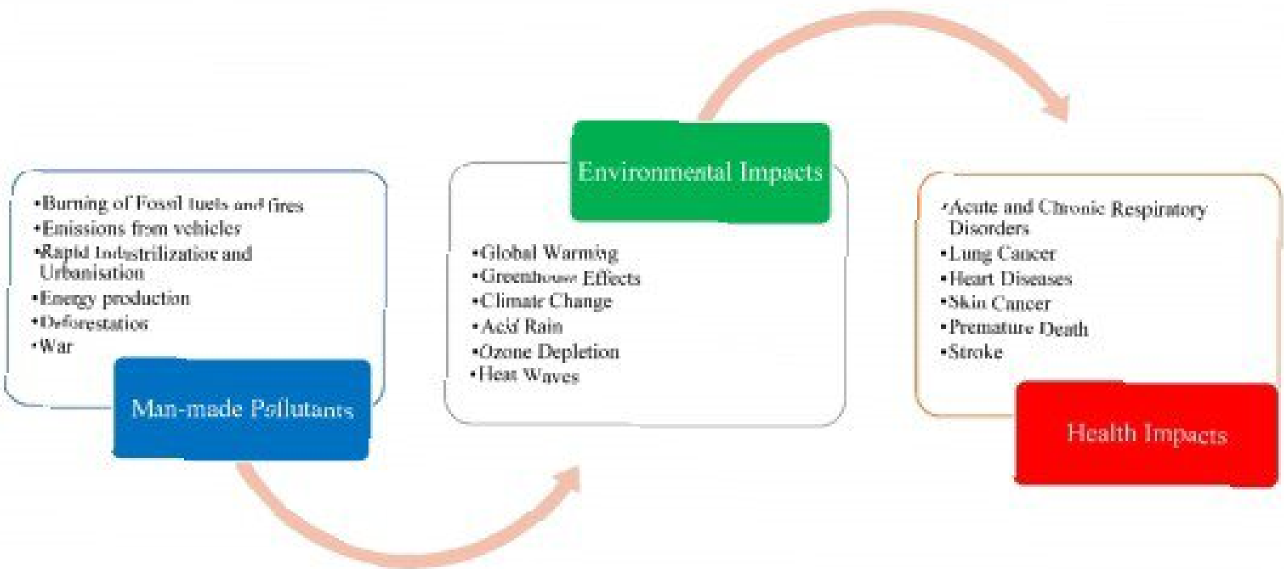


Figure 1. Potential Relationship between Man-made Pollutants, Environmental Impacts and Health Impacts.

Human health and life quality, which are determined by environmental psychosocial, physical, biological, and social characteristics, are factors in environmental health [5]. Climate changes lead to alterations in weather and temperature pattern. Although these changes are natural, humans have been the dominant contributor to climate change since the 19th century, primarily to the burning of fossil fuels which generates CO_2. Ahmed et al. determined the regional and periodic change of CO_2 and Particulate matter in the important Libyan city of Misurata and the measurements were made during the months of November and February once every three days [6]. The results were very useful to understand the regional and periodical characteristics of air pollution. Cetin et al. evaluated the regional and temporal changes in air pollution and measured the CO_2 concentration and particulate matter concentration in various regions of Bursa city. The results of the study revealed that the CO_2 was statistically not significant with respect to the season but the Particulate matter shows, statistically, a 99.9% confidence level by season [7]. In the Turkish case study, the author examined the variation in the indoor CO_2 concentration in the examination hall and the findings indicate that indoor CO_2 levels are higher than 1500 ppm while the start of exams of threshold value within 10 min [8]. In another interesting study, the authors examined the Pb and Cr pollution in the capital city of Turkiye by collecting topsoil samples from 50 regions; thus, it is clear that air pollution is very dangerous to the environment and ecosystem. The earth is currently warming faster than at any other time in recorded history. Warmer temperatures are shifting weather patterns and disturbing nature's normal equilibrium. As a result of climate change, storms, floods, cold spells, and heat waves are expected to have a greater socioeconomic impact. Heat Waves (HWs) are expected to grow increasingly strong and common as a result of man-made climate change. HWs are clearly major events that can induce fast changes in biodiversity patterns as well as ecosystem structure and functioning as a result of human climate change [9]. To overcome the above-mentioned issues, it is very important to forecast air pollution, weather conditions, and climate changes to implement an early-warning system.

Artificial Intelligence is used to imitate the human mind's problem-solving and decision-making abilities. Figure 2 shows the relationship between Artificial Intelligence methods, Machine Learning algorithms, and Deep Learning algorithms. To limit public exposure risks due to pollution, AI should be used as an important method for environwill be able to identify and measure their origins easily. The modern air automated surveillance program uses laboratory analyzes with fairly complicated facilities, large quantities, unreliable activities and high costs [6][7]. For large-scale construction, this renders high cost and wide volume difficult. This machine will only be built at essential control sites of some main firms, so device data cannot forecast the ultimate emissions situation. This thesis suggests integrating IoT technologies with environmental protection to resolve deficiencies in conventional control and detection approaches and to-research costs [8][9]. This work has been carried out based on many previous studies. In the past, studies performed air quality management and surveillance in the house [10]. This work is also focused on our study into remote contact for air quality monitoring. We also established an outdoor quality control program, in comparison to previous studies. A variety of substances like O_3, SO_2, CO and particulate matter can be calculated in the soil. Web sites track air quality remotely [11][12].

2. Related Work

Environmental monitoring practices were checked at home. The author suggests a paradigm for temperature, moisture and light intensity control focused on the combination of ubiquitous, dispersed sensor systems, data collection knowledge system and background understanding and reasoning[13]. It is rewarding to have accurate sensory knowledge. Several camera devices for environmental control have been introduced recently. Many of the detection devices for tracking CO2 (carbon dioxide) are different.

A monitoring system is developed for carbon dioxide levels in remote areas. The machine also monitors the outdoor tracking zone's temperature humidity and light strength. Similarly, the author presents an urban CO_2 monitoring system[14]. It runs outside on 100 square kilograms in a metropolitan environment.

A low power ZigBee sensor network is suggested to track VOC emissions rates in indoor environments. An indoor and outdoor air quality monitoring system based on WSN is presented. A range of sensors in each node is either hardwired or wirelessly connected to the central control device [15]. A control program for air quality is introduced in real-time. The machine consists of seven sensors that control seven gasses.

3. Proposed System

The device can track the air rates of different substances including O_3, SO_2, CO and particulate matter through sensors. Read the Arduino microcontroller sensor detail. The data sent to the cloud system then access the cloud system through a WIFI module on Arduino. The effects of the tracking are available through a cloud Site page. The current model is implemented successfully and can be deployed for real system implementations. Figure 1 shows the design of the system. The sensor MQ-7 is used for reading CO concentrations in the soil. An analog sensor is MQ-7. The characteristics of the MQ7 gas sensor include a strong CO, reliable and long service life. This system uses 5V AC / DC heating power supply which uses 5VDC, distance calculation (20-2000 ppm) to test carbon monoxide gas. The analog pin on Arduino is connected in Figure 2 MQ-7. We use a gas sensor as an analog sensor for calculating ozone concentrations in the soil, to calibrate the Ozone levels. MQ-131 operates on a 5V (VCC) power supply attached to a microcontroller-connection VCC board.

The output voltage on a sensor would rise as the detector detects the gas in the environment, reducing the gas concentration and deoxidating. The importance of the O_3 gas concentrations is determined by the ratio of the sensor's resistance importance to the sensor's resistance when the air is clean.

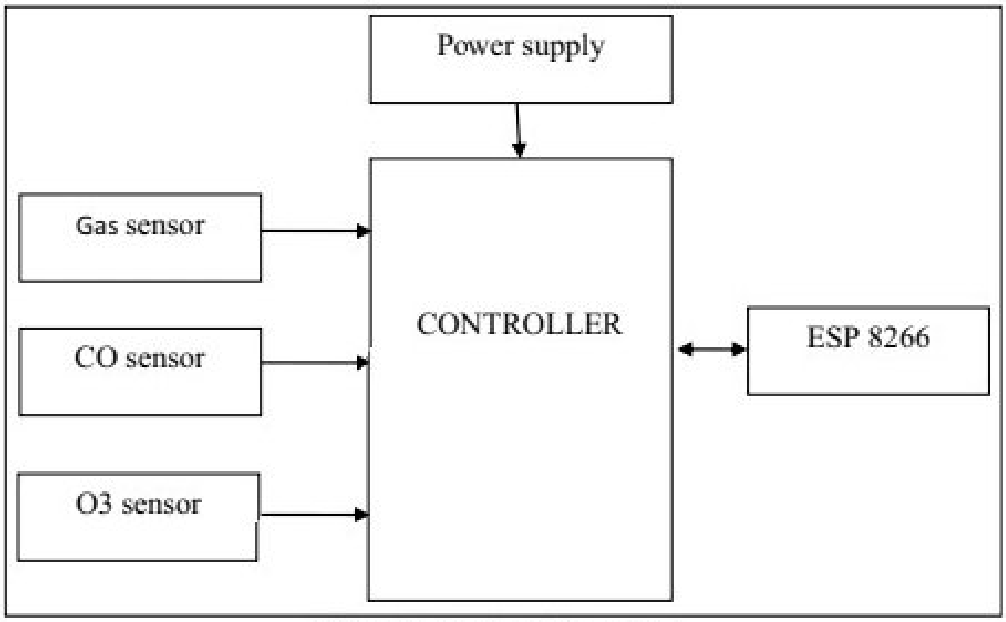


Figure 1: Design of the system

4. Results

A system test was carried out from the results of the design that was carried out. The test has been conducted on campus to monitor conditions of air quality on campus. Figure 2 shows the system results of the simulated prototype module.

Figure 2: Results in cloud page

A system test was carried out from the results of the design that was carried out. The test has been conducted on campus to monitor conditions of air quality on campus. Data on ozone rates and CO particles were derived from the test results for compounds in the air that were analyzed. Each one minute, the data is obtained in the cloud. One may access the webpages from the internet through the web pages of the channel monitoring.

There might be different objectives for the development of the environmental monitoring and surveillance system. Normally, the system will have to provide on-line data and information transfer with a direct /automatically/ on-line quality control of the collected data. Several monitors, sensors and data collection systems may be applied to make on-line data transfer and control possible [3].

The main objectives stated for the development of an air quality measurement and surveillance programme might be to:

– facilitate the background concentration(s) measurements,

– monitor current levels as a baseline for assessment,

– check the air quality relative to standards or limit values,

– detect the importance of individual sources,

– enable comparison of the air quality data from different areas and countries,

– collect data for the air quality management, traffic and land-use planning purposes,

– observe trends (related to emissions),

– develop abatement strategies,

– determine the exposure and assess the effects of air pollution on health, vegetation or building materials,

– inform the public about the air quality and raise the awareness,

– develop warning systems for the prevention of undesired air pollution episodes,

– facilitate the source apportionment and identification,

– supply data for research investigations,

– develop/validate management tools (such as models),

– develop and test analytical instruments and

– to support legislation in relation to the air quality limit values and guidelines.

The relationships between the data collected and the information to be derived from them must be taken into account when a monitoring programme is planned, executed and reported. This emphasizes the need for users and potential users of the data to be involved in planning surveys, not only to ensure that the surveys are appropriate to their needs but also to justify committing the resources.

SCREENING STUDIES AND OPERATIONAL SEQUENCE

Before a final programme design is presented it is also important to undertake a preliminary field investigation, often referred to as a screening study. This may consist of some simple inexpensive measurements (*e.g.* using passive samplers) and simple dispersion models. The data will give some information on the expected air pollution levels, high impacted areas and the general background air pollution in the area.

The number of monitoring stations and the indicators to be measured at each station in the final permanent network may then be decided upon as based on the results of the screening study as well as on the knowledge of the sources and prevailing winds.

Once the objective of air sampling is well-defined and some preliminary results of the screening study are available, a certain operational sequence has to be followed. The best possible definition of the air pollution problem, together with the analysis of the personnel, budget and equipment available, represent the basis for the decision on the following questions:

1. What spatial density of sampling stations is required?

2. How many sampling stations are needed?

3. Where should the stations be located?

4. What kind of equipment should be used?

5. How many samples are needed and during what period?

6. What should the sampling (averaging) time and frequency be?

7. What additional background information is needed?

– meteorology;

– topography;

– population density;

– emission sources and emission rates;

– effects and impacts.

8. What is the best way to obtain the data (configuration of sensors and stations)?

9. How will the data be accessible, communicated, processed and used?

The answers to these questions will vary according to the particular need in each case. Most of the questions will have to be addressed in the site studies and in the selection of sites as addressed below.

Site selection

The urban air quality monitoring programme will normally provide the information to support and facilitate the assessments of the air quality in a selected area and to meet the objectives as stated by the users. Some of the objectives have been presented above.

tion of health and the environment [2]. The first three are also given in the World Bank limit values for ambient air pollution. The World Health Organisation guideline values also include the above indicators [8,9].

Other elements in the design

In the design of the air quality monitoring programme we will also have to include the measurements of meteorology. Weather stations should be located in order to assess the general wind flow over the study area.

Weather stations do not need to be placed at all air quality sites, but some co-locations will decrease the total cost of these measurements.

Before the air quality data can be used to assess the situation in the area, it is important to assure that the data collected are real concentration values, which may be compared to similar information from other areas and countries. For each pollutant, which is measured as the input to the air quality assessment and evaluation, the following main questions may be asked:

– Have the suitable quality assurance procedures been set up for all stages and activities?

– Is technical advice available?

– Is monitoring being carried out at suitable locations?

– Have suitable arrangements for data handling and storage been made and implemented?

The documentation to support the credibility of data collection and the initial data quality assurance are the responsibility of the data provider. This includes the process of data collection, application of calibration factors, initial Quality Assurance procedures (QA/QC), data analysis, data "flagging", rollups (averaging) and reporting. A combination of data record notes, data quality flags and process documentation are all part of this first phase of processing. During the data collection phase, one role of the data provider is to assist in maintaining the process credibility and validity of the data. Good data quality is essential for adequate reporting of the air quality [10].

Data retrieval and storage

For every site there is a need for a data acquisition system (DAS) to receive the measurement values collected by one or several gas or dust analysers, meteorological sensors or other parameters. These parameters must be stored, every minute, every 5 min or every hour locally and then transmitted to a central computer *via* modem and telephone lines. The local storage time must be several days or up to some months in case of problems with the modem, transmission lines or the central computer. A typical dataflow from instruments to a user is shown in Figure 1.

The data retrieval from monitoring stations, which are equipped with modems and telephone lines, may be performed by the Computer centre using a variety of different ways. These may be:

– The Computer centre data base system asks for data automatically once a day (normally during night hours, at 02:00 hrs).

– The Computer centre operator initiates downloading (manually) which requires that the modem is functioning.

– Data are automatically retrieved from the station every hour or every five minutes into the central database.

Data may also be transferred to the central database through a wireless data service such as GPRS (General Pocket Radio Service).

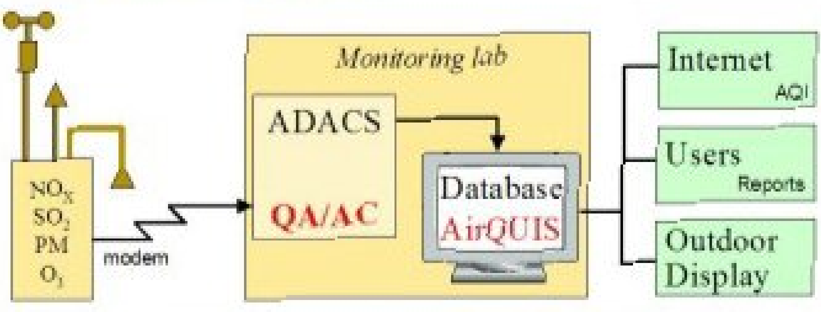


Figure 1. Dataflow from instruments and through the data retrieval system (ADACS) and database to different applications and users. The AirQUIS system was developed by NILU dealing with air pollution, information technology and geographical information systems (GIS). The combination of on-line data collection, statistical evaluations and numerical modeling enable the user to obtain the information, carry out forecasting and future planning of the air quality.

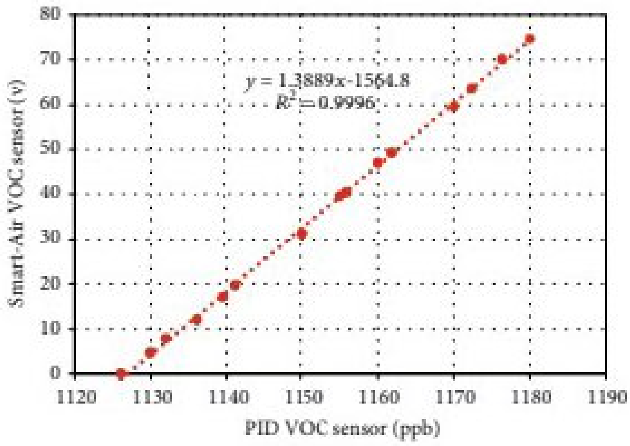


Figure 2: Calibration results of the VOC sensor.

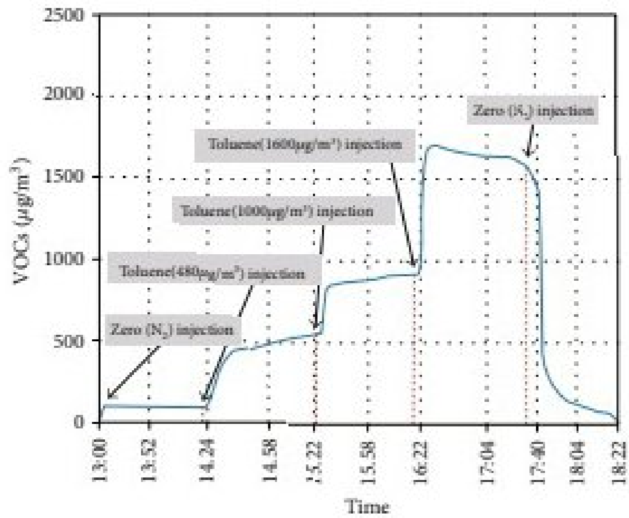


Figure 3: Reliability test results of the VOC sensor.

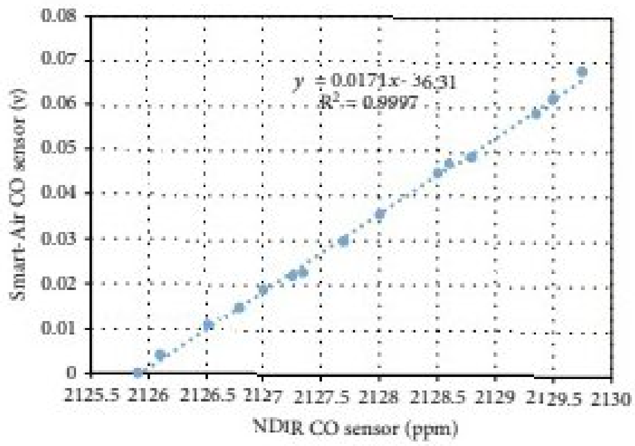


Figure 4: Calibration results of the CO sensor.

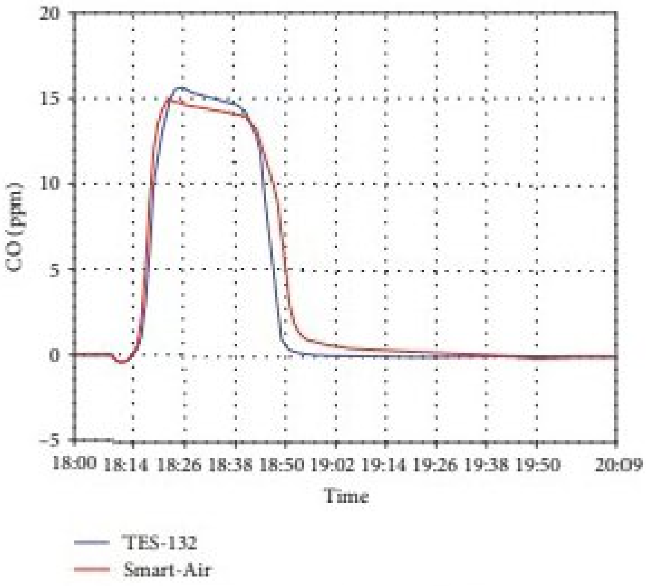


Figure 5: Reliability test results of the CO sensor.

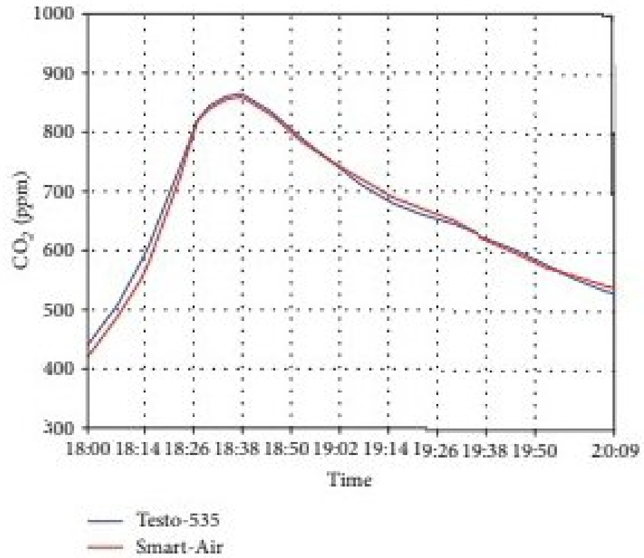


Figure 6: Reliability test results of the CO_2 sensor.

sensor can detect and present accurate readings in a short period of time. Thus, the device was suitable for monitoring indoor air quality.

2.9.3. CO Sensor. The CO sensor used in the study is also a semiconductor type, which is not the official standard CO sensor for indoor air quality measurements. TES-1372 from TES was used in the experiments for calibration and reliability testing because the Ministry recommended an NDIR-type measurement device. The same calibration method used for the VOC sensor was used for the CO sensor. A reliability test was performed after calibration. After the devices were placed in the sample chamber, incense (about 1-inch-long)

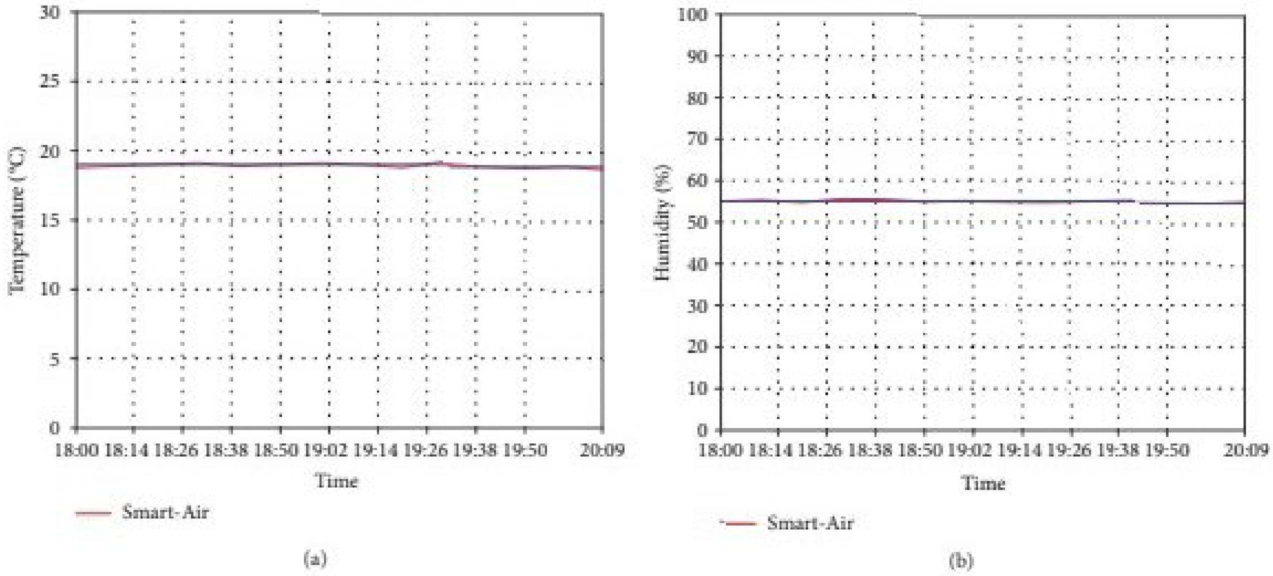


Figure 7: Reliability test results for (a) temperature and (b) humidity.

in a metal cup was placed inside and lighted. The CO sensor from Smart-Air and the NDIR-type device detected the increased concentration of CO associated with the combustion. The data collected from the two devices were compared to evaluate the accuracy of the CO sensor.

The CO sensor was calibrated with the same process used for the VOC sensor calibration. The Smart-Air and the TES-132, a certified device, were placed in the same chamber to measure the concentration of CO gas from the incense. Similar to the VOC sensor, the CO level increased as the voltage output signal increased. The linear conversion model for calibration of the CO sensor is presented in Figure 4.

After calibrating the CO sensor of Smart-Air, the device was placed in the chamber with TES-132 for reliability testing. The results of the reliability test for the CO sensor are provided in Figure 5. The data collected by the NDIR-type CO measurement device showed that the concentration of CO in the chamber dramatically increased with time after incense lighting, gradually decreased with completion of burning, and then dropped dramatically after loss of combustion. The data presented by the CO sensor were similar, indicating the efficacy of the CO sensor. If the device is to be used for a long period of time, periodic maintenance may be required to reduce the possibility of errors. As explained in the experimental method, the assessment of CO sensors followed the standard procedures performed and suggested by the Ministry of Environment, Korea. The contamination level detected from the sensor and certified device generally showed the same trends, supporting the high reliability of the sensor. However, further experiments are required to increase the accuracy of concentration measurement.

2.9.4. CO_2 Sensor. According to the Ministry of Environment, Korea, an NDIR-type sensor is used for verifying CO_2 measurement devices due to its high accuracy in detection

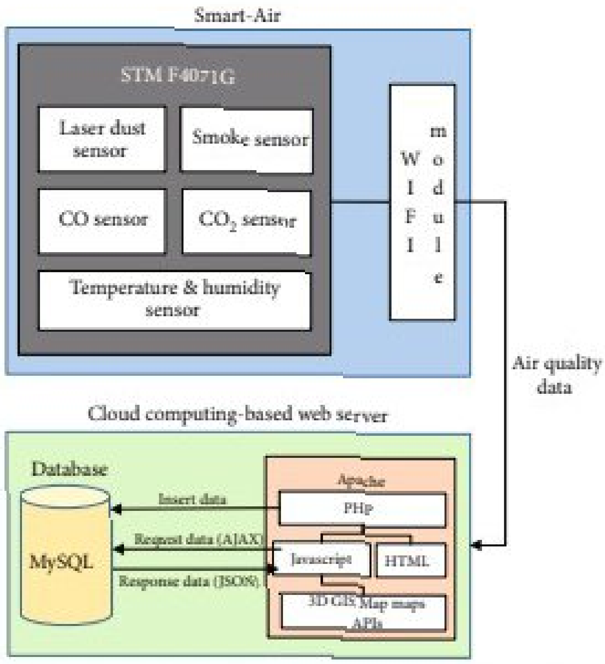


Figure 8: Configuration diagram for the IoT-based indoor air quality monitoring platform.

of CO_2. A CO_2 calibration is performed during sensor manufacturing and is not required for NDIR-type sensors after purchase. Furthermore, these sensors have high stability and do not deteriorate upon exposure to gases or experience sensor burnout. Since the sensor is precalibrated, only a reliability test was performed. A Testo-535, a commercial certified NDIR-type CO_2 measurement device, and the Smart-Air were placed in the temperature-humidity chamber to measure the concentration of CO_2. The reliability of the device was assessed by comparing its result to that of

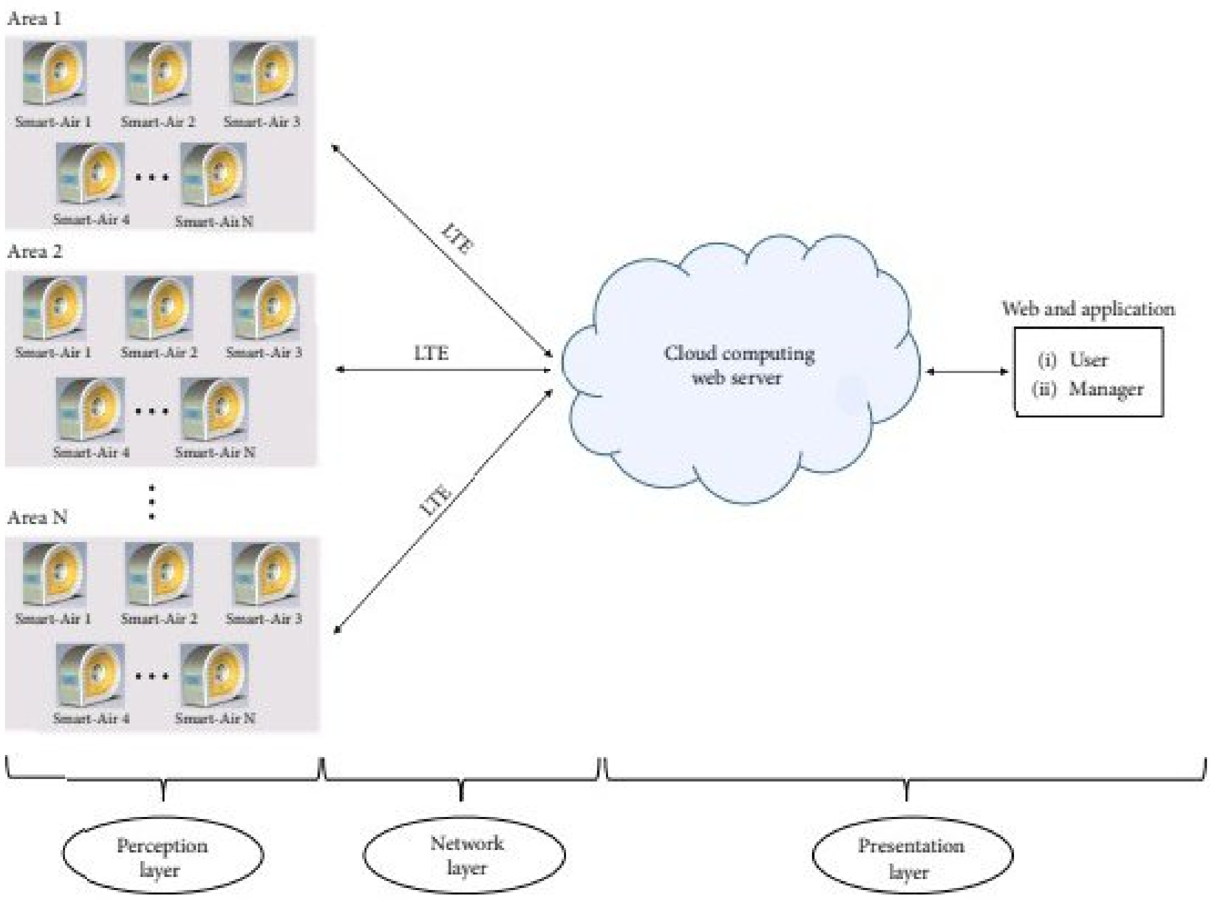


Figure 9: Block diagram of the IoT-based indoor air quality monitoring platform.

Testo-535. The experiment was conducted in the same manner as the method used for the CO sensor. About 1 inch of incense was lighted in a metal cup near the two devices placed in the chamber to sense the CO_2 concentration after incense lighting. The data presented by the two devices were compared to assess the reliability of the CO_2 sensor.

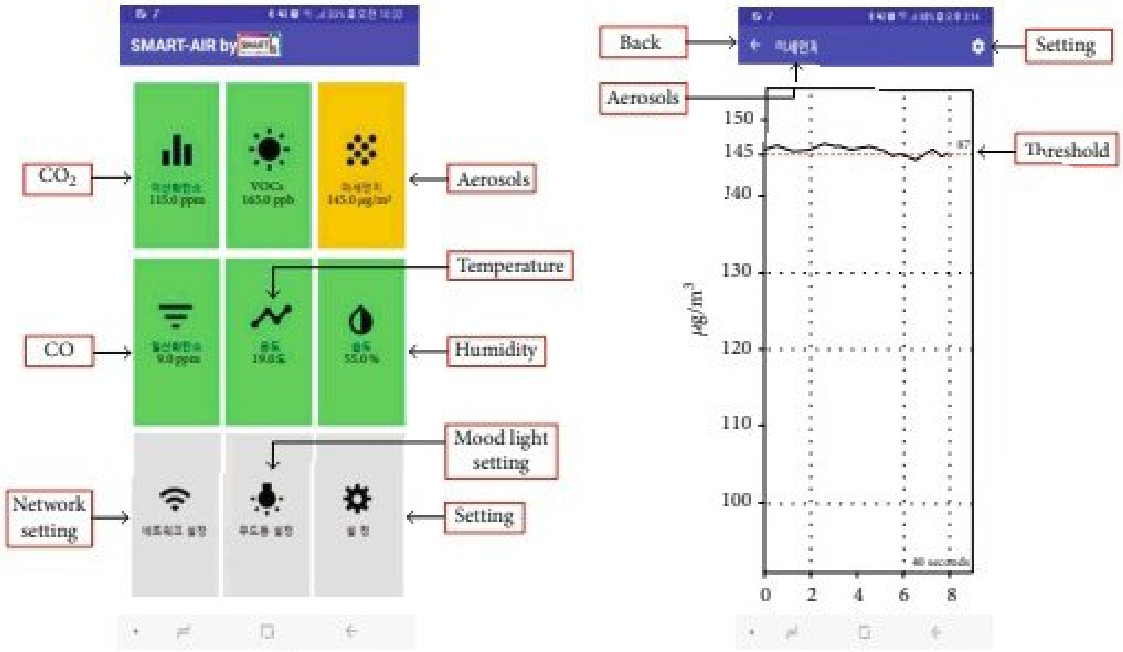
The CO_2 sensors from Smart Air and Testo-535 sensed an increase in CO_2 concentration after lighting until 18:38. As the incense burned, the CO_2 concentration gradually decreased. The two CO_2 sensors presented similar trends, indicating the high reliability of the device, as demonstrated in Figure 6. Therefore, the reliability of the sensor was verified through the experiment.

2.9.5. Temperature-Humidity Sensor. The temperature-humidity sensor was precalibrated in a factory instead of in a laboratory to produce greater accuracy and reliability. Although additional calibration of the sensor was not required, a reliability test was performed. Thus, Smart-Air was placed in the chamber for 2 hours with temperature and humidity set points of 19°C and 55%, respectively. The sensed temperature and humidity were compared to the initial set values for testing the accuracy of the sensor.

The chamber used in the experiment independently maintained specific humidity level and temperature of 19°C and 55%, respectively. The measurements of temperature and humidity from the sensor were observed using an application, and the data were extracted from the web server, as shown in Figures 7(a) and 7(b), respectively. The data collected by the sensor were compared to the initial set values of the chamber. Smart-Air presented measurements as accurate as the set values, verifying the high reliability of the sensor and showing that it did not need extra calibration.

3. An IoT-Based Indoor Air Quality Monitoring Platform

The IoT-based indoor air quality monitoring platform is primarily divided (Figure 8) into the Smart-Air and the web server. The set of sensing devices necessary to collect the data to analyze air quality comprised a laser dust sensor, a CO sensor, a CO_2 sensor, a VOC sensor, and a temperature and humidity sensor. Each device transmitted data to the web server via the LTE module to determine air quality and visualize the result. Furthermore, cloud computing technology was integrated with a web server. The main benefits of the cloud computing-based web server are faster speed, flexibility, and greater accessibility. The web server provided faster and more flexible data processing functions with a large amount of data, which is essential for a monitoring platform. The cloud computing-based web server is easily accessible



(a) (b)

Figure 13: The application of the IoT-based air quality monitoring platform: (a) main page and (b) a real-time graph of aerosol data.

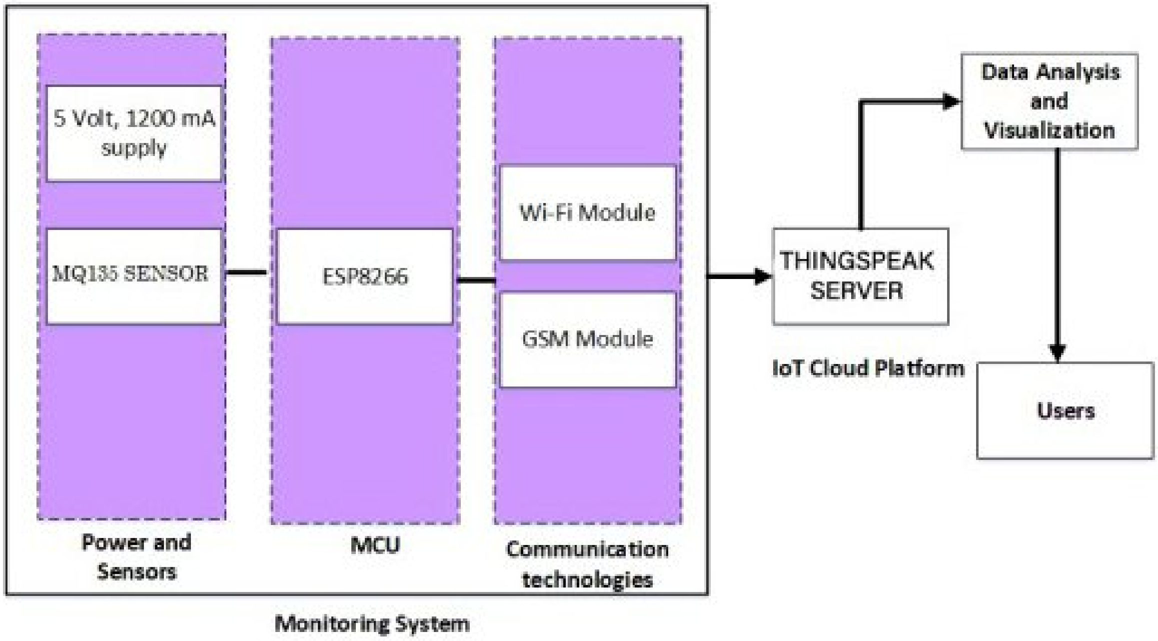
(a) (b)

Figure 14: (a) A pop-up message from the application when the condition of aerosol was moderate. (b) Smart-Air response when the condition was poor.

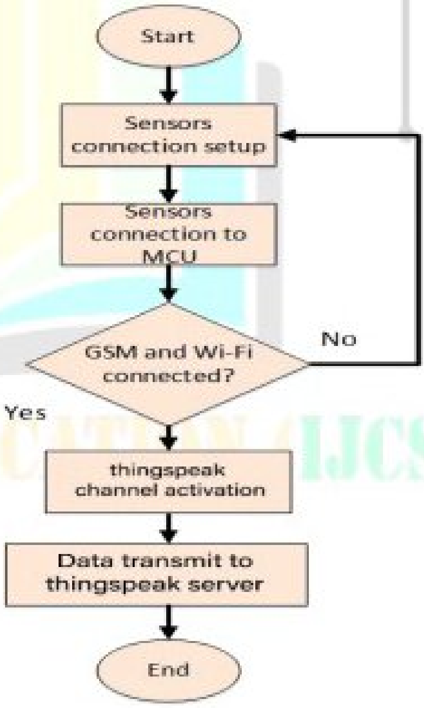
Smart-Air wirelessly transmitted the detected data to the web server, which successfully classified the condition of indoor air quality and displayed it via both the web and the application. Also, the data were saved in the database of the web server as designed such that further studies can be performed on trends of air quality. The experiment showed poor conditions in entrances of the building because it is exposed to outside air more than other locations. However, the platform successfully alerted and visualized poor air quality, as shown in Figure 14. The device changed the LED light color to match the current condition and alerted the manager via a pop-up message as shown in Figure 14(a). Also, LED lights installed in the device successfully displayed the condition especially when the air quality was poor as shown in Figure 14(b). Thus, the manager of the building was able to monitor the air quality of the building ubiquitously and take steps to improve the air quality.

Considering the nature of the platform, it is important to perform qualitative analysis based on user experience. In the experiment, interviews were conducted with building managers who used the platform to manage air quality. Interviewees were very satisfied with its ability to monitor air

2.3 BLOCK DIAGRAM FOR THE WORKING MODEL OF THE SYSTEM



2.4 WORKING PROCESS



It describes the functionality of the system. Firstly, the power supply at 5 V with 1200 mA is required to initialize the system. It ensures the connected sensor in active mode, so that the data from the sensors can be sent to the NodeMCU ESP8266 microcontroller. All the data from sensors being forwarded to Thingspeak server over a GSM and Wi-Fi network. ThingSpeak is an open-source Internet of Things application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network. When the communication network connection cannot be detected, the process is repeated starting from the sensor placement inspection until the communication network connection problem is resolved. Then, the collected data are analyzed and employed on data visualization to receive information updates of the air quality conditions. Finally, the information results are sent through Wi-Fi for detailed monitoring by the end-users.

data visualization.

CIRCUIT DESIGN

The sensors selected for the system were the MQ 135 gas sensor for volatile organic compounds (VOCs) and the MQ 3 gas sensor for alcohol. The sensors were calibrated by exposing them to known levels of pollutants and adjusting the readings to match the expected values. The hardware design also consisted of an ESP8266, Wi-Fi module, MQ 135, MQ 3 gas sensors, an Arduino microcontroller, and a power source.

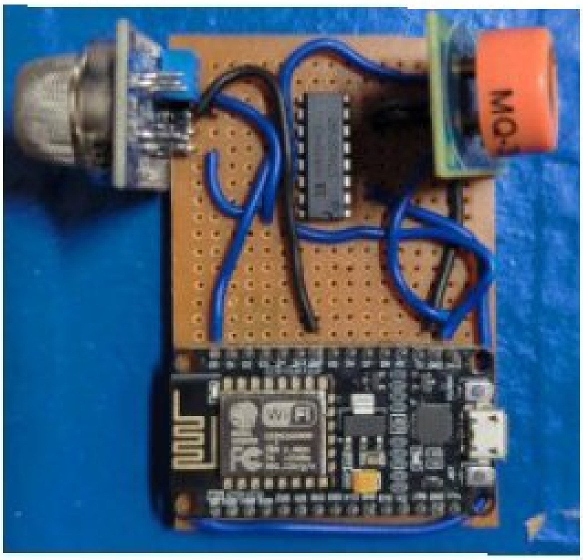


Figure 2: Circuit Design

The sensors were connected to the microcontroller, and the ESP8266 was used to establish a Wi-Fi connection for data transmission. The software development involved programming the microcontroller using Arduino IDE.

The code was designed to read data from the sensors, process it, and transmit it wirelessly to a cloud-based server. The system collects and stores data from the sensors at regular intervals. The collected data were analyzed using machine learning algorithms to predict future pollution levels.

ALGORITHM

The below algorithm is followed to collect data from the sensors.

1. Define the Blynk credentials, WiFi credentials, and other variables required for the code.

2. Setup the serial communication and the Blynk connection using Blynk.begin().

3. Set up the timer to run a function to send data to ThingSpeak every second.

4. Connect to the WiFi network using WiFi.begin() and wait until the connection is established.

5. Define the changeMUX function and set the MUX_A pin as output.

6. In the loop, run the Blynk and timer functions, and read the sensor data from the analog pin A0.

7. Calculate the sensor value 1 (ppm (parts per million)) value for the sensor data using a formula.

8. Read the sensor data from A0 for a total of six times, and take the average of these readings to get the

sensor value 0.

9. Change the MUX_A pin to HIGH, and read the sensor data from A0 for another six times, and take the average of these readings to get the sensor value 1.

10. Connect to ThingSpeak using the WiFiClient object.

11. Build the request string with the ThingSpeak API key and field values (sensorValue0 and sensorValue1) and send the GET request using the HTTPClient object.

12. Delay for a second before running the loop again.

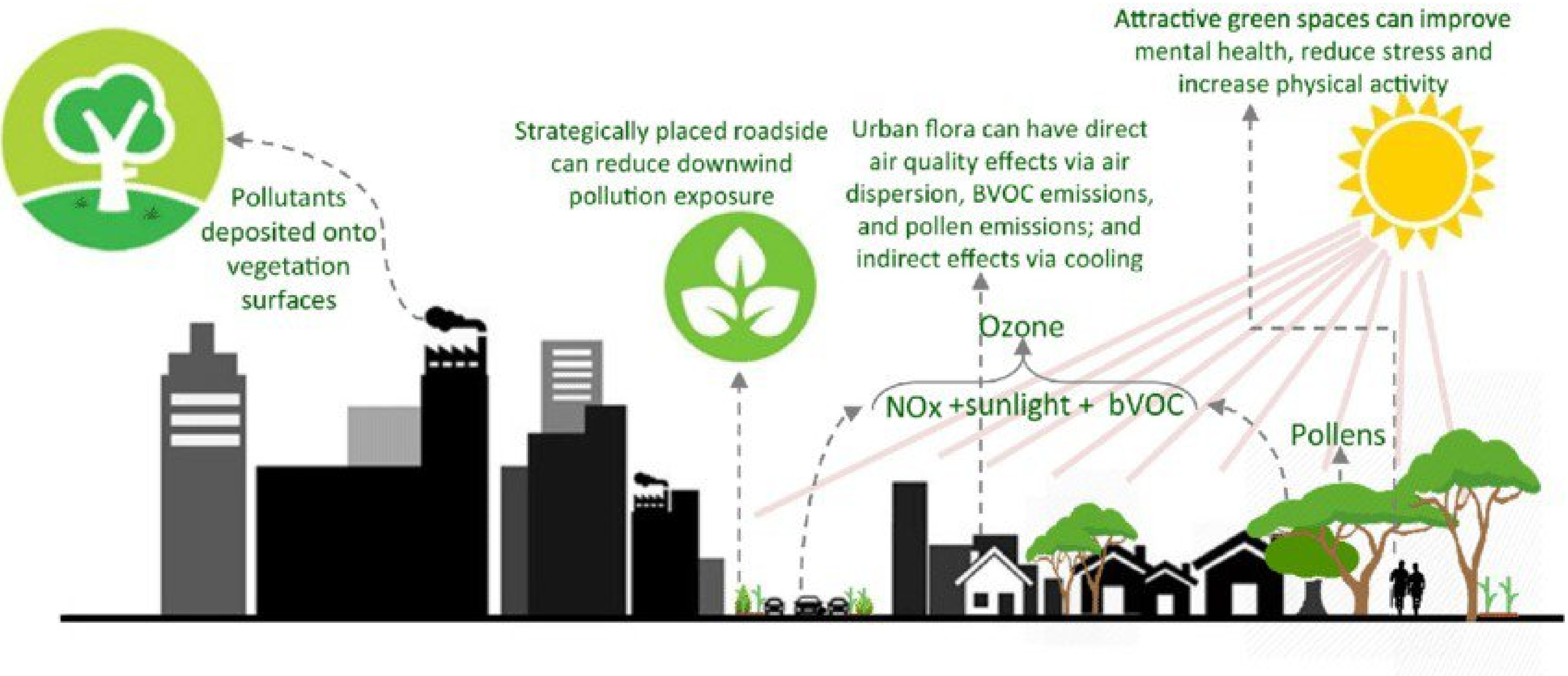
13. Define the function to be called by the timer to send data to ThinkSpeak.

14. Change the MUX_A pin to LOW and read the sensor data from A0.

15. Calculate the ppm value for the sensor data using a formula.

16. Change the MUX_A pin to HIGH and read the sensor data from A0 for a total of six times, and take the average of these readings to get the sensor value 2.

17. Write the sensor value 1 and sensor value 2 to virtual pins V 1 and V 2 respectively using Blynk.virtualWrite().


Attractive green spaces can improve mental health, reduce stress and increase physical activity
Strategically placed roadside can reduce downwind pollution exposure
Urban flora can have direct air quality effects via air dispersion, BVOC emissions, and pollen emissions; and indirect effects via cooling
Pollutants deposited onto vegetation surfaces
Ozone
NOx +sunlight + bVOC
Pollens

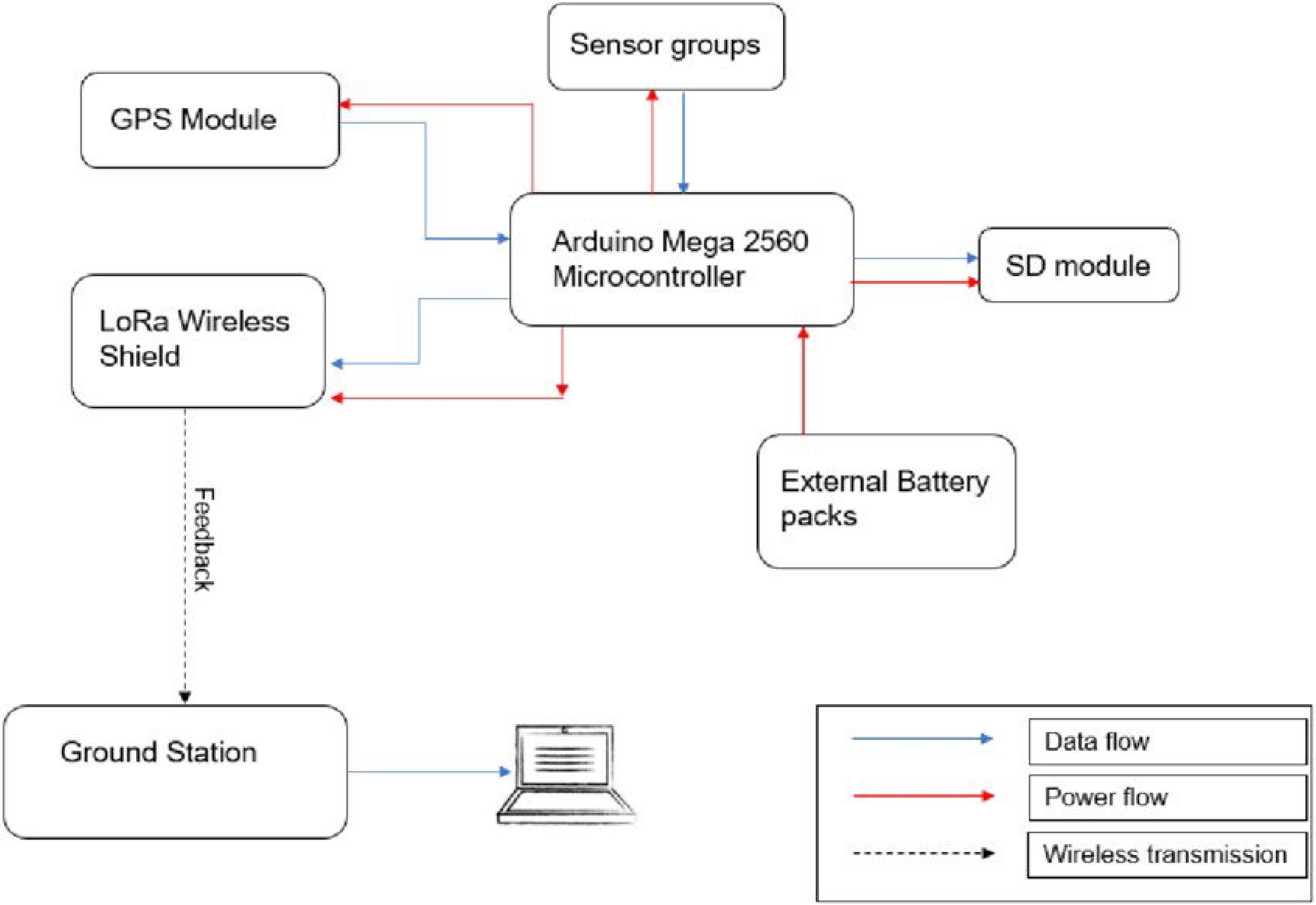
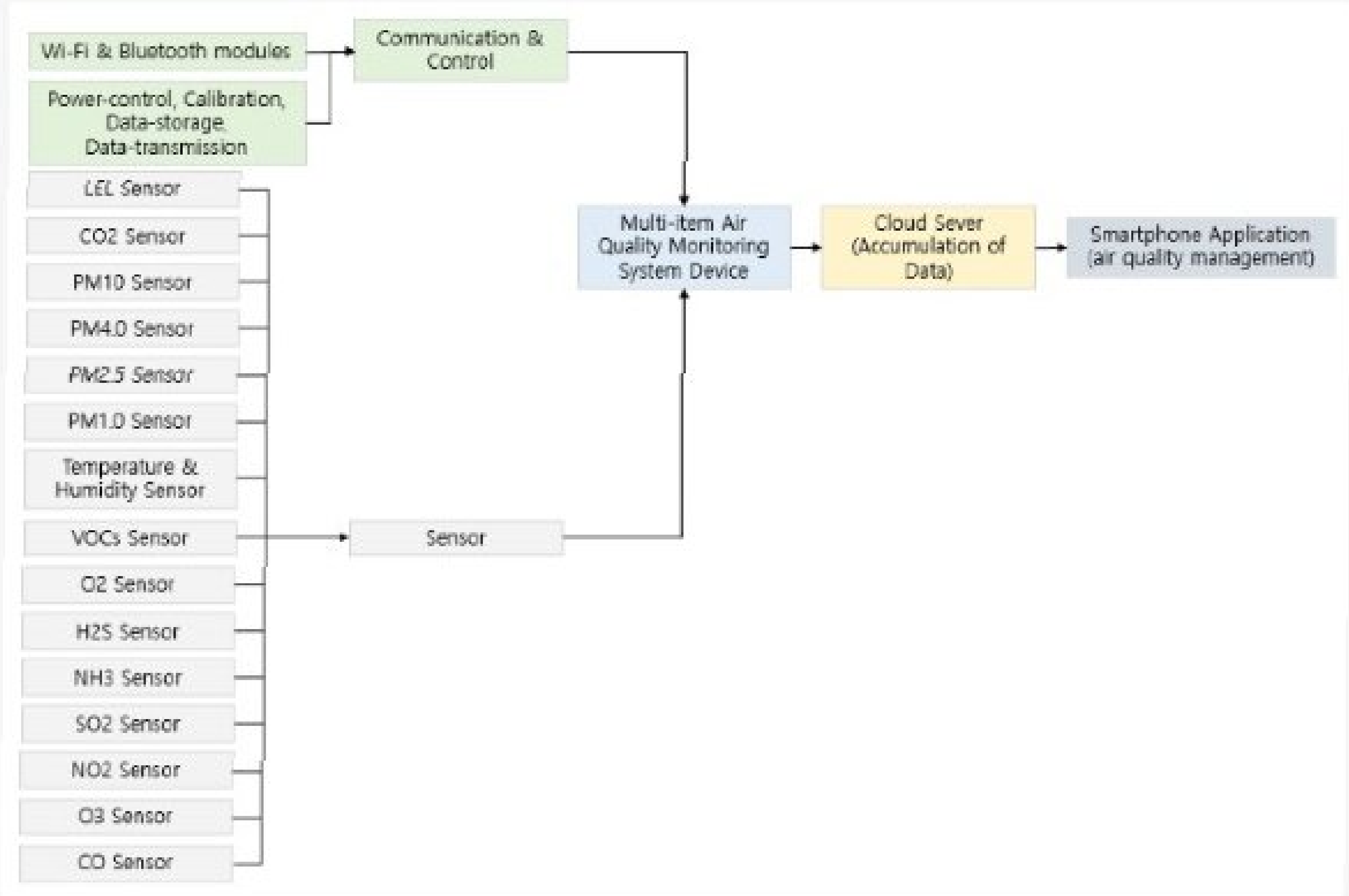
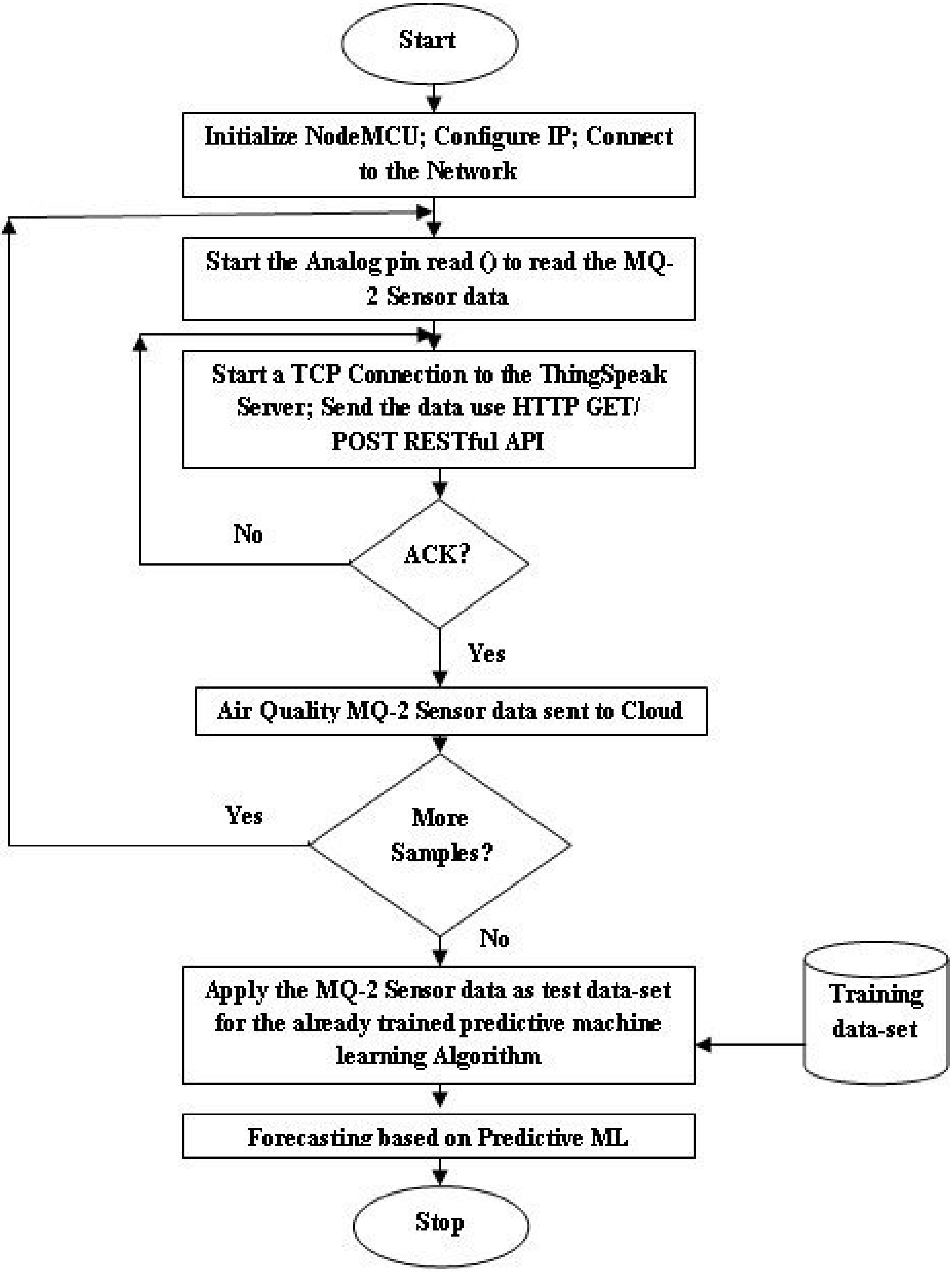
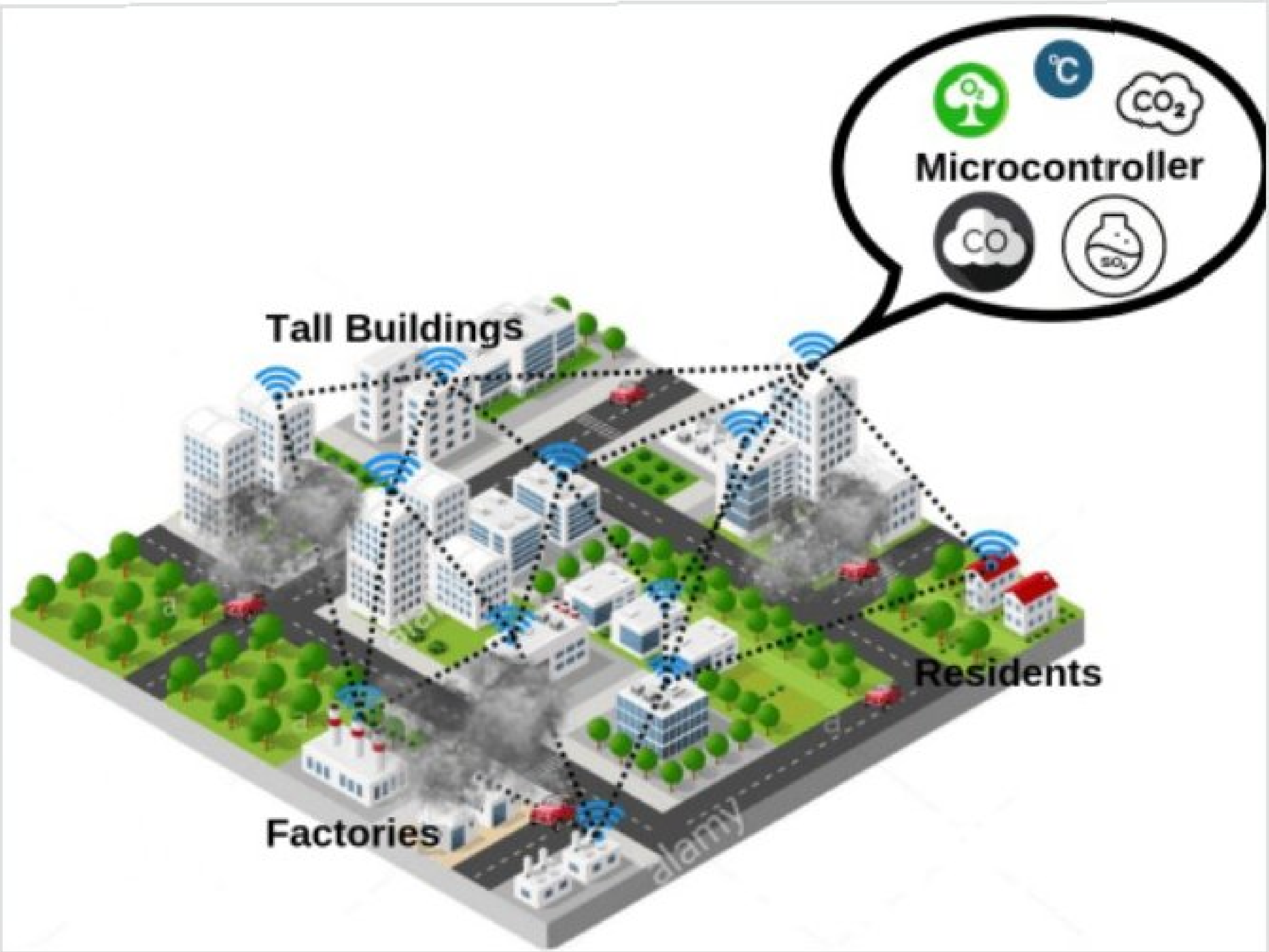

Sensor groups
GPS Module
Arduino Mega 2560
Microcontroller
SD module
LoRa Wireless
Shield
External Battery
packs
Feedback
Ground Station
Data flow
Power flow
Wireless transmission

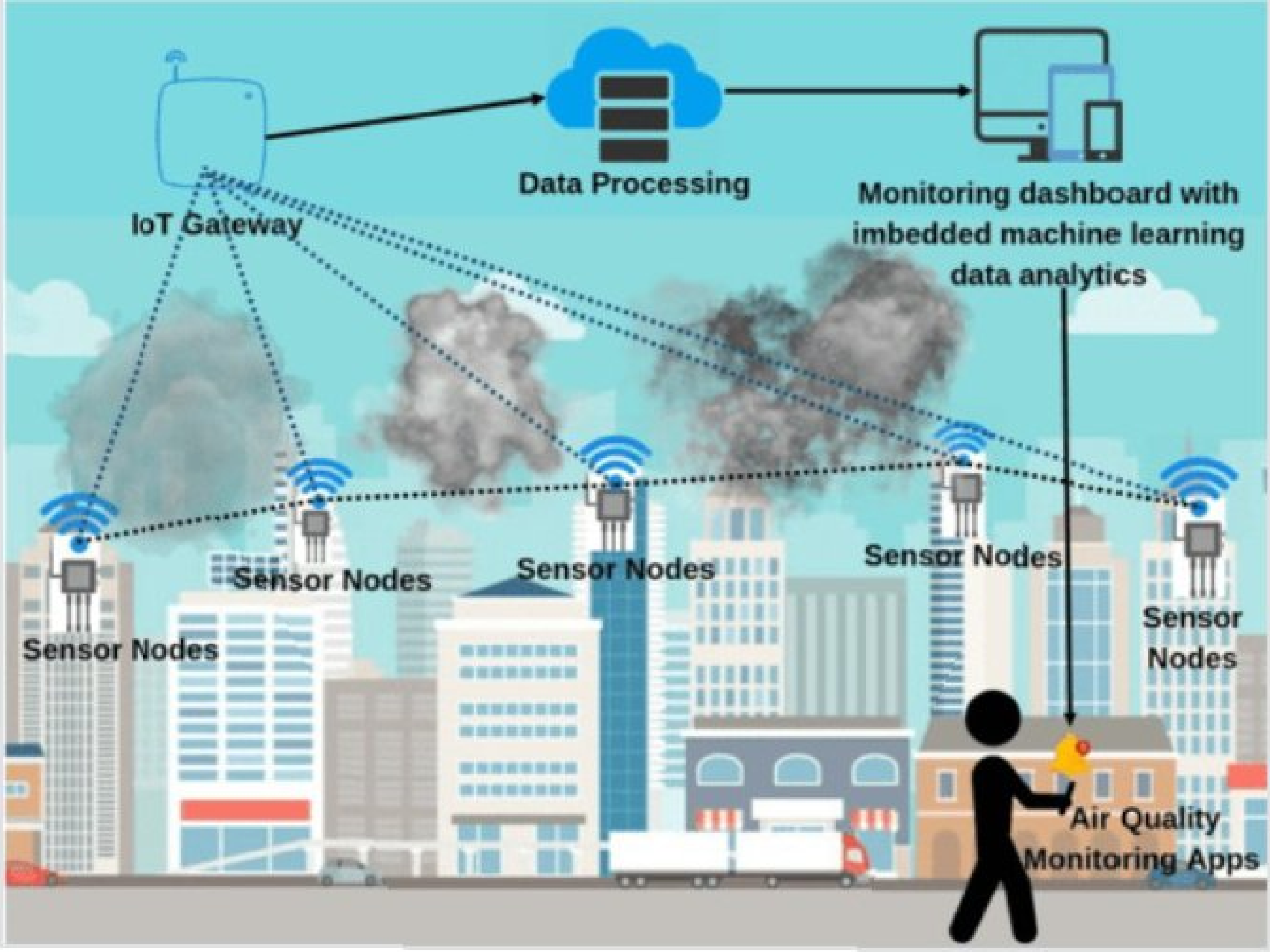
Figure 1. Schematic diagram of multi-item air quality monitoring system.





Start
Initialize NodeMCU; Configure IP; Connect to the Network
Start the Analog pin read () to read the MQ-2 Sensor data
Start a TCP Connection to the ThingSpeak Server; Send the data use HTTP GET/ POST RESTful API
No
ACK?
Yes
Air Quality MQ-2 Sensor data sent to Cloud
Yes
More Samples?
No
Apply the MQ-2 Sensor data as test data-set for the already trained predictive machine learning Algorithm
Training data-set
Forecasting based on Predictive ML
Stop


Microcontroller
°C
CO₂
CO
Tall Buildings
Residents
Factories


IoT Gateway
Data Processing
Monitoring dashboard with imbedded machine learning data analytics
Sensor Nodes
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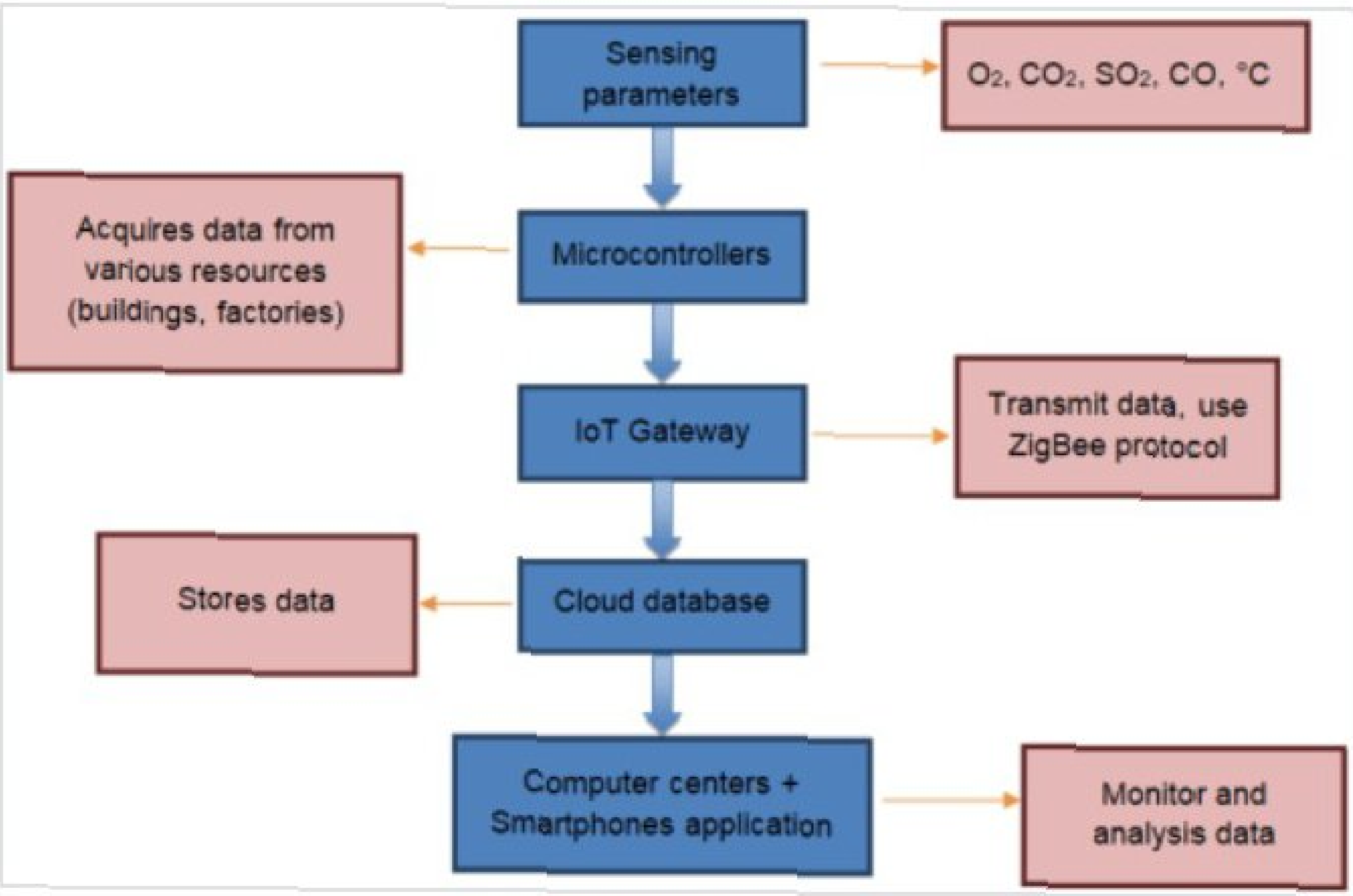
Air Quality Monitoring Apps


Sensing parameters
O2, CO2, SO2, CO, °C
Microcontrollers
Acquires data from various resources (buildings, factories)
IoT Gateway
Transmit data, use ZigBee protocol
Cloud database
Stores data
Computer centers + Smartphones application
Monitor and analysis data

STEP 1: Bill of Materials

Things you would need:

Nodemcu 1.0 ESP8266

MQ2 gas sensor

MQ9 gas sensor

PMS3003 G3 particle sensor

3.3V to 5V boost converter

180ohm resistor x2 and 330 ohm resistor x2

Analog Multiplexer 4051 (CD4051BE)

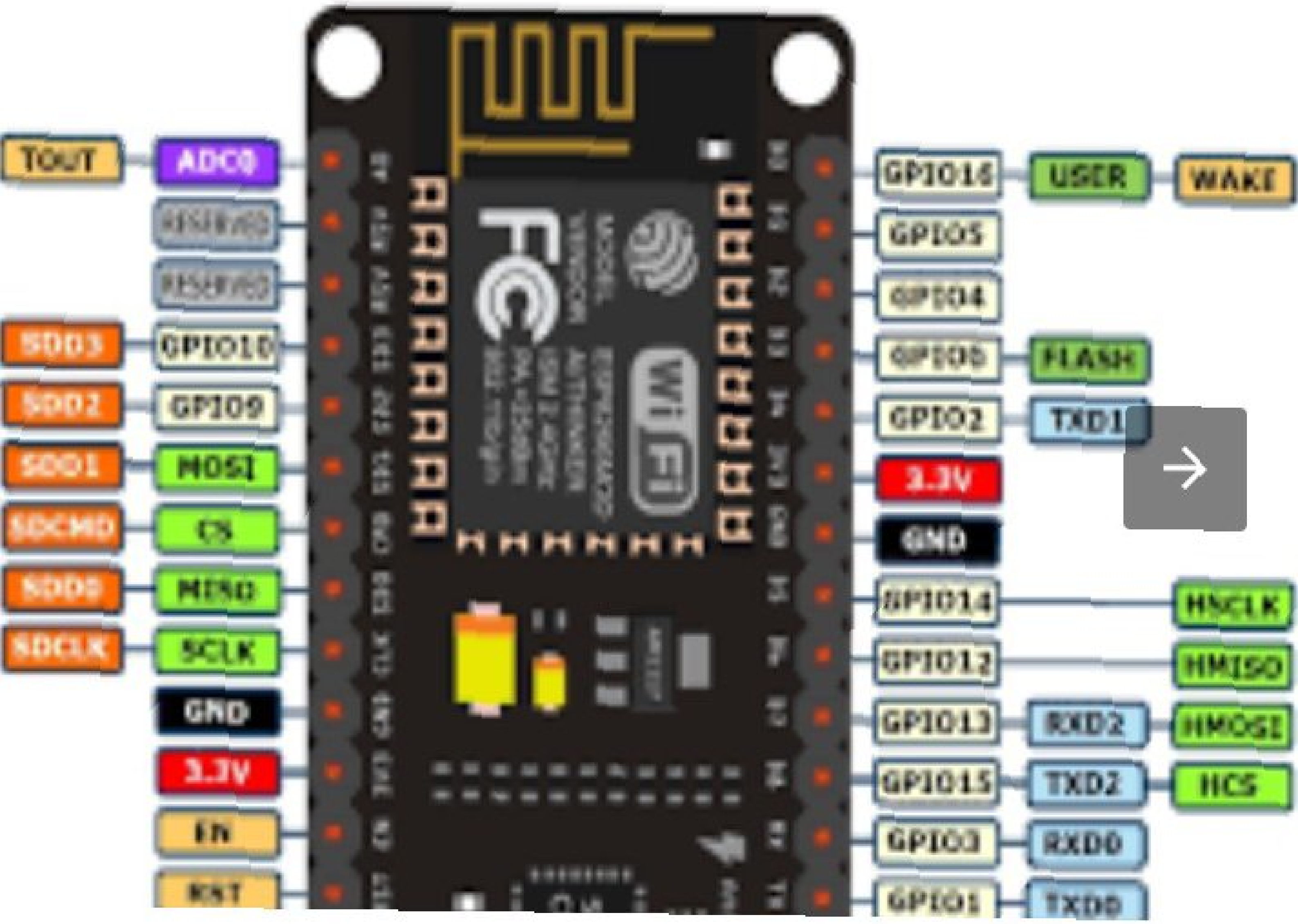
1.3 inches OLED monitor SSD1306

7.4V Li-ion battery

Li-ion battery Charger Board

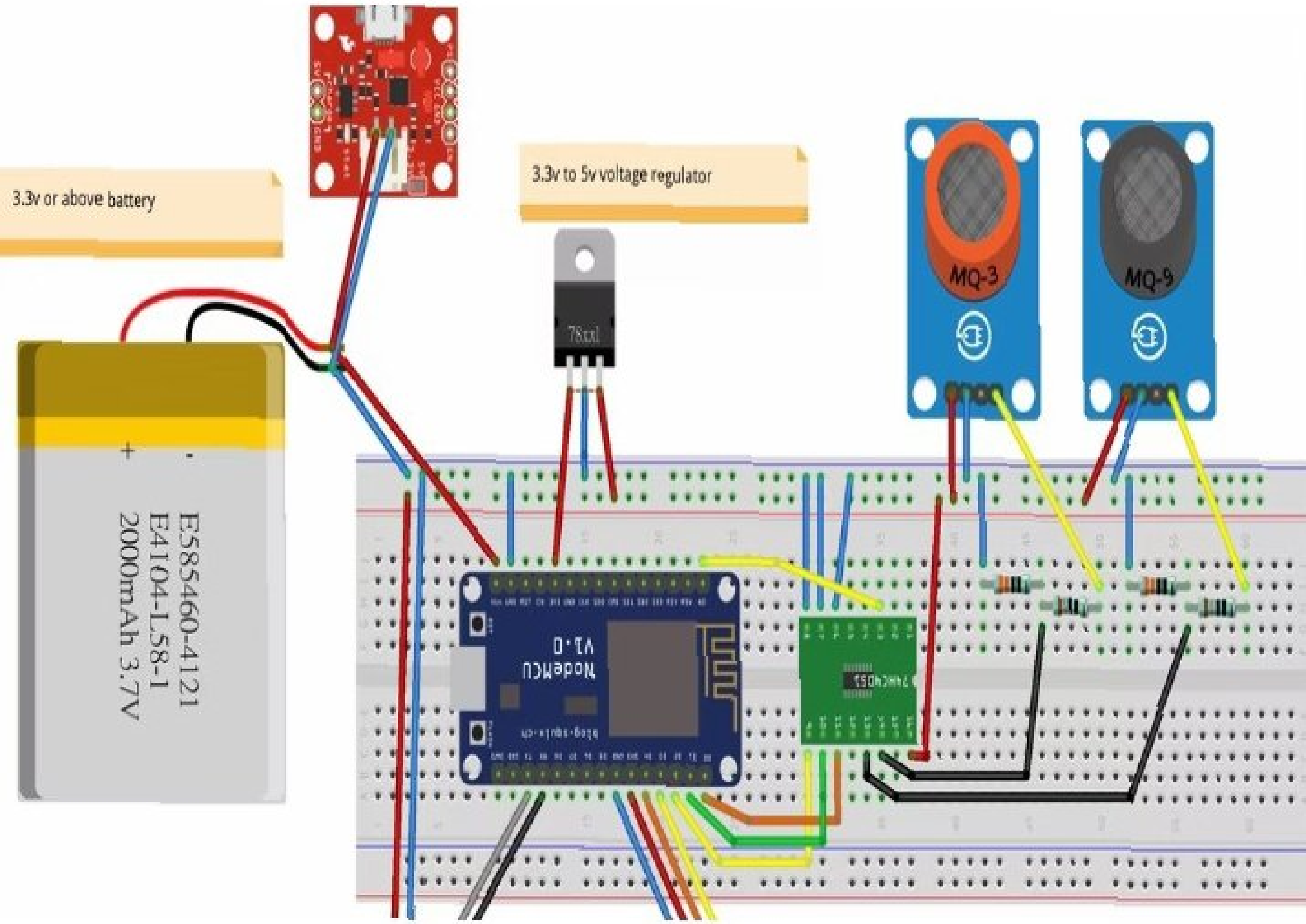
Breadboard

STEP 2: Nodemcu 1.0 ESP8266



Nodemcu 1.0 ESP8266 is a very good micocontroller for developing IoT project because it has an inbuilt WiFi function by ESP8266 chip. It provides easy and very stable connection to the internet.

STEP 3: Connection



The above is the connection of all different components.

STEP 4: Step 3: Connecting MQ2 and MQ9 Gas Sensor

MQ2 and MQ9 gas sensor both have four pins:

VCC

GND

DO (Digital Control)

AO (Analog Output)

The analog output of MQ2 and MQ9 is between 0V to 5V whereas the analog pin of nodemcu can only read between 0V to 3.3V. That means nodemcu cannot read the data if MQ2 or MQ9 sensor output is above 3.3V. The data read is not accurate. Therefore, voltage is needed step down.

In this project, voltage divider by two resistors is used. The voltage output is determined by the ratio of the value of two resistors. I use 180ohm as R1 and 330ohm as R2 so that Vout is 3.3V.

So, Vin is connected to AO pin of MQ gas sensors. Vout is connected to channels of the multiplexer.

Only three pins of each sensor are used:

Vcc to 5V supply
GND to nodemcu GND pin
Vout of voltage divider to CD4051BE channel 1 and channel 2(pin14 and 15)

Multiplexer connection:

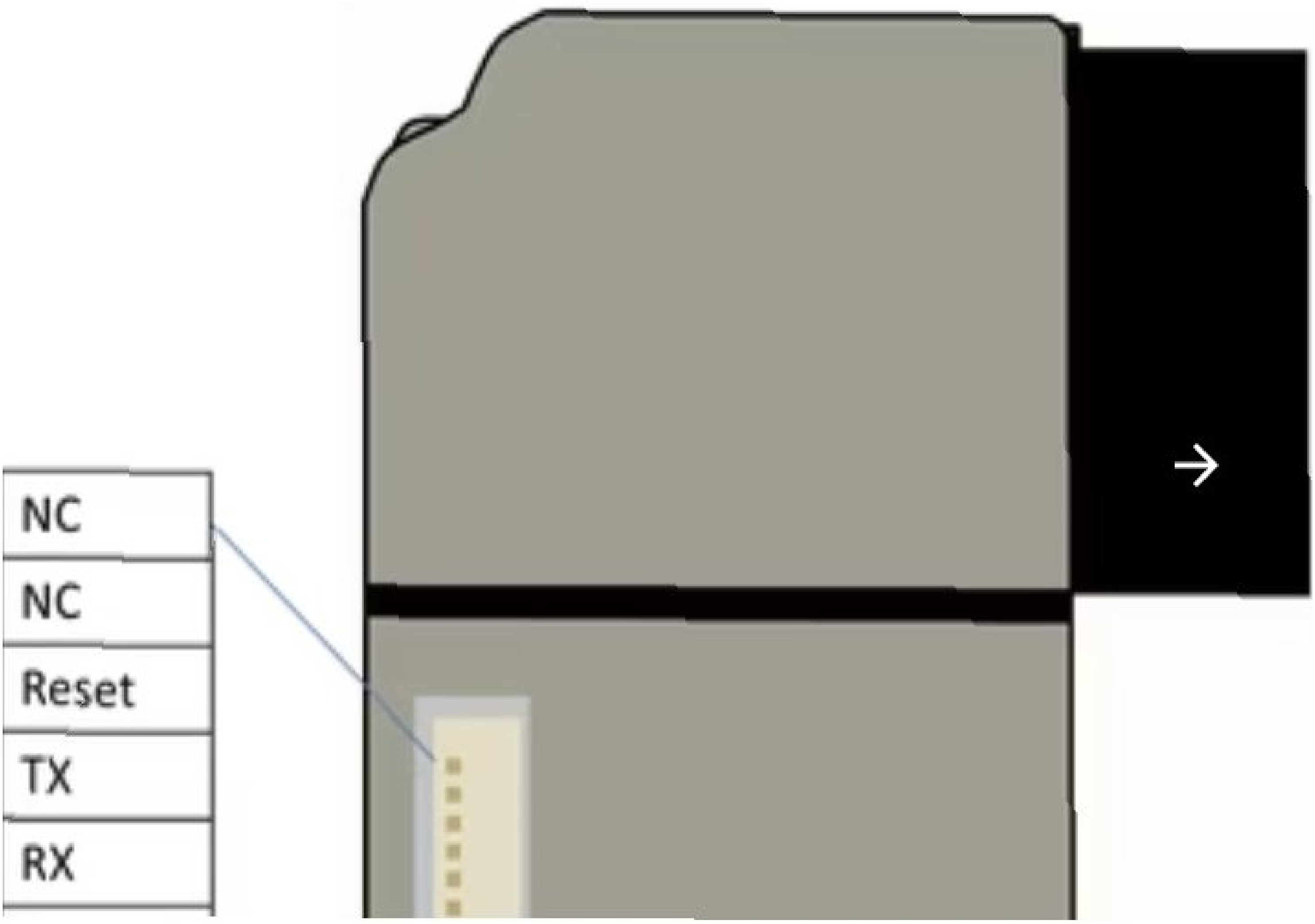
Vdd (pin 16) to 5V supply
INH, Vee, Vss (pin 6, 7, 8) to nodemcu GND pin
common out/in (pin 3) to nodemcu A0 pin
A, B, C (pin 11, 10, 9) to nodemcu D0, D1, D2

A, B, C (pin11, 10, 9) are used to select channel for output.

A, B, C are digital input which means only read 0 and 1.

3-digit binary number is formed in the order of CBA.

STEP 5: Connecting PMS3003 Sensor



PMS3003 has 8 pins for different purposes. In fact, only 4 pins is used in this project:

VCC (pin 1) to 5V supply

GND (pin 2) to nodemcu GND pin

RXD (pin 4) to nodemcu tx pin

TXD (pin 5) to nodemcu rx pin

STEP 6: Connecting 1.3 Inches OLED Displag SSD1306

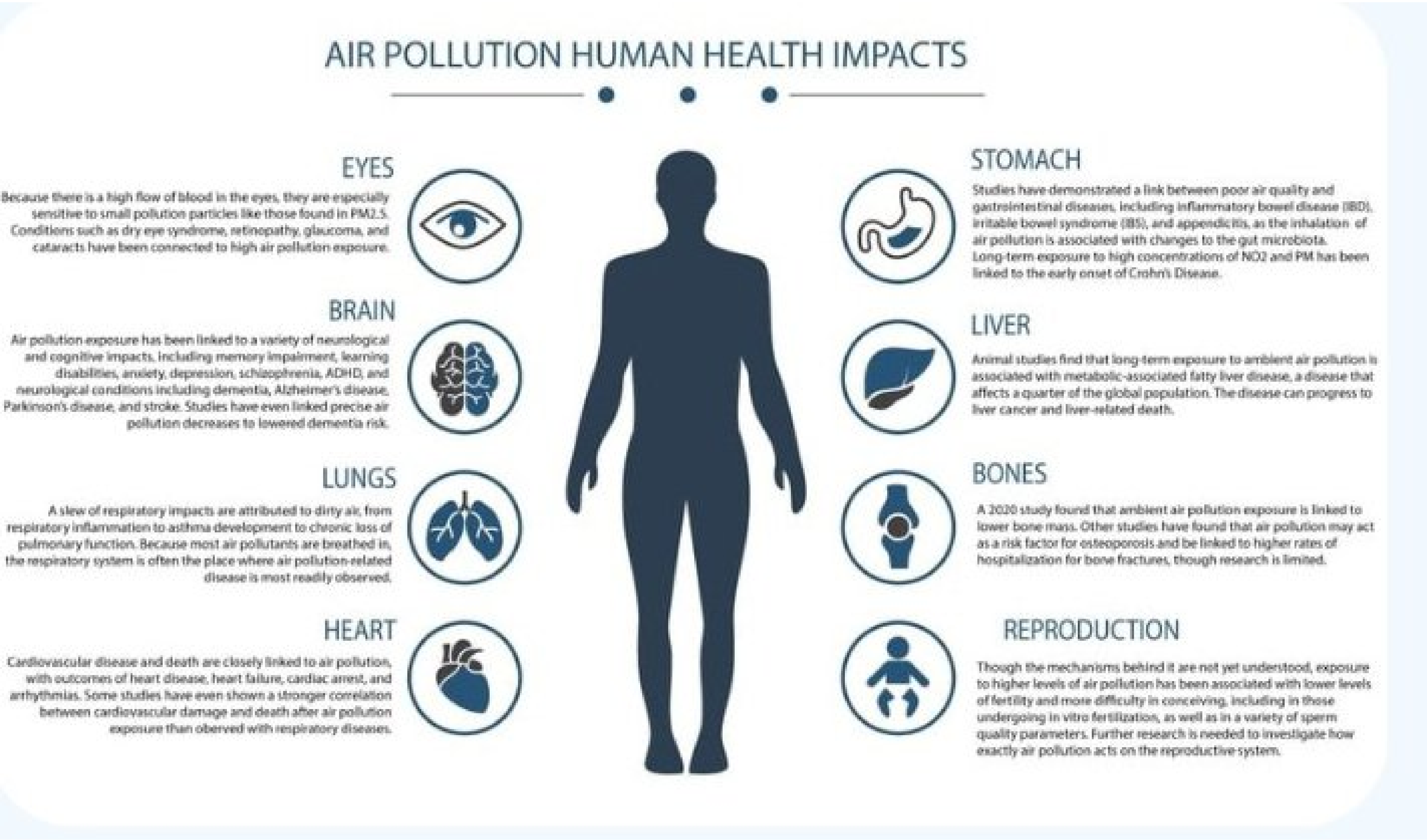
It has 4 four pins. Connection:

VCC to 3.3V pin of nodemcu

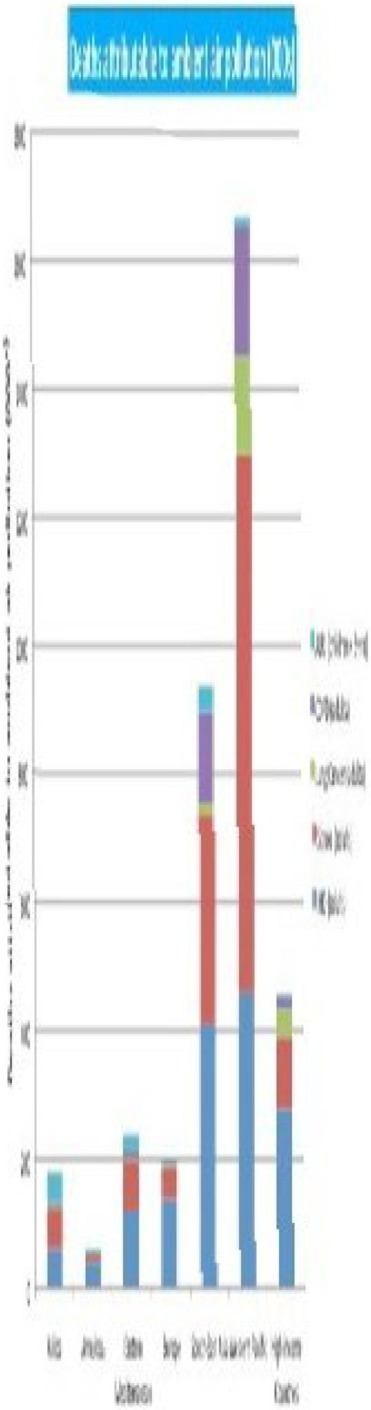
GND to GND pin of nodemcu

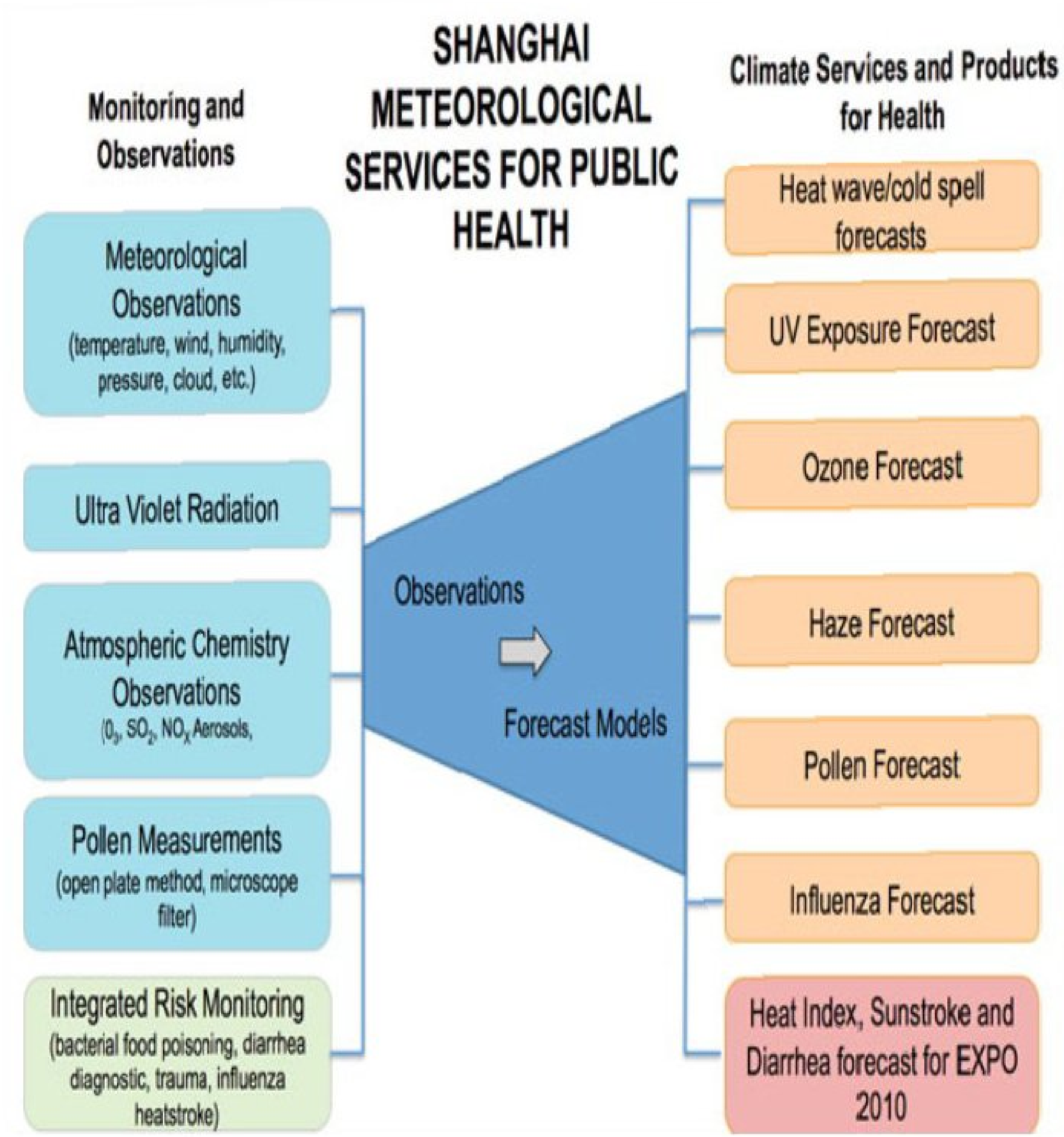
SCL to D3 pin of nodemcu

SCA to D4 pin of nodemcu


AIR POLLUTION HUMAN HEALTH IMPACTS
EYES
Because there is a high flow of blood in the eyes, they are especially sensitive to small pollution particles like those found in PM2.5. Conditions such as dry eye syndrome, retinopathy, glaucoma, and cataracts have been connected to high air pollution exposure.
BRAIN
Air pollution exposure has been linked to a variety of neurological and cognitive impacts, including memory impairment, learning disabilities, anxiety, depression, schizophrenia, ADHD, and neurological conditions including dementia, Alzheimer's disease, Parkinson's disease, and stroke. Studies have even linked precise air pollution decreases to lowered dementia risk.
LUNGS
A slew of respiratory impacts are attributed to dirty air, from respiratory inflammation to asthma development to chronic loss of pulmonary function. Because most air pollutants are breathed in, the respiratory system is often the place where air pollution-related disease is most readily observed.
HEART
Cardiovascular disease and death are closely linked to air pollution, with outcomes of heart disease, heart failure, cardiac arrest, and arrhythmias. Some studies have even shown a stronger correlation between cardiovascular damage and death after air pollution exposure than oberved with respiratory diseases.
STOMACH
Studies have demonstrated a link between poor air quality and gastrointestinal diseases, including inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), and appendicitis, as the inhalation of air pollution is associated with changes to the gut microbiota. Long-term exposure to high concentrations of NO2 and PM has been linked to the early onset of Crohn's Disease.
LIVER
Animal studies find that long-term exposure to ambient air pollution is associated with metabolic-associated fatty liver disease, a disease that affects a quarter of the global population. The disease can progress to liver cancer and liver-related death.
BONES
A 2020 study found that ambient air pollution exposure is linked to lower bone mass. Other studies have found that air pollution may act as a risk factor for osteoporosis and be linked to higher rates of hospitalization for bone fractures, though research is limited.
REPRODUCTION
Though the mechanisms behind it are not yet understood, exposure to higher levels of air pollution has been associated with lower levels of fertility and more difficulty in conceiving, including in those undergoing in vitro fertilization, as well as in a variety of sperm quality parameters. Further research is needed to investigate how exactly air pollution acts on the reproductive system.

Deaths attributable to ambient air pollutuion in 2012 (000s)




SHANGHAI METEOROLOGICAL SERVICES FOR PUBLIC HEALTH
Monitoring and Observations
Meteorological Observations (temperature, wind, humidity, pressure, cloud, etc.)
Ultra Violet Radiation
Atmospheric Chemistry Observations (O_3, SO_2, NO_X Aerosols,
Pollen Measurements (open plate method, microscope filter)
Integrated Risk Monitoring (bacterial food poisoning, diarrhea diagnostic, trauma, influenza heatstroke)
Observations
Forecast Models
Climate Services and Products for Health
Heat wave/cold spell forecasts
UV Exposure Forecast
Ozone Forecast
Haze Forecast
Pollen Forecast
Influenza Forecast
Heat Index, Sunstroke and Diarrhea forecast for EXPO 2010

THANK YOU