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Arduino and Sensor Based Air Pollution Monitoring System Using IOT

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Abstract - *Internet of Things (IoT) may be a worldwide system of "smart devices" which will sense and connect with their surroundings and interact with users and other systems. Global pollution is one among the main concerns of our era. Existing monitoring systems have inferior precision, low sensitivity, and need laboratory analysis. Therefore, improved monitoring systems are needed. To overcome the issues of existing systems, we propose a three-phase pollution monitoring system. An IoT kit was prepared using some sensors, Arduino IDE (Integrated Development Environment), and a Wi-Fi module. These kits are often physically placed in various cities to monitoring pollution. The sensors gather data from air and forward the data to the Arduino IDE. The Arduino IDE transmits the info to the cloud via the Wi-Fi module. It can be monitored from android mobile phone also. The proposed system is predict quality of air using different sensors and stored data in database and cloud so any one can retrieve data from anywhere anytime. Furthermore, air quality data are often wont to predict future air quality index (AQI) levels.*

Key Words: **AQI, IDE, IoT, PM, Arduino.**

1. INTRODUCTION

Nowadays the air condition is much polluted. In recent years, car emissions, chemicals from factories, smoke and dust are everywhere. That is the reason why now air condition is much polluted. The effect of air pollution is very bad for our health, especially for place where the air in our body is taken for breathing. In our lungs may cause some diseases, such as asthma, cough, and lung disorders [18].

Air contamination has been a gigantic worry in nowadays. It became necessary to monitor air pollution and to keep it well within the limits for a better future and healthy living. Air contaminations cause different medical problems. Among this, CO, which is a result of fragmented ignition of fills, is the significant benefactor. A vehicular fume is a significant wellspring of CO. The wellbeing risk because of steady presentation to CO is generally genuine, for the individuals who experience the ill effects of cardiovascular ailment. Particulates, then again called as environmental particulate issue (PM), or fine particles, are modest particles of strong or fluid suspended in a gas. Expanded degrees of fine particles noticeable all around are connected to wellbeing perils, for example, coronary illness, change lung capacity and causes lung disease. Air contamination is liable for some medical issues in the urban territories. Generally, the air contamination status in Delhi has experienced numerous adjustments as far as the degrees of poisons and the control estimates taken to lessen them. It was evaluated that 3000 metric huge amounts of air toxins were transmitted each day in Delhi, with a significant commitment from vehicular contamination (67%), trailed by coal-based warm power plants (12%). There was a rising pattern in contamination as checked by the Central Pollution Control Board (CPCB). The system comprises of 621 working stations covering 262 urban communities/towns in 29 states and 5 Union Territories of the nation. There are state contamination control sheets (SPCBs), guided and actually helped by CPCB. The Kerala State Pollution Control Board is an assemblage of under Department of Health and Family Welfare. The board is resolved to give contamination free condition to the individuals of state. In any case, right now their checking limits too hardly any locales, which is a significant disadvantage [19].

Air pollution means presence of high concentrations of harmful gases such as dust, smoke. Inhaling these gases can increase the chances of health problem. In fact, dust when inhaled can cause breathing problems, damage lung tissue, and boost up existing health problems. Greenhouse gases trap heat and make the earth warmer. Human activities are responsible for almost all of the increases in greenhouse gases. Therefore, every federal government has stringent regulations which require prevention and reduction of emission levels.

Sensor networks are dense wireless networks of small, low-cost sensors, which collect and disseminate environmental data. Wireless sensor networks facilitate monitoring and controlling of physical environments from remote locations with better accuracy. They have applications in a variety of fields such as environmental monitoring, indoor climate control, surveillance, structural monitoring, medical diagnostics, disaster management, and emergency response, ambient air monitoring and gathering sensing information in inhospitable locations.

Air pollution is a health and environmental issue across all countries of the world, but with large differences in severity. In the interactive map we show death rates from air pollution across the world, measured as the number of deaths per 100,000 people of a given country or region.

We see that the death rates tend to be highest across Sub-Saharan Africa and South Asia. This highlights the large differences globally: death rates in the highest burden countries are more than 100 times greater than across much of Europe and North America.

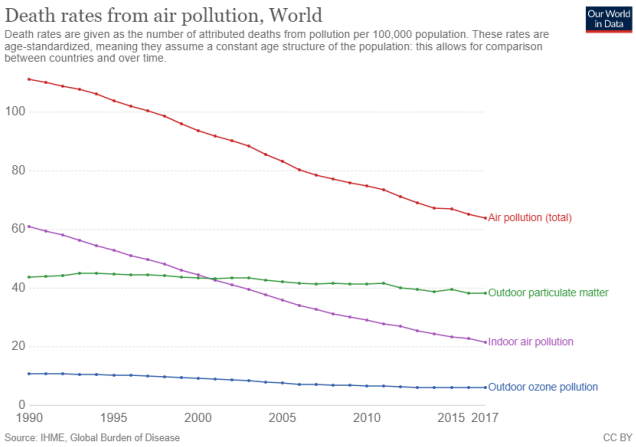


Fig -1: Air Pollution Graph

The burden of air pollution tends to be greater across both low and middle-income countries for two reasons: indoor pollution rates tend to be high in low-income countries due to a reliance on solid fuels for cooking; and outdoor air pollution tends to increase as countries industrialize and shift from low-to-middle incomes.

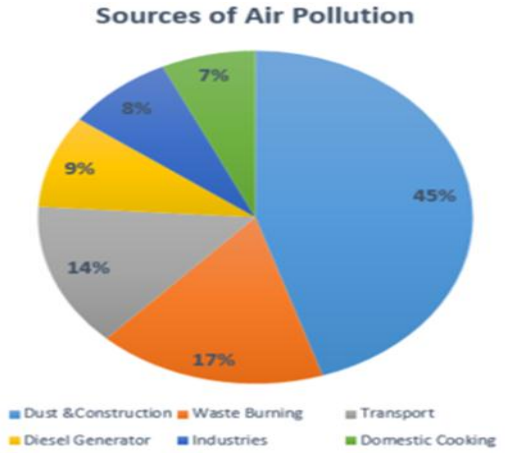


Fig -2: Air Pollution Reasons

2. LITERATURE

[1] Air quality monitoring systems that can monitor gas such as CO and Sox on ambient air in a real-time and can be accessed with internet line have been developed. Sensor element on this system is based on Nano structured zinc oxide thin film synthesized using wet chemical route. Monitoring system is designed using Arduino Uno microcontroller as analog to digital converter, and Ethernet shield for data transmission, computer server for database center and data acquisition. The data from this monitoring system can be accessed and viewed as web-page. The sensor element that used in this system is made at nanostructure so it will yield high sensitivity. The optimum experimental parameters that will be used are temperature, exposure time to gas target, sampling period, and also ratio for regeneration time. Measurements will be held under well-controlled and artificially CO/Sox polluted atmosphere.

[2] Due to the increasing industrialization and the massive urbanization, air pollution monitoring is being considered as one of the major challenges of smart cities. Many air pollution monitoring systems have been proposed in the literature, among which wireless sensor networks seem to be a leading solution. A careful deployment of sensors is therefore necessary to get better Performances while ensuring a minimal financial cost. In this paper, the citywide wireless sensor networks are considered and tackle the minimum-cost node positioning issue for air pollution monitoring. The proposed system has an efficient approach that aims to find optimal sensors and sinks locations while ensuring air pollution coverage and network connectivity. Unlike most of the existing methods, which rely on simple and generic detection models, our approach is based on the spatial analysis of pollution data, allowing to take into account the nature of the pollution phenomenon.

[3] A Wi-Fi based plug and sense smart device for dedicated air pollution monitoring using Internet of Things is designed. This system designed on device to cloud architecture in IoT for monitoring air pollution precisely. Once the sensor node reads individual pollutants composition and location coordinates, Air quality index (AQI) will be calculated using linear segmented principle with greater Vancouver AQI table and Max operator aggregation method. Based on AQI value, corresponding LED will be actuated for indication and health impact with precaution steps messages will be displayed on the screen. All those data will be pushed to thing speak cloud storage, an open source application Programming interface for IoT based devices. These pushed data along with Date and time can be retrieved as a separate excel sheet for future analysis. Through thing view android app, real time pollution level with location can be visualized in terms of line graph. With the implementation of this low cost and small size smart device, alert can be given to people to wear anti-pollution mask and reroute path in transportation where there is high air pollution ensuring high reliability and consistency.

Wireless Sensor Network (WSN) is an active field of research due to its emerging importance in many applications including environment and habitat monitoring, health care applications, traffic control and military network systems. With the recent breakthrough of Micro-Electro-Mechanical Systems (MEMS) technology whereby sensors are becoming smaller and more versatile, WSN promises many new application areas in the near future. Typical applications of WSNs include monitoring, tracking and controlling. Some of the specific applications are habitat monitoring, object tracking, nuclear reactor controlling, fire detection, traffic monitoring, etc. Initial development into WSN was mainly motivated by military applications. However, WSNs are now used in many civilian application areas for commercial and industrial use, including environment and habitat monitoring, healthcare applications, home automation, nuclear reactor controlling, fire detection and traffic control. This transition from the use of WSN solely in military applications has been motivated due to the nature of WSNs which can be deployed in wilderness areas, where they would remain for many years, to monitor some environmental variables, without the need to recharge/replace their power supplies. Such

characteristics help to overcome the difficulties and high costs involved in monitoring data using wired sensors. Below are some areas where WSN have been successfully deployed to monitor the environment.

The air and sound pollution monitoring system is absolutely important for detecting wide range of gases, also sensors have long life time, easily available, less cost, easy to handle and are compact. Quality of air can be checked indoor as well as outdoor. This system has simple drive circuit, works on real time and has visual output. The main objective of this paper is to ensure that the air and sound pollution is monitored and kept in control by taking measure accordingly. The proposed paper has certain limitations regarding humidity which should be less than ninety-five percent and exact measurement of contaminating gases cannot be detected in ppm. This paper can be used for monitoring pollution level and also to prevent excess of pollution which can cause huge problem in future. This paper gives an idea on how we can give instant alert to the authorities. The cost effective IOT technology is used. Hence air and sound pollution is monitored by using this technology. [4] The Automatic Air & Sound management system is a step forward to contribute a solution to the biggest threat. The air & sound monitoring system overcomes the problem of the highly-polluted areas which is a major issue. It supports the new technology and effectively supports the healthy life concept. This system has features for the people to monitor the amount of pollution on their mobile phones using the application. So, it becomes very reliable and efficient for the Municipal officials along with the Civilians to monitor environment. Letting civilians also involved in this process adds an extra value to it. As civilians are now equally aware and curious about their environment, this concept of IOT is beneficial for the welfare of the society. And it is implemented using the latest technology. [5]

This IOT based air and noise pollution monitoring device is a great step towards a healthy living. With the help of this device not only the municipal authorities but even the common people can participate in the process of controlling pollution and ensure safe environment. These automatic devices, once installed are capable of continuously tracking the pollution level and analyze the detected information. The most highlighting feature of this device is that the output is represented in digital as well as analog format with the help of a simple mobile application which is usable on all android devices like smart phones, tablets, PDA's etc. The device itself is very eco-friendly and does not harm the environment in any way. Moreover, it is based on one of the modern technologies and also inexpensive as compared to other technologies developed so far and can be installed anywhere. [6]

For creating the system, first we did the research based on the system about IOT and various sensors. Sensors of air and sound based on availability and economical price were selected. For the interaction of internet with the system we are using a Wi-Fi module which is connected to the microcontroller through the serial port. So, the measured data is sent from the module to any location with it range from the data can be fetched using a laptop /mobile. We have tested this system at various places. We have used it at the places where standard devices for the measurement of pollutants are installed to compare those measured values with our system output values. [7]

The Automatic Air & Sound management system is a step forward to contribute a solution to the biggest threat. The air & sound monitoring system overcomes the problem of the highly-polluted areas which is a major issue. It supports the new technology and effectively supports the healthy life concept. This system has features for the people to monitor the amount of pollution on their mobile phones using the application. To implement this need to deploy the sensor devices in the environment for collecting the data and analysis. By deploying sensor devices in the environment, we can bring the environment into real life i.e. it can interact with other objects through the network. Then the collected data and analysis results will be available to the end user through the Wi-Fi. The data can be an important source when addressing the issue of the impacts of motorcycles at idles (e.g. waiting for a green light) on air quality. Moreover, to achieve real-time monitoring, the data of CO concentration in a particular place could be reviewed from mobile communication devices, such as PDAs, smart phones, and tablet PCs to help keep air quality in check.[8]

This paper presents a network for both indoor and outdoor air quality monitoring. The sensor response is strongly dependent on parameters such as temperature, humidity, and cross influence of the other gases. For the calculation of several air quality values two types of sensor data processing architectures are implemented using JavaScript and Lab VIEW Web publisher technologies. The first one is a neural network algorithm implemented in JavaScript in the embedded server (Web sensor) and represents one of the main novelties of the work. The second software architecture is implemented in the network PC and performs tasks like sensing nodes data reading through TCP/IP remote control, air pollution events detection and gas concentration estimation based on neural network inverse models of gas sensors and data logging and Web publishing of air quality data. [9]

The ideal portable device is to have embedded sensors installed on subjects, e.g., a vehicle, a person, or an animal. Sensor device is an innovative integrated sensor system using novel design polymer modified tuning fork sensors. The device encompasses sample collection and transport, sample conditioning with interferon's removal and sample air zeroing capabilities for baseline establishments, thus enabling it to form a standalone and portable unit. Ambient air is being drawn into the device either through the particle filter (detection mode) or the zero filters (calibration mode). The filtered air is then subsequently passed through the interfere filter for sample conditioning and then introduced to the tuning fork sensors inside a sensor cartridge. The responses of the sensors will subsequently be digitized and transmitted wirelessly to a user interface device, such as a cell phone or a less portable device, such as a laptop or desktop computer. Bluetooth technology, a widely available wireless communication standard, is employed in the wireless communication of the device; enabling high flexibility in user interface selection. [10]

This paper proposes vehicular Wireless sensor networks (VSN) architecture to monitor microclimate based on GSM short messages and geographic information of vehicles. They show prototype to monitor the concentration of carbon dioxide (CO2) gas in areas of interest. CO2 gas is a critical index of air quality and global warming. In our prototype, a vehicle is equipped with a CO2 sensor, a GPS receiver, and a GSM module, which form a ZigBee based intra-vehicle wireless network. Each of such vehicles thus serves as a vehicular sensor.

These vehicular sensors roam inside the area of interest and periodically report their sensed data through GSM short messages. The reported data is collected by a server, which is integrated with Google Maps to demonstrate the result. [11] The proposed wireless sensor network air pollution monitoring system (WAPMS) comprises of an array of sensor nodes and a communications system which allows the data to reach a server. The sensor nodes gather data autonomously and the data network is used to pass data to one or more base stations, which forward it to a sensor network server. The system send commands to the nodes in order to fetch the data, and also allows the nodes to send data out autonomously. The development of the system is to help the government to devise an indexing system to categorize air pollution. [12]

This paper proposed an urban air quality monitoring system based on the wireless Sensor network (WSN) technology and incorporated with the global system for mobile communications (GSM). The system consists of sensor node, a gateway, and a back-end platform controlled by the Lab VIEW program through which sensing data can be stored in a database. The proposed system can provide micro-scale air quality monitoring in real-time through the WSN technology. [13] This paper describes MAQS (Mobile Air Quality Sensing), a personalized mobile sensing system for IAQ (indoor air quality) monitoring. MAQS estimates human-dependent air quality factors (e.g., CO2 and contagious viruses) using CO2 concentration, and estimates other air quality factors (e.g., volatile organic compounds (VOCs)) using air exchange rates. MAQS integrates smart phones and portable sensing devices to deliver personalized, energy efficient, IAQ information. [14] In proposed work they use a MiCS-OZ-47 sensor from e2v to sense the ozone concentration in the atmosphere based on the measured resistance of the sensor's tin dioxide (SnO2) layer. Digital communication is achievable over the board's RS232-TTL interface, which is directly connected to an off-the-shelf HTC Hero Smartphone providing a USB Mini-B port. They show that it is feasible to use Gas Mobile to create collective high-resolution air pollution maps. This is essential to obtain widespread acceptance of participatory sensing equipment. [15]

A main apprehension in such networks is energy efficiency because gas sensors are power-hungry, and the sensor node must operate unattended for several years on a battery power supply. [16]

The system consists of several distributed monitoring stations that communicate wirelessly with a backend server using machine-to-machine communication. Each station is equipped with gaseous and meteorological sensors as well as data logging and wireless communication facility. The backend server collects real time data from the stations and converts it into information delivered to users through web portals and mobile applications. Data over four months has been collected and performance analysis and assessment are performed. [17]

3. EXISTING SYSTEM

3.1 A low-power real-time air quality monitoring system using LPWAN based on LoRa:

This paper introduces a low-power continuous air quality observing framework dependent on the LoRa Remote Communication innovation. The proposed framework can be spread out in a huge number in the checking zone to shape sensor arrange. The framework coordinates a solitary chip microcontroller, a few air contamination sensors (NO2, SO2, O3, CO, PM1, PM10, PM2.5), Long Range (LoRa) - Modem, a sunlight-based PV-battery part and graphical UI (GUI). As correspondence module LoRa sends the information to the local observing unit and afterward the information would be spared in the cloud.

The range tests at an outside zone show that LoRa can reach to around 2Km. The TX power is just about 110mA which is lower contrasted and other utilized remote innovation. A simple to utilize GUI was structured in the framework. In light of LoRa innovation, GUI, and Solar PV 9 battery part the framework has a few dynamic highlights, for example, ease, and long separation, high inclusion, and long gadget battery life, simple to work.

3.2 An embedded system model for air quality monitoring:

Goal of the paper is to introduce a framework model which can encourage the evaluation of wellbeing impacts caused because of indoor air contamination just as open air and can suggest the human earlier about the hazard he/she going to have, here we are centering our work in setting to unfavorably susceptible patients as they will be educated by this instrument to such an extent that they can make sure about themselves without really encountering the hazard factors, here a detecting system based microcontroller outfitted with gas sensors, optical residue molecule sensor, mugginess and temperature sensor has been utilized for air quality checking. The plan included different units mostly: detecting unit, handling unit, power unit, show unit, correspondence unit. This work will apply the methods of electrical designing with the information on ecological building by utilizing sensor systems to quantify Air Quality Parameters.

4. SYSTEM DESIGN

4.1 Arduino:

4.1.1 Arduino UNO R3:

Arduino is a single-board microcontroller meant to make the application more accessible which are interactive objects and its surroundings. The hardware features with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models consists a USB interface, 6 analog input pins and 14 digital I/O pins that allows the user to attach various extension boards.

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In order to get started, they are simply connected to a computer with a USB cable or with an AC-to-DC adapter or battery. Arduino Uno Board varies from all other boards and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

4.2 ESP8266:

•ESP8266 is a cost-effective Wi-Fi module that supports both TCP/IP and microcontrollers. It runs at 3V with maximum voltage range around 3.6V. More often than not, it also comes under name ESP8266 Wireless Transceiver.
•This module stays ahead of its predecessor in terms of processing speed and storage capability. It can be interfaced with the sensors and other devices and requires very little modification and development to make it compatible with other devices.
•Components and GPIO pins interfaced on the little chip are very compact that makes it suitable for hard to reach places.
•It covers little space and everything is laid out on the PCB board quite precisely that no external circuitry is required to put this device in the running condition.
•No external RF circuitry is required as this module comes with self-calibrated RF capability that makes it suitable to work under all operating conditions.
•It is a very useful device for wireless networking; however, there are some limitations i.e. external logic level converter is needed as it doesn't support 5-3V logic shifting.

4.3 DHT11 Humidity Sensor:

DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmed in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect.

4.4 MQ-2 Sensors:

The MQ-2 Smoke sensor can detect or measure gasses like LPG, Alcohol, Propane, Hydrogen, CO and even methane. The module version of this sensor comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comes in handy when you are only trying to detect one particular gas. When it comes to measuring the gas in ppm the analog pin has to be used, the analog pin also TTL driven and works on 5V and hence can be used with most common microcontrollers.

Fig -3: Air Pollution Reasons

Using an MQ sensor it detects a gas is very easy. You can either use the digital pin or the analog pin to accomplish this. Simply power the module with 5V and you should notice the power LED on the module to glow and when no gas it detected the output LED will remain turned off meaning the digital output pin will be 0V. Remember that these sensors have to be kept on for pre-heating time (mentioned in features above) before you can actually work with it. Now, introduce the sensor to the gas you want to detect and you should see the output LED to go high along with the digital pin, if not use the potentiometer until the output gets high. Now every time your sensor gets introduced to this gas at

this particular concentration the digital pin will go high (5V) else will remain low (0V).

5. PROPOSED SYSTEM

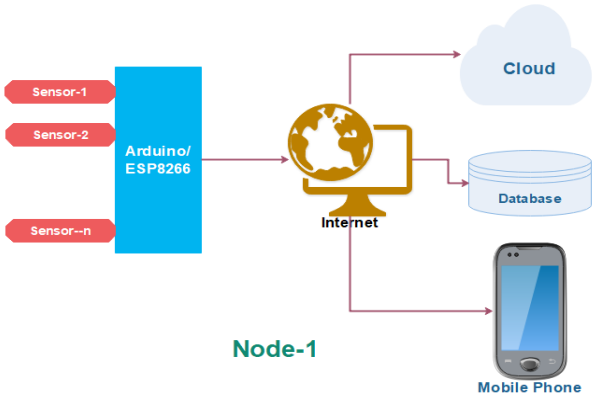


Fig -4: Node-1

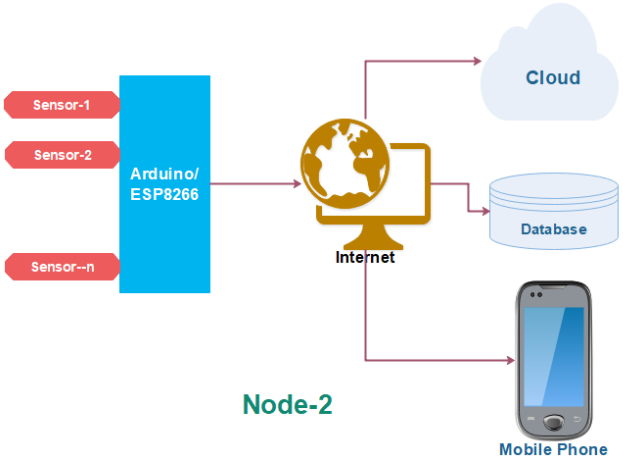


Fig -5: Node-2

Right now we are going to make an IOT Based Air Pollution Monitoring System in which we will screen the Air Quality over a webserver utilizing web and will trigger warning when the air quality goes down past a specific level, implies when there are adequate measure of unsafe gases are available noticeable all around like CO2, smoke, liquor, benzene, and NH3. It will show the air quality on the website page with the goal that we can screen it no problem at all.

•In this proposed system, two nodes will be used.
•The Arduino microcontroller used to access values of sensors and send to server using Wi-Fi device.
•The server will store values in database, so user will get history of sensors values.
•The values can be processed and send to cloud to see current values of sensor.
•The output will be on computer and android mobile phone.
•The values of sensors can be accessed using web page also.
•The nodes are situation at different location and the pollution level can be detected and store on database.
•From that database the values can be fetched anytime and anywhere.

The nodes are two only so here we are not using GPS for location, instead of it we will use the images of location.

6. IMPLEMENTATION

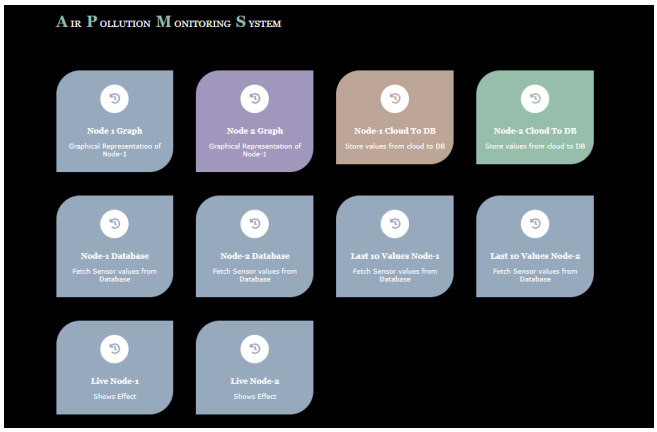


Fig -6: Dash Board

Above figure 6 shows, the front page of project, which contains Graph of Node first, second. The node first and second sensors values inserted in database from cloud. Node first and second all values shows from database. The last 10 values shows of Node first and second. Last block shows the live data of Node first and second.

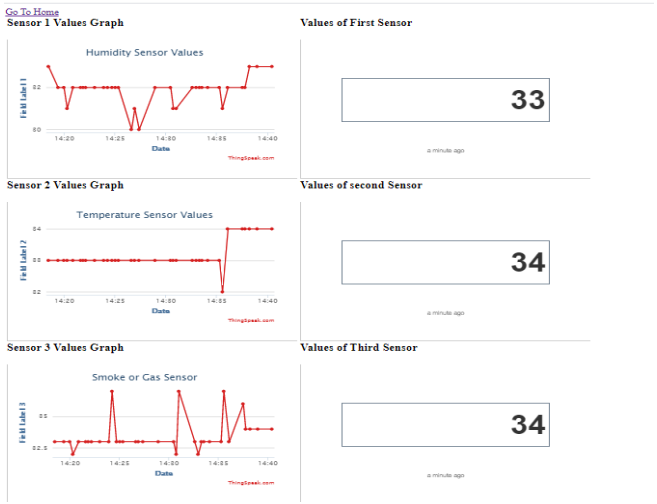


Fig -7: Graph and Values of Node-1

The above figure 7 shows the graph of node-1 and respective sensors values.

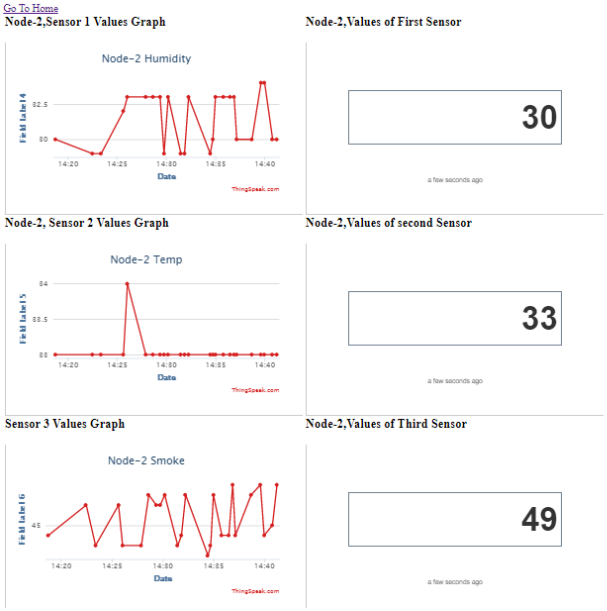
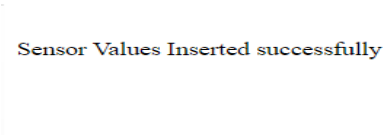


Fig -8: Graph and Values of Node-2

The above figure 8 shows the graph of node-2 and respective sensors values.

Retriving values from cloud to database.



Data inserted from cloud to database.

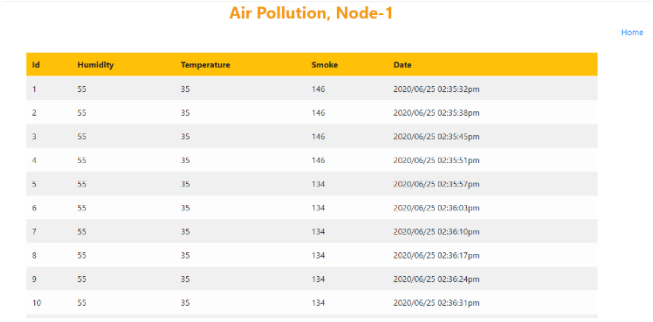


Fig -9: Node-1 Database values

Figure 9 shows the all database values from database.

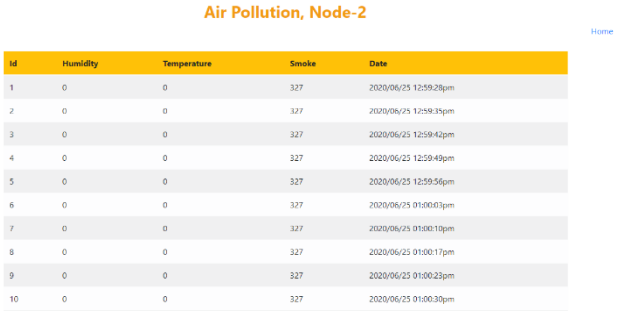


Fig -10: Node-2 Database values

Figure 10 shows the all database values from database.

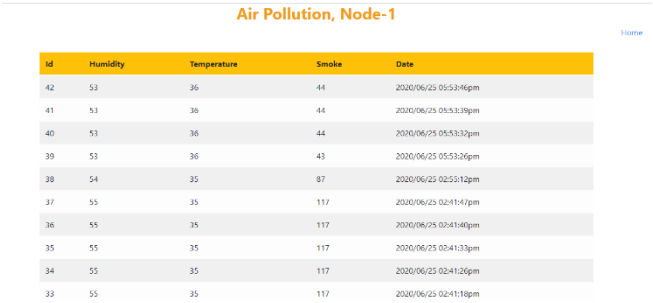


Fig -11: Last Ten record Node-1

Figure 11 shows the last ten values from database.

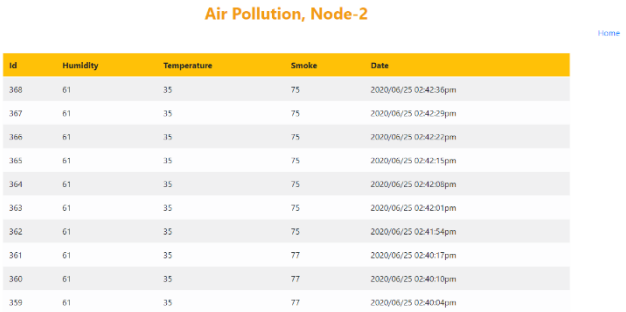


Fig -12: Last Ten record Node-2

Figure 12 shows the last ten values from database.

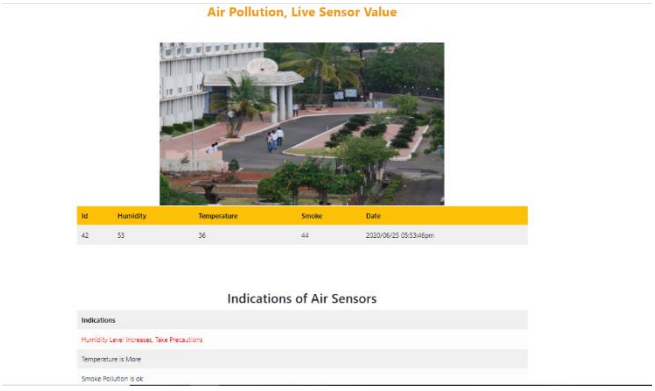


Fig -13: Live values Node-1

Figure 13 shows the current values of all sensors values of Node-1

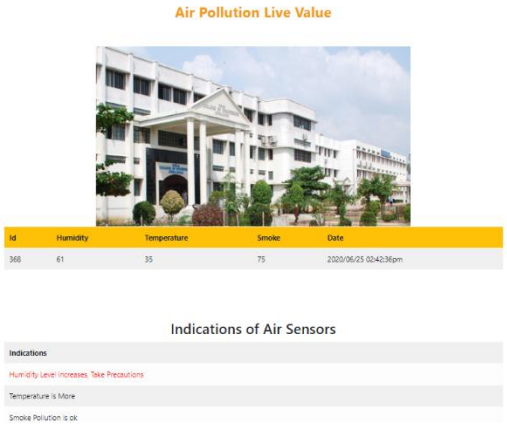


Fig -14: Live values Node-2

Figure 14 shows the current values of all sensors values of Node-2.

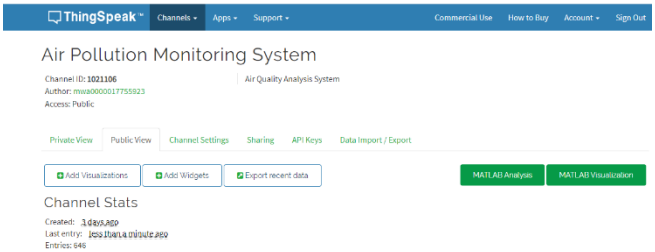


Fig -15: ThingSpeak Cloud Dashboard

7. ACKNOWLEDGMENT

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8. CONCLUSION

The framework to screen the demeanor of condition utilizing Arduino microcontroller, IOT Technology is proposed to improve the nature of air. With the utilization of IoT innovation upgrades the way toward checking different parts of the condition, for example, air quality observing issues proposed right now sensor gives the feeling of various sorts of risky gas and Arduino is the core of this task. Which controls the whole procedure. The Wi-Fi module associates the entire procedure to the web.

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