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RESEARCH ARTICLE OPEN ACCESS

A study on Indoor air pollution detection by smart sensors

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ABSTRACT:
Indoor air pollution is the world largest environmental problem in the poor and developing countries like India because India having large number of village and urban areas within state areas. Most of village peoples are not using proper clean fuel for their cooking. The Indoor air pollution in urban areas is continuously increased by pollution in the environment which is a health related problem. It affects the health in terms of eye irritation, nose, headache, breathing problems and heart problems. The amount of air pollution in outside the building environment is lower than inside the office buildings in Madurai kamaraj university campus. The amount of air pollution in indoor is approximately 3 times higher than outside building air . This study is deal with analysis the indoor air pollution in various places in Madurai Kamaraj University campus, Madurai and find out whether the air pollution is high or low as compared with Indian standard and WHO data reference. This will help to improve the in comfort working zone in this office, because the most of the time the students and staffs are in the lab and office. The parameter taking into consideration are HCHO, CO, PM2.5, PM10, CO, Temperature and Humidity. With help of above parameter monitoring and controlling of parameter would lead to creation of smart class room inside the campus. The elder staffs are more affected due to indoor air pollution with the age of 50 and above. This present study also gives a solution to the indoor air pollution in USIC class room -MKU and various places inside this campus. The IOT based indoor air pollution and reporting system project used to give a real report and know the indoor air pollution condition at particular place /class room.

Keywords: Smart sensor, compact sensor, Digital IOT sensor, Efficient IOT sensor, Mini Wi-Fi data transfer, data around world, future IOT sensor

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I. INTRODUCTION:

The Madurai kamaraj University is the oldest university in Tamil Nadu state, India. The Madurai kamaraj University consist of 77 departments and 20 schools with covered an area of 750 acres. This is very close to NH85 highways form Madurai to Theni Main road. It is located in the urban area of Palkalai Nager, Madurai to Theni main road, Madurai-21. The location of MKU in the internet identification is located as latitude 9.94148 and longitude 78.008896 and GPS co ordinates 9^0 56' 29.1048" N and 78^0 0' 32.0256 E. The study of indoor air pollution in this paper is mainly focus on particular places to monitor and collected the data. The limitation of this study would lead to create a smart office in the working place.

The IOT based weather monitoring system is used to get a weather conditions at a particular places in India/world.[1] The weather monitoring systems normally having different types of sensor such as rain fall, temperature and humidity sensors.[2]The internet of Things(IOT) based on weather monitoring system gives a solution to smart office based on weather conditions monitored in a particular place and data transfer through internet anywhere in the world.[3] The IOT is the future technology which connect any type of instrument to internet and communicate other devices with more efficiently.[4] The sensors are given a physical property of measurement and convert into suitable signal voltage which is understood by Arduino Uno board arrangement and software.[5] The indoor parameter which was more affected in the working places when we used the building roof material such as Asbestos. We must take care of the other indoor parameters like carbon monoxide, Lead, Mold, Radon and volatile organic compounds (VOCs). So the AQI values may affected by the above indoor parameter inside the working places.[6] The health related symptoms such as headache, eye irritation, fatigue, dry throat, sinus congestion, dizziness and nausea were an indication to indoor air pollution in the working places.[7]

When we monitor the different indoor parameters in a class room/ home, we can create zero indoor air pollution by introducing more ventilation (forced ventilation) or more window openings.[8]

II. METHODOLOGY:

Indoor air pollution system consist of Arduino Uno board, smart sensors, open source Arduino Uno software and a laptop computer with network connection. The Prana Air smart sensor compact pack –portable instrument also used to support this paper. The sample data were taken in Madurai kamaraj University campus (USIC centre), Madurai by using a Laptop with an Arduino Uno board connection arrangement with necessary sensors. In this system three sensors (Temperature, Humidity and CO2 sensor) were used in a bread board with Arduino Uno board connection. The board was connected to laptop through a USB port. The various data were collected and tabulated to express our views in a chart format for better understanding. All the data analysis were carried out with help of data sample taken in a particular place(USIC centre), date and time compared with Indian standard data/ WHO standards to give a better solution to create a smart home/office.

Indoor air quality standards:

Table: 1 Threshold values for indoor quality parameters:

Parameters		**Units**	**Classifications**
			Class A
Basic IAQ parameters	CO_2	ppm	Ambient + 350
	PM 2.5	µg/m^3	<15
	CO	µg/m^3	<2
	TVOC (equivalent to isobutylene)	µg/m^3	<200
Complementary IAQ parameters	PM 10	µg/m^3	<50
	CH_2O	µg/m^3	<30
	SO_2	µg/m^3	<40
	NO_2	µg/m^3	<40
	O_3	µg/m^3	<50
	Total Microbial count	CFU/ m^3	Indoor <= ambient
Occupant satisfaction		%	90

Table 2: Threshold value for various VOCs in IAQ

Parameter	Units	Threshold value
Formaldehyde(HCHO)	µg/m^3	30
Toluene	µg/m^3	300
Acetone(2-propanone)(C3H5O)	µg/m^3	-
Benzene	µg/m^3	3
Acetaldehyde	µg/m^3	140
Epichlorohydrin(106-89-8)	µg/m^3	3
Naphthalene(91-20-3)	µg/m^3	9

Table 3: AQI Average as per TNPCB (Tamil Nadu pollution control Board):

AQI	**Remark**	**Colour**	**Possible health impacts**
0-50	**Good**	**Green**	**Minimal impact**
51-100	**Satisfactory**	**Light Green**	**Minor breathing discomfort to sensitive people**
101-200	**Moderate**	**Yellow**	**Breathing discomfort to the people with lungs, asthma and heart diseases**
201-300	**Poor**	**Orange**	**Breathing discomfort to most people on prolonged exposure**
301-400	**Very poor**	**Red**	**Respiratory illness on prolonged exposure**
401-500	**Severe**	**Dark brown**	**Affects healthy people and seriously impacts those with existing diseases**

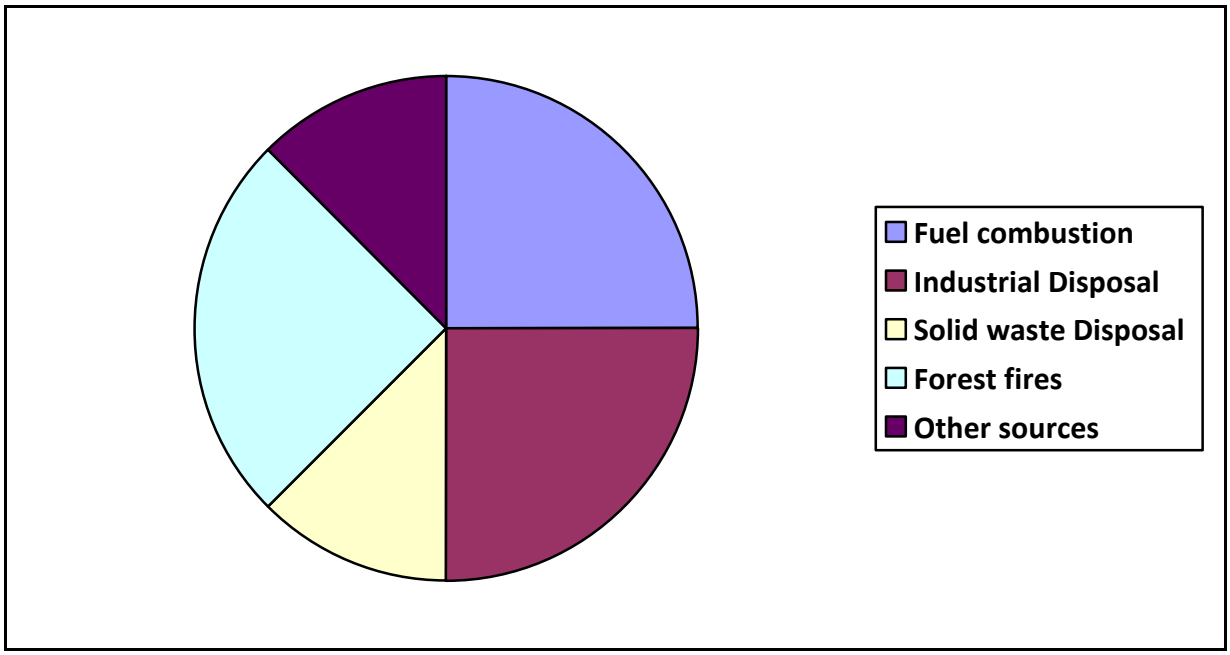


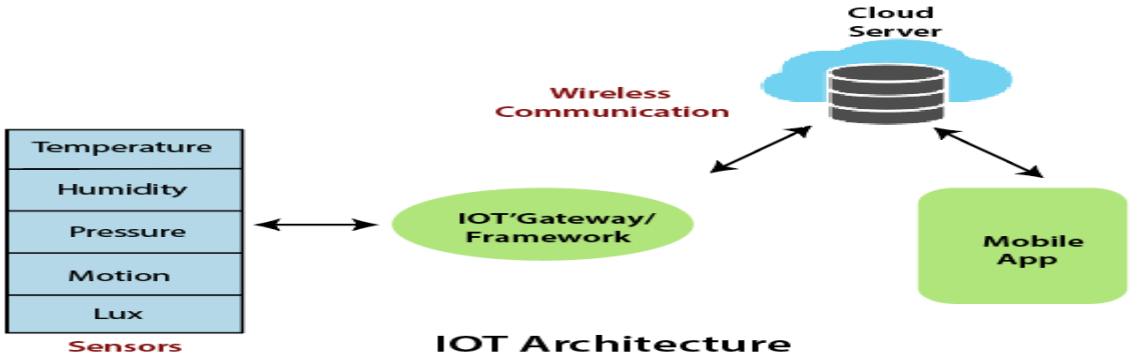
Fig 1: Air pollution component

III. SYSTEM ARCHITECTURE:

The internet of Things (IOT):

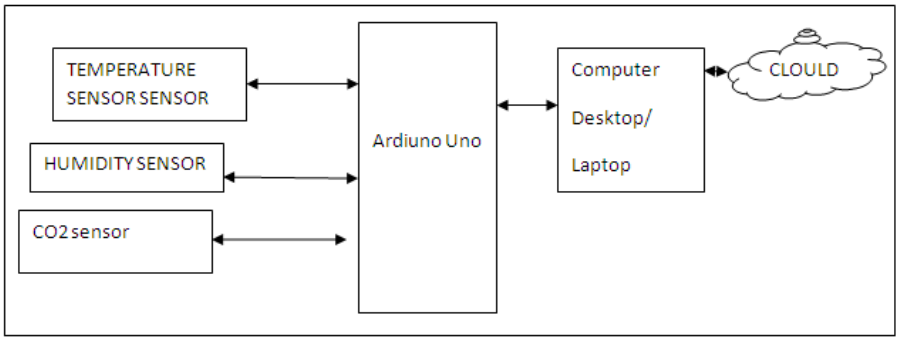
" The Internet of Things(IOT) is a system of inter related computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human to computer interaction"

This is the new technology recently popular among the researchers because utilize more easily and get efficient and accurate result in digital/analog mode output



IV. SYSTEM ARCHITECTURE:

A.SYSTEM DESIGN FOR INDOOR AIR POLLUTION:



Arduino Uno Board:

Arduino Uno is open source software available in the Internet. It is a microcontroller with having inbuilt ADC. It is operated with +5V Dc voltage. The USB cable is used to connect the Arduino Uno Board with USB port of the system. It having 14 Nos. of I/O pins, 6-Analog pin, 3-Nos. of Ground pin and 6-Nos. of PWM pins are available in the board.

The board was activated by one power supply with 3.3V and another pin with 5V DC pin. Also one Tx and One Rx pin also available to communicate of data sending/receiving with Wi-Fi board or communicate with another Arduino Uno board that is board to board communication. In this system proposed model used with Arduino Uno board, Arduino software and hardware circuit for sensor and other connections.

B: SENSORS:

The system consists of CO_2, Temperature and humidity sensors. These sensors are used to measure the humidity, temperature and CO_2 level as a environmental parameter. The sensor outputs are in the form of analog voltage. The microcontroller in the Arduino Uno microcontroller will convert them into a Digital signal. These digital signals also available in the serial monitor graph as a continuous data output. It is possible to store all the data in a Excel format sheet with help of special software PLX-DAQ Tag for future reference.

C: TEMPERATURE AND HUMIDITY SENSOR:

The Commercial DHT11 sensor which is available in the market as a dual sensor type in a single unit(pack). The humidity sensor and thermistor are used to measure the quality of surrounding air and gives an digital output on digital pin in Arduino Uno Board. Some sensor not having the analog pins. The output may be obtained for every second based the program coding written (1000 µsec). The power supply required is 3-5V. It works well for the range of 20-80% humidity reading with 5% accuracy. The temperature reading is measured by this sensor in the range of 0-50℃ with +/-2 ℃ accuracy.

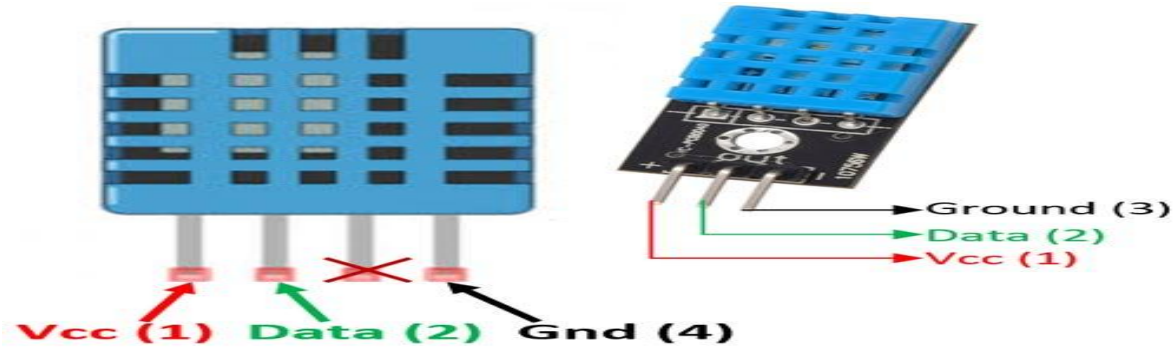


Figure 2: Temperature and Humidity sensor DHT11

D: Carbon dioxide sensor:

The carbon dioxide sensors available in the code MG-811 module. It is more sensitivity to CO2 gas particularly. The operating voltage is VCC: 6V DC. The output may be in the form of Analog mode. We can easily convert in to digital form with help of Arduino Uno Board circuit and its software. This sensor is more compatible for Arduino Uno and Raspberry pi. It is used in Green house analysis. The threshold value for carbon dioxide is 350 ppm as per ASHRAE –American standard. The carbon dioxide gases would be come from automobile combustion and Industrial exhaust gases mixed with air as a outdoor source.

E: Formaldehyde (HCHO) gas sensor:

It is a odour gas available in the form cent and nail polishes in office/home places. It leads to asthma when the threshold value is high in office/class room. The threshold value is 30 µg/m^3. We observed that the value of HCHO is within the limit in the class room/USIC/MKU

E: Wi-Fi MODULE:

The utilized Arduino Uno ESP8266 board was a special kind in this series, which having a inbuilt Wi-Fi module with TC/IP protocol. So that the system was easily connected to Wi-Fi Network in the form of plug-in type arrangement. It can work with a supply voltage of 3.3V. The initial connections were initializing with AT commands to configure the Arduino Uno board. Some times more than one Arduino Uno board was used and communicates between them in form of client-server mode. The disadvantage was found in this board was only having minimum number of analog pins.

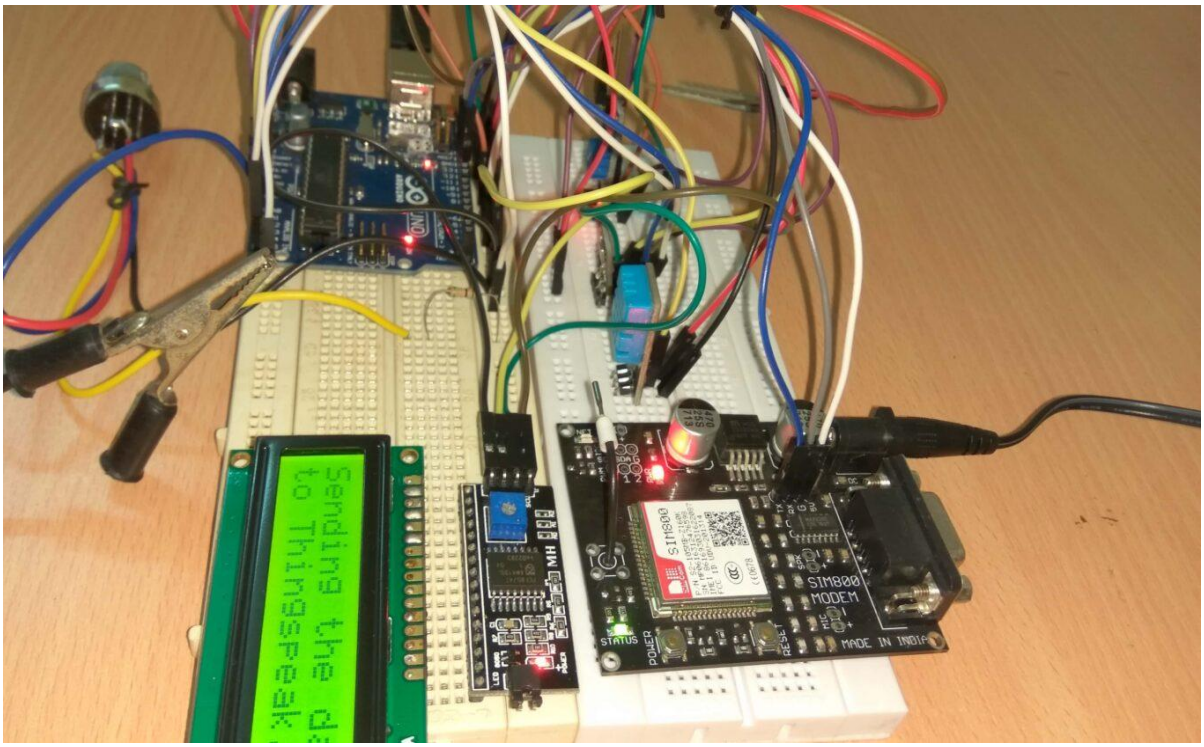


Figure 3 : Ardunio Uno board fitted with various sensor setup

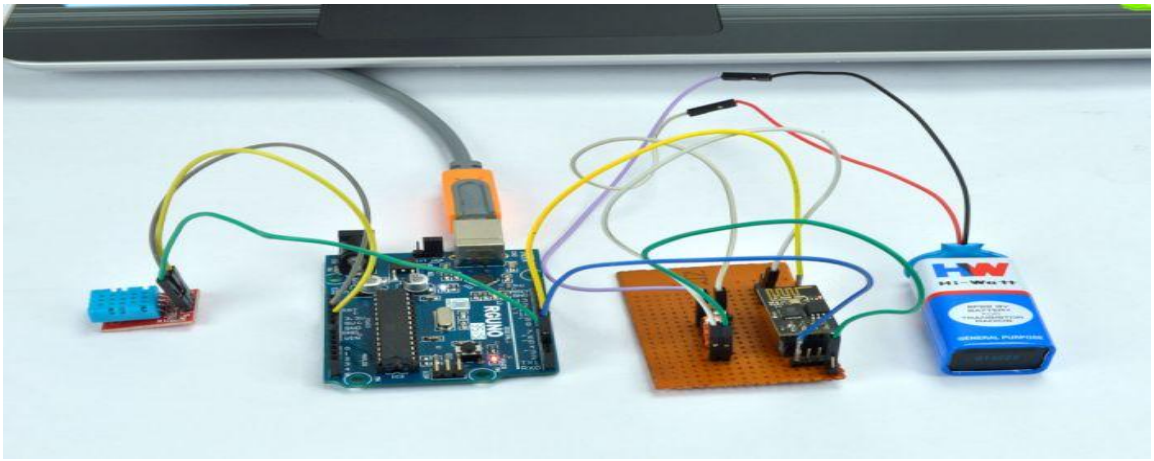


Figure 4: Arduino Uno board with 9V DC power supply

V. RESULT AND DISCUSSION:

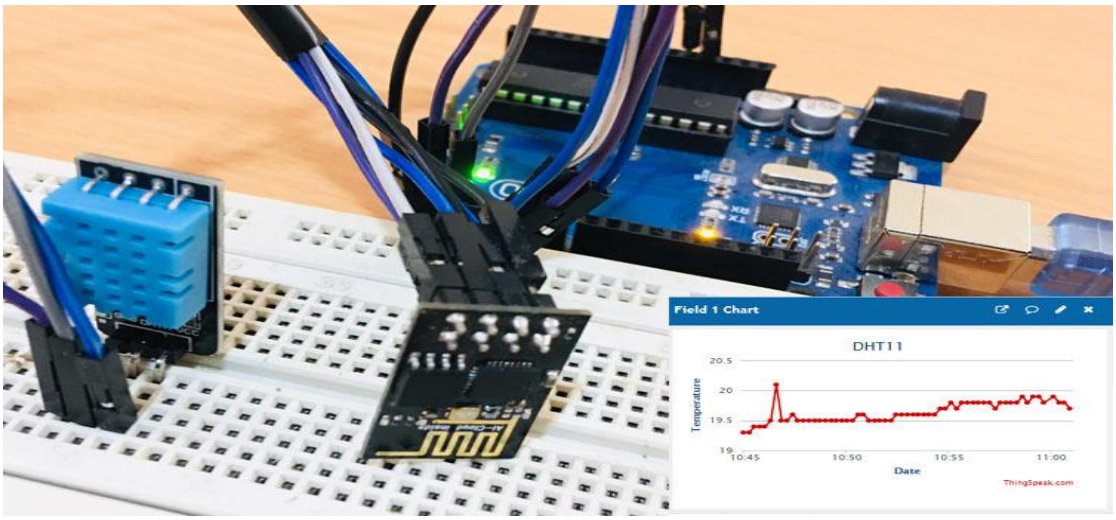


Figure 5: Arduino Uno board with 9V DC power supply

From the above set up we can easily get the data from it. The parameter of temperature standard value is:(20.5-23.7) degree centigrade in winter. This temperature value is compared with temperature observed in USIC were (22-35) degree centigrade. The temperature measured was high during this period, which affects the human health. The American relative humidity standard is -RH : (30%-60%). The observed data lies between (65-88)%. The observed humidity limit was high when compared with its American standard value. The date on which the samples were taken particular day Dec 12, 2020(12-12-2020) at MKU campus, USIC centre. In the USIC Class room, the number of students occupied was 11 and class room area (16x14)m^2 with A/c provision. The CO_2 observed was 419 ppm, which was a high value, when compared with the CO_2 standard value of :(350 ppm). The sample data taken would gives information about the USIC class room status. It gives the real data for the research observer. So, we can easily establish smart class room in USIC.

GRAPH DETAILS:

The graph was drawn for table-5 values for AQI, Temperature, Humidity, and CO_2 parameters Value.

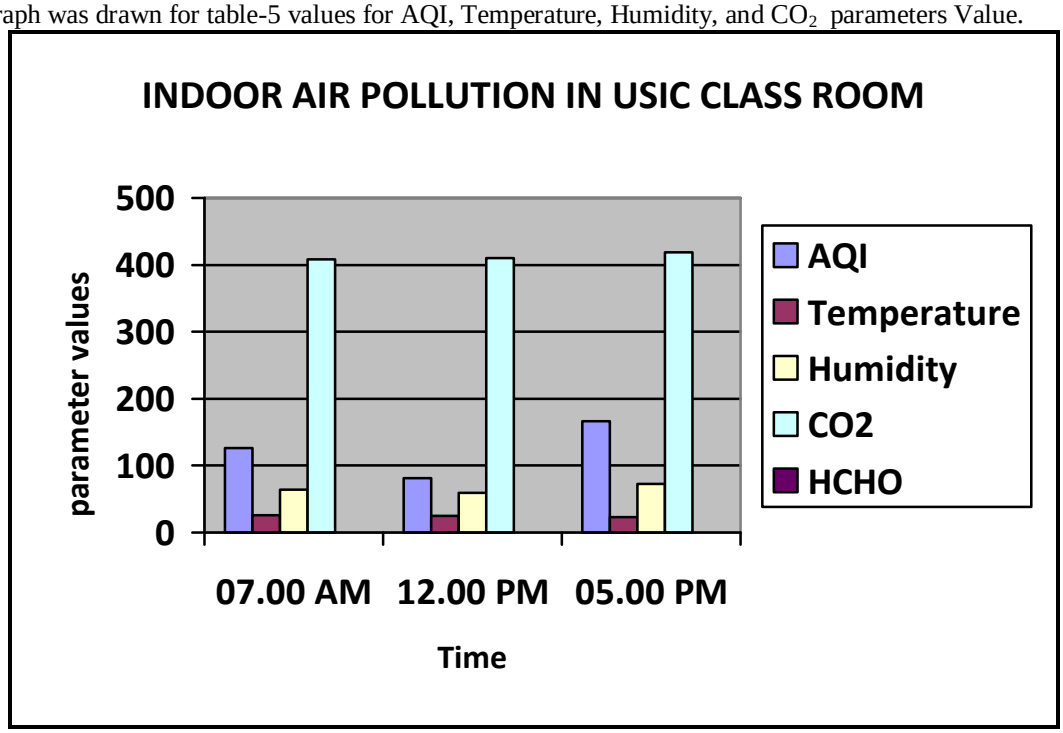


Table 5: Indoor air pollution for column graph :

Parameters	07.00 AM	12.00 PM	07.00 PM
AQI µg/m^3	126	81	166
Temperature(℃)	26	25	23
Humidity(%)	64	59	73
CO_2 µg/m^3	408	410	419
HCHO µg/m^3	0.09	0.05	0.04

VI. CONCLUSION:

In this study we come to a conclusion that the indoor air pollution was monitored and analyzed inside the Madurai kamaraj university campus. This gives a solution to indoor pollution, through which the current status of indoor air pollution inside the USIC-MKU were found. The data shows that all the data monitored in USIC building were high. This may be lead to a health related problems in students and working staffs within the building, because most of the time the staffs and students were available in the class room on University working days from (10 A.M to 5.45 P.M) . This arrangement gives an idea about establishment of smart class room /office /Lab in this University and create a pollution free environment in the working places. This gives a complete solution to the Indoor air pollution inside the USIC. When a indoor air pollution inside the campus increases would lead to the headache and uncomforting zone inside the working places. The further study on this matter would leads to zero indoor air pollution by advanced detection method like Advanced IOT based remote sensor technology with remote data transfer method with Wi-Fi and mobile phone message transfer.

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