An IoT based Portable Air Quality Monitoring System with CO and CO_2 Detector

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***Abstract*— Air pollution gives large impact on life quality and poses a threat towards the ecosystem. Evolution in number of vehicles and industrial activities from day to day affect the air quality especially in urban areas. People cannot avoid of owning a vehicle but they can avoid carrying out an outdoor activity such as jogging, hiking or even picnic at the polluted air areas. This project is to develop a portable IoT based on air quality monitoring system with CO and CO_2 detector by using Arduino microcontroller. User can monitor the air quality of the areas which they concerned by using this device. Most of the existing air pollution monitoring system is immobile and not concerning on monitoring the most harmful gases exist in atmosphere. This portable project focusing on a system that monitor air quality using MQ135, monitor temperature and humidity using DHT22 sensor as well as two of the most harmful pollutants exist, carbon monoxide and carbon dioxide using MQ7 and CO_2 gas sensor. Next, the objective of developing this system is to analyze data collected from all sensors used within three days, at three different places, one day for each place. Data will be collected on 8am to 9am, 12pm to 1pm, 5pm to 6pm and 8pm to 9pm and the data collected will be displayed in the form of graph using ThingSpeak platform.**

Keywords—CO, CO_2, Internet of Things, monitoring

I. INTRODUCTION

Portable air quality monitoring system with carbon monoxide and carbon dioxide detector IoT based is a portable project that will monitor air quality for three days at three different places. The idea of developing this system is when the occurrence of air pollution affects human's health either in short or long-term effect whether they live in healthy lifestyle or not. Level of air pollution increases as the number of vehicles on road as well as industrial activities increases day by day especially in urban areas. Air pollution has large influence on the concentration of constituents in the atmosphere leading to effects like global warming and acid rains (Infoplease, 2000). Not only effect on the atmosphere, some of air pollutants will affect living things such as plants and animals directly (Universe, 1995).

The system will implement based on Internet of Things (IoT) concept. This approach is to make the internet more fascinating thereby enable devices such as sensors, actuators are easily communicating with each other and can be controlled remotely. MQ135 sensor is used to monitor air quality while the MQ7 is used to monitor concentration of carbon monoxide. The CO_2 gas sensor is used to monitor concentration of carbon dioxide. Meanwhile, DHT22 sensor is to monitor ambient temperature as well as humidity. Reading received from the MQ135 and MQ7 sensors are converted from voltage to ppm. Data collected by these sensors will be sent to ThingSpeak software using an Arduino as data hub. The result will be displayed in the form of graph. The graph will inform user of which place and what time that are the most suitable and safe to do an outdoor activity.

II. RELATED WORKS

The project by (Alkandari & Moein, 2018) which is "Implementation of Monitoring System for Air Quality using Raspberry PI" are related with proposed project. Raspberry Pi are used as a microcontroller in this project. The system will inform user by email when the value of gases concentration goes beyond specified limit. Sensors used in this project are DHT22 (for temperature and humidity), TGS260 (general), MICS-2710 (nitrogen dioxide) and MICS-5525 (carbon monoxide).

In this "Air Pollution Monitoring System" project, real time wireless air pollution monitoring by using wireless sensor network (WSN) by (Rewatkar & Khatri, 2017) were developed. Gas sensor (MQ7 and MQ4) are calibrated using calibration technologies to sense concentration of carbon monoxide and carbon dioxide. These pre-calibrated gas sensors are then integrated with the wireless sensor motes for field deployment at the campus and the Coimbatore city using multi hop data aggregation algorithm. In order to view real-time pollution data via the Internet, light weight middleware and a web interface were developed in this project to ease user. These data can be viewed in form of numbers and charts. Technique called data fusion is implemented in this project to

enable data analysis from parameters like temperature and humidity sensed along with gas concentrations.

The "IoT based Air Quality Monitoring System" project by (Mathematics, 2017) introduced WSN-based air excellence monitoring system basically for urban areas and focus on dangerous emitted gases like carbon monoxide and nitrogen dioxide. Open firmware and software based on a bellum's gas sensing capable motes are used in this monitoring framework. Carbon monoxide and nitrogen dioxide sensor used in this project are developed and installed on Air Quality Monitoring System circuit. Values obtained from the sensor involved are sent to mobile via IoT central server and then displayed on computer screen.

The "IOT Based Indoor Air Pollution Monitoring using Raspberry PI" project is developed using Raspberry Pi by (Sivasankari, 2018) and programmed using Python language. In this project, concentration of smoke, carbon monoxide, nitrogen dioxide as well as temperature and humidity are monitored. If there is high in reading of concentration of gases, it will trigger an alarm to notify user. Threshold value can be fixed accordingly to trigger out alarm. Data recorded are sent to an IP address and plotted in a graph every half an hour using ThingSpeak platform. Sensors used in this system are humidity sensor, MQ2 sensor, Mics 2714 NO2, LM35 temperature sensor and MQ7 sensor. When sensors are interfaced with Raspberry Pi it gives reading in parts per million(ppm).

The "Indoor Air Quality Monitoring System Using Raspberry Pi for Energy Efficiency in Classrooms" project developed by (Balta, Yalcin, & Ozmen, 2018) comes out with a system that monitor air quality inside the classroom by using Raspberry Pi as a microcontroller and gateway application. The project collects data of concentration of carbon dioxide, humidity and temperature. Networked sink nodes using 77535 CO_2/Temp./RH Meter are developed to measure the parameters needed.

III. PROPOSED SYSTEM

For this "An IoT based Portable Air Quality Monitoring System with CO and CO_2 Detector" project, below are the criteria that have been considered in order to set up the prototype.

i. List the electronic components to be used in the project. Prepare the schematic diagram layout of the project. Study on how to connect sensors; MQ135, MQ7, CO_2 gas sensor and DHT22 to Arduino Uno R3.

ii. Determine the software that are going to be used to program the controller. USB Cable Type B is used to powered up and to program the Arduino controller.

iii. Data collected by all the sensors via ESP 8266 01S Wi-Fi module is then uploaded and store in cloud storage. Data collected from sensors used will be uploaded to ThingSpeak server by using Arduino as data hub.

iv. LCD I2C is used to display real-time data for user.

A. Hardware

Figure 1 shows the hardware components that are used for this project while Figure 2 shows the complete prototype after been assembled.

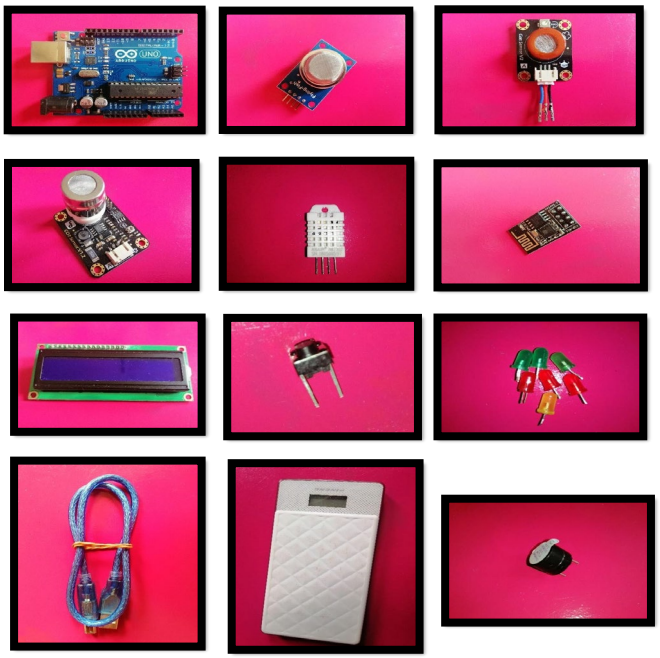

Figure 1: Hardware components

Figure 2: The final prototype

B. *Flow chart*

Figure 2 shows the flow chart of the project.

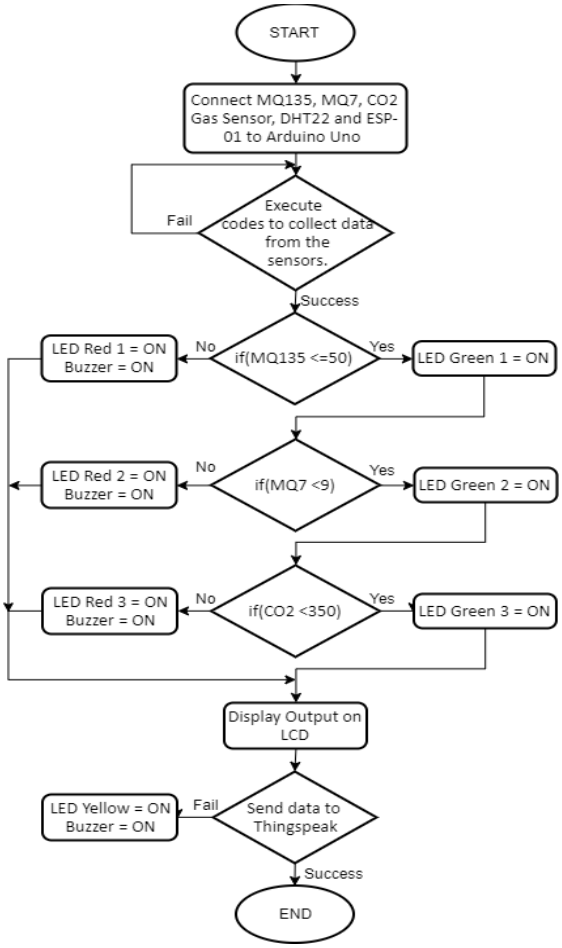

Figure 2: Flow chart of the system

Arduino IDE is the software used to compile, run and upload the code to the Arduino Uno R3. Figure 3 shows the coding to configure MQ135 and MQ7 sensors.

Figure 3: Sensor configuration via Arduino IDE

IV. RESULT AND DISCUSSIONS

In this section, the prototype will record the air quality reading at three places which are Tasik Danau Kota Setapak, Bukit Dinding Wangsa Maju and Taman Botani Perdana. It is placed for 3 days, each place will collect sensor reading starts at 8.00 am to 9.00 am, 12.00 pm to 1.00 pm, 5.00 pm to 6.00 pm and 8.00 pm to 9.00 pm. Figure 4 shows the web interface for ThingSpeak, an IoT analytics software that is used to visualize the data collected into graph. From the graph, user can analyze and conclude the most suitable time and place to conduct an outdoor activity.

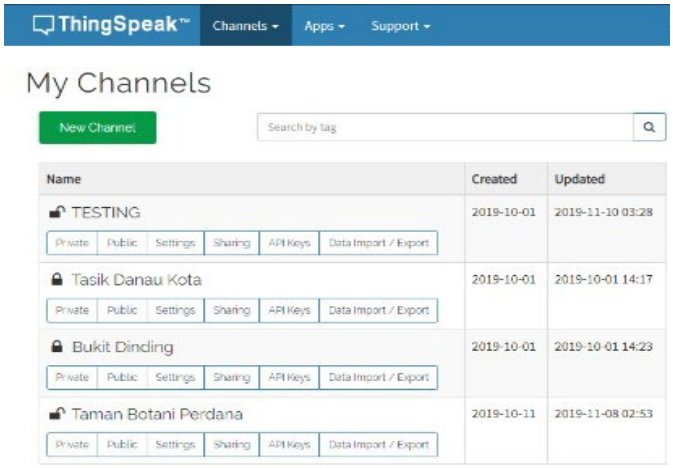

Figure 4: Web Interface for ThingSpeak

A. *Air Quality Index*

Figure 5 below shows the reading of the air quality index between the three places Tasik Danau Kota (TDK), Bukit Dinding (BD) and Taman Botani Perdana (TBP).

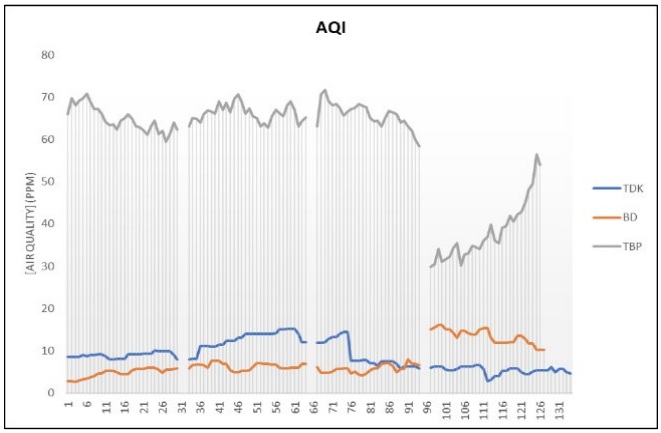

Figure 5: AQI reading between 3 places

From the graph, it can be concluded that air quality level at Taman Botani Perdana is the poorest among them. The average calculation for AQI at Taman Botani Perdana is 53.36 PPM. Referring to Table 1, the air quality at this place is considered as moderate level. Tasik Danau Kota and Bukit Dinding record an average reading of air quality level as at 7.94 and 6.29 PPM respectively. The air quality for both places are considered satisfactory and air pollution poses little or no risk. We use Table 1 as the air quality index guideline for this project.

Table 1: AQI table (Virginia, 2016)

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51-100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	> 300	Health warnings of emergency conditions. The entire population is more likely to be affected.

B. Carbon monoxide

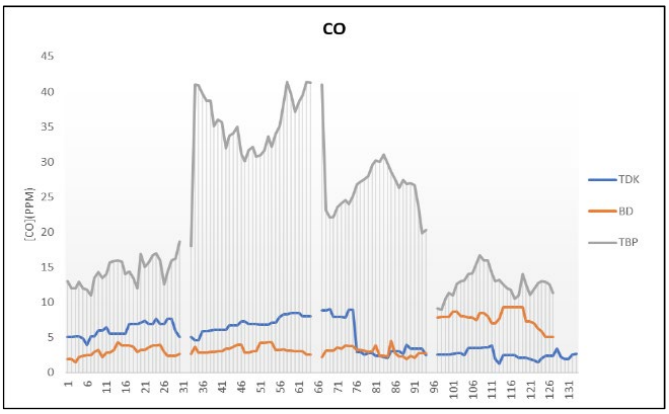

Figure 6: CO reading between 3 places

Same as previous graph, Taman Botani Perdana has the highest value of carbon monoxide compared to Bukit Dinding and Tasik Danau Kota. According to CO PPM in Table 2, Taman Botani Perdana with the CO average value of 21.41 PPM is still considered good but if compared to average at Bukit Dinding (3.90 PPM) and Tasik Danau Kota (4.69 PPM), both of the places record a very good reading.

Table 2: CO concentration in Air (Wohlfarth, n.d.)

CO CONCENTRATION IN AIR	INHALATION TIME AND SYMPTOMS
9 ppm	ASHRAE maximum allowable concentration for short exposure in a living area.
50 ppm	Maximum allowable concentration for continuous exposure in any 8-hour period.
200 ppm	Headache, tiredness, dizziness and nausea after 2 to 3 hours.
400 ppm	Frontal headache within 1 to 2 hours and life threatening after 3 hours. Maximum allowable amount (air-free) in flue gases.
800 ppm	Dizziness, nausea and convulsions within 45 minutes. Unconsciousness within 2 hours. Death within 2 to 3 hours.
1,600 ppm	Headache, dizziness and nausea within 20 minutes. Death within 1 hour.
3,200 ppm	Headache, dizziness and nausea within 5 to 10 minutes. Death within 30 minutes.
6,400 ppm	Headache, dizziness and nausea within 1 to 2 minutes. Death within 10 to 15 minutes.
12,800 ppm	Death within 1 to 3 minutes.

C. Carbon dioxide

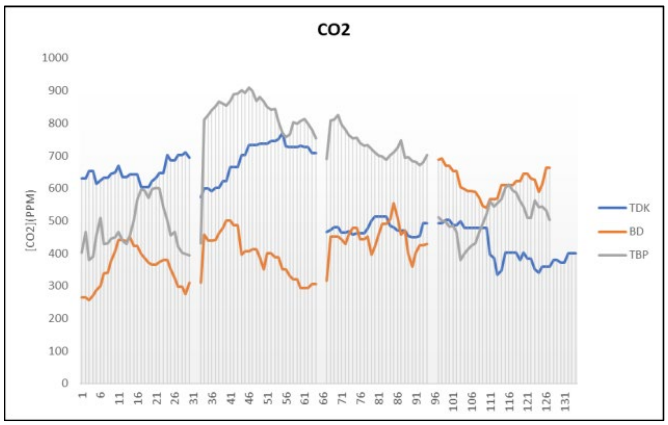

Figure 7: CO_2 reading between 3 places

According to Figure 7, the graph pattern at the three chosen places is almost equal. But if the average is calculated, carbon dioxide average at Taman Botani Perdana has the highest among them with value of 614.14 PPM. If refer to CO_2 table in Table 3, CO_2 level between 400 to 600 is considered as excellent but at Taman Botani Perdana, the air quality in terms of carbon dioxide falls under good CO_2 category. For Tasik Danau Kota and Bukit Dinding, the average PPM value for carbon dioxide is 517.31 and 427.72 PPM respectively. Both places are considered having an excellent air quality in terms of carbon dioxide.

Table 3: CO_2 Table (Rtu & Light, n.d.)

CO_2 [ppm]	Air Quality
2100	BAD Heavily contaminated indoor air Ventilation required
2000	
1900	
1800	
1700	
1600	
1500	MEDIOCRE Contaminated indoor air Ventilation recommended
1400	
1300	
1200	
1100	
1000	FAIR
900	
800	GOOD
700	
600	EXCELLENT
500	
400	

D. Temperature

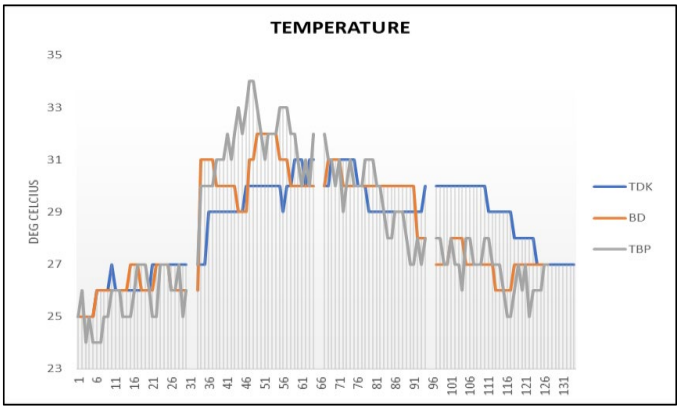

Figure 8: Temperature graph between 3 places

Based on the graph in Figure 8, the average temperature at the three places is likely equal. At Tasik Danau Kota, the average temperature is 27.88 °C whereas at Bukit Dinding and Taman Botani Perdana the average temperature is 28.16 °C. It can be concluded that the temperature at all places is normal and excellent.

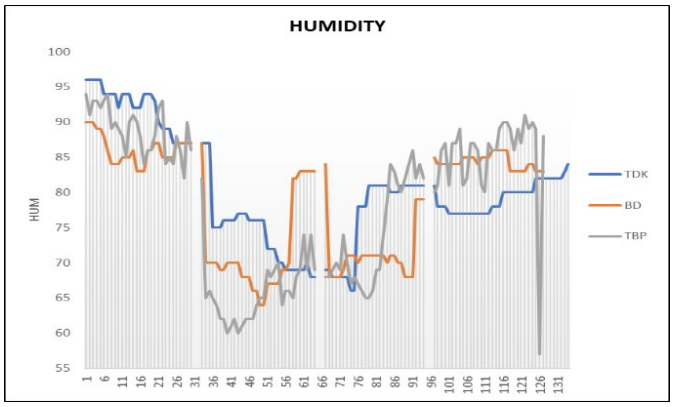

Figure 9: Humidity graph between 3 places

According to Figure 9, Tasik Danau Kota has the highest average humidity value of 78.47 RH. From the reading, the area is considered moist. While the average humidity value at Bukit Dinding and Taman Botani Perdana is 77.20 and 77.07 RH respectively. We can say that the humidity result is as per recorded perhaps due to the frequent raining. So, the place is moist all day long and justifies the reading collected by DHT22 sensor.

The table 4 below records the overall findings for the three places.

Table 4: Overall result

	AQI	CO	CO2	TEMP	HUM
TASIK DANAU KOTA	Good	Excellent	Excellent	Normal	Moist
BUKIT DINDING	Excellent	Excellent	Excellent	Normal	Moist
TAMAN BOTANI PERDANA	Moderate	Moderate	Good	Normal	Slightly Moist

V. CONCLUSION

The development of this project is to help user to monitor air quality, concentration of carbon monoxide as well as carbon dioxide, the ambient temperature and the humidity. This project focus group is those people who love to spend their time by carrying out outdoor activities. Dangerous gases emitted by vehicles in Kuala Lumpur especially, contribute a lot to air pollution. Majority of people carry out activities outside their houses, such as jogging at the park, go out for a picnic, etc and they did not aware on the air quality of the area. So, with this portable air quality monitoring system with carbon monoxide

and carbon dioxide detector, user can simply bring it anywhere with them and check whether thearea is polluted or not.

From the result collected, it can be concluded the project has met the initial objectives set. Most of the previous monitoring system that has been reviewed, only MQ135 and MQ7 are used. This project has included CO_2 gas sensor as an extra reference for the user. On the other hand, without a proper conversion of the two analog sensor, MQ135 and MQ7, the actual PPM value may not be accurate. As an IoT based project, the major constraint is the internet connection. The data cannot be sent to ThingSpeak server if the internet connection is down.

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