Study of PM2.5 Spatial and Temporal Variation using IoT and AirLink Sensors at Kaeng Krachan Dam, PetchBuri, Thailand

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Abstract

Fine particles are an air pollutant that poses concerns to people's health when levels in the air are high. Kaeng Krachan Dam Phetchaburi Province, Thailand, receives a large number of tourists visiting each year. And is the main source of water supply for the community. This study has the following objectives: (1) to build an IoT sensor to determine PM 2.5, temperature and Humidity, (2) To study the problem of PM2.5 air quality in communities around Kaeng Krachan Dam, (3)to study and develop Arduino IDE programming and send data to Cloud for comparison. In this study, We installed PM1, 2.5 and 10 sensors at three Kaeng Krachan Dam, the upper and the lower dam areas. We used the GLOBE Observer App Cloud Protocols to collect cloud data and correlate it with the PM results. Google sheets software was used to import PM data from the IoT and Davis server. From the data collected, it was found that there was a prevalence of dust particles PM 1, PM 2.5, and PM 10. Around Kaeng Krachan Dam, both upper and lower. Additionally, PMs increase around 8:00 a.m. in the hotel's parking area and decrease in the middle of the night. But there may be other factors that affect the PMs, such as burning garbage, barbecue parties, or traffic areas. The custom-made sensors have been proven to work. But the data must be calibrated with standard sensors on the market to assure the quality of the measurements. Machine Learning is also needed to go beyond linear calibration. It was recommended to continue the study of the causes and relationships of PM and cloud prevalence and sensor calibration as the trend of rising PM is observed toward the winter season where rain and wind are significantly reduced.

Keywords: Particulate Matter; PM 1; PM 2.5; PM 10; IoT; Iot Sensors; Arduino IDE

i.Introduction

Quality monitoring for sustainability for natural resources such as clean air is indeed vital. Nowadays, quality monitoring is augmented and far-reaching because of the advent of advanced technologies like Internet of Things (IoT). The Internet of Things as a technological infrastructure gives us a platform to possibly connect devices anywhere in the world via wireless connections and even extends to sensor technology applications. IoT is by far used in different applications For example, to measure the amount of Particulate matter with diameter of less than 2.5 micron (PM2.5), also known as Final Particles, the United States Environmental Protection Agency, US. EPA (United State Environmental Protection Agency), has set a standard value of Small dust particles in the air that are harmful to human health are recorded using PM (Particulate Matters) as a criterion for measuring air quality (Manaphan Phoyan Et al., 2022). PM2.5 is dust in the air that has Diameter 2.5 microns, 1 of 8, measuring air quality standards in the atmosphere (Dust Monitoring Group of Chulalongkorn University, 2019)

With the advent of these new technologies, application on determination of PM 2.5 using IoT sensors is within reach. Air is one of the most profitable and valuable sources since it is the fundamental need of all the individuals. PM 2.5 determination would give us the advantages of preventing the occurrence of problems such as air pollution and do necessary steps to minimize or mitigate the problem. High levels of PM2.5 can cause serious health effects to local people. Long-term exposure to high PM2.5 levels causes serious diseases such as lung cancer, stroke, heart disease and diabetes (WHO, 2016; Bowe et al., 2018).

Kaeng Krachan Dam is the largest western dam in Thailand. Blocking the Phetchaburi River At Khao Chao area and Khao Mai Ruak close to Kaeng Krachan Subdistrict Kaeng Krachan District Phetchaburi Province. It's on the upstream side of Phet Dam up the road 27 kilometers. The dam ridge is 760 meters long, 8 meters wide and 58 meters high. The dam ridge level is 106 meters above mean sea level. The base is 250 meters wide at its widest point. The reservoir has an area of 46.5 square kilometers and a capacity of 710 million cubic meters(Royal Irrigation Department, n.d.).The important benefit of dams is to store water. They collect water from the flood season and release it for use in agriculture. consumption during water shortages Dams are still used to prevent flash floods during the flood season. The dam will act to slow down the speed of the water. Allow water to flow through only the appropriate amount. At present, dams have another main function: generating electricity. Part of the electricity in Thailand comes from electricity generated from dams(Thailandplus, 2021). The aforementioned reasons motivated the researchers to conduct this study with the objectives (1) to build an IoT sensor to determine PM 2.5, temperature and Humidity , (2) To study the problem of PM2.5 air quality in communities around Kaeng Krachan Dam , (3)to study and develop Arduino IDE programming and send data to Cloud for comparison.

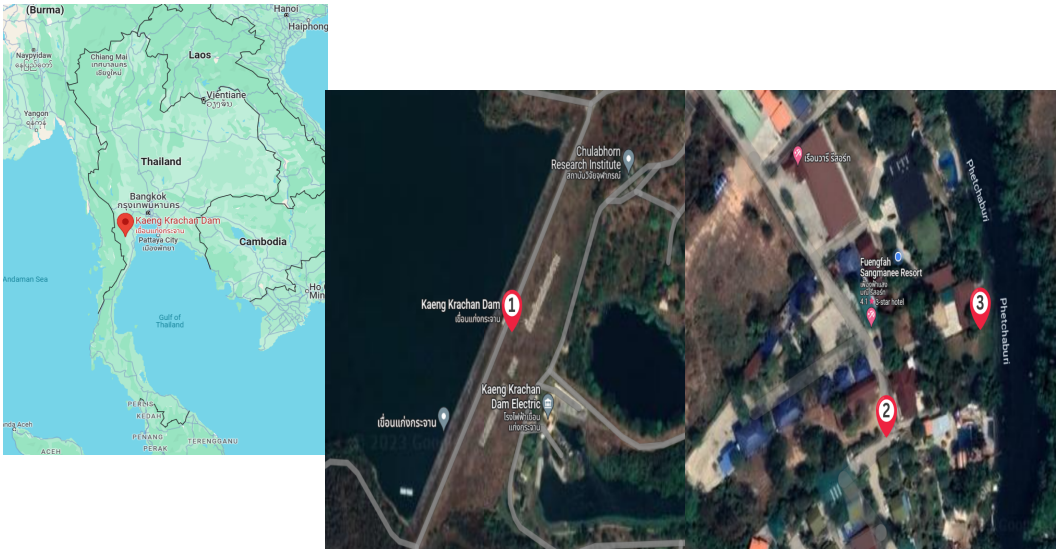
ii. Materials and Methods

A. Study Area Description

Figure 1 shows the study location. The study location has 3 locations.

Along Kaeng Krachan Dam, Point A (12.916904, 99.629972), Ruean Waree Hotel parking ramp, Point B (12.905380753648805, 99.64283665610594) and along the river, Ruean Waree Hotel, Point C (12.905564820303297, 99.64355418682459).

The study site was the Kaeng Krachan Dam (Latitude 12.8954095845, Longitude 99.6319976221) in Phetchaburi province, in the Central region of Thailand (Fig. 1). . The annual precipitation is 774–1879 mm, with an average temperature of 20-34 C. The Kaeng Krachan. The site's elevation is about between 37 and 1,231 meters above the sea level, and it experiences a tropical monsoon climate. Dam was initiated in 1983 with an area of 409,000 ha (1,800,000 rai in local unit) which consists of Seven main species of trees— ***Xylia xylocarpa, Bombax ceiba, Schleichera oleosa, Croton oblongifolius Roxb., Lagerstroemia floribunda, Vitex canescens Kurz , Lannea coromandelica (Houtt.) Merr.***



B. Figure 1. Study Site

B. Materials

B.1. Hardware and Software component of PM 2.5 IoT Sensor (Appendix A)

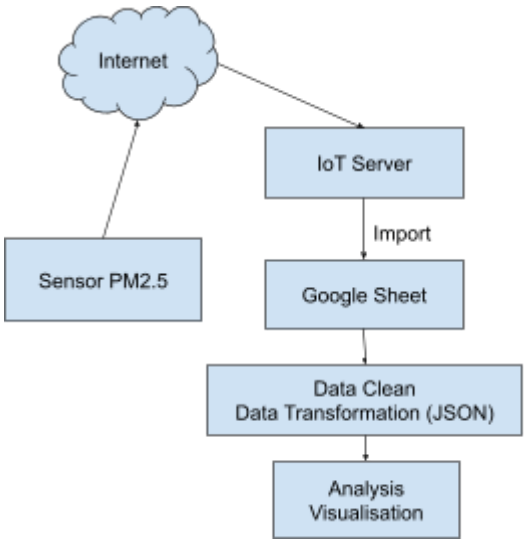
1. PM 2.5 Laser Dust Sensor.
2. Davis Arilink Sensor
3. 4 Jumper wires (male and Female).
4. Node MCU.Electrical Box Casing.
5. Wifi pocket.
6. Power bank.
7. Arduino IDE.
8. Breadboard.

9. USB wires.
10. Computer.

C. Methods of Operation and Data Collection

C.1. PM 2.5 Iot Sensor Construction and Operation

1. Place the NodeMCU on the breadboard. The rest of the instructions assume the front (with the holes) of the PM 2.5 sensor is facing you.
2. Connect the jumper wire to the PM 2.5 sensor. The second pin of the DHT 22 (from the left). You should connect it to D2, D3 on the MCU, 3v3 or Vin on the MCU. The last pin of the PM 2.5 sensor (from the left) is the Ground pin. It should be connected to GND.
3. Connect the Micro-USB to MCU and PM 2.5 sensor and connect it to the notebook.
4. Open ARDUINO IDE software and set up the SoftwareSerial library. It can be installed using Arduino's library manager.



5. Open your Arduino IDE and copy the following code. (Figure 2):

```
const char* ssid     = "TVOWalailak2021"; //ชื่อwifiโรงแรม ริมน้ำ
const char* password = "TVOwifi@007"; //password


const int analogInPin = A0;
int sensorValue = 0;

#define DHTPIN D4
#define DHTTYPE DHT22

DHT dht(DHTPIN, DHTTYPE);

SoftwareSerial mySerial(D2,D3); // RX, TX
unsigned int pm1 = 0;
unsigned int pm2_5 = 0;
unsigned int pm10 = 0;

void setup() {
  Serial.begin(9600);
  while (!Serial) ;
  Serial.println(F("IoT AI Module v 1.0"));
  Serial.println(F("CoE for Ecoinformatics, Walailak University
  Serial.println(F("(c) 2023 Krisanadej Computing"));
  Serial.println(F("DHTxx test!"));
```

Figure 2. Arduino Code for Laser Dust Sensor

6. Opening up your server with a browser, you should see the data. (Figure 3):

{"T":"{2023,11,27,00,06,46}","Temp":"26.20","Humid":"76.00","CO":"218","TimeStamp":"6420522","PM1":"1","PM25":"4","PM10":"5"},
{"T":"{2023,11,27,00,16,56}","Temp":"26.30","Humid":"75.30","CO":"214","TimeStamp":"7030695","PM1":"1","PM25":"7","PM10":"7"},
{"T":"{2023,11,27,00,27,07}","Temp":"26.10","Humid":"76.40","CO":"211","TimeStamp":"7640865","PM1":"1","PM25":"5","PM10":"7"},
{"T":"{2023,11,27,00,32,12}","Temp":"26.10","Humid":"76.90","CO":"192","TimeStamp":"7946025","PM1":"0","PM25":"7","PM10":"7"},
{"T":"{2023,11,27,00,37,17}","Temp":"26.10","Humid":"76.80","CO":"188","TimeStamp":"8251193","PM1":"1","PM25":"10","PM10":"10"},
{"T":"{2023,11,27,00,42,22}","Temp":"26.20","Humid":"76.10","CO":"208","TimeStamp":"8556360","PM1":"1","PM25":"7","PM10":"8"},
{"T":"{2023,11,27,00,47,27}","Temp":"26.10","Humid":"75.80","CO":"204","TimeStamp":"8861519","PM1":"1","PM25":"8","PM10":"8"},
{"T":"{2023,11,27,00,52,32}","Temp":"26.20","Humid":"75.70","CO":"199","TimeStamp":"9166687","PM1":"1","PM25":"7","PM10":"7"},
{"T":"{2023,11,27,00,57,38}","Temp":"26.20","Humid":"76.50","CO":"207","TimeStamp":"9471848","PM1":"4","PM25":"11","PM10":"11"},
{"T":"{2023,11,27,01,02,43}","Temp":"26.20","Humid":"76.90","CO":"205","TimeStamp":"9777105","PM1":"0","PM25":"4","PM10":"5"},
{"T":"{2023,11,27,01,07,48}","Temp":"26.20","Humid":"77.10","CO":"204","TimeStamp":"10082270","PM1":"4","PM25":"7","PM10":"8"},
{"T":"{2023,11,27,01,12,53}","Temp":"26.20","Humid":"76.60","CO":"196","TimeStamp":"10387511","PM1":"0","PM25":"5","PM10":"5"},
{"T":"{2023,11,27,01,17,58}","Temp":"26.10","Humid":"76.10","CO":"201","TimeStamp":"10692673","PM1":"5","PM25":"11","PM10":"13"},
{"T":"{2023,11,27,01,23,04}","Temp":"26.20","Humid":"75.90","CO":"199","TimeStamp":"10997841","PM1":"1","PM25":"7","PM10":"8"},
{"T":"{2023,11,27,01,28,09}","Temp":"26.10","Humid":"76.60","CO":"199","TimeStamp":"11303008","PM1":"0","PM25":"2","PM10":"2"},
{"T":"{2023,11,27,01,33,14}","Temp":"26.30","Humid":"77.20","CO":"200","TimeStamp":"11608167","PM1":"0","PM25":"4","PM10":"4"},
{"T":"{2023,11,27,01,38,19}","Temp":"26.20","Humid":"77.40","CO":"197","TimeStamp":"11913333","PM1":"1","PM25":"5","PM10":"7"},
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{"T":"{2023,11,27,02,08,50}","Temp":"26.10","Humid":"77.60","CO":"188","TimeStamp":"13744225","PM1":"0","PM25":"4","PM10":"5"},
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{"T":"{2023,11,27,03,04,47}","Temp":"26.10","Humid":"78.10","CO":"185","TimeStamp":"17101070","PM1":"2","PM25":"8","PM10":"8"},
{"T":"{2023,11,27,03,09,52}","Temp":"26.10","Humid":"77.50","CO":"181","TimeStamp":"17406272","PM1":"5","PM25":"11","PM10":"11"},

Figure 3. PM Sensor Data Generated from the Server

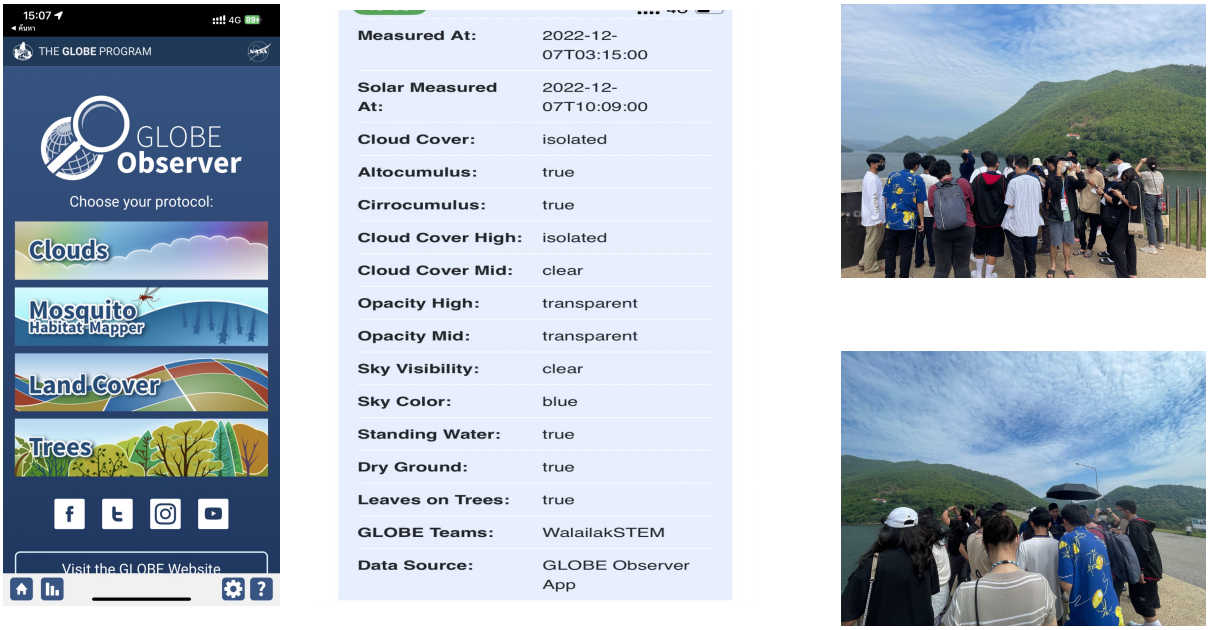

Figure 4. Cloud data collected using the GLOBE Observer: Cloud application.

iii. Results and Discussion

A. Particulate Matters (PM)

Figure 5A, 5B, 5C,5D, 5E, 5F shows the amount of PM2.5 dust recorded for 3 days (27-29/2023) from sensor 1 at the dam crest, sensor 2 at the parking lot and sensor 3 along the river next to the resort dam. As in this graph, The sensors PM 02

will be at the parking lot of Rueanwaree Hotel. (12.915713825083957, 99.63073622300088) It was found that the dust particles recorded by the PM 02 sensor were quite high at night near Rueanwaree Hotel. This is an area with heavy traffic during the market and is a residential and resort area. This can be concluded from information found in the hotel parking area. During the day, there will be a lot of smoke from motorcycle exhaust pipes. And there will be a grill in the hotel area at night. Meanwhile, on the dam where the PM01 sensor is located, higher particle values were recorded during the day. This may be because the area is a stop for sightseeing and photography, causing locals to wander throughout the morning.

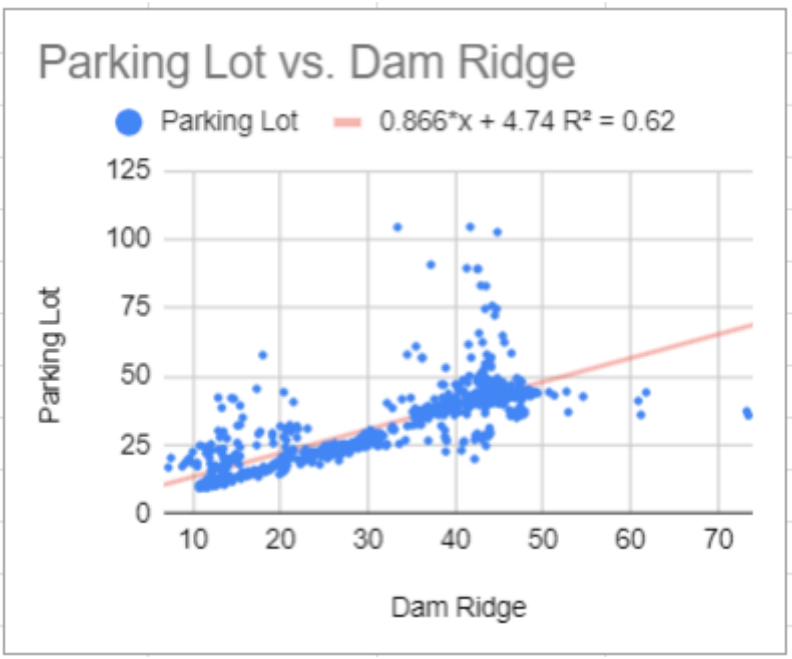

Figure 5A: Graph comparing PM2.5 values between the AirLink air quality meter and the researcher's air quality meter. Dam ridge area and parking lot

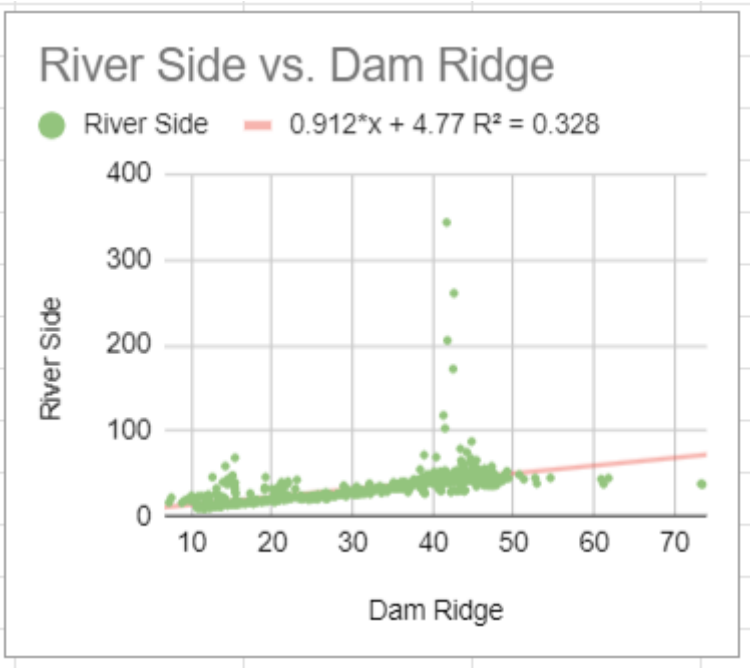

Figure 5B: Graph comparing PM2.5 values between the AirLink air quality meter and the researcher's air quality meter. Dam Ridge area and riverside

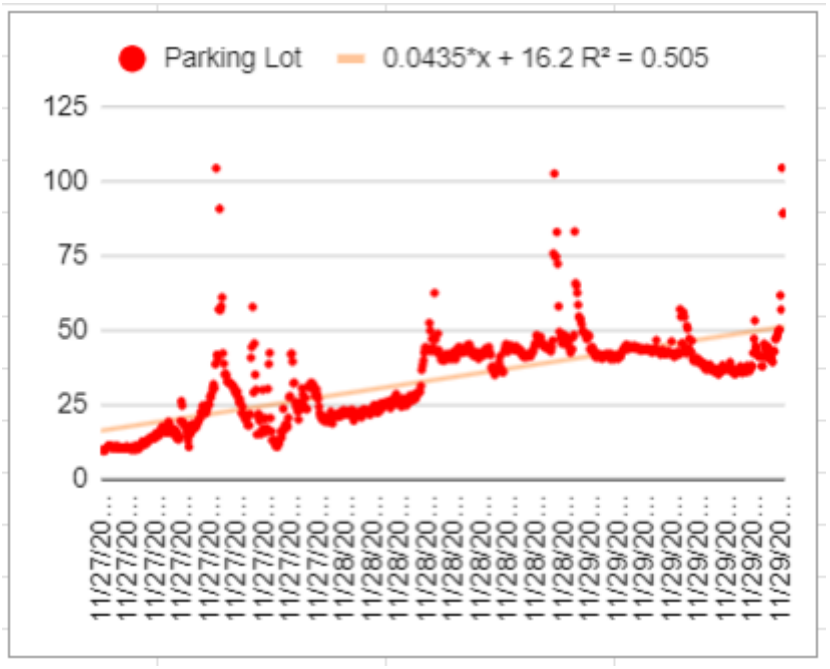

Figure 5C: Graph comparing PM2.5 values between the AirLink air quality meter and the researcher's air quality meter. Parking Lot

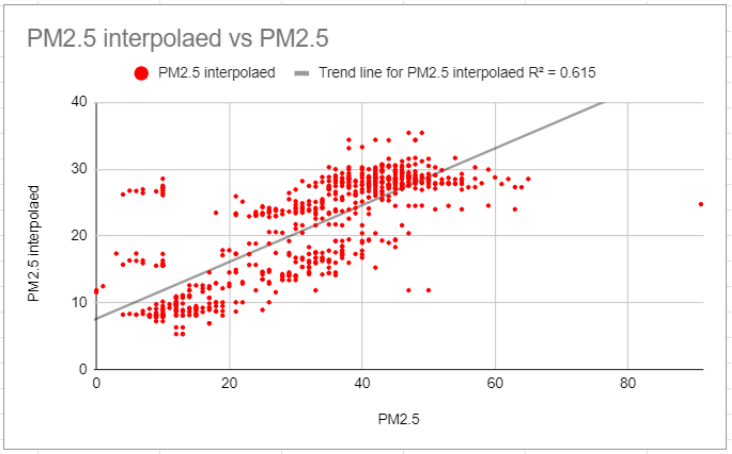

Figure 5D Compare the pm 2.5 value of the AirLink air quality meter and the researcher's air quality measuring device. Dam Ridge area

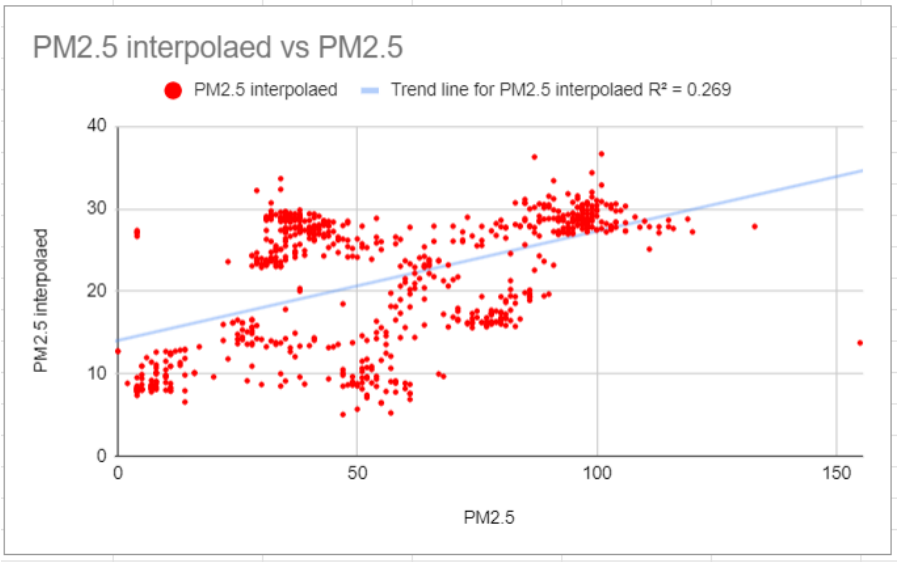

Figure 5E Compare the pm 2.5 value of the AirLink air quality meter and the researcher's air quality measuring device. Parking Lot

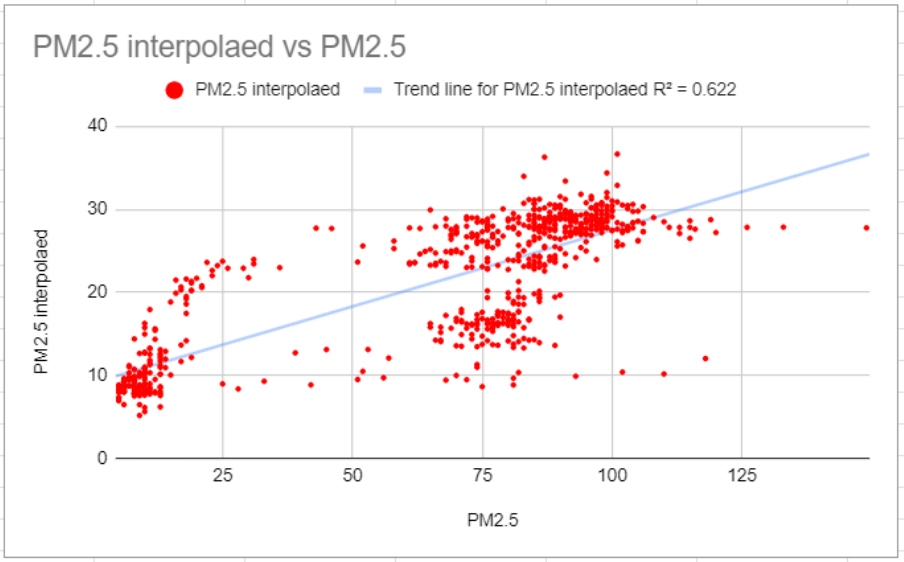

Figure 5F Compare the pm 2.5 value of the AirLink air quality meter and the researcher's air quality measuring device. River Side area

B. GLOBE Cloud protocol

Cloud data was collected using the Globe Observer application, a cloud data collection and study system. This is because clouds can affect air quality in many ways, such as clouds acting as cover, which reduces the amount of sunlight that hits the earth's surface. May affect pollution such as ground-level ozone. Which is an important component of smog.

Clouds or floating masses of water vapor condense. Can affect the composition of gasses and particles in the air. Air and ground temperature, wind speed, direction, and humidity level All of this may vary according to the vertical and horizontal size of the cloud. This includes when clouds form, move and dissipate.

The least amount of clouds to no clouds in the sky. At the time of the collection of data recorded from the Globe Observer application, the cloud data collection and study system. As shown in Figure 4, this is related to the amount of dust detected by the PM sensor at the same time as data collection (Figures 5A to C). Additionally, Figures 5A to C show that the device was installed in different areas and dates show that equipment in the parking area, as shown in Figure 5B, has higher dust levels than in the area. The dam ridge and riverside are as shown in the graphs in Figures 5A and 5C. Due to the high volume of vehicles traveling there, the amount of dust has increased. When compared to the other two areas, the area along the river (Figure 5C) has a higher amount of dust. The dam area (Figure 5A) at night (PM 3 sensor) has less dust than during the day.

C. Conclusion

Conclusion: After testing, it was found that the AirLink air quality meter and the researcher's measuring device were compared as shown in Table (5E) in the Dam Ridge area. (5F)Parking LOt and (5G) River Side areas It was found that the value obtained was close to 1, but in the chart (5G), the value of the graph was not close to one, which indicates that this tool still has some shortcomings but can be used as a replacement. AirLink air quality measurement device obtained PM2.5 values in the parking lot area that were higher than the dam ridge area at regular intervals, as shown in graph (5A). In the area next to the river, PM2.5 values were higher than the dam ridge area (5B). And in the parking area, the PM2.5 value gradually increased from the first day of testing, as shown in graph (5C).

D. Suggestions

Air pressure and wind speed should be measured to check for other factors. that affects the amount of PM2.5 besides temperature In addition, the installation points for both PM2.5 meters should be chosen to be as similar as possible to reduce data discrepancies. And increase the installation of PM2.5 meters to get more data and be able to analyze it accurately.

I would like to claim IVSS badges

1. I make an impact

The report clearly describes how a local issue led to the research questions or makes connections between local and global impacts. The students need to clearly describe or show how the research contributed to a positive impact on their community through making recommendations or taking action based on findings. This study is Fine particulate matter (PM2.5) is an air pollutant that is a concern for people's health. PM2.5 is able to travel deeply into the respiratory tract, reaching the lungs. Exposure to fine particles can cause short-term health effects such as eye, nose, throat and lung irritation, coughing, sneezing, runny nose and shortness of breath.

2. I am a STEM professional.

The report clearly describes collaboration with a STEM professional that enhanced the research methods, contributed to improved precision, and supported more sophisticated analyses and interpretations of results. The data from the sensors were used to analyze the results. Graph to see how the data relates.

3. I am an engineer

The report uses student-generated sources of evidence to describe an engineering problem, looks at solutions through engineering, or optimizes a design to address a real-world problem, and describes the potential impact of the engineering principles on the environment. We developed a PM2.5 sensor to collect data by ourselves. and compared with commercially available sensors.

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