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A New Android Application Framework (AAF) For API $PM_{2.5}$ Data Management System

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Abstract: Air Pollution Index (API) is used in Malaysia to measure the ambient air quality and $PM_{2.5}$ is one of its parameters. Therefore, it is important to monitor the $PM_{2.5}$ for ambient air quality monitoring and especially during haze event. However, most of the $PM_{2.5}$ sampler available for research and monitoring by university and monitoring provider are in manual mode in which the data was logged into the equipment data logger, and it was manually extracted from the data logger to personal computer to analyze. This would cause a difficulties of monitoring person to monitor and report the data in a real time. The problem become worst during the Movement Control Order (MCO) period as well as during the haze event or rainy season as the access to the site for data extraction was limited. Therefore, this project is aimed to propose an Android Application Framework (AAF) containing IoT device to monitor the real-time ambient air quality and disseminate computed API information through social media platform. Mobile apps such as Blynk apps was encouraged as it is simple and user friendly to monitor real-time ambient $PM_{2.5.}$ Mobile apps with high mobility enable user to control remotely on desirable outcomes at any time. There are six stages to plan and accomplish in relation to make proposed AAF succeed. This included the E-Sampler interface with IoT, mobile application, data management, data management system, API judgement, and information dissemination. As a result,

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proposed AAF has fully utilized in obtaining real-time pollutants data and finally analyze $PM_{2.5}$ to obtain real-time API information. IoT device has successfully interface with E-Sampler, to obtain raw data and able to be downloaded for further analysis. In conclusion, AAF has functioned great, enabling the collection of raw data at fingertips. The API information were collected, calculated, analyzed, and finally disseminate to the public through Facebook and Instagram.

Keywords: Android Application Framework (AAF), Real-Time Ambient Air, Social Media Platform

1. Introduction

With the rapid urbanization and industrialization, aggressive economic activities and excessive exploitation are shifting the natural beauty environment towards degradation. As a developing country, Malaysia is currently facing a series of challenges from environmental issues. Climate change, global warming, depletion of ozone layer, various environmental pollution, ecosystem degradation, and excretion of harmful waste are few of anthropogenic catastrophes [1]. The Rakyat Post (TRP) online news reported that according to the World Air Quality Index (WAQI), Malaysia has an average API reading of 266 declared as the most polluted country in the world in 2019 due to the occurrence of haze [2]. In Malaysia, Air Pollution Index (API) is used as the ambient air quality measurement. The World health Organization (WHO) new Malaysia ambient air quality guidelines (AQG) in Table 1 are designed to offer guidance in reducing the health impacts of air pollution[3]. API calculation in Table 2 is totally based on Air Quality Index (AQI) that has been accepted at the international level by United States Environmental Protection Agency (USEPA)[4]. The air pollutants concentration limit has been strengthened in stages until 2020 with three interim targets were set for all API parameters as a guideline[5].

Table 1: New Malaysia Ambient Air Quality Standard [5]

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015) µg/m³	IT-2 (2018) µg/m³	Standard (2020) µg/m³
Particulate Matter with the size of less than 10 micron (PM_{10})	1 Year	50	45	40
	24 Hour	150	120	100
Particulate Matter with the size of less than 2.5 micron ($PM_{2.5}$)	1 Year	35	25	15
	24 Hour	75	50	35
Sulfur Dioxide (SO_2)	1 Hour	350	300	250
	24 Hour	105	90	80
Nitrogen Dioxide (NO_2)	1 Hour	320	300	280
	24 Hour	75	75	70
Ground Level Ozone (O_3)	1 Hour	200	200	180
	8 Hour	120	120	100
*Carbon Monoxide (CO)	1 Hour	35	35	30
	8 Hour	10	10	10

*mg/m³

API is developed in a way easily understood ranges of values as a mean of reporting the quality of air instead of the actual concentration of air pollutants. Sub-index formula for PM2.5 will be implemented to the raw data. The ranges also reflect its effects on human health ranging from good to hazardous. The API ranges can be classified into five range, which are good (0-50), moderate (51-100), unhealthy (101-200), very unhealthy (201-300), and hazardous (greater than 300)[6]. The color indication in Table 3 will be used in this project to show the real-time API status from anytime.

Table 2: Sub-index formula for $PM_{2.5}$ [6]

API	BREAKPOINT OF CONCENTRATION	EQUATION FOR API
	X=PM2.5 concentration (24h average, unit;µg/m3)	
0-50	0≤X≤12.0	API=4.1667 x X
51-100	12.1≤X≤75.5	API=0.7741 x (X-12.1) + 51
101-200	75.5≤X≤150.4	API=1.3218 x (X-75.5) + 101
201-300	150.5≤X≤250.4	API=0.9909 x (X-150.5) + 201
301-400	250.4≤X≤350.4	API=0.9909 x (X-250.5) + 301
401-500	350.4≤X≤500.4	API=0.6604 x (X-350.5) + 401

Table 3: Reading for API

Reading for API	
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very Unhealthy
Above 300	hazardous

Met-One E-Sampler instrument is used currently in UTHM Parit Raja to measure particulate. Several sensors were used to obtain raw data. This included Wind Speed and Wind Direction sensor, Ambient Relative Humidity (RH) sensor, Internal Relative Humidity (RH) sensor, Ambient, Temperature (AT) sensor, Pressure sensor, and Flow sensor[7]. In the conventional framework shows in Figure 1, E-Sampler instrument is set-up to collect data manually from the equipment data logger and send to the laptop or PC with installed software. Then, the raw data is downloaded in Excel acceptable format, imported to Excel, and proceed with further analysis.

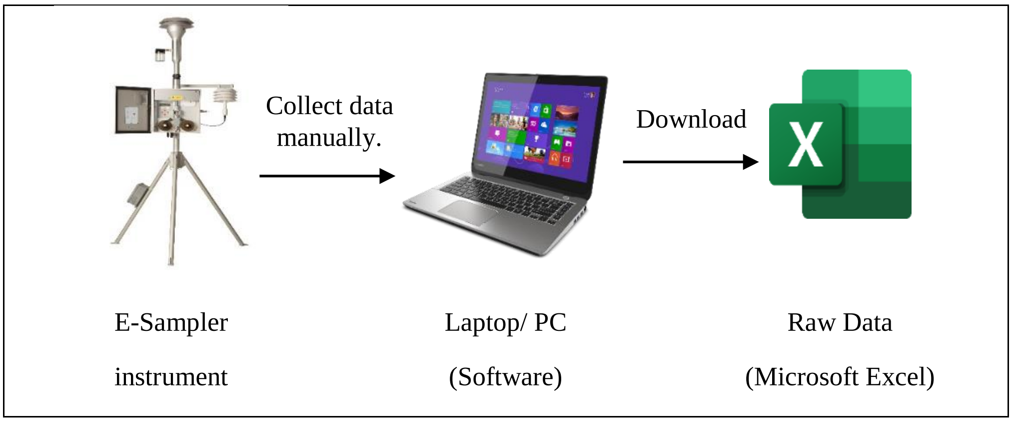


Figure 1: Conventional framework

UTHM Parit Raja campus has encountered this challenge were lacking an appropriate and advance framework to monitor the real-time ambient air quality. The current collecting data process is using the conventional framework that required more labor effort and consumed time. PM2.5 sampler available for research and monitoring by university and monitoring provider are in manual mode in which the data was logged into the equipment data logger, and it was manually extracted from the data logger to personal computer to analyze. The problem become worst during the Movement Control Order (MCO) 2020 as well as during the haze event or rainy season as the access to the site for data extraction was limited. Real-time data collection become impractical and impossible. This is then delayed the data analysis process as well as incapable to provide real-time API information to the public. To accomplish advance real-time monitoring on ambient air, an appropriate android application framework (AAF) in Figure 2 is required with the integration of hardware, IoT device, software, and application. This framework included six stages: The E-Sampler, Mobile Apps, Data Management, Data Management System, API Judgement, and Information Dissemination. This make the process from collecting data to distributing information will become simpler, faster, and easier.

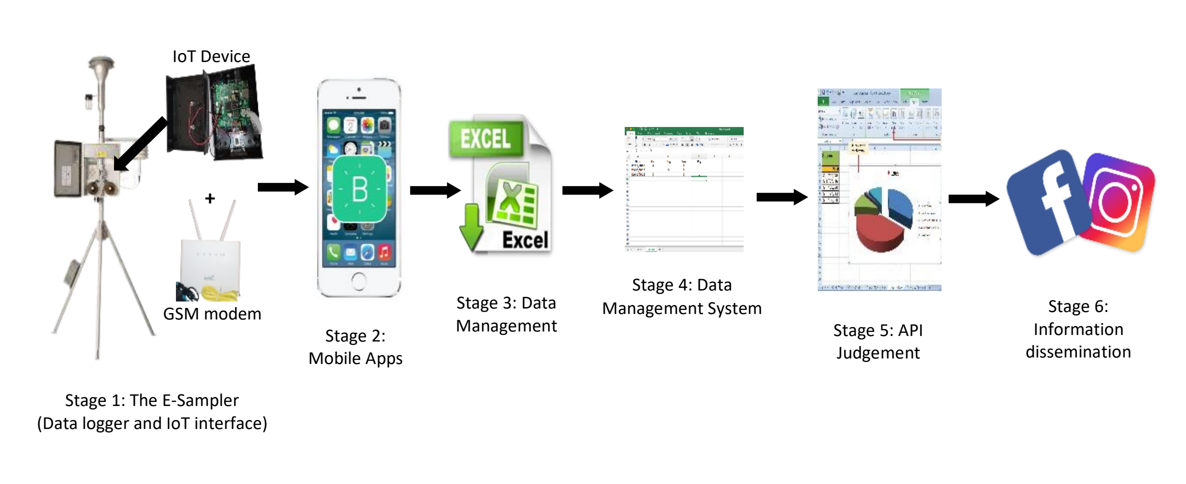


Figure 2: Android Application Framework (AAF)

1.1 Objectives

The aim of this study is to propose a framework containing IoT device to monitor the real-time ambient air quality and disseminate computed API information through social media platform. The objectives of this study are:

i. To compute the Air Pollution Index (API) of previous $PM_{2.5}$ collected data for March, April, June, and July 2020 using data management system.
ii. To establish a medium for computed information dissemination through social media Facebook and Instagram.
iii. To propose a new android application framework containing IoT device to monitor real-time ambient air quality for selected model of E-sampler.

1.2 Project Scope and Limitation

The scope of this study centers on the ability of an android application framework to monitor the real-time ambient air quality in UTHM Parit Raja campus area with the aids of calculation of API and distribute ambient air information to the public. The study will revolve around workability and functionality on the new proposed android application framework (AAF) toward data collection and data analyses to obtain real time API information. Some limitations of the study are:

i. Study will be conducted outdoor only, indoor air quality is not examined. Due to MCO period during COVID-19 pandemic, data management system was computed using the previous collected $PM_{2.5}$ data.
ii. The study is focusing on API parameter $PM_{2.5}$ only.
iii. The social media platform used are limited to Facebook and Instagram.

iv. Stage 1 to stage 3 of proposed AAF is at preliminary stage. There is no existing framework able to collect data continuously.

2. Methodology

To monitor real-time ambient air quality in UTHM Parit Raja campus area, an advance proposed android application framework (AAF) that included E-Sampler instrument, IoT, mobile apps, data management system and social media platform was proposed. A selected outdoor location in UTHM Parit Raja campus is fixed for placing E-Sampler instrument as well as the IoT device and GSM modem. Previous real-time $PM_{2.5}$ data was collected and used for analysis purposes in the formulated Microsoft Excel, which is named as data management system. In this project, Excel is fully used for calculation of API and analysis of ambient air quality status. Lastly, the analyzed API result and API related information is scattered and disseminated through social media platform, Facebook, and Instagram.

The methods applied in this chapter are based on the study objectives as mentioned, for then to be achieved. This study focuses on the proposed android application framework which included six stages. The methodology flow chart of this study is shown in Figure 3.

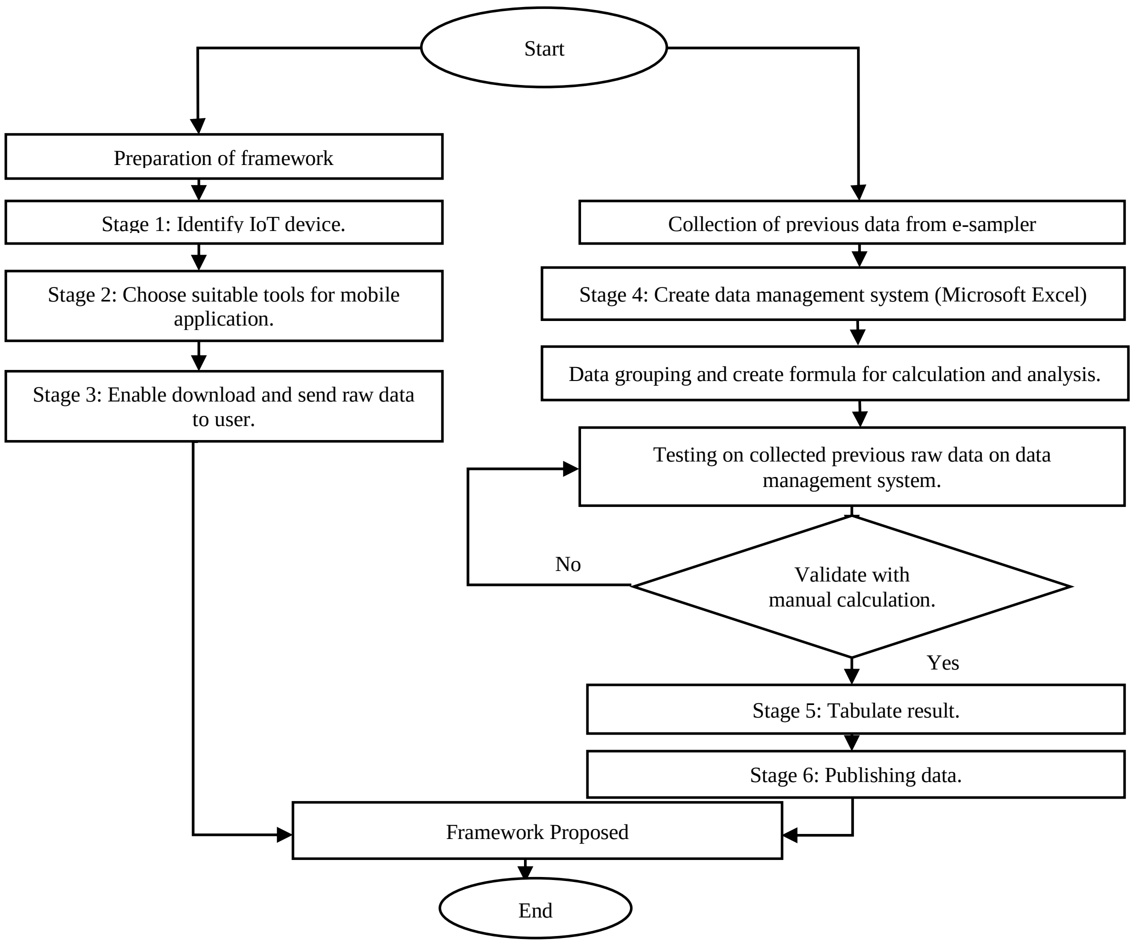


Figure 3: Methodology flow chart of this study

2.1 Stage 1 – The E-Sampler (Data Logger and IoT Interface)

Met-One E-Sampler instrument was selected for the usage of this project. It was ensured that it have the memory of 4,369 internal data logger that records data over time for 182 days or 1 record/hour in 3 days or 1 record/min, and in relation to have built in sensors and external sensors. A suitable IoT device was proposed make the connection between E-Sampler with the mobile apps.

2.2 Stage 2 – Mobile Application

A suitable tool (Blynk app) was selected in this stage. Blynk apps in Figure 4 was downloaded and was set up by creating a new Blynk account as well as create a new project. Blynk was connected to the hardware through supported cellular, and the initial empty project was then modified by adding widgets. Blynk apps was design with buttons to control E-Sampler remotely, display sensors data, stored data, and display plotted graph. Blynk app was designed to present periodic data, which included live or real-time, 15 minutes, 30 minutes, an hour, a day, a week, or a month. The displayed data was designed, color was used to differentiate data and improve on visual satisfaction.

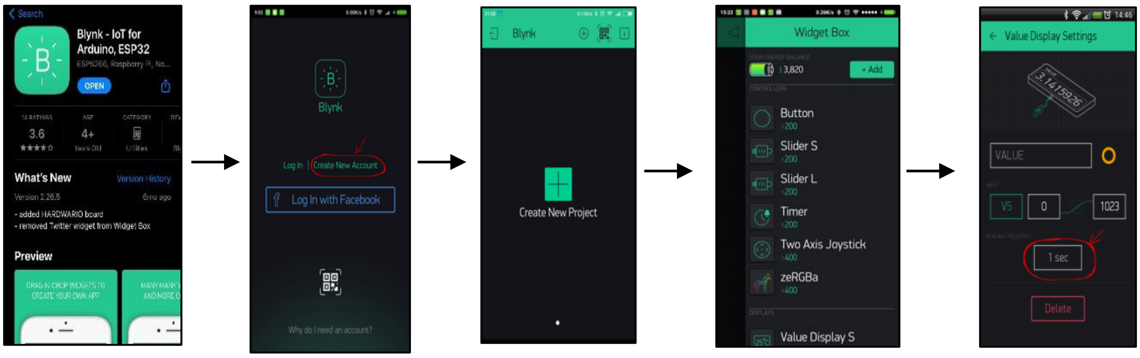


Figure 4: Blynk app setting up process

2.3 Stage 3 – Data management

As mentioned previously, the designed Blynk apps with buttons and setting was able to control E-Sampler remotely, display sensors data, stored data, and display plotted graph. Generated and stored data was requested to download and export. The exported data file format was supported by Microsoft Excel.

2.4 Stage 4 – Data Management System

At this stage, Microsoft Excel was used for data management system. Appropriate formula and equation were designed for the overall process in obtaining the final API information based on USEPA standard. Moreover, detailed conditioned formula was constructed to obtain secondary data that will be used for analyzing purpose. That included formula for obtaining $PM_{2.5}$ concentration tier, API, API tier, and API color. The raw data was then grouped and organized according to time, week, year, month, day and tabulate the raw data into breakdown data.

2.5 Stage 5 – API Judgement

Coloring method is used to determine API status for a certain period. The color indicates ambient air status according to USEPA standard, either good (blue), moderate (green), unhealthy (yellow), very unhealthy (orange), hazardous (red), or emergency (red). A conditioned formula has set to generate a tabulated result of API with the color. Another method used was plotted graph method. Daily plot graph visualizes better on the changes of ambient air quality based on hourly measurement. Instead of that, daily graph of API was also plotted monthly as well.

2.6 Stage 6 – Information Dissemination

With the purpose of data distribution on API related information, there are various approach available. From the choices of website, short message service (SMS), e-mail, social media, radio, and television, in this project, the proposed approach is via social media platform, Facebook, and Instagram. API information will be updated on these social media from time to time. At this stage, a poster template was designed using Canva apps. In the poster template, several API related information was designed. This included university and faculty logo, and the sources of posted API information by FTK UTHM was inserted. Besides, API status with its color indication as well as the color description were designed in the poster.

3. Results and Discussion

The proposed android application framework (AAF) in this project involved the usage of hardware and software. E-Sampler instrument is connected to IoT device and Blynk app through cellular connection. Data management system has designed to perform calculation and analysis on previous collected raw data. Social media platform had successfully created and finally API information is updated to the platform, Facebook and Instagram periodically.

3.1 Location of Data Collection

UTHM Parit Raja campus is located at Batu Pahat, Johor. It was selected to collect $PM_{2.5}$ from ambient air to be analyzed to obtain API related information on the location. Through observation from Google Map as Figure 5, UTHM Parit Raja campus was surrounded by plenty of plantation and pervious surface, compared to buildings and houses. Northern part of campus is a huge lawn, southern part has rows of houses along the road, shop lot and buildings were built compactly along the main road from east to west direction.

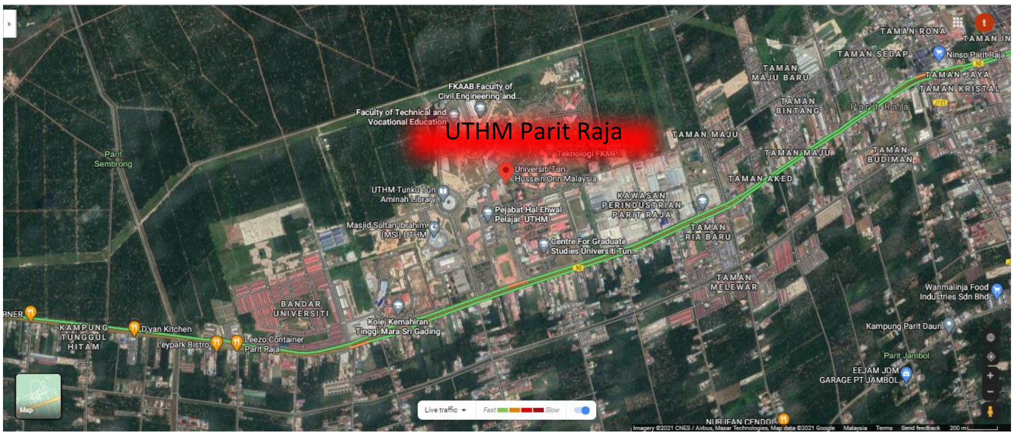


Figure 5: UTHM Parit Raja campus (Google Map)

3.2 Stage 1 – The E-Sampler (Data Logger and IoT Interface)

IoT device and E-Sampler data logger were connected physically in laboratory to test on the functionality of IoT device. Global System for Mobile Communication (GSM) modem is a wireless modem that communicate with the GSM network, to generate, transmit and decode data from IoT device to Blynk apps. A block diagram is shown at Figure 6 on the connection between E-Sampler instrument, IoT device and GSM modem. The proposed system at this stage is still undergo development and improvement, and yet to be fully established and validated.

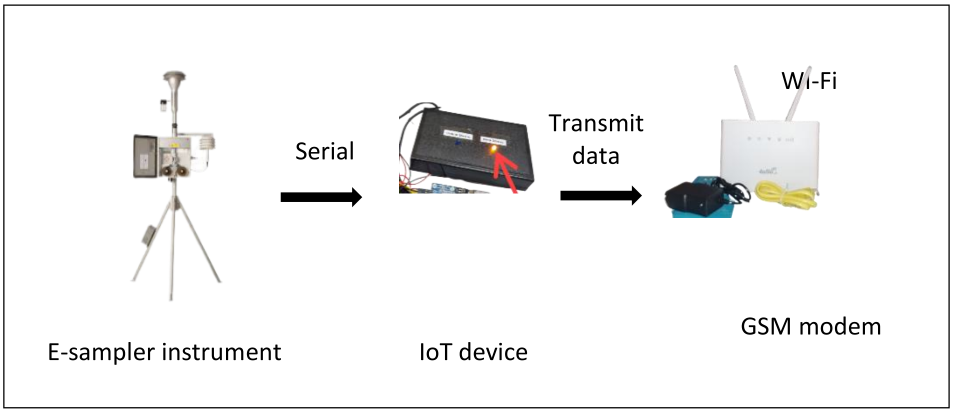


Figure 6: Block diagram of hardware

Proposed IoT device were tested out in laboratory together with E-Sampler data logger as shown in Figure 7 below. In Figure 8 shows on the IoT device, data status is lighted indicate that data is successfully transmitted from E-Sampler data logger to Blynk apps.

Figure 7: Testing on the functionality of IoT device

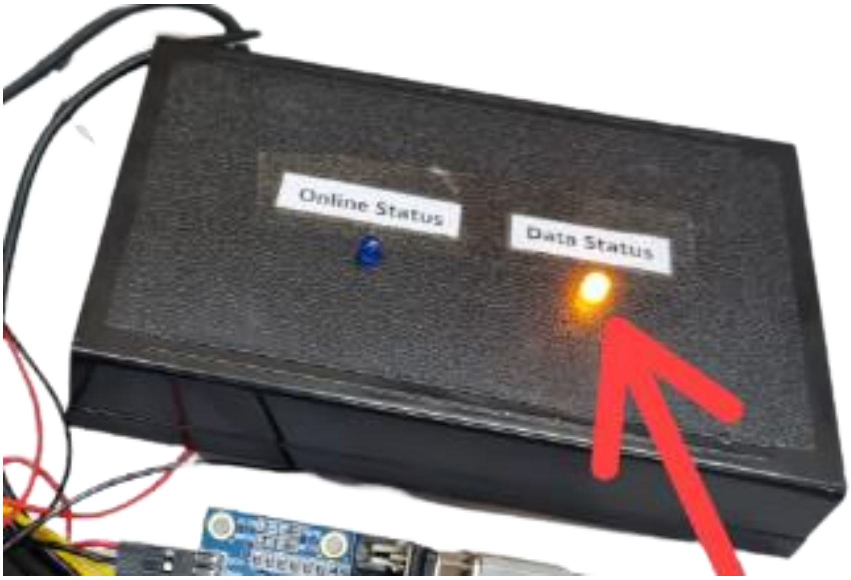


Figure 8: Data transmitting

3.3 Stage 2 – Mobile Application

As a preliminary result, Blynk app are currently able to achieve all the function smoothly. Data were collected, stored, and displayed as graph. Referring to Figure 9, sensors data and plotted graph were displayed with desirable time frame.

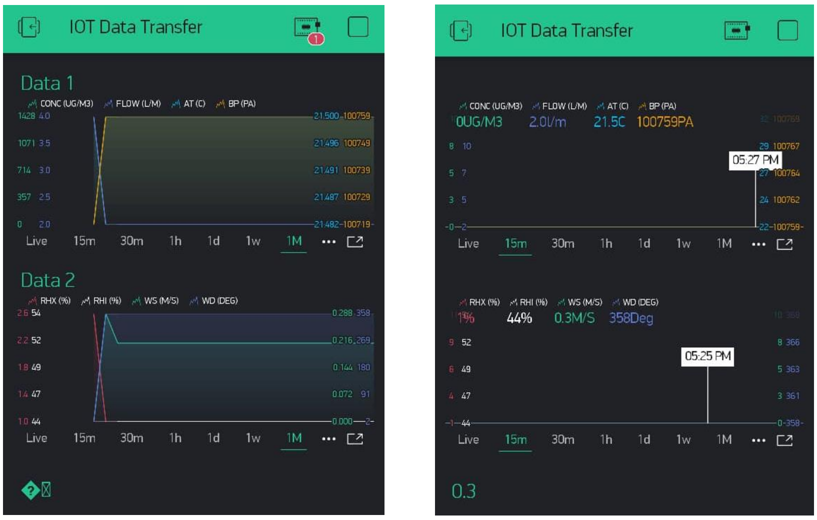


Figure 9: Displayed data information on Blynk app

In the plotted graph, color presented indicate on specific raw data. These eight raw data where prescribe with their specific color and this shows in Table 4.

Table 4: Color indication on raw data

Data	Colour	Abbreviation	Raw Data
1	Green	CONC (UG/M3)	$PM_{2.5}$ concentration (µg/m^3)
	Purple	FLOW (L/M)	Volumetric flow rate (l/m)
	Blue	AT (C)	Ambient temperature (°C)
	Orange	BP (PA)	Barometric pressure (pa)
2	Red	RHX (%)	External relative humidity (%)
	White	RHI (%)	Internal relative humidity (%)
	Blue	WS (M/S)	Wind speed (m/s)
	Purple	WD (DEG)	Wind direction (°)

3.4 Stage 3 – Data Management

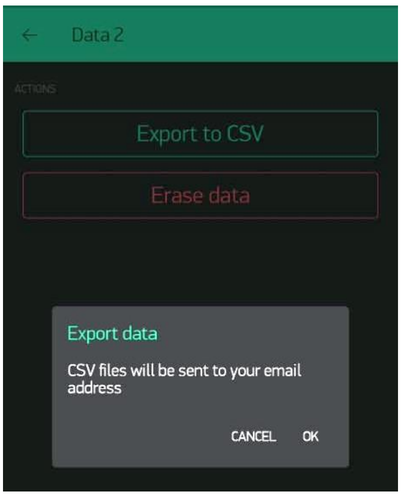


Figure 10: Download display in Blynk app

As a preliminary results, the download function in Blynk apps works successfully. Data were successfully downloaded as shown in Figure 10 in CSV file format that were supported by Microsoft Excel. Besides, selected raw data are also currently able to send to user through email address. Nevertheless, continuous observation on the function of Blynk apps to guarantee the accuracy of data collected.

3.5 Stage 4 – Data Management System

The raw data used in this system is collected manually in previous. There are two excel file in total to generate API information for the month of March ~ April and the month of June ~ July. In each Excel, there are six sheets which own their responsible to store raw data, grouping and breakdown data, perform calculation, tabulate data and finally generate a complete API information. In "Raw Data" sheets, raw data has successfully imported into the system without ammendment and editing on it. This is shown in Figure 11. The formula needed for API calculation is pasted into raw data sheet and act as the guideline for designing formula in the following steps.

Raw Data Set 1

	Time	Conc (µG/	Flow (l/m)	WS (M/S)	WD (Deg)
5	3/4/2020 11:00	5	1.8	0.9	112
6	3/4/2020 12:00	5	2	1.1	132
7	3/4/2020 13:00	5	2	1	121
8	3/4/2020 14:00	5	2	1.2	198
9	3/4/2020 15:00	7	2	0.8	120
10	3/4/2020 16:00	8	2	1.6	304
11	3/4/2020 17:00	11	2	1.4	353
12	3/4/2020 18:00	16	2	1.5	126
13	3/4/2020 19:00	22	2	0.8	31
14	3/4/2020 20:00	24	2	0.3	115
15	3/4/2020 21:00	26	2	0.4	122
16	3/4/2020 22:00	35	2	0.3	117
17	3/4/2020 23:00	35	2	0.3	124
18	3/5/2020 0:00	17	2	0.3	125
19	3/5/2020 1:00	20	2	0.3	125
20	3/5/2020 2:00	20	2	0.3	123
21	3/5/2020 3:00	15	2	0.3	118
22	3/5/2020 4:00	15	2	0.3	117
23	3/5/2020 5:00	13	2	0.3	119
24	3/5/2020 6:00	14	2	0.3	127
25	3/5/2020 7:00	14	2	0.3	119
26	3/5/2020 8:00	13	2	0.3	115
27	3/5/2020 9:00	11	1.9	0.3	115
28	3/5/2020 10:00	10	2	0.6	106
29	3/5/2020 11:00	10	2	0.7	104
30	3/5/2020 12:00	9	2	0.6	107
31	3/5/2020 13:00	11	2	0.5	122
32	3/5/2020 14:00	10	2	0.7	123
33	3/5/2020 15:00	11	2	0.6	121

Calculation Formula Set 1

	API	BREAKPOINT OF CONCENTRATION	EQUATION FOR API
	X=PM2.5 concentration(24h average, unit;µg/m3)		
GOOD	0-50	0≤X≤12.0	API=4.1667 x X
MODERATE	51-100	12.1≤X≤75.5	API=0.7741 x (X-12.1) + 51
UNHEALTHY	101-200	75.5≤X≤150.4	API=1.3218 x (X-75.5) + 101
VERY UNHEALTHY	201-300	150.5≤X≤250.4	API=0.9909 x (X-150.5) + 201
VERY UNHEALTHY	301-400	250.4≤X≤350.4	API=0.9909 x (X-250.5) + 301
HAZARDOUS	401-500	350.4≤X≤500.4	API=0.6604 x (X-350.5) + 401

	API	BREAKPOINT OF CONCENTRATION	EQUATION FOR API
	X=PM10 concentration(24h average, unit;µg/m3)		
GOOD	0-50	X≤50	API=X
MODERATE	51-100	50≤X≤150	API=50 + [(X-50) x 0.5]
UNHEALTHY	101-200	150≤X≤350	API=100 + [(X-50) x 0.5]
VERY UNHEALTHY	201-300	350≤X≤420	API=200 + [(X-350) x 1.4286]
VERY UNHEALTHY	301-400	420≤X≤500	API=300 + [(X-420) x 1.25]
HAZARDOUS	401-500	X>500	API=400 + (X-500)

Remarks

1. Refer Cell F334 for amendment made on data set.

User Manual | Raw Data | Clean Data | Helper | Statistic | API_PM_x

Figure 11: Raw data set

Pivot table of computed data from raw data shown in Figure 12 when raw data was successfully organized and grouped into time, week, month, day, and hour.

Copy & Paste Data Set

	Time	Conc (µG/M3)	Flow (l/m)	WS (M/S)	WD (Deg)
5	3/4/2020 11:00	5	1.8	0.9	112
6	3/4/2020 12:00	5	2	1.1	132
7	3/4/2020 13:00	5	2	1	121
8	3/4/2020 14:00	5	2	1.2	198
9	3/4/2020 15:00	7	2	0.8	120
10	3/4/2020 16:00	8	2	1.6	304
11	3/4/2020 17:00	11	2	1.4	353
12	3/4/2020 18:00	16	2	1.5	126
13	3/4/2020 19:00	22	2	0.8	31
14	3/4/2020 20:00	24	2	0.3	115
15	3/4/2020 21:00	26	2	0.4	122
16	3/4/2020 22:00	35	2	0.3	117
17	3/4/2020 23:00	35	2	0.3	124
18	3/5/2020 0:00	17	2	0.3	125
19	3/5/2020 1:00	20	2	0.3	125
20	3/5/2020 2:00	20	2	0.3	123
21	3/5/2020 3:00	15	2	0.3	118
22	3/5/2020 4:00	15	2	0.3	117
23	3/5/2020 5:00	13	2	0.3	119
24	3/5/2020 6:00	14	2	0.3	127
25	3/5/2020 7:00	14	2	0.3	119
26	3/5/2020 8:00	13	2	0.3	115
27	3/5/2020 9:00	11	1.9	0.3	115

Breakdown Date & Timestamp Details

Time	week	year	month	day	hour	Conc (µ	Flow (l/	WS (M/	WD (De
3/4/2020 11:00	10	2020	3	4	11	5	1.8	0.9	112
3/4/2020 12:00	10	2020	3	4	12	5	2	1.1	132
3/4/2020 13:00	10	2020	3	4	13	5	2	1	121
3/4/2020 14:00	10	2020	3	4	14	5	2	1.2	198
3/4/2020 15:00	10	2020	3	4	15	7	2	0.8	120
3/4/2020 16:00	10	2020	3	4	16	8	2	1.6	304
3/4/2020 17:00	10	2020	3	4	17	11	2	1.4	353
3/4/2020 18:00	10	2020	3	4	18	16	2	1.5	126
3/4/2020 19:00	10	2020	3	4	19	22	2	0.8	31
3/4/2020 20:00	10	2020	3	4	20	24	2	0.3	115
3/4/2020 21:00	10	2020	3	4	21	26	2	0.4	122
3/4/2020 22:00	10	2020	3	4	22	35	2	0.3	117
3/4/2020 23:00	10	2020	3	4	23	35	2	0.3	124
3/5/2020 0:00	10	2020	3	5	0	17	2	0.3	125
3/5/2020 1:00	10	2020	3	5	1	20	2	0.3	125
3/5/2020 2:00	10	2020	3	5	2	20	2	0.3	123
3/5/2020 3:00	10	2020	3	5	3	15	2	0.3	118
3/5/2020 4:00	10	2020	3	5	4	15	2	0.3	117
3/5/2020 5:00	10	2020	3	5	5	13	2	0.3	119
3/5/2020 6:00	10	2020	3	5	6	14	2	0.3	127
3/5/2020 7:00	10	2020	3	5	7	14	2	0.3	119
3/5/2020 8:00	10	2020	3	5	8	13	2	0.3	115
3/5/2020 9:00	10	2020	3	5	9	11	1.9	0.3	115

Figure 12: Computed data from raw data

Secondary data were obtained when detailed conditioned formula and equations were designed in "Helper" sheet. Secondary data included concentration tier, API, API tier, and API colour information. This is shown in Figure 13 below. Lastly, the calculated API results is successfully tabulated in "Statistic" sheet that shows in Figure 14 below.

```
=IF(AND($T$8>=K9,$T$8<=L9),M9,IF(AND($T$8>=K10,$T$8<=L10),M10,IF(AND($T$8>=K11,$T$8<=L11),M11,IF(AND($T$8>=K12,$T$8<=L12),M12,IF(AND($T$8>
IF(AND($T$8>=K14,$T$8<=L14),M14,"ERROR"))))))
```

K | L | M | N | O | P | Q | R | S | T | U

[API] Calculation Formula Part 1: Define Conc_Tier and use appropriate Conc_Formula to find API.

Initial	End	Conc_Tier
0	12	1
12.1	75.5	2
75.5	150.4	3
150.5	250.4	4
250.4	350.4	5
350.4	500.4	6

Conc_Tier	Equation
1	512.5041
2	136.8477
3	163.7855
4	173.7503
5	174.6603
6	250.759

FORMULA PM2.5	123	<< Try with any value input
Conc_Tier Formula	3	validated w/o sheet name & lock cell
Conc_Eq Formula	163	validated w/ sheet name & lock cell & integer

Figure 13: Secondary data generated from formula and equation

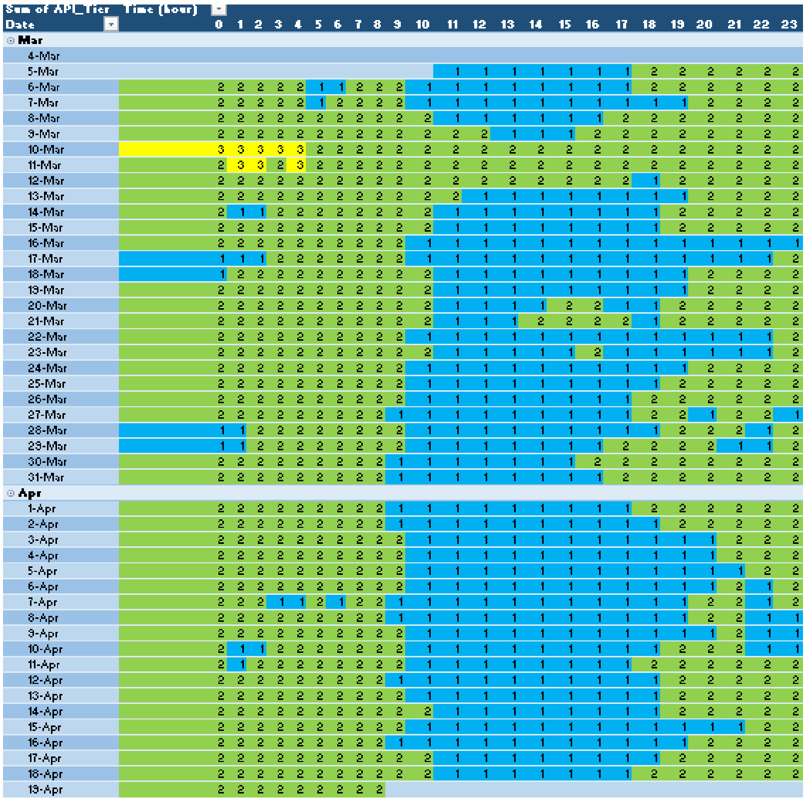
Concentration X = PM [x] | 2.5

<<< Datestamp & Timestamp in deta
<<< API Configuration

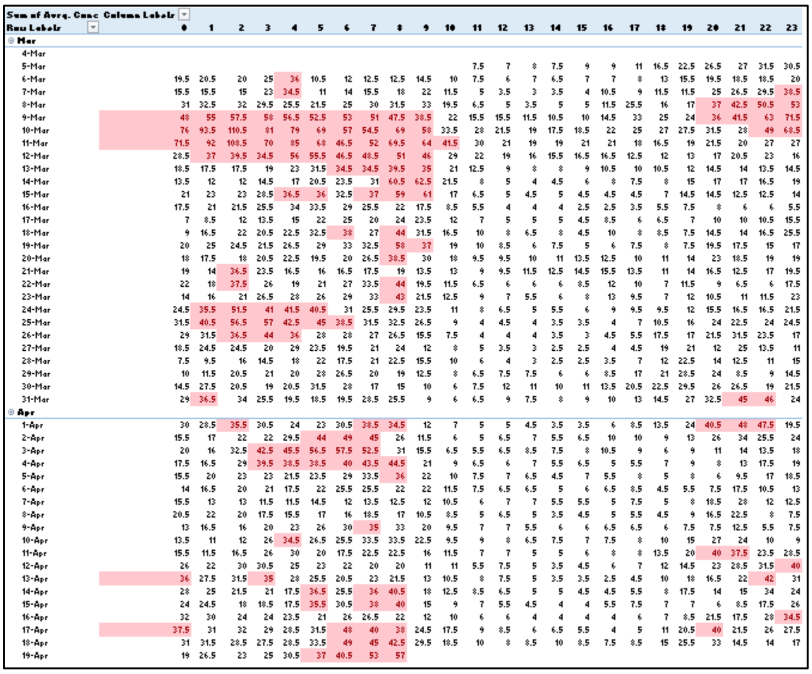
	Time	week	year	mont	day	hour	Conc (µG/	Avrg. C	API	API_T	Status	Col
8	3/4/2020 11:00	10	2020	3	4	11	5	[redacted]	[redacted]	[redacted]	ERROR	ERROR
9	3/4/2020 12:00	10	2020	3	4	12	5	[redacted]	[redacted]	[redacted]	ERROR	ERROR
10	3/4/2020 13:00	10	2020	3	4	13	5	[redacted]	[redacted]	[redacted]	ERROR	ERROR
11	3/4/2020 14:00	10	2020	3	4	14	5	[redacted]	[redacted]	[redacted]	ERROR	ERROR
12	3/4/2020 15:00	10	2020	3	4	15	7	[redacted]	[redacted]	[redacted]	ERROR	ERROR
13	3/4/2020 16:00	10	2020	3	4	16	8	[redacted]	[redacted]	[redacted]	ERROR	ERROR
14	3/4/2020 17:00	10	2020	3	4	17	11	[redacted]	[redacted]	[redacted]	ERROR	ERROR
15	3/4/2020 18:00	10	2020	3	4	18	16	[redacted]	[redacted]	[redacted]	ERROR	ERROR
16	3/4/2020 19:00	10	2020	3	4	19	22	[redacted]	[redacted]	[redacted]	ERROR	ERROR
17	3/4/2020 20:00	10	2020	3	4	20	24	[redacted]	[redacted]	[redacted]	ERROR	ERROR
18	3/4/2020 21:00	10	2020	3	4	21	26	[redacted]	[redacted]	[redacted]	ERROR	ERROR
19	3/4/2020 22:00	10	2020	3	4	22	35	[redacted]	[redacted]	[redacted]	ERROR	ERROR
20	3/4/2020 23:00	10	2020	3	4	23	35	[redacted]	[redacted]	[redacted]	ERROR	ERROR
21	3/5/2020 0:00	10	2020	3	5	0	17	[redacted]	[redacted]	[redacted]	ERROR	ERROR
22	3/5/2020 1:00	10	2020	3	5	1	20	[redacted]	[redacted]	[redacted]	ERROR	ERROR
23	3/5/2020 2:00	10	2020	3	5	2	20	[redacted]	[redacted]	[redacted]	ERROR	ERROR
24	3/5/2020 3:00	10	2020	3	5	3	15	[redacted]	[redacted]	[redacted]	ERROR	ERROR
25	3/5/2020 4:00	10	2020	3	5	4	15	[redacted]	[redacted]	[redacted]	ERROR	ERROR
26	3/5/2020 5:00	10	2020	3	5	5	13	[redacted]	[redacted]	[redacted]	ERROR	ERROR
27	3/5/2020 6:00	10	2020	3	5	6	14	[redacted]	[redacted]	[redacted]	ERROR	ERROR
28	3/5/2020 7:00	10	2020	3	5	7	14	[redacted]	[redacted]	[redacted]	ERROR	ERROR
29	3/5/2020 8:00	10	2020	3	5	8	13	[redacted]	[redacted]	[redacted]	ERROR	ERROR
30	3/5/2020 9:00	10	2020	3	5	9	11	[redacted]	[redacted]	[redacted]	ERROR	ERROR
31	3/5/2020 10:00	10	2020	3	5	10	10	[redacted]	[redacted]	[redacted]	ERROR	ERROR
32	3/5/2020 11:00	10	2020	3	5	11	10	7.5	31	1	GOOD	BLUE
33	3/5/2020 12:00	10	2020	3	5	12	9	7	29	1	GOOD	BLUE
34	3/5/2020 13:00	10	2020	3	5	13	11	8	33	1	GOOD	BLUE
35	3/5/2020 14:00	10	2020	3	5	14	10	7.5	31	1	GOOD	BLUE
36	3/5/2020 15:00	10	2020	3	5	15	11	9	37	1	GOOD	BLUE
37	3/5/2020 16:00	10	2020	3	5	16	10	9	37	1	GOOD	BLUE
38	3/5/2020 17:00	10	2020	3	5	17	11	11	45	1	GOOD	BLUE
39	3/5/2020 18:00	10	2020	3	5	18	17	16.5	54	2	MODERATE	GREEN
40	3/5/2020 19:00	10	2020	3	5	19	23	22.5	59	2	MODERATE	GREEN
41	3/5/2020 20:00	10	2020	3	5	20	29	26.5	62	2	MODERATE	GREEN
42	3/5/2020 21:00	10	2020	3	5	21	28	27	62	2	MODERATE	GREEN
43	3/5/2020 22:00	10	2020	3	5	22	28	31.5	66	2	MODERATE	GREEN
44	3/5/2020 23:00	10	2020	3	5	23	26	30.5	65	2	MODERATE	GREEN
45	3/6/2020 0:00	10	2020	3	6	0	22	19.5	56	2	MODERATE	GREEN
46	3/6/2020 1:00	10	2020	3	6	1	21	20.5	57	2	MODERATE	GREEN
47	3/6/2020 2:00	10	2020	3	6	2	20	20	57	2	MODERATE	GREEN
48	3/6/2020 3:00	10	2020	3	6	3	35	25	60	2	MODERATE	GREEN
49	3/6/2020 4:00	10	2020	3	6	4	57	36	69	2	MODERATE	GREEN
50	3/6/2020 5:00	10	2020	3	6	5	8	10.5	43	1	GOOD	BLUE
51	3/6/2020 6:00	10	2020	3	6	6	10	12	50	1	GOOD	BLUE

Figure 14: Tabulated result

3.5 Stage 5 – API Judgement



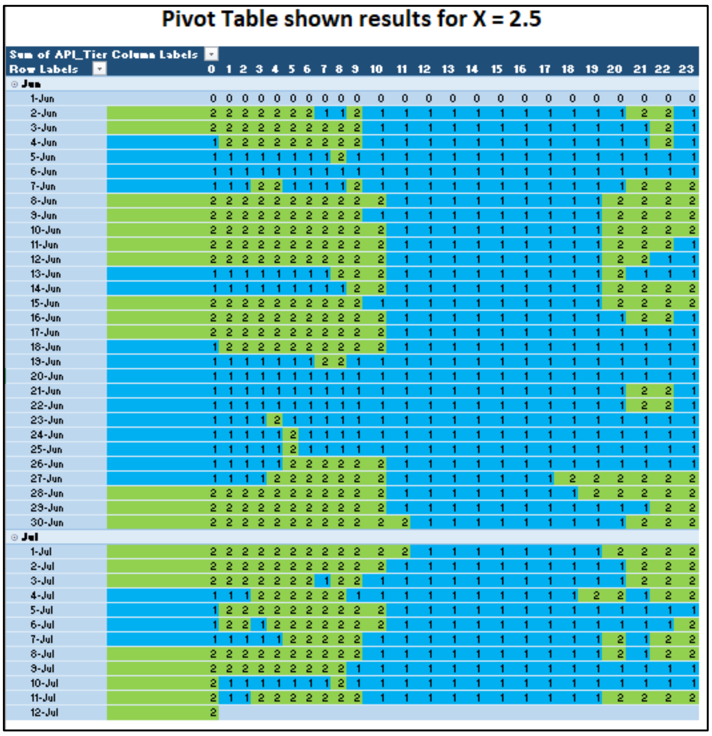
(a)



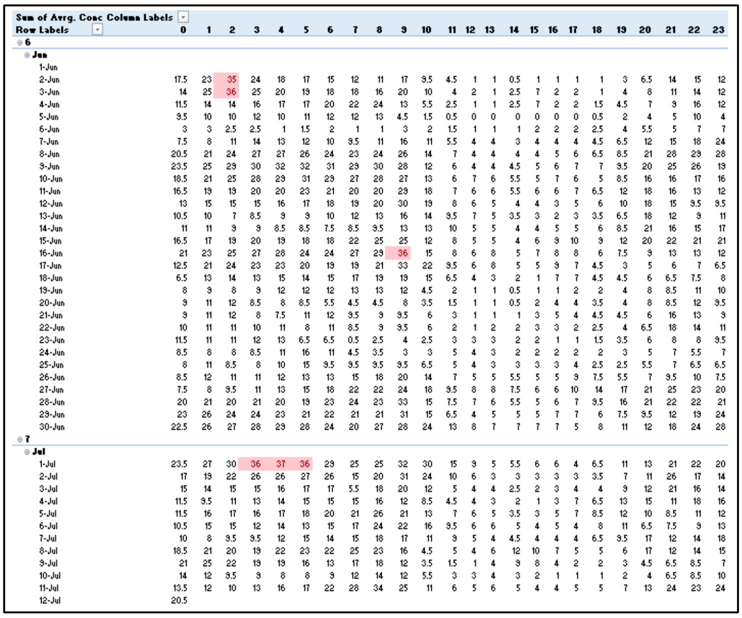
(b)

Figure 15: (a) API colour indication result from 04th March 2020 until 19th April 2020; (b) API from 04th March 2020 until 19th April 2020

Figure 15 shows the generated March and April API information is tabulated according to time and were highlighted with color. From the results obtained in Figure15(a), there are 8 slots highlighted yellow, which indicated the ambient air was at unhealthy state. Exception of 10th March, 11 th March and 12 th March having moderate status, majority results shows that from early 10am to everning 6 pm, the ambient air status was good. In general, 6 pm onward until the next morning 10am, the ambient air is at moderate state. On the other hand, the ambient air has exceeded the 2020 ambient air quality limit standard even though the result shows it was at the moderate state. According to Figure 15 (b), from 8 pm to 10 am, there are random day when ambient air exceeded the limit standard. However, on 10th March, 2 am ambient air quality had obviously achieved the highest API value (110.5 μg/m^3).



(a)



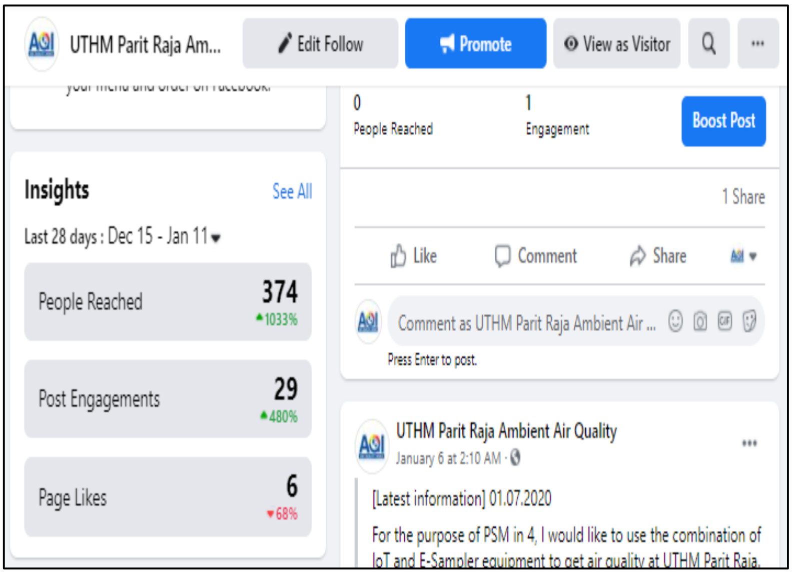
(b)

Figure 16: (a) API colour indication result from 01st June 2020 until 12th July 2020; (b) API from 01st June 2020 until 12th July 2020

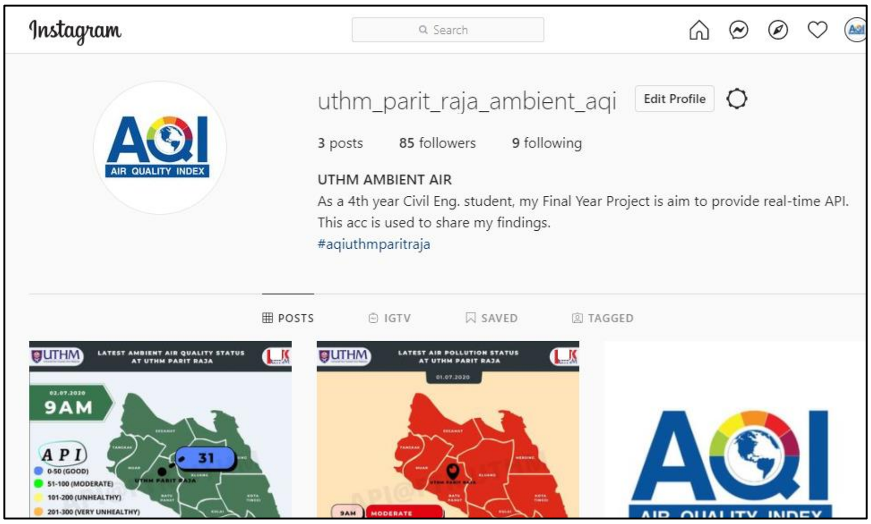
Figure 16 shows the generated June and July API information is tabulated according to time and were highlighted with color. From the result obtained in Figure 16 (a) shows that majority API results from 10 am to 8 pm were highlighted blue which represent ambient air were at the good state. However, minor results shows highlighted green from 8pm to 10am, this represent the ambient air were at moderate state during this period of time. Besides, the ambient air has exceeded the 2020 ambient air quality limit standard even though the result shows it was at the moderate state. According to Figure 16(b), there are 6 slots highlighted red that indicate the over limit time and concentration value. Nevertheless, they were exceeding only 1 and 2 μg/m^3 in random day mostly in the morning.

3.6 Stage 6 – Information Dissemination

As a result, social media platform has slowly engaged with public. Figure 17 (a) shows the post engagement has increased 480.00 %, and to people reached has increased 1033.00 % at Facebook platform. For instagram account, Figure 17 (b) shows total current engagement is with 85 followers. This shows that social media platform is successful in engaging public and information are disseminate easily.



(a)



(b)

Figure 17: (a) Facebook platform engagement; (b) Instagram platform engagement

The designed poster shown in Figure 18 has been posted on both Facebook and Instagram platform. In the poster, API related information such as API status and description, API range, and real-time API were published.

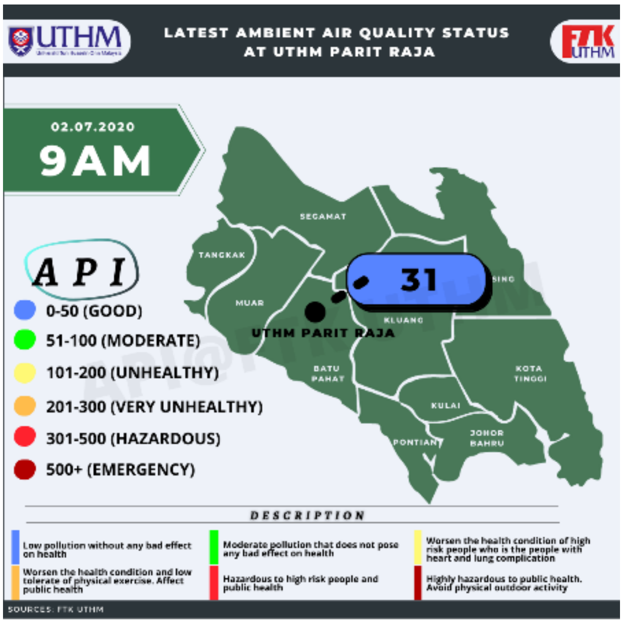


Figure 18: Poster API

4. Conclusion

Android application framework has function great in this whole project. Although stage 1 to stage 3 are still under development, however, operator can obtain real-time information from AAF developing process. The implementation of IoT device into the framework has make the whole process from collecting data until obtaining raw data fast and simple. This also illustrates the importance of AAF in makes life easier, mainly when covid-19 pandemic hits Malaysia. With the aid of AAF, operators can obtain raw data downloaded from Blynk app and able to monitor the ambient air quality anytime at anywhere.

According to the results from previous chapter, it can be observed that in the month of March and April 2020, ambient air quality is poorer compared with the month of June and July 2020. The amount of concentration exceeding standard limit in June and July are 6, with the highest concentration of 37 µg/m3. This shows the ambient air in UTHM Parit Raja in these two months has improved. Instead, the highest concentration from the month of March and April is 110.5 µg/m^3 (ambient air condition: unhealthy). This will worsen the health condition of high-risk people who is with heart and lung complications. The ambient air condition also increases aggravation of heart and lung disease and premature mortality in persons with cardiopulmonary disease and the elderly. Sensitive groups are encouraged to avoid prolonged exertion and stay indoors. The changes on ambient air may closely relate to the activities held in campus on the period. As several standard operating procedure (SOP) has been carried out in UTHM Parit Raja campus from April 2020, attendance of worker, lecturer and student were decreased. Hence, transportation and laboratory work in campus were greatly reduced. Therefore, this is believing that ambient air quality in the month of June and July is better.

Three objectives of the project were achieved throughout the whole process of study. At the end of this study, API for the month of March, April, June, and July 2020 were calculated and computed. Proposed new data management system is fully utilized in getting API in UTHM Parit Raja in this project. Besides, Facebook page and Instagram account were established to disseminate API related information. By spreading the project account to public, the respond from people are good. Friends and strangers started to follow and get engaged with the Facebook and Instagram platform to get API information. This is good to increase public awareness on the importance of air quality, as it will largely affect human daily activities. Lastly, a new android application framework is proposed to monitor real-time ambient air quality in UTHM Parit Raja campus area. This new framework is useful especially user is able to control remotely on the E-Sampler to collect desire data.

4.1 Recommendations

This study had served to improve in collecting data from manually collecting data to using IoT device and software to collect real-time data and shorten the analysis process by using data management system. However, further improvement and modification can still be made for future studies of similar nature. A few of recommendation are given as such:

- Improve on the functionality and efficiency of data management system. The current system is designed just for PM2.5. This limits the usage of system to calculate and analyze other API parameters. The system is operated manually, this may consume time when large amount of database is imported into the system.
- Study on the extent, impact of new framework to the university and public. As this framework may lead UTHM Parit Raja become an API hotspot to provide real-time API to the public.
- Social media platform should be shared to more friends and relatives, to continuously increase the engagement of the platform with public.

Acknowledgement

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