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# A new Android Application Framework (AAF) for API $PM_{2.5}$ data management system

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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 PM2.5 is one of its parameters for ambient air quality monitoring. However, most of the $PM_{2.5}$ samplers available for research and monitoring by universities and monitoring providers are in manual mode in which the data was logged into the equipment data logger and was manually extracted to the personal computer before analysis. Therefore, this project is aimed to propose an Android Application Framework (AAF) containing IoT devices to monitor the real-time ambient air quality and disseminate computed API information through the social media platform. In this study, mobile apps which are Blynk was used and enabled the user to control remotely desirable outcomes at any time. E-sampler IoT interface, mobile application, data management, data management system, API judgment and information dissemination are proposed to make AAF succeed. As a result, the proposed AAF has been fully utilized in obtaining real-time pollutants data and finally analyzing $PM_{2.5}$ to obtain real-time API information. IoT device has successfully interface with E-Sampler, to obtain raw data and be able to be downloaded for further analysis. In conclusion, AAF has functioned great and information was disseminated to the public through social media.

## 1. Introduction

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 the ozone layer, various environmental pollution, ecosystem degradation, and excretion of harmful waste are a few 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 based on

Air Quality Index (AQI) that has been accepted at the international level by the 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 (μg/m³) | | |
|---|---|---|---|---|
| | | IT-1 (2015) | IT-2 (2018) | Standard (2020) |
| Particulate Matter with the size | 1 Year | 50 | 45 | 40 |
| of less than 10 microns ($PM_{10}$) | 24 Hour | 150 | 120 | 100 |
| Particulate Matter with the size | 1 Year | 35 | 25 | 15 |
| of less than 10 microns ($PM_{2.5}$) | 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 | 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 means of reporting the quality of air instead of the actual concentration of air pollutants. A sub-index formula for $PM_{2.5}$ 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 ranges, 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 at any time.

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

| API | Breakpoint of concentration X=PM2.5 concentration (24h average, unit;μg/m³) | Equation for API |
|---|---|---|
| 0-50 | $0 \leq X \leq 12.0$ | API=4.1667 x X |
| 51-100 | $12.1 \leq X \leq 75.5$ | API=0.7741 x (X-12.1) + 51 |
| 101-200 | $75.5 \leq X \leq 150.4$ | API=1.3218 x (X-75.5) + 101 |
| 201-300 | $150.5 \leq X \leq 250.4$ | API=0.9909 x (X-150.5) + 201 |
| 301-400 | $250.4 \leq X \leq 350.4$ | API=0.9909 x (X-250.5) + 301 |
| 401-500 | $350.4 \leq X \leq 500.4$ | 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 shown in Figure 1, the E-Sampler instrument is set up to collect data manually from the equipment data logger and send it to the laptop or PC with the installed software. Then, the raw data is downloaded in Excel acceptable format, imported to Excel, and proceeded with further analysis.

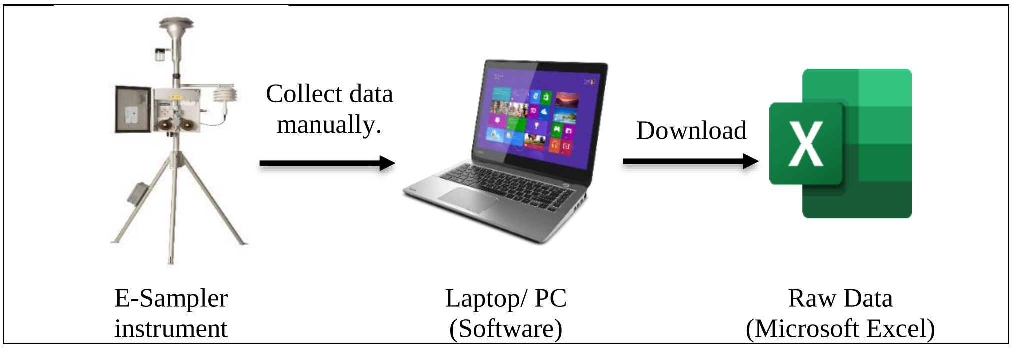



**Figure 1.** Conventional framework.

UTHM Parit Raja campus has encountered this challenge where lacking an appropriate and advanced 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 is 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 becomes 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 advanced 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 makes the process from collecting data to distributing information will become simpler, faster, and easier.

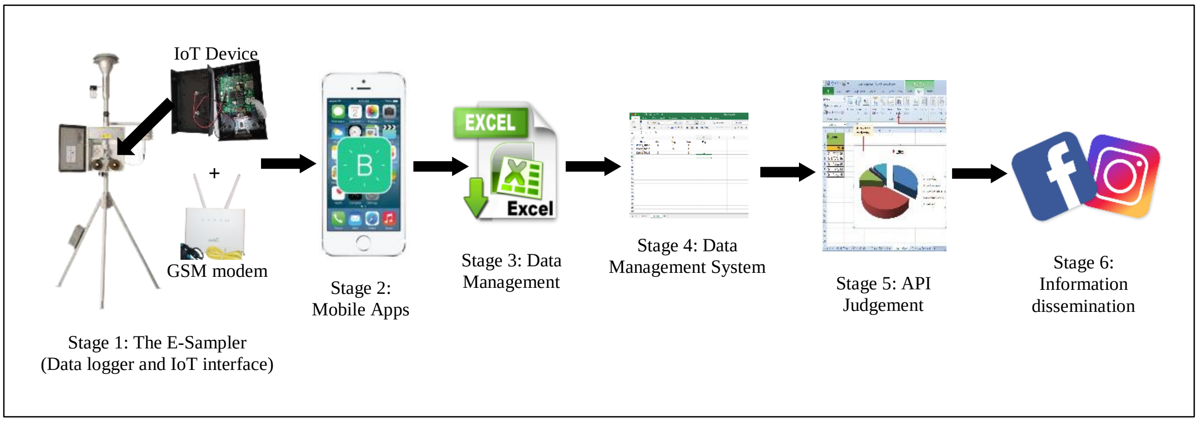



**Figure 2:** Android Application Framework (AAF).

### *1.1. Objectives*
This study aims to propose a framework containing an IoT device to monitor the real-time ambient air quality and disseminate computed API information through the social media platform. The objectives of this study are:

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

1. The study will be conducted outdoor only, indoor air quality is not examined. Due to the MCO period during the COVID-19 pandemic, the data management system was computed using the previously collected $PM_{2.5}$ data.
2. The study is focusing on API parameter $PM_{2.5}$ only.
3. The social media platform users are limited to Facebook and Instagram.
4. Stage 1 to stage 3 of the proposed AAF is at a preliminary stage. There is no existing framework able to collect data continuously.

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

The methods applied in this chapter are based on the study objectives as mentioned, which are 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.

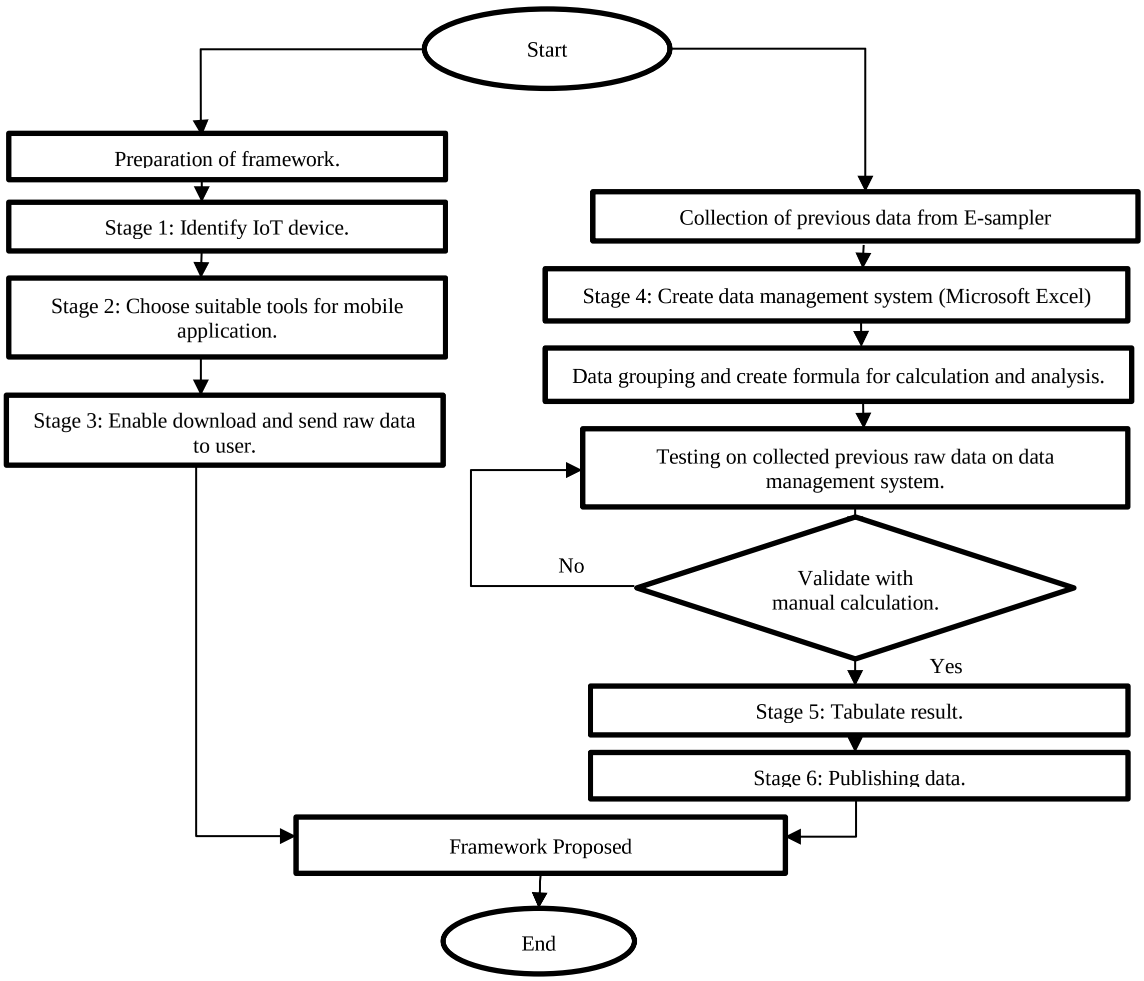



**Figure 3.** Methodology flow chart of this study.

### *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 has the memory of 4,369 internal data loggers that record data overtime for 182 days or 1 record/hour in 3 days or 1 record/min, and in relation to having built-in sensors and external sensors. A suitable IoT device was proposed to make the connection between E-Sampler the mobile apps.

### *2.2. Stage 2- Mobile application*

A suitable tool (Blynk app) was selected in this stage. The Blynk app in Figure 4 was downloaded and was set up by creating a new Blynk account as well as creating a new project. Blynk was connected to the hardware through supported cellular, and the initial empty project was then modified by adding widgets. Blynk app was designed with buttons to control E-Sampler remotely, display sensors data, stored data, and display plotted graphs. 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 visual satisfaction.

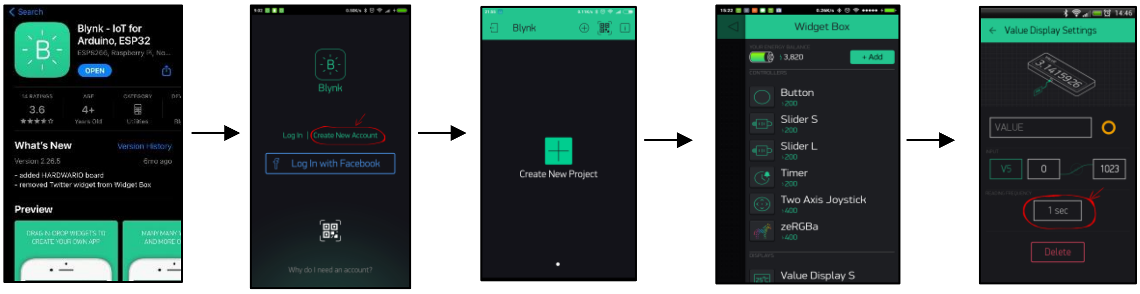


**Figure 4.** Blynk app setting up process.

### *2.3. Stage 3- Data management*

As mentioned previously, the designed Blynk app with buttons and settings was able to control E-Sampler remotely, display sensors data, stored data, and display plotted graphs. 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 the data management system. Appropriate formulas and equations were designed for the overall process of obtaining the final API information based on the USEPA standard. Moreover, the detailed conditioned formula was constructed to obtain secondary data that will be used for analyzing purposes. That included the formula for obtaining $PM_{2.5}$ concentration tier, API, API tier, and API color. The raw data were then grouped and organized according to time, week, year, month, day and tabulated raw data into breakdown data.

### *2.5. Stage 5- API Judgment*

The 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 been set to generate a tabulated result of API with the color. Another method used was plotted graph method. The daily plot graph visualizes better with the changes of ambient air quality based on hourly measurement. Instead of that, the daily graph of API was also plotted monthly as well.

### *2.6. Stage 6- Information dissemination*

There are several approaches available for data dissemination on API-related information. 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 platforms, 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 the university and faculty logo and the sources of posted API information by FTK UTHM were inserted. Besides, API status with its color indication as well as the color description was designed in the poster.

## 3. Result 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 a cellular connection.

The data management system has been designed to perform calculations and analyses on previously 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, the UTHM Parit Raja campus was surrounded by plenty of plantation and pervious surface, compared to buildings and houses. The northern part of the campus is a huge lawn, the 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.

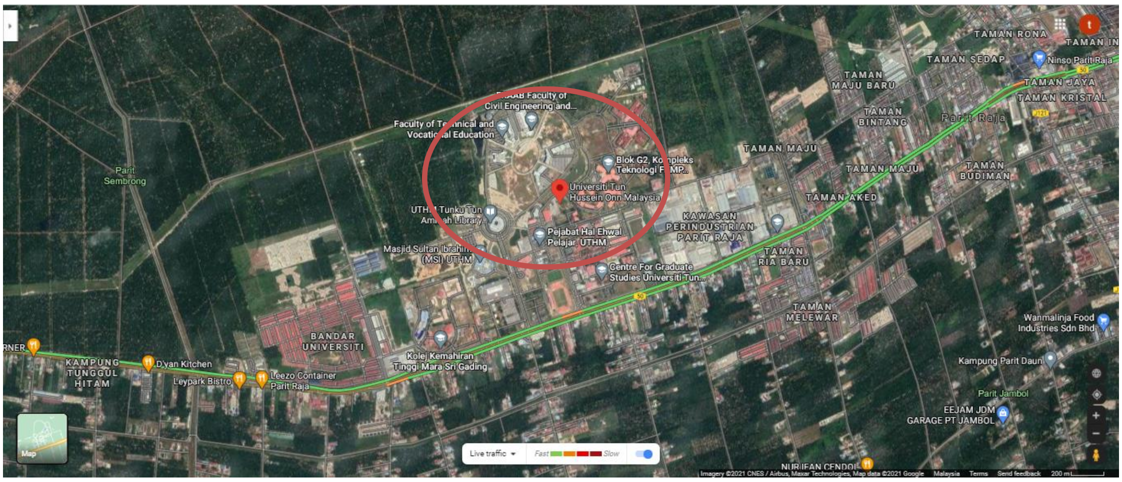



**Figure 5.** UTHM-Parit Raja Campus (Google Map).

### *3.2. Stage 1- The E-Sampler (Data Logger and IoT Interface)*

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

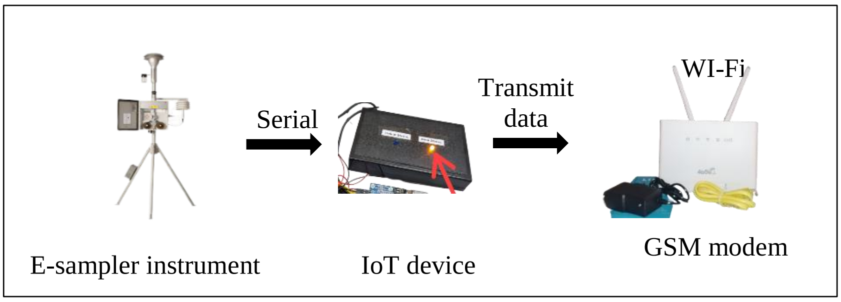



**Figure 6.** Block diagram of hardware.

The proposed IoT device was tested out in the laboratory together with an E-Sampler data logger as shown in Figure 7 below. 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 the IoT device.

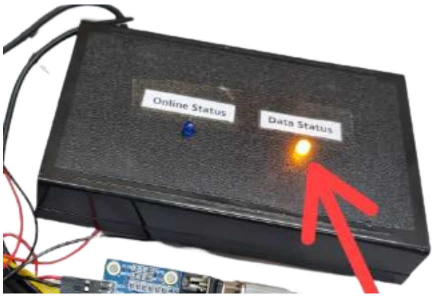



**Figure 8.** Data transmitting.

### *3.3. Stage 2- Mobile Application*

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

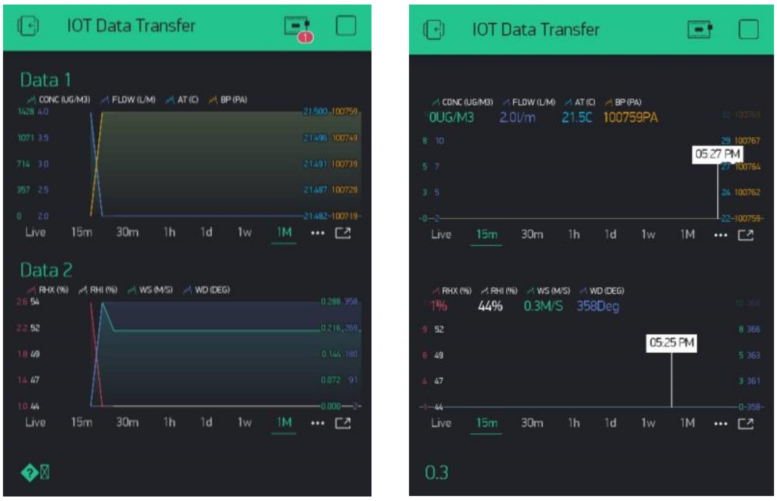



**Figure 9.** Displayed data information on the Blynk app.

In the plotted graph, the color presented indicates specific raw data. These eight raw data were prescribed 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*

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

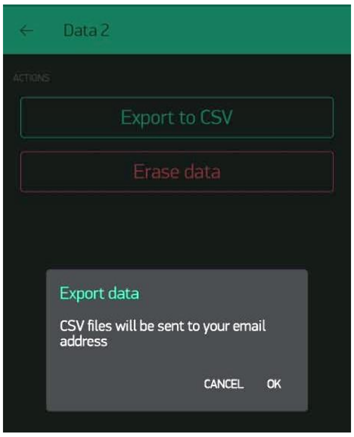
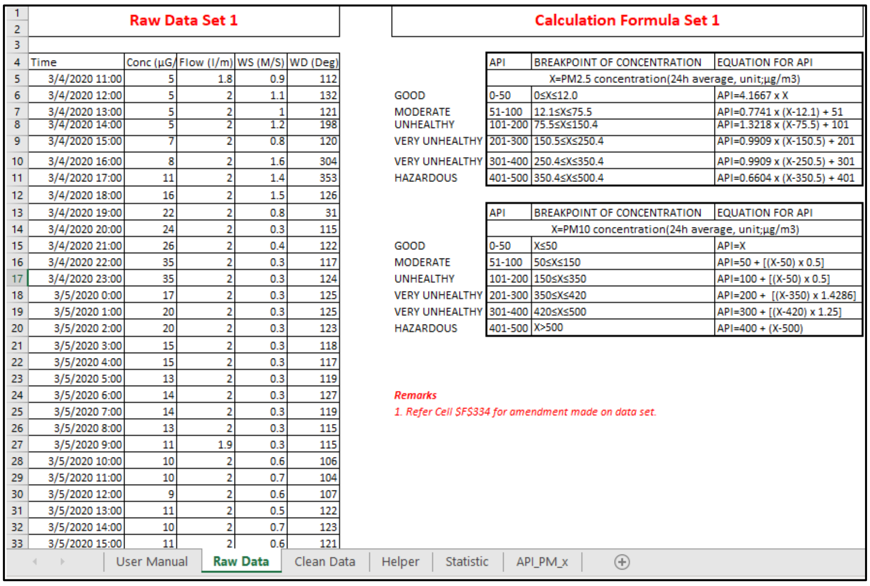



**Figure 10.** Download display in Blynk app.

*3.5. Stage 4 - Data Management System*

The raw data used in this system is collected manually in previous. There is 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 to store raw data, group and break down data, perform calculations, tabulate data and finally, generate complete API information. In “Raw Data” sheets, raw data has successfully been imported into the system without amendment and editing on it. This is shown in Figure 11. The formula needed for API calculation is pasted into the raw data sheet and acts as the guideline for designing the 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 |

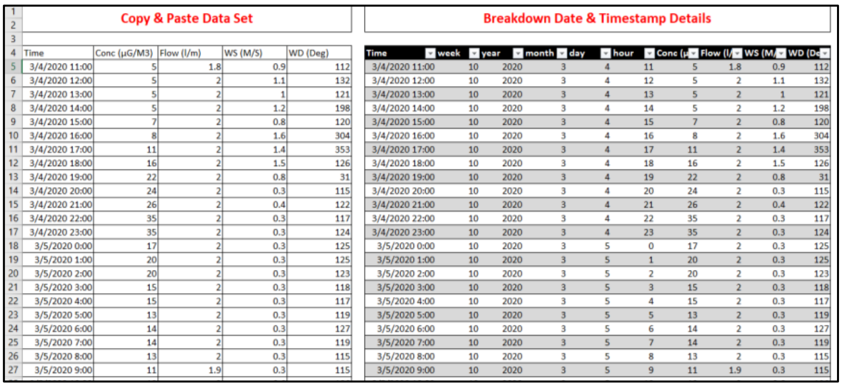
| | API | BREAKPOINT OF CONCENTRATION | EQUATION FOR API |
|---|---|---|---|
| | X=PM10 concentration(24h average, unit;µg/m3) | | |
| GOOD | 0-50 | X≤50 | API=X |
| MODERATE | 51-100 | 50≤X≤150 | API=50 + [(X-50) x 0.5] |
| UNHEALTHY | 101-200 | 150≤X≤350 | API=100 + [(X-50) x 0.5] |
| VERY UNHEALTHY | 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 $F$334 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**

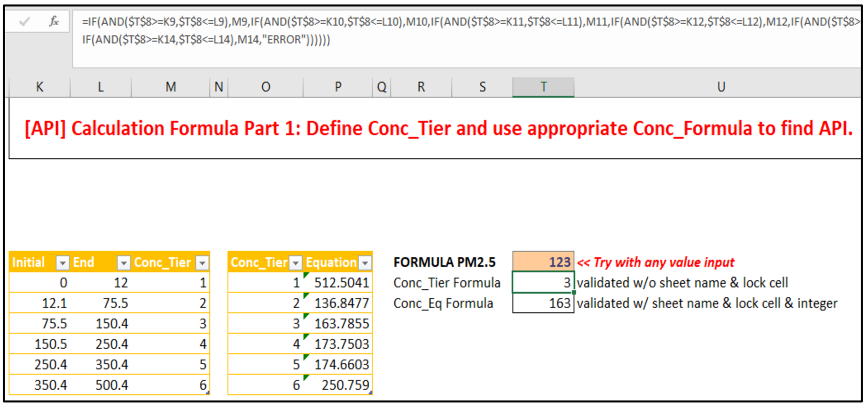
| | Time | Conc (µG/M3) | Flow (l/m) | WS (M/S) | WD (Deg) |
|---|---|---|---|---|---|
| 5 | 3/4/2020 11:00 | 5 | 1.8 | 0.9 | 112 |
| 6 | 3/4/2020 12:00 | 5 | 2 | 1.1 | 132 |
| 7 | 3/4/2020 13:00 | 5 | 2 | 1 | 121 |
| 8 | 3/4/2020 14:00 | 5 | 2 | 1.2 | 198 |
| 9 | 3/4/2020 15:00 | 7 | 2 | 0.8 | 120 |
| 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 formulas and equations were designed in the "Helper" sheet. Secondary data included concentration tier, API, API tier, and API color information. This is shown in Figure 13 below. Lastly, the calculated API results are successfully tabulated in the "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"))))))

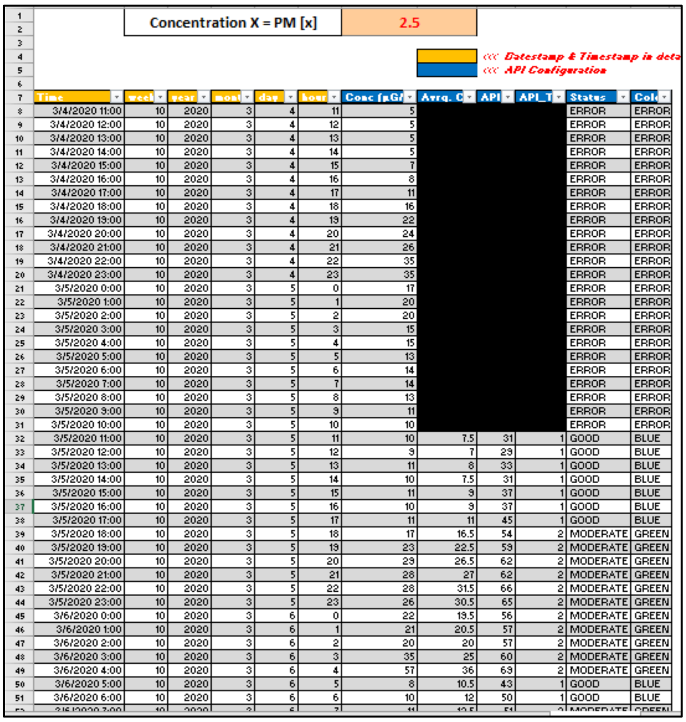
[API] Calculation Formula Part 1: Define Conc_Tier and use appropriate Conc_Formula to find API.

| 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

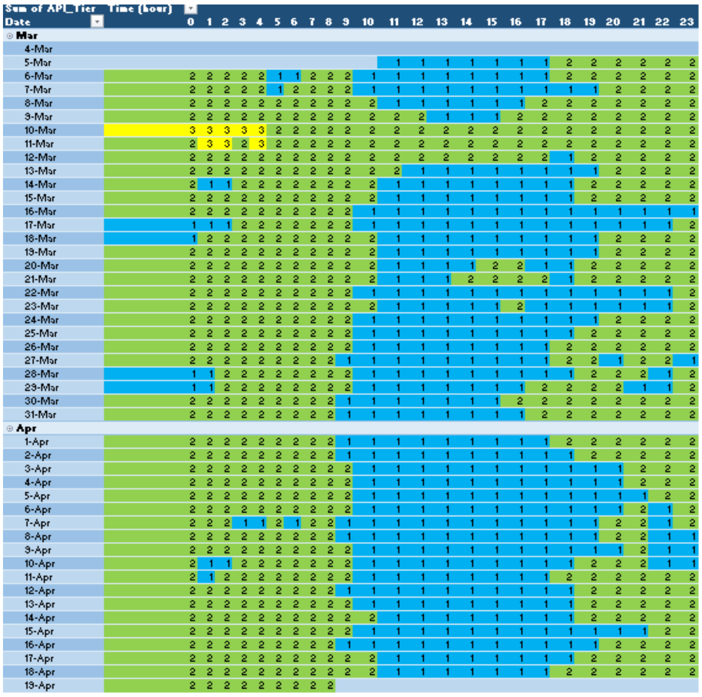
<<< Datestamp & Timestamp in deta
<<< API Configuration

| 7 | Time | week | year | mont | day | hour | Conc (µG/ | Avrg. C | API | API_T | Status | Colo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |

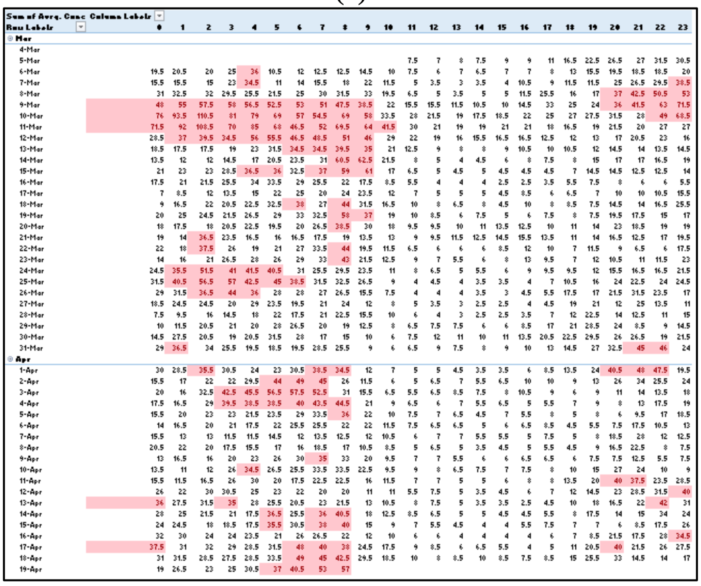
**Figure 14.** Tabulated result.

*3.6. Stage 5 - API Judgement*

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



(a)



(b)

**Figure 15.** (a) API color indication result from 04th March 2020 until 19th April 2020; (b) API from 04th March 2020 until 19th April 2020.

Figure 16 shows the generated June and July API information is tabulated according to time and was highlighted with color. The result obtained in Figure 16(a) shows that the majority of API results from 10 am to 8 pm were highlighted blue which represents ambient air was in a good state. However, minor results show highlighted green from 8 pm to 10 am, this represents the ambient air was at a moderate state during this period. Besides, the ambient air has exceeded the 2020 ambient air quality limit standard even though the result shows it was at a 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/$m^3$ on the random day mostly in the morning.

Pivot Table shown results for X = 2.5

| Sum of API_Tier Row Labels (Column Labels) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| 3-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| 4-Jun | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| 5-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7-Jun | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 8-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 9-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 10-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 11-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 |
| 12-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 |
| 13-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| 14-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 15-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 16-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| 17-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18-Jun | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 21-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| 22-Jun | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| 23-Jun | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 24-Jun | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25-Jun | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 26-Jun | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 27-Jun | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| 28-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| 29-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| 30-Jun | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| Jul | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-Jul | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 2-Jul | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 3-Jul | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| 4-Jul | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| 5-Jul | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6-Jul | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 7-Jul | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 |
| 8-Jul | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 |
| 9-Jul | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10-Jul | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11-Jul | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 |
| 12-Jul | 2 | | | | | | | | | | | | | | | | | | | | | | | |

(a)

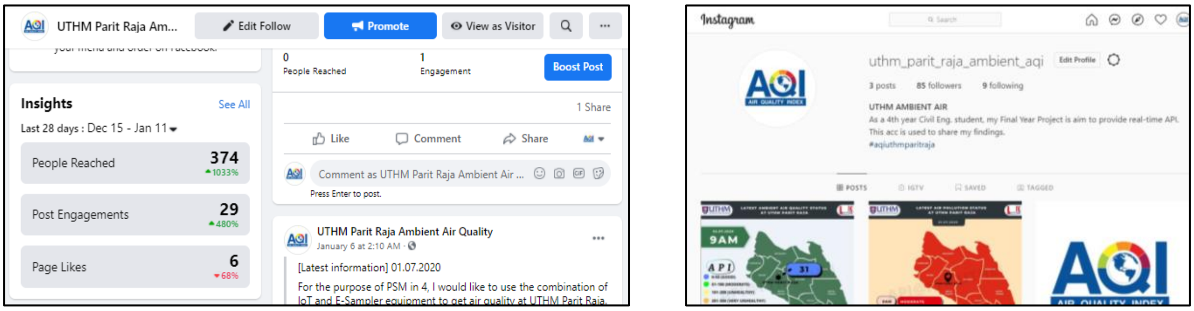
| Sum of Avrg. Conc Row Labels (Column Labels) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | | | | | | | | | | | | | | | | | | | | | | | |
| Jun | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-Jun | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-Jun | 17.5 | 23 | 35 | 24 | 18 | 17 | 15 | 12 | 11 | 17 | 9.5 | 4.5 | 1 | 1 | 0.5 | 1 | 1 | 1 | 1 | 3 | 6.5 | 14 | 15 | 12 |
| 3-Jun | 14 | 25 | 36 | 25 | 20 | 19 | 18 | 18 | 16 | 20 | 10 | 4 | 2 | 1 | 2.5 | 7 | 2 | 2 | 1 | 4 | 8 | 11 | 14 | 12 |
| 4-Jun | 11.5 | 14 | 14 | 16 | 17 | 17 | 20 | 22 | 24 | 13 | 5.5 | 2.5 | 1 | 1 | 2.5 | 7 | 2 | 2 | 1.5 | 4.5 | 7 | 9 | 16 | 12 |
| 5-Jun | 9.5 | 10 | 10 | 12 | 10 | 11 | 12 | 12 | 13 | 4.5 | 1.5 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 2 | 4 | 5 | 10 | 4 |
| 6-Jun | 3 | 3 | 2.5 | 2.5 | 1 | 1.5 | 2 | 1 | 1 | 3 | 2 | 1.5 | 1 | 1 | 1 | 2 | 2 | 2 | 2.5 | 4 | 5.5 | 5 | 7 | 7 |
| 7-Jun | 7.5 | 8 | 11 | 14 | 13 | 12 | 10 | 9.5 | 11 | 16 | 11 | 5.5 | 4 | 4 | 3 | 4 | 4 | 4 | 4.5 | 6.5 | 12 | 15 | 18 | 24 |
| 8-Jun | 20.5 | 21 | 24 | 27 | 27 | 26 | 24 | 23 | 24 | 26 | 14 | 7 | 4 | 4 | 4 | 4 | 5 | 6 | 6.5 | 8.5 | 21 | 28 | 29 | 28 |
| 9-Jun | 23.5 | 25 | 29 | 30 | 32 | 32 | 31 | 29 | 30 | 28 | 12 | 6 | 4 | 4 | 4.5 | 5 | 6 | 7 | 7 | 9.5 | 20 | 25 | 26 | 19 |
| 10-Jun | 18.5 | 21 | 25 | 28 | 29 | 31 | 29 | 27 | 28 | 27 | 13 | 6 | 7 | 6 | 5.5 | 5 | 7 | 6 | 5 | 8.5 | 16 | 16 | 17 | 16 |
| 11-Jun | 16.5 | 19 | 19 | 20 | 20 | 23 | 21 | 20 | 20 | 29 | 18 | 7 | 6 | 6 | 5.5 | 6 | 6 | 7 | 6.5 | 12 | 18 | 16 | 13 | 12 |
| 12-Jun | 13 | 15 | 15 | 15 | 16 | 17 | 18 | 19 | 20 | 30 | 19 | 8 | 6 | 5 | 4 | 4 | 3 | 5 | 6 | 10 | 18 | 15 | 9.5 | 9.5 |
| 13-Jun | 10.5 | 10 | 7 | 8.5 | 9 | 9 | 10 | 12 | 13 | 16 | 14 | 9.5 | 7 | 5 | 3.5 | 3 | 2 | 3 | 3.5 | 6.5 | 18 | 12 | 9 | 11 |
| 14-Jun | 11 | 11 | 9 | 9 | 8.5 | 8.5 | 7.5 | 8.5 | 9.5 | 13 | 13 | 10 | 5 | 5 | 4 | 4 | 5 | 5 | 6 | 8.5 | 21 | 16 | 15 | 17 |
| 15-Jun | 16.5 | 17 | 19 | 20 | 19 | 18 | 18 | 22 | 25 | 25 | 12 | 8 | 5 | 5 | 4 | 6 | 9 | 10 | 9 | 12 | 20 | 22 | 21 | 21 |
| 16-Jun | 21 | 23 | 25 | 27 | 28 | 24 | 24 | 27 | 29 | 36 | 15 | 8 | 6 | 8 | 5 | 7 | 8 | 8 | 6 | 7.5 | 9 | 13 | 13 | 12 |
| 17-Jun | 12.5 | 21 | 24 | 23 | 23 | 20 | 19 | 19 | 21 | 33 | 22 | 9.5 | 6 | 8 | 5 | 5 | 9 | 7 | 4.5 | 3 | 5 | 6 | 7 | 6.5 |
| 18-Jun | 6.5 | 13 | 14 | 13 | 15 | 14 | 15 | 17 | 19 | 19 | 15 | 6.5 | 4 | 3 | 2 | 1 | 7 | 7 | 4.5 | 4.5 | 6 | 6.5 | 7.5 | 8 |
| 19-Jun | 8 | 9 | 8 | 9 | 12 | 12 | 12 | 13 | 13 | 12 | 4.5 | 2 | 1 | 1 | 0.5 | 1 | 1 | 2 | 2 | 4 | 8 | 8.5 | 11 | 10 |
| 20-Jun | 9 | 11 | 12 | 8.5 | 8 | 8.5 | 5.5 | 4.5 | 4.5 | 8 | 3.5 | 1.5 | 1 | 1 | 0.5 | 2 | 4 | 4 | 3.5 | 4 | 8 | 8.5 | 12 | 9.5 |
| 21-Jun | 9 | 11 | 12 | 8 | 7.5 | 11 | 12 | 9.5 | 9 | 9.5 | 6 | 3 | 1 | 1 | 1 | 3 | 5 | 4 | 4.5 | 4.5 | 6 | 16 | 13 | 9 |
| 22-Jun | 10 | 11 | 11 | 10 | 11 | 8 | 11 | 8.5 | 9 | 9.5 | 6 | 2 | 1 | 2 | 2 | 3 | 3 | 2 | 2.5 | 4 | 6.5 | 18 | 14 | 11 |
| 23-Jun | 11.5 | 11 | 11 | 12 | 13 | 6.5 | 6.5 | 0.5 | 2.5 | 4 | 2.5 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1.5 | 3.5 | 6 | 8 | 8 | 9.5 |
| 24-Jun | 8.5 | 8 | 8 | 8.5 | 11 | 16 | 11 | 4.5 | 3.5 | 3 | 3 | 5 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 5 | 7 | 5.5 | 7 |
| 25-Jun | 8 | 11 | 8.5 | 8 | 10 | 15 | 9.5 | 9.5 | 9.5 | 9.5 | 6.5 | 5 | 4 | 3 | 3 | 3 | 3 | 4 | 2.5 | 2.5 | 5.5 | 7 | 6.5 | 6.5 |
| 26-Jun | 8.5 | 12 | 11 | 11 | 12 | 13 | 13 | 15 | 18 | 20 | 14 | 7 | 5 | 5 | 5.5 | 5 | 5 | 9 | 7.5 | 5.5 | 7 | 9.5 | 10 | 7.5 |
| 27-Jun | 7.5 | 8 | 9.5 | 11 | 13 | 15 | 18 | 22 | 22 | 24 | 18 | 9.5 | 8 | 8 | 7.5 | 6 | 6 | 10 | 14 | 17 | 21 | 25 | 23 | 20 |
| 28-Jun | 20 | 21 | 20 | 21 | 20 | 19 | 23 | 24 | 23 | 33 | 15 | 7.5 | 7 | 6 | 5.5 | 5 | 6 | 7 | 9.5 | 16 | 21 | 22 | 22 | 21 |
| 29-Jun | 23 | 26 | 24 | 24 | 23 | 21 | 22 | 21 | 21 | 31 | 15 | 6.5 | 4 | 5 | 5 | 5 | 7 | 7 | 6 | 7.5 | 9.5 | 12 | 19 | 24 |
| 30-Jun | 22.5 | 26 | 27 | 28 | 29 | 28 | 24 | 20 | 27 | 28 | 24 | 13 | 8 | 7 | 7 | 7 | 7 | 5 | 8 | 11 | 12 | 18 | 24 | 28 |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | |
| Jul | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-Jul | 23.5 | 27 | 30 | 36 | 37 | 36 | 29 | 25 | 25 | 32 | 30 | 15 | 9 | 5 | 5.5 | 6 | 6 | 4 | 6.5 | 11 | 13 | 21 | 22 | 20 |
| 2-Jul | 17 | 19 | 22 | 26 | 26 | 27 | 26 | 15 | 20 | 31 | 24 | 10 | 6 | 3 | 3 | 3 | 3 | 3 | 3.5 | 7 | 11 | 26 | 17 | 14 |
| 3-Jul | 15 | 14 | 15 | 15 | 16 | 17 | 17 | 5.5 | 18 | 20 | 12 | 5 | 4 | 4 | 2.5 | 2 | 3 | 4 | 4 | 9 | 12 | 21 | 16 | 14 |
| 4-Jul | 11.5 | 9.5 | 11 | 13 | 14 | 15 | 15 | 15 | 16 | 12 | 8.5 | 4.5 | 4 | 3 | 2 | 1 | 3 | 7 | 6.5 | 13 | 15 | 11 | 18 | 16 |
| 5-Jul | 11.5 | 16 | 17 | 16 | 17 | 18 | 20 | 21 | 26 | 21 | 13 | 7 | 6 | 5 | 3.5 | 3 | 5 | 7 | 8.5 | 12 | 10 | 8.5 | 11 | 12 |
| 6-Jul | 10.5 | 15 | 15 | 12 | 14 | 13 | 15 | 17 | 24 | 22 | 16 | 9.5 | 6 | 6 | 5 | 4 | 5 | 4 | 8 | 11 | 6.5 | 7.5 | 9 | 13 |
| 7-Jul | 10 | 8 | 9.5 | 9.5 | 12 | 15 | 14 | 15 | 18 | 17 | 11 | 9 | 5 | 4 | 4.5 | 4 | 4 | 4 | 6.5 | 9.5 | 17 | 12 | 14 | 18 |
| 8-Jul | 18.5 | 21 | 20 | 19 | 22 | 23 | 22 | 25 | 23 | 16 | 4.5 | 5 | 4 | 6 | 12 | 10 | 7 | 5 | 5 | 6 | 17 | 12 | 14 | 15 |
| 9-Jul | 21 | 25 | 22 | 19 | 19 | 16 | 13 | 17 | 18 | 12 | 3.5 | 1.5 | 1 | 4 | 9 | 8 | 4 | 2 | 2 | 3 | 4.5 | 6.5 | 8.5 | 7 |
| 10-Jul | 14 | 12 | 9.5 | 9 | 8 | 8 | 9 | 12 | 14 | 12 | 5.5 | 3 | 3 | 4 | 3 | 2 | 1 | 1 | 1 | 2 | 4 | 6.5 | 8.5 | 10 |
| 11-Jul | 13.5 | 12 | 10 | 13 | 16 | 17 | 22 | 28 | 34 | 25 | 11 | 6 | 5 | 6 | 5 | 4 | 4 | 5 | 5 | 7 | 13 | 24 | 23 | 24 |
| 12-Jul | 20.5 | | | | | | | | | | | | | | | | | | | | | | | |

(b)

**Figure 16.** (a) API color indication result from 01st June 2020 until 12th July 2020; (b) API from 01st June 2020 until 12th July 2020.

*3.7. Stage 6 – Information Dissemination*

As a result, social media platform has slowly engaged with the public. Figure 17(a) shows the post engagement has increased 480%, and to people reached has increased 1033% at the Facebook platform. For the Instagram account, Figure 17(b) shows the total current engagement is with 85 followers. This shows that social media platform is successful in engaging the public and information are disseminated 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 platforms. In the poster, API-related information such as API status and description, API range, and real-time API were published.

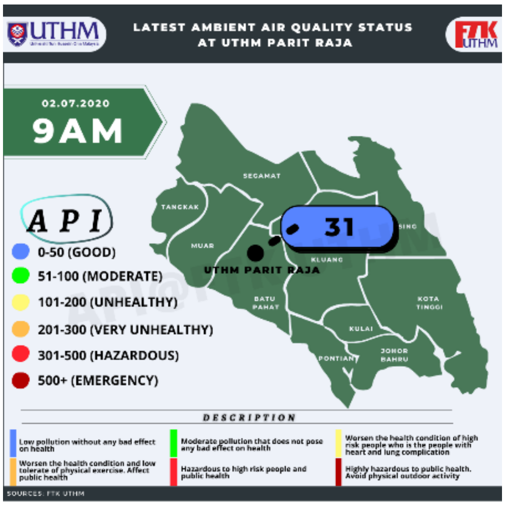



**Figure 18.** Poster API.

## 4. Conclusion

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

According to the results from the 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 the standard limit in June and July is 6, with the highest concentration of 37 μg/$m^3$. 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 110.5μg/$m^3$ (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 in ambient air may closely relate to the activities held on campus during the period. As several standard operating procedures (SOP) were implemented at the UTHM Parit Raja campus from April 2020, attendance of workers, lecturers and students were decreased. Hence, transportation and laboratory work on campus was greatly reduced. Therefore, this is believing that ambient air quality is greater in June and July.

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. The 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 the public, the response from people is good. Friends and strangers started to follow and get engaged with the Facebook and Instagram platforms 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 the UTHM Parit Raja campus area. This new framework is useful, especially since the user can control remotely on the E-Sampler to collect desired data.

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

1. Improve the functionality and efficiency of the data management system. The current system is designed just for $PM_{2.5}$. This limits the usage of the system to calculate and analyze other API parameters. The system is operated manually, this may consume time when a large amount of database is imported into the system.
2. Study on the extent, the impact of the new framework to the university and public. This framework may lead UTHM Parit Raja to become an API hotspot to provide real-time API to the public.
3. Social media platforms should be shared with more friends and relatives, to continuously increase the engagement of the platform with the public.

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