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REAL-TIME MONITORING OF CRITERIA POLLUTANTS AND WEATHER CONDITIONS VIA THE IOT

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ABSTRACT

Both in the city and in industrial areas there are few monitoring stations for criteria pollutants that are punctual and mobile, and the existing ones have few monitoring variables, so there is not enough information to alert the inhabitants of the possible health risks that can be generated by the abuse of these pollutants. With this innovation, we stablish a mobile, remote, and timely monitoring of criteria pollutants and climate variables in real time through the Internet of Things, to alert the inhabitants of the environmental pollution conditions and weather conditions to take appropriate measures and act accordingly to reduce health risks from these pollutants in citizens and industries.

KEYWORDS: Criteria pollutants, real time, Internet of things, climate variables, innovation.

1 INTRODUCTION

With the project we will provide remote, mobile, and timely monitoring of criteria pollutants and weather variables in real time through the Internet of Things, to alert inhabitants of environmental pollution conditions and weather conditions to take relevant measures and act accordingly to reduce health risks.

Real-time monitoring allows you to stay up to date on information changes and improves management decision making.

The process of continuous diagnostic monitoring will allow us to track the status of the system, identify whether atypical events are occurring, and assist with the detection of the source of incidents.

2 MATERIALS AND METHODS

2.1 MATERIALS

The following materials are needed for the development of this application and the monitoring station: Grove BME280 sensor, Plantower PMS7003 Sensor, Feather Screw Terminal, Particle Photon, Particle to Adafruit Feather Adapter, Weather Meter Kit, MQ-9 Carbon Monoxide combustible gas sensor, MQ131 Ozone gas sensor.

2.1.1 GROVE - BAROMETER SENSOR (BME280)

Figure 1: Grove BME280 sensor.

Grove – Temp & Humi & Barometer Sensor (BME280) is a breakout board for Bosch BMP280 high-precision, low-power combined humidity, pressure, and temperature sensor.[1] This module can be used to measure temperature, atmospheric pressure, and humidity accurately and fast. As the atmospheric pressure changes with altitude, it can also measure approximate altitude of a place. It can be connected to a microcontroller with I^2C (integrated with Grove socket) or through SPI bus. We have also provided highly abstracted library to make this more product easier to use.

Operating range: atmospheric pressure (300-1100hPa), temperature (-45 to 85C) and relative humidity (0-100%). High accuracy, absolute accuracy of ±1.0 hPa for pressure, ±1 accuracy for temperature and ±3% for humidity. This module can be connected to the IoT device with I2C protocol. The Grove-Barometer Sensor is shown in Figure 1.

2.1.2 PLANTOWER PMS7003 SENSOR

Figure 2: Plantower PMS7003 Sensor.

The PLANTOWER PMS7003 is a kind of digital and universal particle concentration sensor, which can be used to obtain the number of suspended particles in the air, i.e. the concentration of particles, and output them in the form of digital interface. This sensor can be inserted into variable instruments related to the concentration of suspended particles in the air or other environmental improvement equipments to provide correct concentration data in time.[2] With a measuring range of 0.3 ~ 1.0; 1.0 ~ 2.5; 2.5 ~ 10 Micrometers (μm) with a resolution of 1 μg/m3. The unit of volume of particle number is 0.1 L and the unit of mass concentration is in μg/m3. Its operating voltage is 4.5 ~ 5.0v DC at 100 mA or less. The PLANTOWER PMS7003 Sensor is shown in Figure 2.

2.1.3 FEATHER SCREW TERMINAL FOR PARTICLE AND FEATHER MODULES

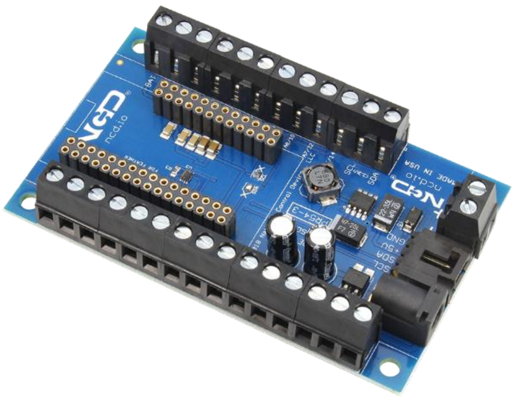

Figure 3: Feather Screw Terminal.

This FTSCREW Breakout Board offers a convenient screw terminal breakout board and power solution for Particle Argon, Boron, Xenon or Adafruit Feather devices. The FTSCREW includes an integrated I2C port for easy expansion to the entire ncd.io I2C product line. The FTSCREW is compatible with the Key Fob Receiver expansion, allowing Key Fob commands to be sent directly to the GPIO of the Particle Argon, Boron, Xenon, or

Feather modules.[3] Use our optional Ethernet overlay shield to add Ethernet communications to all Feather compatible devices. This screw-terminal breakout board comes with an on-board switching power supply. The on-board power supply can deliver 5V at 2 Amps. The input voltage range is 6.5V-22V DC.

Connect sensors for light level monitoring, gas level detection, temperature, and humidity monitoring, as well as many types of motion, acceleration, and direction sensors. Connect our entire array of relay controllers, digital I/O expanders, PWM controllers, and current monitoring devices to your next IoT application with a simple daisy-chain interface.

The Feather Screw Terminal for Particle and Adafruit Feather Modules provides a +5V I2C communications, making it one of the most important expansions available. The Feather I2C Screw Terminal Breakout Shield for Particle and Feather Modules allows you to easily handle the hardware side of IoT and automation so you can focus on the software. The Feather Screw Terminal Feather is shown in Figure 3.

2.1.4 PARTICLE PHOTON

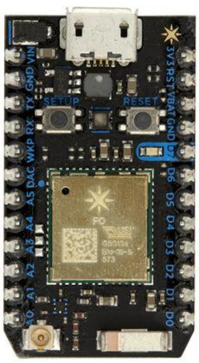

Figure 4: Particle Photon.

The Photon is a tiny Wi-Fi IoT device for creating connected projects and products for the Internet of Things. It's easy to use, it's powerful, and it's connected to the cloud.[4] The board itself uses a Cypress Wi-Fi chip (one that can be found in Nest Protect, LIFX, and Amazon Dash) alongside a powerful STM32 ARM Cortex M3 microcontroller. The Particle Photon is shown in Figure 4.

2.1.5 SENTIENT THINGS - PARTICLE TO ADAFRUIT FEATHER ADAPTER

The Sentient Things Particle to Feather Adapter includes circuitry that uses the regulated 3.3V from the Photon or Electron.[5] The Particle 3.3V is fed to the Feather 3.3V output and is enabled (high) per the Feather standard using the 3V enable pin. The Feather Adapter is shown in Figure 5.

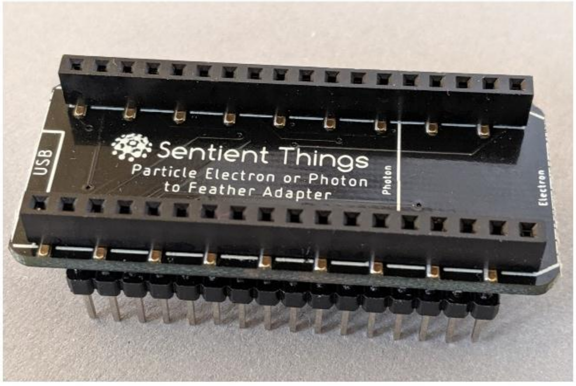

Figure 5: Particle to Adafruit Feather Adapter.

2.1.6 SPARKFUN - WEATHER METER KIT

Figure 6: Weather Meter Kit.

This kit includes a wind vane, cup anemometer, and tipping bucket rain gauge, with associated mounting hardware.[6] These sensors contain no active electronics, instead using sealed magnetic reed switches and magnets to take measurements. A voltage must be supplied to each instrument to produce an output. The Weather Meter Kit is shown in Figure 6.

2.1.7 RAIN GAUGE

The rain gauge is a self-emptying tipping bucket type. Each 0.011” (0.2794 mm) of rain causes one momentary contact closure that can be recorded with a digital counter or microcontroller interrupt input. The gauge's switch is connected to the two center conductors of the attached RJ11-terminated cable.

2.1.8 ANEMOMETER

The cup-type anemometer measures wind speed by closing a contact as a magnet moves past a switch. A wind speed of 1.492 MPH (2.4 km/h) causes the switch to close once per second. The anemometer switch is connected to the inner two conductors of the RJ11 cable shared by the anemometer and wind vane (pins 2 and 3.)

2.1.9 WIND VANE

The wind vane is the most complicated of the three sensors. It has eight switches, each connected to a different resistor. The vane's magnet may close two switches at once, allowing up to 16 different positions to be indicated. An external resistor can be used to form a voltage divider, producing a voltage output that can be measured with an analog to digital converter, as shown below. The switch and resistor arrangement is shown in the diagram to the right. Resistance values for all 16 possible positions are given in the table. Resistance values for positions between those shown in the diagram are the result of two adjacent resistors connected in parallel when the vane's magnet activates two switches simultaneously.

2.1.10 MQ-9 CARBON MONOXIDE COMBUSTIBLE GAS SENSOR ADC121C 12-BIT ADC I2C MINI MODULE

Figure 7: MQ-9 Carbon Monoxide combustible gas sensor.

The MQ-9 Gas sensor makes it easy to monitor carbon monoxide and combustible gas concentration levels using our I2C Mini Module form factor. The MQ9 is connected to an ADC121C 12-Bit Analog to Digital converter, which is capable expanding to 9 gas sensors per I2C port using just two address jumpers (making full use of the floating address system).[7]

The MQ-9 is capable of sensing carbon monoxide air concentration levels between 10 and 1,000ppm and combustible gas air concentration levels between 100 and 10,000ppm. The ideal sensing condition for the MQ9 is 20°C ±2°C at 65% ±5% humidity. An internal preheater inside the sensor helps achieve the ideal sensing conditions, but the datasheet recommends over 48 hours for preheating to achieve optimal accuracy. Because of the internal preheater, this sensor requires more current than most of our I2C Mini Modules. We measured 139ma for this I2C Mini Module, so we strongly recommend planning a power strategy for your I2C master device to deliver no-less than 150ma per sensor! This sensor comes pre-calibrated to the datasheet's recommended values; however, final calibration may be required for accurate measurements, as we do not stock the equipment for full-scale calibration of these sensors.

All I2C Mini Modules are designed to operate at 5VDC. Using a convenient 4-Pin plug, devices can be daisy chained onto the I2C Bus, eliminating the need for soldering. Simply plug together the devices you need for your next automation application. Pull-up resistors are included with all NCD master devices. If you are wiring in your own I2C port, on-board 4.7K jumper-selectable pull-up resistors are available for convenience purposes. The MQ9 Sensor is shown in Figure 7.

2.1.11 MQ131 OZONE GAS SENSOR ADC121C 12-BIT ADC I²C MINI MODULE

Figure 8: MQ131 Ozone gas sensor.

The MQ131 ozone gas sensor makes it easy to monitor ozone concentration levels using our I2C Mini Module form factor. The MQ131 is connected to an ADC121C 12-Bit Analog to Digital converter, which is capable expanding to 9 gas sensors per I2C port using just two address jumpers (making full use of the floating address system).[8]

The MQ131 ozone gas sensor is capable of sensing ozone air concentration levels between 10ppm and 1000ppm. The ideal sensing condition for the MQ131 is 20°C ±2°C at 65% ±5%

humidity. An internal preheater inside the sensor helps achieve the ideal sensing conditions, but the datasheet recommends over 24 hours for preheating to achieve optimal accuracy. Because of the internal preheater, this sensor requires more current than most of our I2C Mini Modules. We measured 139ma for this I2C Mini Module, so we strongly recommend planning a power strategy for your I2C master device to deliver no-less than 150ma per sensor! This sensor comes pre-calibrated to the datasheet's recommended values; however, final calibration may be required for accurate measurements, as we do not stock the equipment for full-scale calibration of these sensors.

All I2C Mini Modules are designed to operate at 5VDC. Using a convenient 4-Pin plug, devices can be daisy chained onto the I2C Bus, eliminating the need for soldering. Simply plug together the devices you need for your next automation application. Pull-up resistors are included with all NCD master devices. If you are wiring in your own I2C port, on-board 4.7K jumper-selectable pull-up resistors are available for convenience purposes. The MQ131 Sensor is shown in Figure 8.

3 RESULTS

Figure 9 shows the system integration. The BME280 sensor, which is a relative humidity, atmospheric pressure and temperature sensor, is connected to the I2C communication port of the IoT Particle Photon device through the SDA (data line) and SCL (clock line) pins. The PMS7003 sensor, capable of measuring the concentration of suspended particles, is connected to the UART serial port of the IoT Particle Photon device via the RX and TX pins. The MQ-9 and MQ-131 sensor measures the concentration of gases in the Ozone and Carbon Monoxide, both sensors are connected in serial mode to the I2C communication port. The IoT Particle Photon device is mounted on a Feather adapter which is connected to the Feather Screw Terminal.

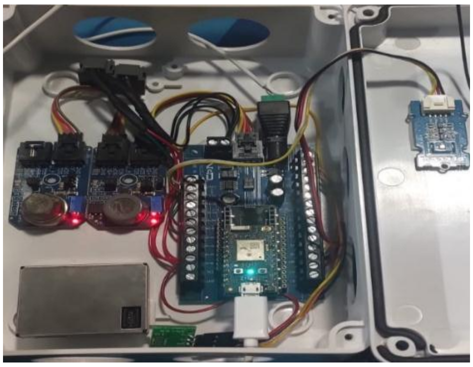

Figure 9: Diagram of components and electrical connections of the node.

Figure 10 shows the node built and installed, the real-time readings obtained by each of the sensors were collected by the Particle Photon device and sent to the Ubidots web platform, which represented the data in real time through numerical data, graphs and histograms to obtain an average of data from each sensor and verify how good the air quality is and thus support to take the necessary measures and actions for environmental improvement.

Figure 10: Node assembled.

3.1 GRAPHICS

Figure 11 shows the behavior of the particles suspended in the air at 10 µm particle size (PM10) in the city, the Y axis shows the maximum interval that the particles should reach according to the Mexican Official Standard, while the X axis represents the elapsed time.

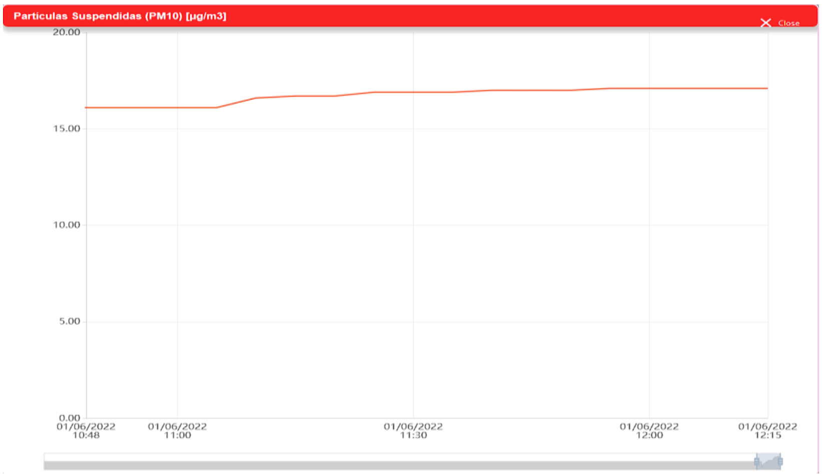

Figure 11: Particles Suspended in the air at 10 µm particle size.

Figure 12 shows the behavior of the particles suspended in the air at 2.5 µm particle size (PM2.5) in the city, the Y axis shows the maximum interval that the particles should reach according to the Mexican Official Standard, while the X axis represents the elapsed time.

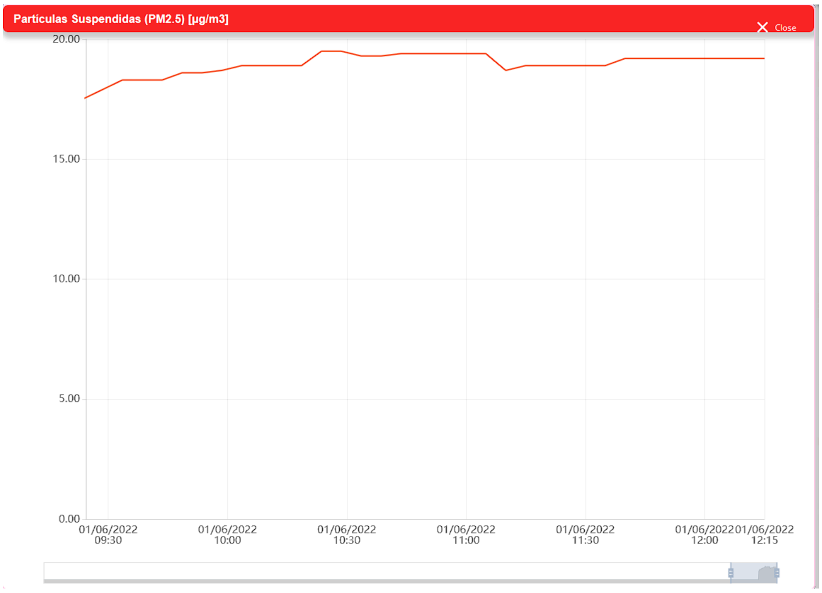

Figure 12: Particles Suspended in the air at 2.5 µm particle size.

Figure 13 shows the temperature in degrees Celsius (°C), we represent the Y-axis as the minimum which is -20 degrees and the maximum as 50 degrees and the X-axis as the elapsed time.

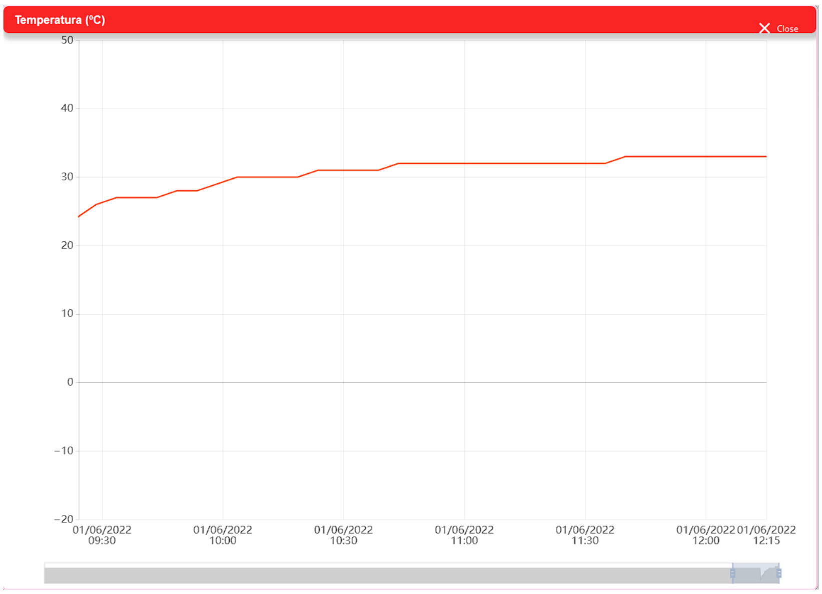

Figure 13: Temperature in degrees Celsius.

In figure 14 we represent the relative humidity as a percentage (%) on the Y-axis, the X-axis the elapsed time.

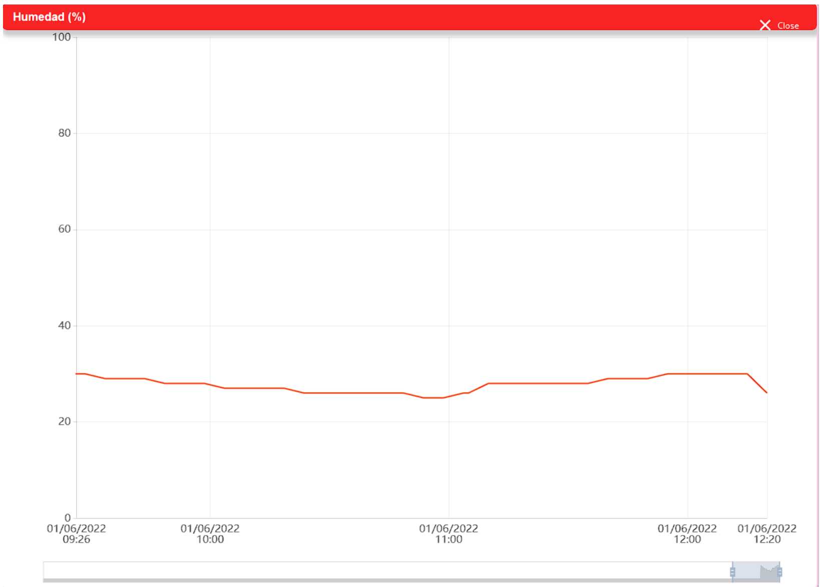

Figure 14: Humidity.

In figure 15 we show the atmospheric pressure which we represent it in pascal values (Pa), the Y-axis can be expanded depending on the last maximum value and the X-axis the time.

Figure 15: Atmospheric Pressure.

In figure 16 we show the precipitation intensity which is measured in millimeters (mm), in the Y axis we take the levels being the maximum value as heavy precipitation and the X axis as the elapsed time.

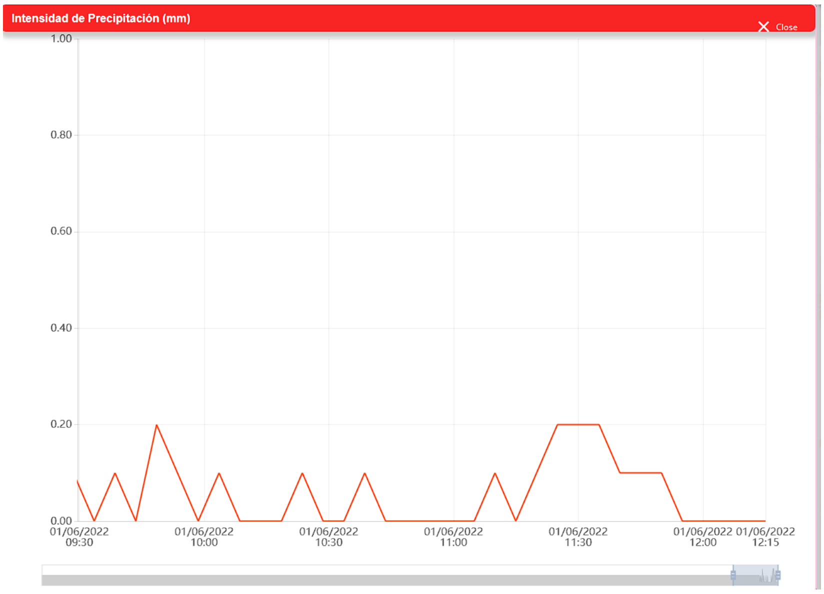

Figure 16: Precipitation Intensity.

Figure 17 shows carbon monoxide (CO), the Y-axis represents the minimum and maximum values based on the Mexican Official Standards, and the X-axis represents the elapsed time. The values shown were converted to adjust the devices to urban areas.

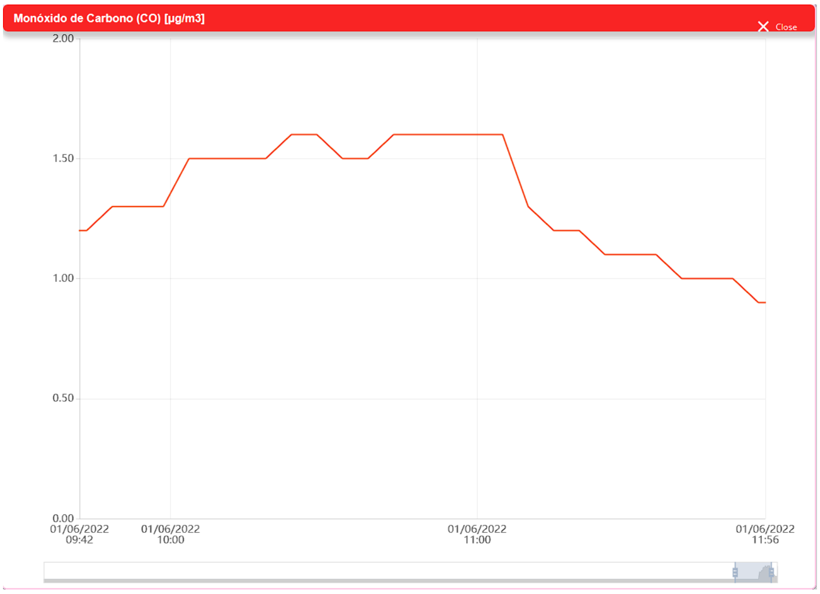

Figure 17: Carbon Monoxide.

Figure 18 shows ozone (O3), the Y-axis represents the minimum and maximum values based on the Mexican Official Standards, and the X-axis represents the elapsed time. The values shown were converted to adjust the devices to urban areas.

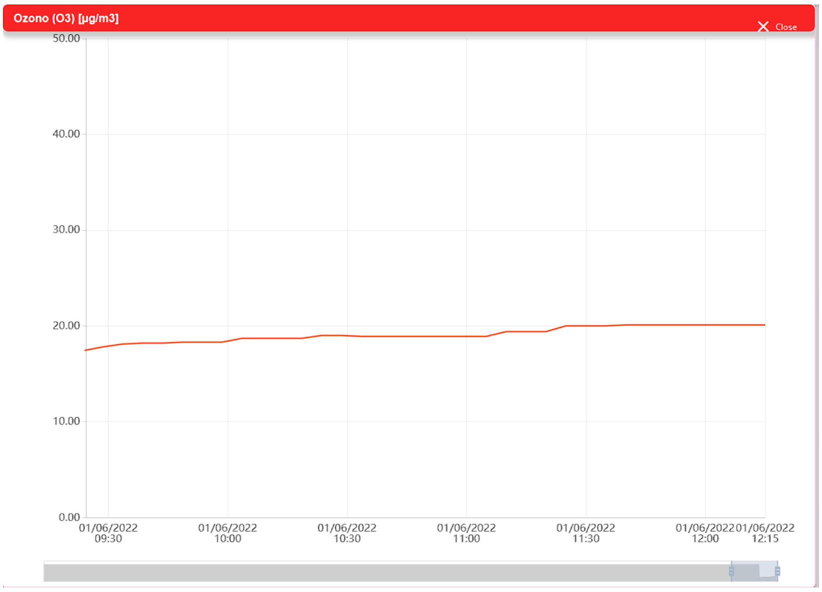

Figure 18: Ozone.

In Figure 19 we represent the altitude represented as meters above sea level (amsl), the Y-axis represents the current altitude of the city, and the X-axis the elapsed time.

Figure 19: Altitude.

Figure 20 represents the wind speed values represented by kilometers per hour (km/h), the Y-axis is a value taken from the values given over time, and the X-axis as the time.

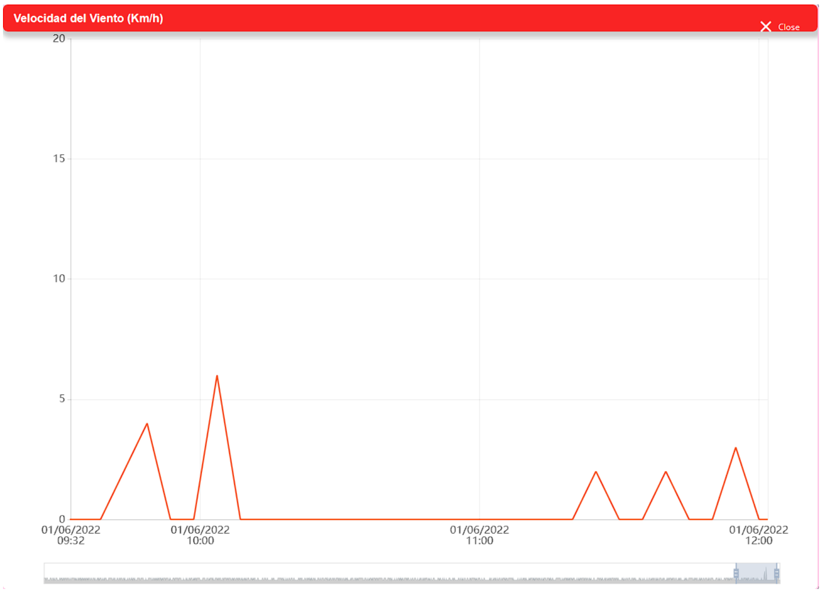

Figure 20: Wind Speed.

Figure 21 shows the wind direction taken in degrees (°), in the graph is represented as the places where the wind direction has been the longest, as well as where it is currently positioned.

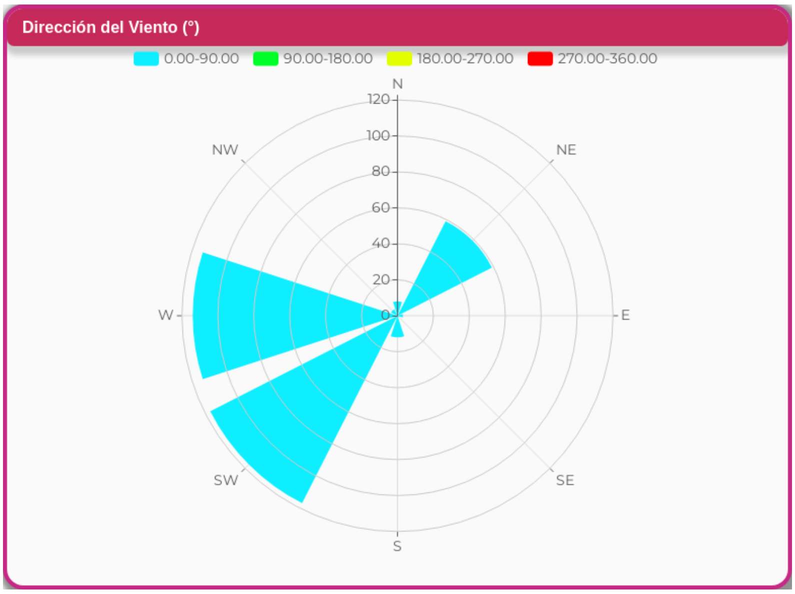

Figure 21: Wind Direction.

CONCLUSIONS

An IoT node was developed capable of monitoring in real time temperature, relative humidity, atmospheric pressure, altitude, Ozone, Carbon Monoxide and the concentration of polluting particles in sizes of 2.5 and 10 micrometers. The data of the variables were graphed in Ubidots Platform which allows to visualize each one of the data so that the end user is alerted to each one of the variables.

In the project procedure we had problems with the ozone (O3) and carbon monoxide (CO) sensors, because these sensors are for industrial use, they read relatively high values that in normal cases would not be used for urban areas. In this case we investigated solutions to solve this problem, we modified the code of the devices, as well as their formulas so that they would give us accurate values or similar to the standards that apply in Mexico.

REFERENCES

1. Author Unknown. (May 07, 2015). Grove - Barometer Sensor (BME280). May 20, 2022, de Seeed Studio Sitio web: https://wiki.seeedstudio.com/Grove-Barometer_Sensor-BME280/
2. Yong, Z. (Jun 01, 2016). Digital universal particle concentration sensor. May 20, 2022, de Plantower Sitio web: https://aqicn.org/air/sensor/spec/pms7003-english-v2.5.pdf
3. Feather Screw Terminal For Particle and Feather Modules. May 22, 2022, de NCD.io Sitio web: https://store.ncd.io/product/feather-screw-terminal-for-particle-and-feather-modules/
4. Author Unknown. (Without Date). Particle Photon. May 22, 2022, de Particle Sitio web: https://store.particle.io/products/photon.
5. Autor Unknown. (Without Date). Particle To Feather Adapter. May 23, 2022, de Sentient Things, Inc. Sitio web: https://docs.sentientthings.com/particle-to-feather-adapter-board
6. Author Unknown. (Without Date). Weather Meter. May 23, 2022, de Sparkfun Start Something Sitio web: https://learn.sparkfun.com/tutorials/weather-meter-hookup-guide/all.
7. Author Unknown. (Without Date). MQ-9 Semiconductor Sensor for CO/Combustible Gas. May 24, 2022, de Henan Hanwei Electronics Co., Ltd Sitio web: https://store.ncd.io/product/mq-9-carbon-monoxide-combustible-gas-sensor-adc121c-12-bit-adc-i2c-mini-module/.
8. Author Unknown. (March 10, 2010). MQ131 Ozone Gas Sensor ADC121C 12-Bit ADC I^2C Mini Module. May 24, 2022, de Zhengzhou Winsen Electronics Technology Co., Ltd Sitio web: https://store.ncd.io/product/mq131-ozone-gas-sensor-adc121c-12-bit-adc-i%C2%B2c-mini-module/.