AIR QUALITY CHECKING AND TRACKING FOR ENVIRONMENTAL COMPLIANCE:

An IoT-Based Air Quality Monitoring System

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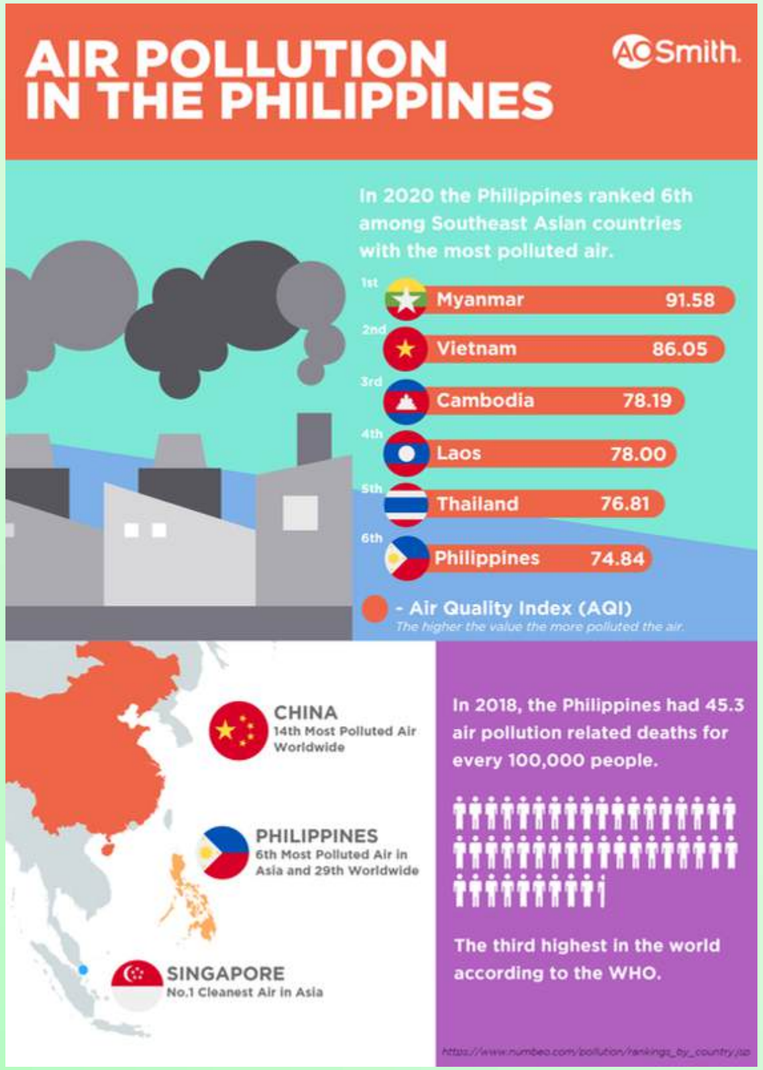
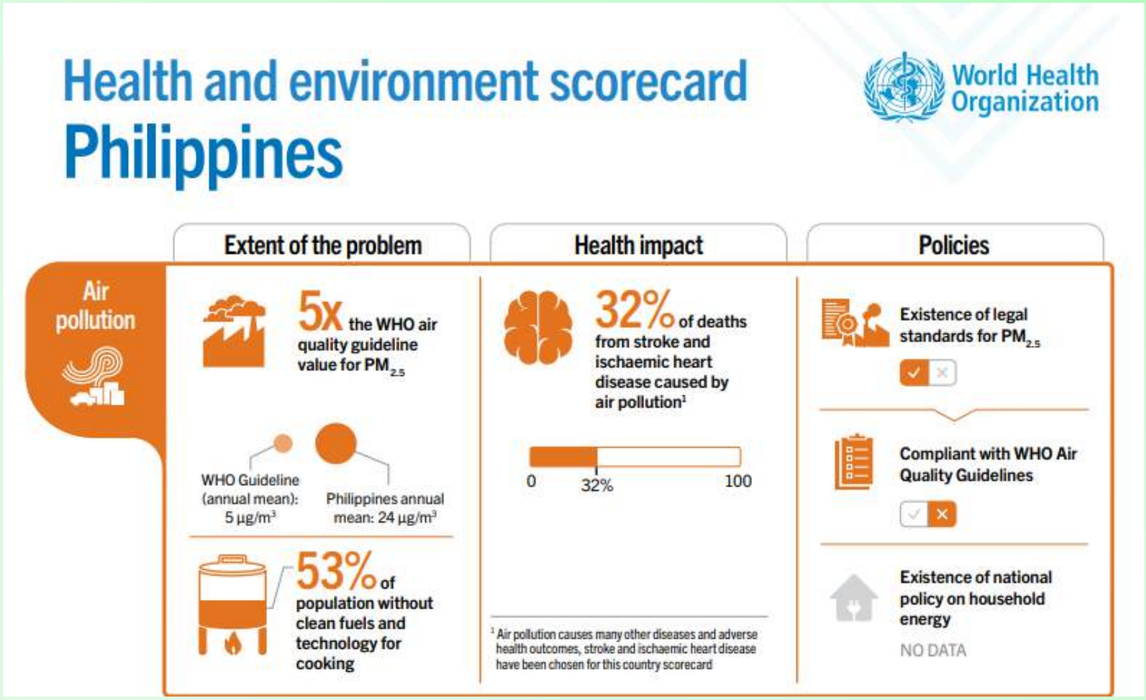
INTRODUCTION

2020





2022

STATEMENT OF THE PROBLEM

The absence of a dedicated air quality monitoring station from CENRO limits access to real-time data, making it difficult to detect pollution levels and enforce effective environmental policies.

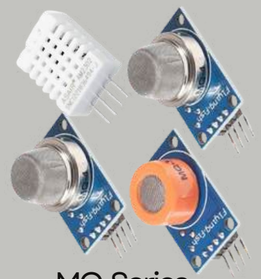
OBJECTIVES OF THE STUDY

The general objective of this study is to design and implement an IoT-based air quality monitoring system for the City of Cabuyao, capable of detecting specific air pollutants emitted from various pollution sources within the city.

OVERVIEW OF SCOPE AND FEATURES

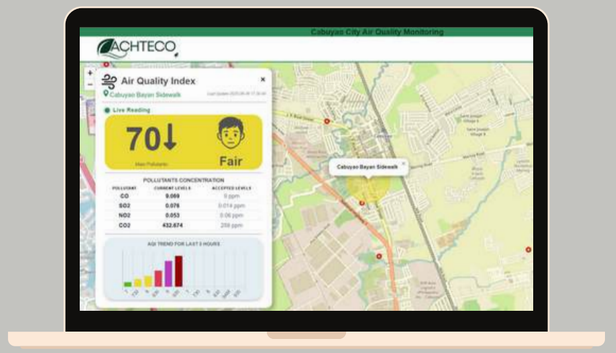
- Gas Detection, Temperature and Humidity Monitoring and Location Tracking,
- Web-Based Monitoring System and LCD Interface, and
- Power and Internet Connection Management.

Pollutants (NO_2, SO_2, CO, CO_2,)
Temperature and Humidity
Coordinates

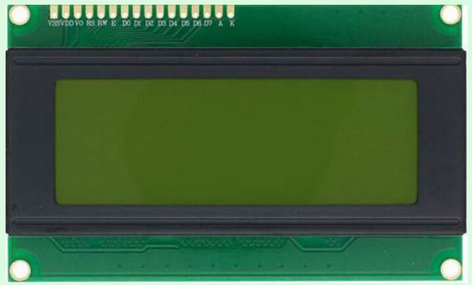


MQ Series (MQ2, MQ7, MQ135) and DHT22 sensors

NEO-6M GPS



Website Interface



ESP32 module

METHODOLOGY

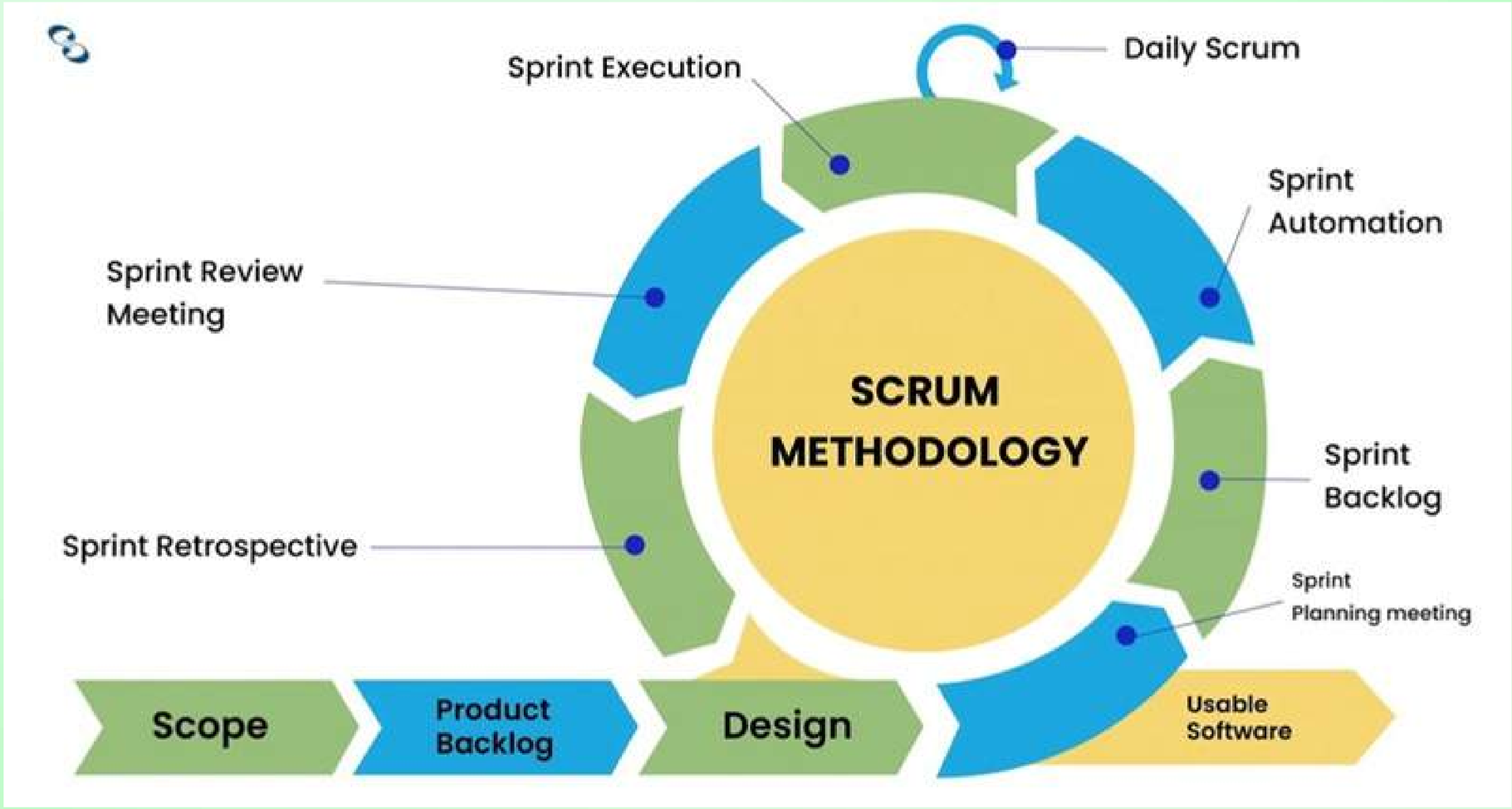


Figure 5. Scrum Methodology (p.59)

RESULTS AND DISCUSSIONS

EXPERIMENTAL SETTING

Location

- Cabuyao Bayan Sidewalk
- Pulo Barangay Hall Intersection

Location Testing

Figure 6. Deployment Locations for Air Quality Monitoring (p.78)

EXPERIMENTAL SETTING

Ideal System Installation

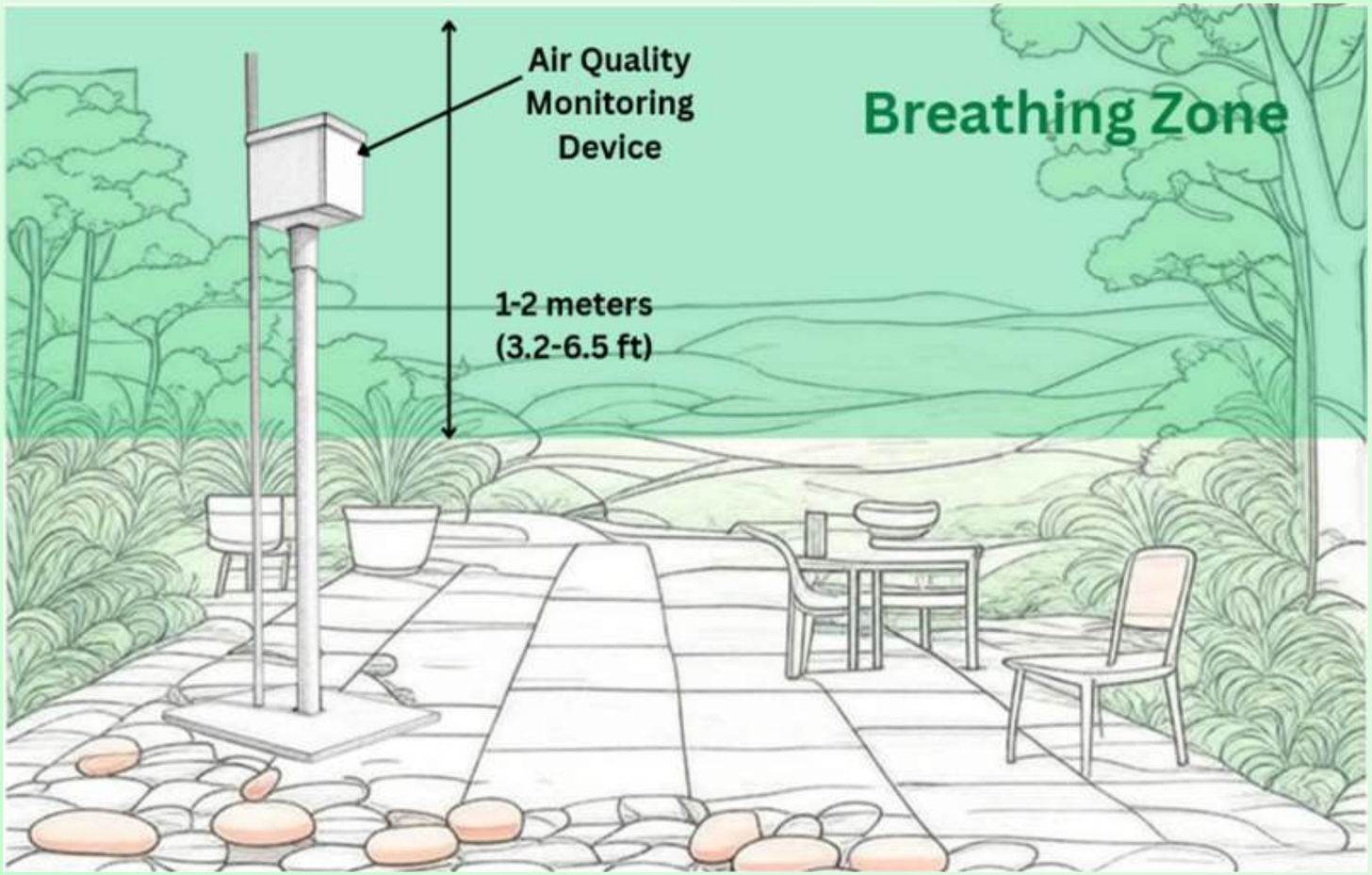


Figure 7. Ideal System Installation Setup (p.79)

EXPERIMENTAL SETTING

Block Diagram

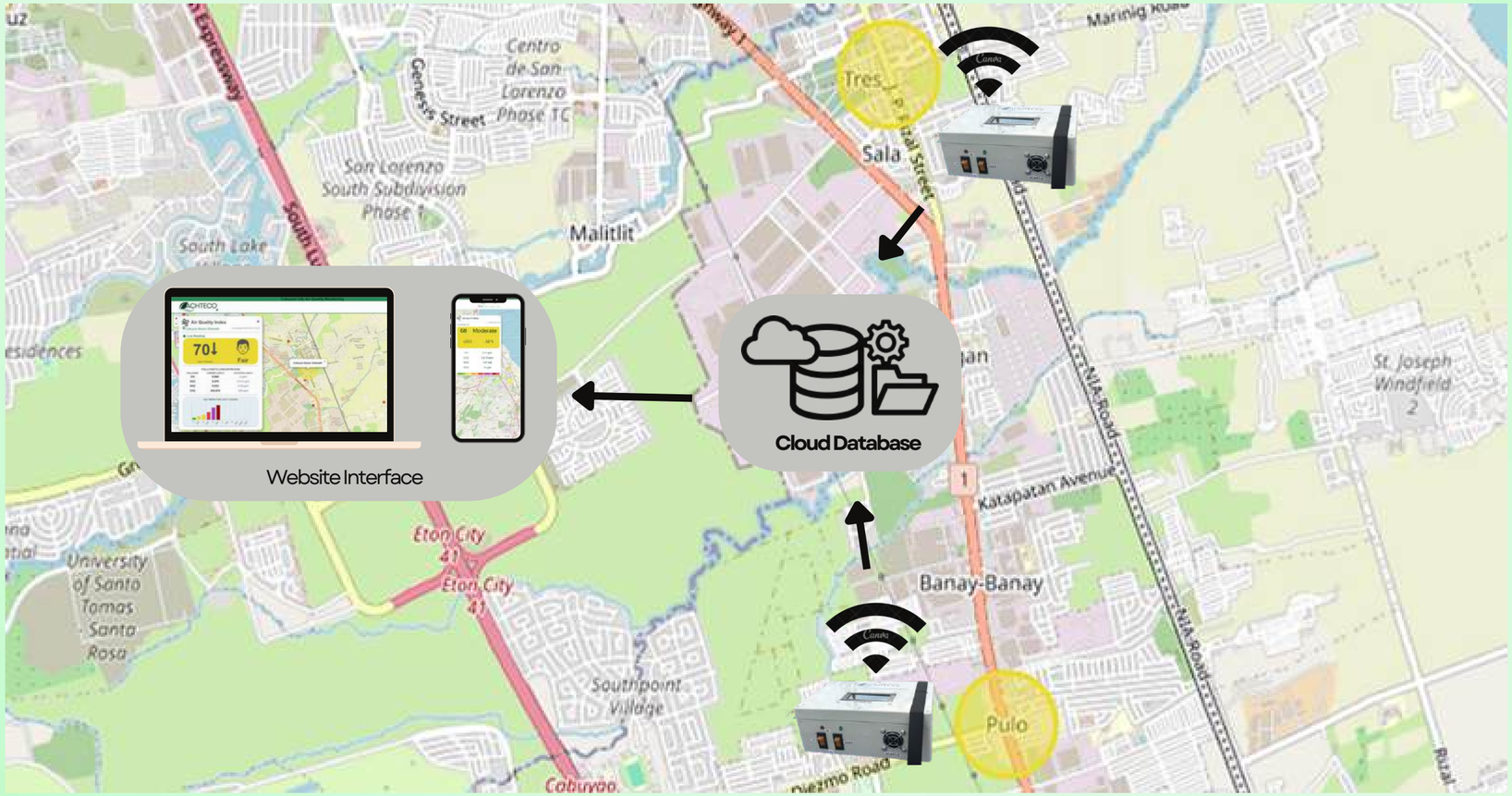


Figure 8. Block Diagram of the System Setup (p.80)

EXPERIMENTAL SETTING

Air Quality Monitoring System Architecture Diagram

System Architecture

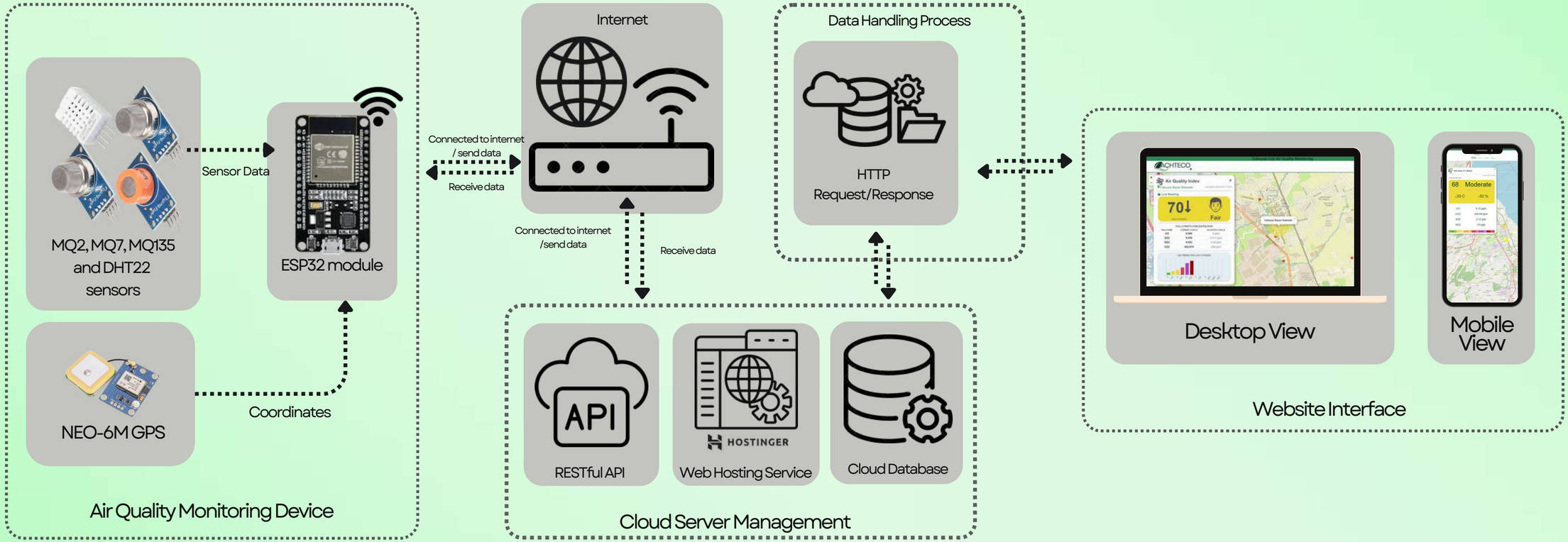
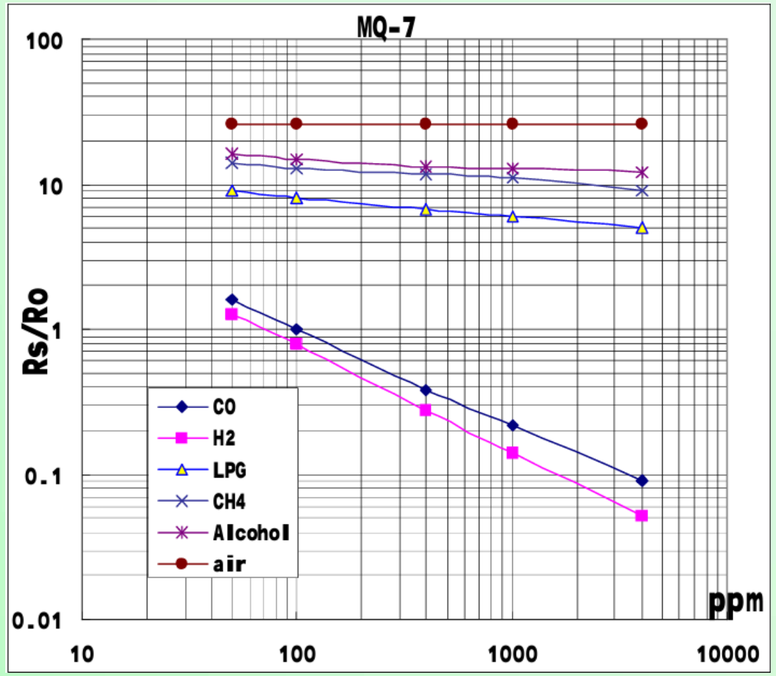


Figure 9. System Architecture (p.81)

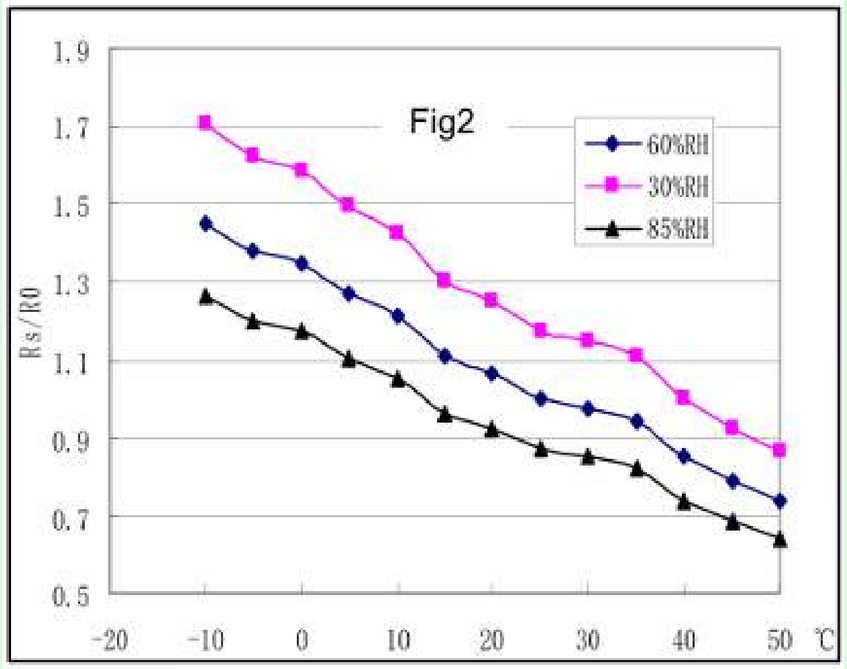
EXPERIMENTAL SETTING

Self-Calibration Testing

Sensor Datasheet



Dependence of the MQ sensors on temperature and humidity.

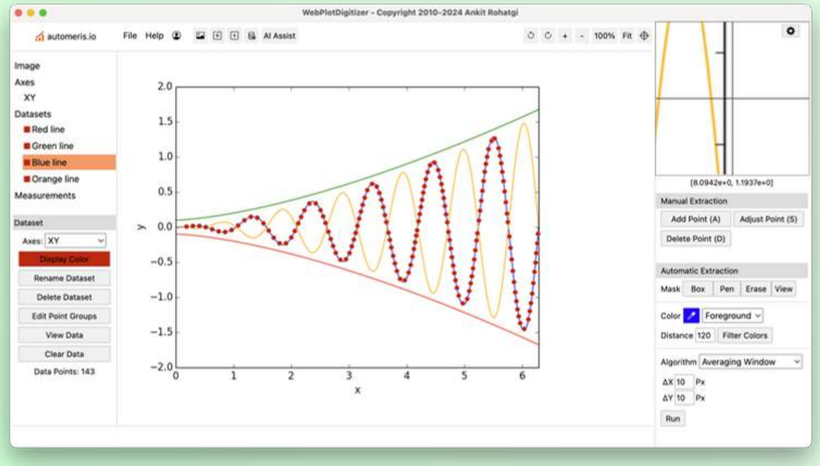


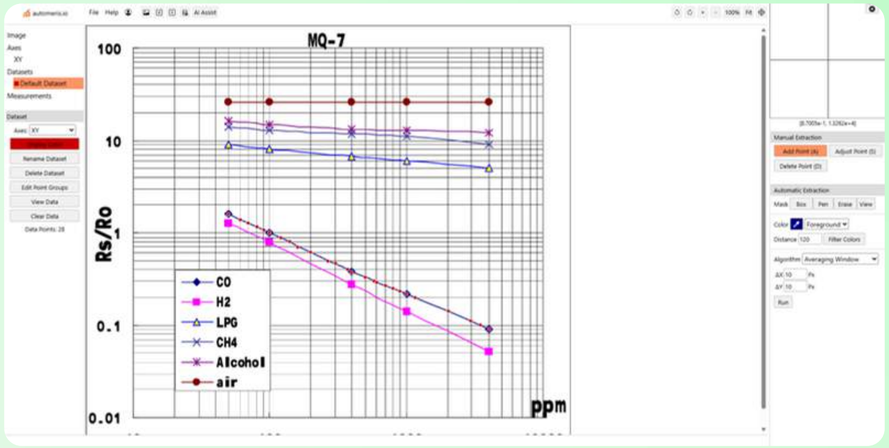

```
#define CORA .00035
#define CORB .02718
#define CORC 1.39538
#define CORD .0018
#define CORE -.003333333
#define CORF -.001923077
#define CORG 1.130128205
```

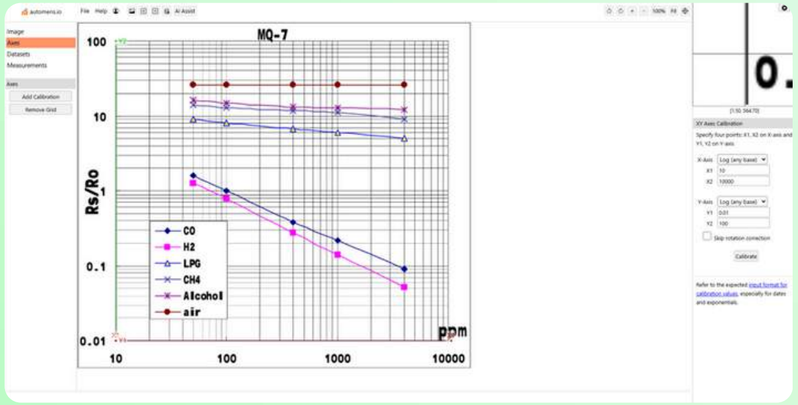
EXPERIMENTAL SETTING

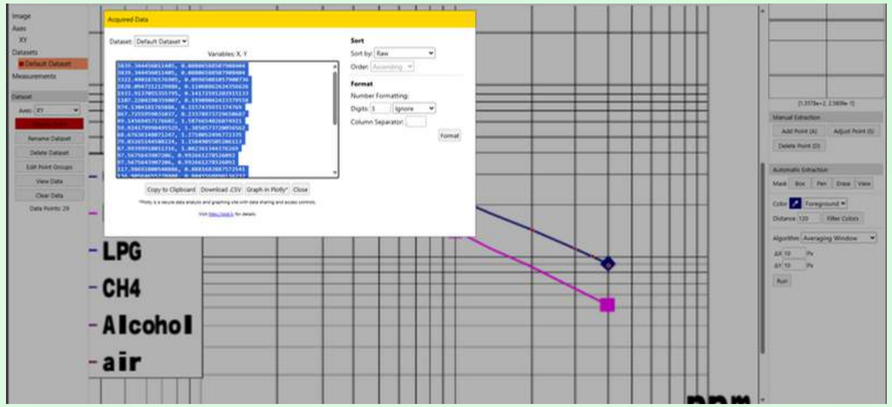
Self-Calibration Testing

WebPlotDigitizer









EXPERIMENTAL SETTING

Self-Calibration Testing

R - Script

MQ gas sensor datasheet correlation function coefficients estimation and constants estimations

```
# An R script to estimate MQ gas sensors correlation curve and compute Ro, min and max Rs/Ro
#
# Copyright (c) Davide Gironi, 2016
#
# Released under GPLv3.
# Please refer to LICENSE file for licensing information.

# How to use this script:
# 1) set limits as datasheet curve ("xlim" and "ylim")
#    ex.
#      xlim = c(10, 1000)
#      ylim = c(0.1, 10)
# 2) find out datasheet curve points, and write it out (to "pointsdata")
#    each line it's a point on cartesian coordinate system
#    the useful WebPlotDigitizer app can help you extract points from the graph
#    ex.
#      pointsdata = "
#        10.052112405371744, 2.283698378106183
#        20.171602728600178, 1.8052797165878915
#        30.099224396434586, 1.5715748803154423
#        50.09267987761949, 1.3195287228519417
#        80.38812026903305, 1.1281218760133969
#        90.12665922665023, 1.0815121769656304
#        100.52112405371739, 1.0430967861855598
#        199.62996638292853, 0.8000946404902397
#      "
# 3) optional for Ro estimation: measure the sensor resistance (set it to "mres" ohm value) at a k
```

```
#set input values
xlim = c(10, 10000)
ylim = c(0.1, 100)
minppm = 0
maxppm = 0
mres = 0
mppm = 0
pointsdata = "
[illegible]
"
```

Output

```
Correlation function coefficients
Estimated a
  100
Estimated b
  1.513

[Execution complete with exit code 0]
```

EXPERIMENTAL SETTING

Self-Calibration Testing

Table 7. Constants used in reading gas measurements (p.77)

Gas	ATMO (ppm)	PARa	PARb
SO2	0.045	3.90719	1.99513
NO2	0.065	284.8729	0.49825
CO	6.0	100.0023	1.513
CO2	423.85	116.60206	2.76903

EXPERIMENTAL SETTING

Third-party Testing

Table 9. Third Party-Testing Results (Test #1) (p.80)

Pollutants	Reference Device Reading (in ppm)	Actual Device Reading (in ppm)	Accuracy	Remark
CO	3.71	3.696	99.98%	EXCELLENT
CO_2	411.6	411.69	99.62%	EXCELLENT
SO_2	0.0344	0.03419	99.39%	EXCELLENT
NO_2	0.0267	0.02657	99.51%	EXCELLENT

Table 10. Third Party-Testing Results (Test #2) (p.80)

Pollutants	Reference Device Reading (in ppm)	Actual Device Reading (in ppm)	Accuracy	Remark
CO	3.78	3.779	98.54%	EXCELLENT
CO_2	411.7	411.714	98.39%	EXCELLENT
SO_2	0.038	0.03787	98.53%	EXCELLENT
NO_2	0.0272	0.02724	98.42%	EXCELLENT

Table 10. Third Party-Testing Results (Test #3) (p.81)

Pollutants	Reference Device Reading (in ppm)	Actual Device Reading (in ppm)	Accuracy	Remark
CO	3.84	3.833	98.33%	EXCELLENT
CO_2	411.7	411.669	98.79%	EXCELLENT
SO_2	0.038	0.03805	98.53%	EXCELLENT
NO_2	0.0274	0.02745	98.43%	EXCELLENT

EXPERIMENTAL SETTING

Third-party Testing

Table 9. Results of Paired t-test (p.82)

Pollutants	Average of Reference Device Readings (in ppm)	Average of Actual Device Readings (in ppm)	p-value	Remark
CO	3.776	3.769	0.1902	No Significant Difference
CO_2	411.66	411.69	0.5643	No Significant Difference
SO_2	0.0368	0.0367	0.3356	No Significant Difference
NO_2	0.0271	0.0270	0.8406	No Significant Difference


Cabuyao Bayan Sidewalk
Pulo Intersection
Centro de San Lorenzo Phase 1C
Genesis Street
San Lorenzo South Subdivision Phase 1
South Lake Village
South Luxon Expressway
E2
Greenfield Parkway
Mamplasan
Niugan
Katapatan Avenue
St. Joseph Windfield 2
Etori City
41
University of Santo Tomas Santa Rosa
Southpoint Village
Pulo

REAL-TIME MONITORING OF AQI

Setup of the Device

Table 13. Average concentration of Pollutants in Pulo Barangay Hall Intersection (p.84)

Pollutants	Prototype Reading	Accepted Ambient Value	Remark
CO	7.959	9	ACCEPTABLE
CO_2	391.036	400	ACCEPTABLE
SO_2	0.072	0.07	ACCEPTABLE
NO_2	0.04	0.08	ACCEPTABLE

Table 14. Average concentration of Pollutants in Cabuyao Bayan Sidewalk (p.84)

Pollutants	Prototype Reading	Accepted Ambient Value	Remark
CO	7.832	9	ACCEPTABLE
CO_2	372.560	400	ACCEPTABLE
SO_2	0.071	0.07	ACCEPTABLE
NO_2	0.042	0.08	ACCEPTABLE

REAL-TIME MONITORING OF AQI

Compatibility Testing

Compatibility Testing were performed in various platform to ensure the smooth usage of the website in both mobile and desktop. The ideal resolution for desktop is 1920x1080 and mobile is 1080 x 2340

SCREEN-RECORDING LINK

Table 15-16. Compatible Desktop and Mobile Browsers (p.85)

Platform	Chrome	Firefox	Safari	Edge
Mac	✓	✓	✓	N/A
Windows	✓	✓	N/A	✓
Android	✓	✓	N/A	✓
iOS	✓	✓	✓	✓

User Acceptance Test Results

Results showed the most of the respondents strongly agree with the statements form the User Acceptance questionnaire

Objective 1: 3.509

Objective 2: 3.5

Objective 3: 3.475

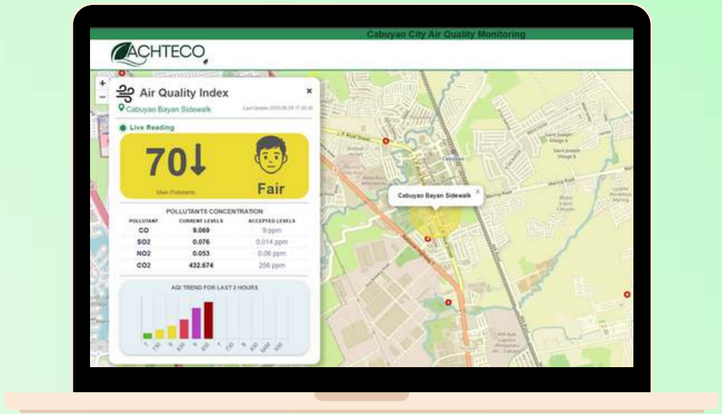
Unit Testing

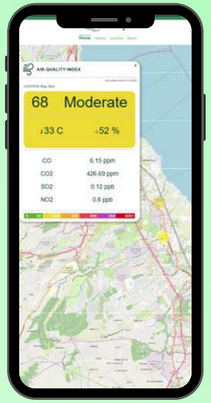
All the functions of the website were tested individually to see if they will run as intended.

PASSED

CONCLUSION

ACHTECO





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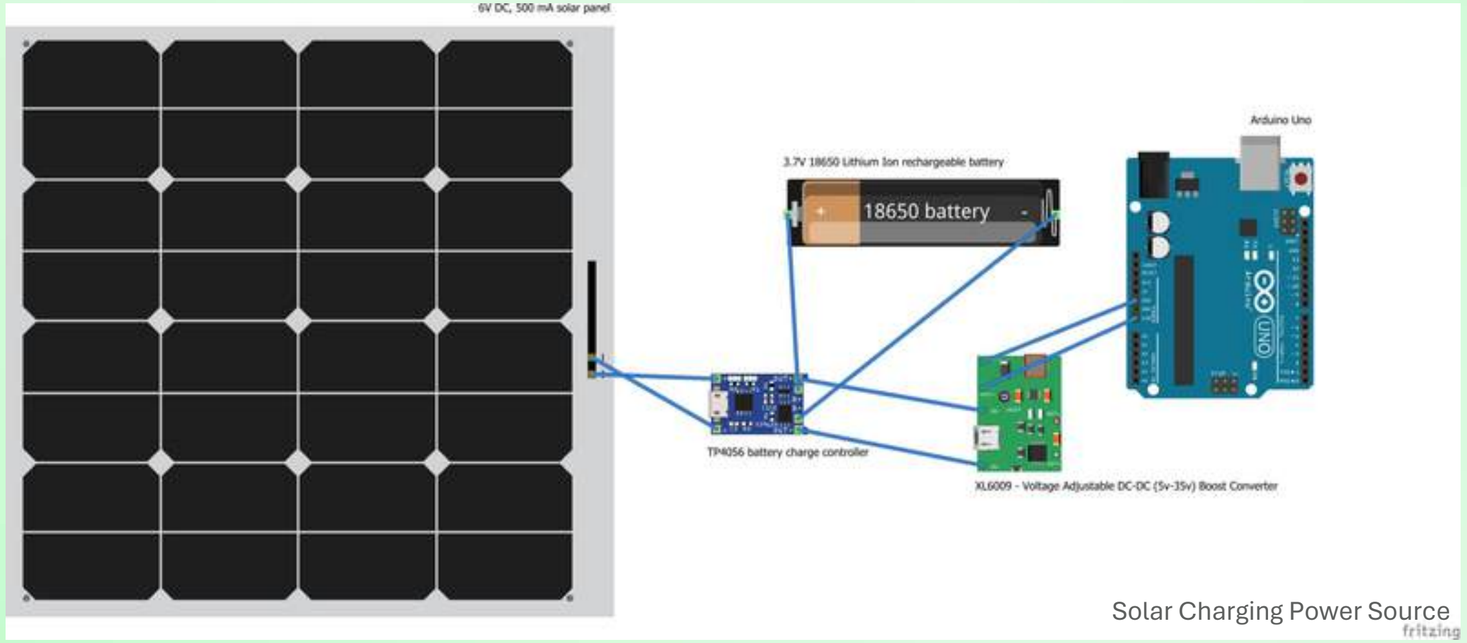
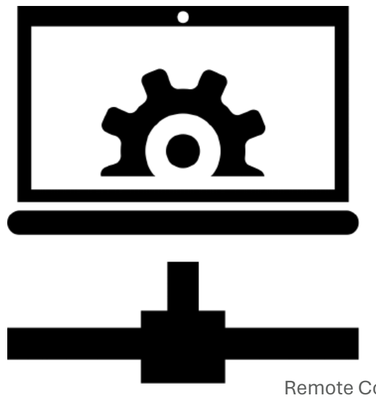
RECOMMENDATIONS



Solar Charging Power Source

PM Sensors



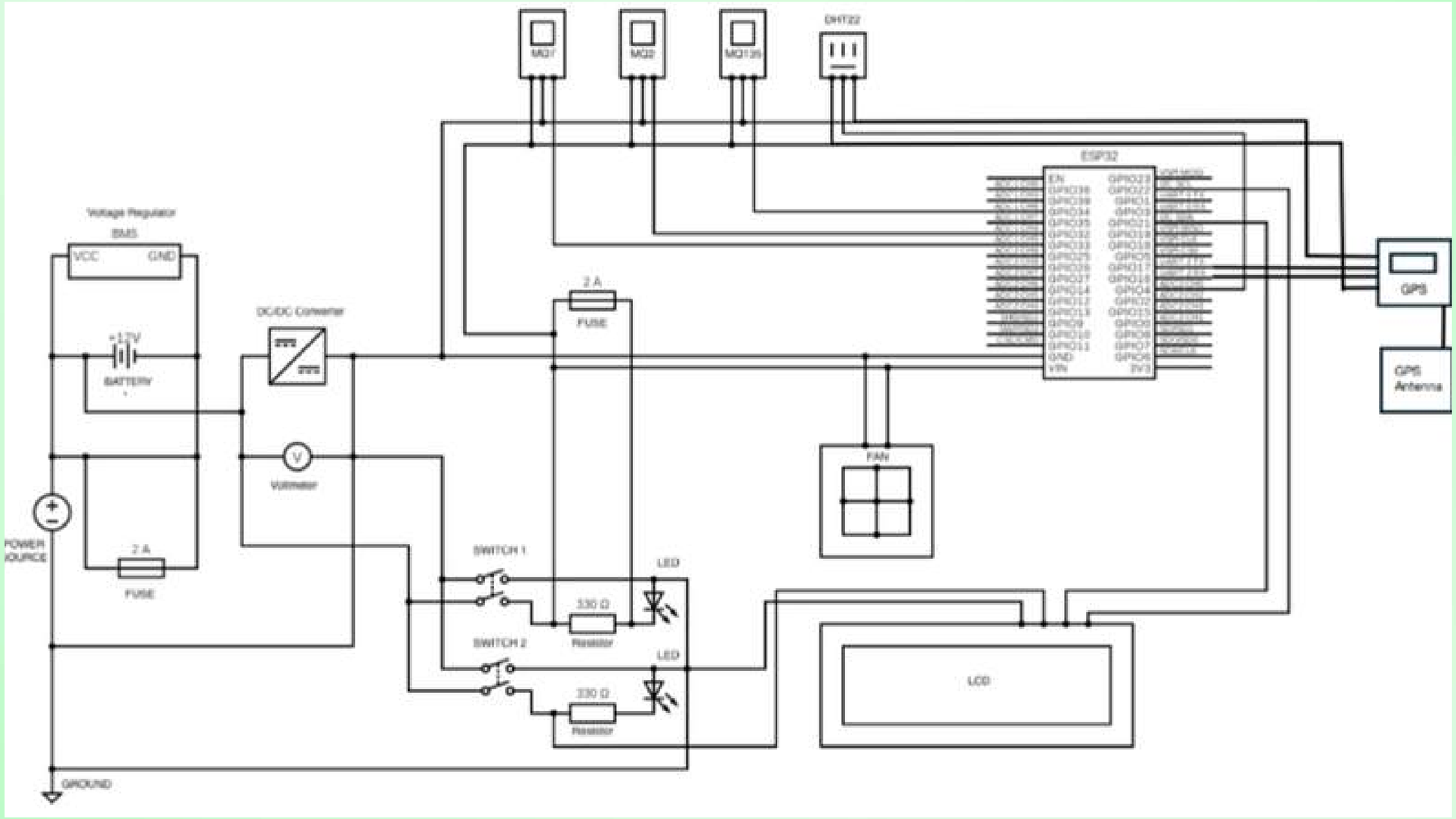
Remote Configuration

LCD Touchscreen Interface

Thank You

Website Presentation

Schematic Diagram



Appendix I (p.116)

Hardware

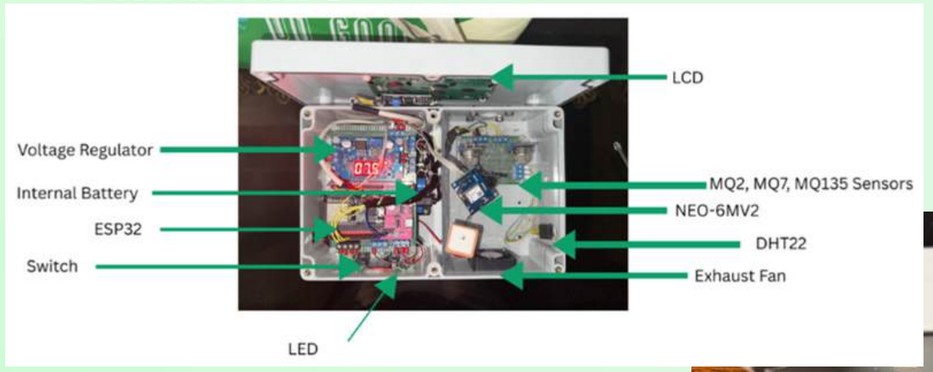
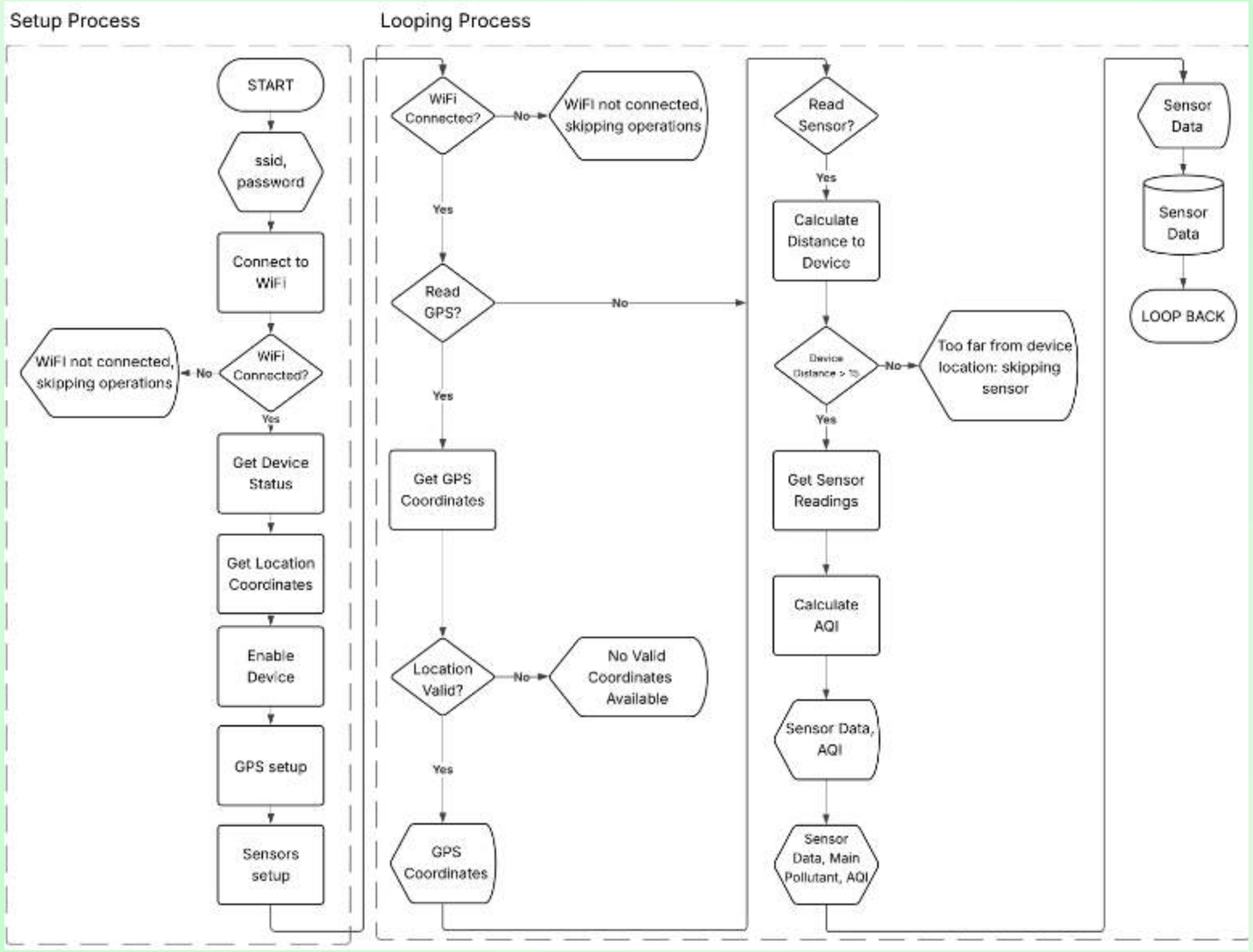


Figure 11. Device Components (p.76)

System Flowchart



Appendix G (p.114)

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \ x \ R_{load}$$

VAL is the analog sensor value
Rload is a fixed load resistance of the sensor

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \; x \; R_{load}$$

$$Correction\ Factor = CORa\ x\ t\ x\ t \quad CORb\ x\ t + CORc \quad (h \ - 33)\ x\ CORd$$

constants ***CORa*** to ***CORg*** are predefined values provided by the manufacturer and are used to calibrate each sensor during the data processing stage

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \; x \; R_{load}$$

$$Correction\ Factor = CORe\ x\ t + CORf\ x\ h + CORg$$

constants ***CORa*** to ***CORg*** are predefined values provided by the manufacturer and are used to calibrate each sensor during the data processing stage

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \; x \; R_{load}$$

$$Correction\ Factor = CORa\ x\ t\ x\ t \quad CORb\ x\ t + CORc \quad (h \ - 33)\ x\ CORd$$

$$Correction\ Factor = CORe\ x\ t + CORf\ x\ h + CORg$$

$$Corrected\ Res = \frac{Res}{Correction\ Factor}$$

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \; x \; R_{load}$$

$$Correction\ Factor = CORa\ x\ t\ x\ t \quad CORb\ x\ t + CORc \quad (h \ - 33)\ x\ CORd$$

$$Correction\ Factor = CORe\ x\ t + CORf\ x\ h + CORg$$

$$Corrected\ Res = \frac{Res}{Correction\ Factor}$$

$$Corrected\ R_0 = Corrected\ Res\ x \left(\left(\frac{ATMO}{PARa} \right)^{\frac{1}{PARb}} \right)$$

ATMO is the value of the pollutant in clean air.

PARa, and ***PARb*** are gas-specific calibration constants used to convert the sensor's analog readings into gas concentrations, expressed in parts per million

Formula for calculating PPM

$$Res = \left(\frac{(4095)}{VAL} - 1 \right) \; x \; R_{load}$$

$$Correction\ Factor = CORa\ x\ t\ x\ t \quad CORb\ x\ t + CORc \quad (h \ - 33)\ x\ CORd$$

$$Correction\ Factor = CORe\ x\ t + CORf\ x\ h + CORg$$

$$Corrected\ Res = \frac{Res}{Correction\ Factor}$$

$$Corrected\ R_0 = Corrected\ Res\ x \left(\left(\frac{ATMO}{PARa} \right)^{\frac{1}{PARb}} \right)$$

$$Corrected\ PPM = para\ x\ pow \left(\left(\frac{CorrectedRes}{CorrectedR0} \right)^{-parb} \right)$$

Thank You

Third-Party Testing

Accuracy formula

$$accuracy = 1 - \frac{|(Va - Ve)|}{Ve} \cdot 100$$

Va = actual value

Ve = expected value

Paired t-test formula

$$t = \frac{\overline{D}}{s_{D}/\sqrt{n}}$$

t = t-value

D = mean of differences

S_D = standard deviation

n = no. of samples

Third-Party Testing

Accuracy

Table 9. Third Party-Testing Results (Test #1) (p.80)

Pollutants	Reference Device Reading (in ppm)	Actual Device Reading (in ppm)	Accuracy	Remark
CO	3.71	3.696	99.98%	EXCELLENT
CO_2	411.6	411.69	99.62%	EXCELLENT
SO_2	0.0344	0.03419	99.39%	EXCELLENT
NO_2	0.0267	0.02657	99.51%	EXCELLENT

$$accuracy = 1 - \frac{|(Va - Ve)|}{Ve} \cdot 100$$

$$NO_2\ accuracy = 1 - \frac{|(0.02657 - 0.0267)|}{0.0267} * 100$$

NO_2 accuracy = 99.51 %

Third-Party Testing

Paired t-test

CO2 Instrument	CO2 System	NO2 Instrument	NO2 System	SO2 Instrument	SO2 System	CO Instrument	CO System
411.6	411.6887	0.0267	0.02657	0.0344	0.03419	3.71	3.696
411.7	411.714	0.0272	0.02724	0.038	0.03787	3.78	3.779
411.7	411.669	0.0274	0.02745	0.038	0.03805	3.84	3.833
Average	Average	Average	Average	Average	Average	Average	Average
411.6667	411.6906	0.0271	0.02709	0.0368	0.0367	3.77666667	3.76933
Accuracy		Accuracy		Accuracy		Accuracy	
99.9941971		99.95077529		99.73662701		99.80544747	

excel formula for solving **p-value of a paired t-test**			
= t.test(array1,array2,tails(two),type(paired)			
t-test p-value	t-test p-value	t-test p-value	t-test p-value
0.564298854	0.840636185	0.33556805	0.190168809

Appendix P (p.126)

CO2	1	2	3
Instrument	411.6	411.7	411.7
System	411.6887	411.714	411.669

$$t = \frac{\bar{D}}{s_{D/\sqrt{n}}}$$

STEP 1

$H_o: \mu_1 = \mu_2$ (claim)

$H_1: \mu_1 \neq \mu_2$

STEP 2

a=0.05

d.f=3-1=2

CV=4.303

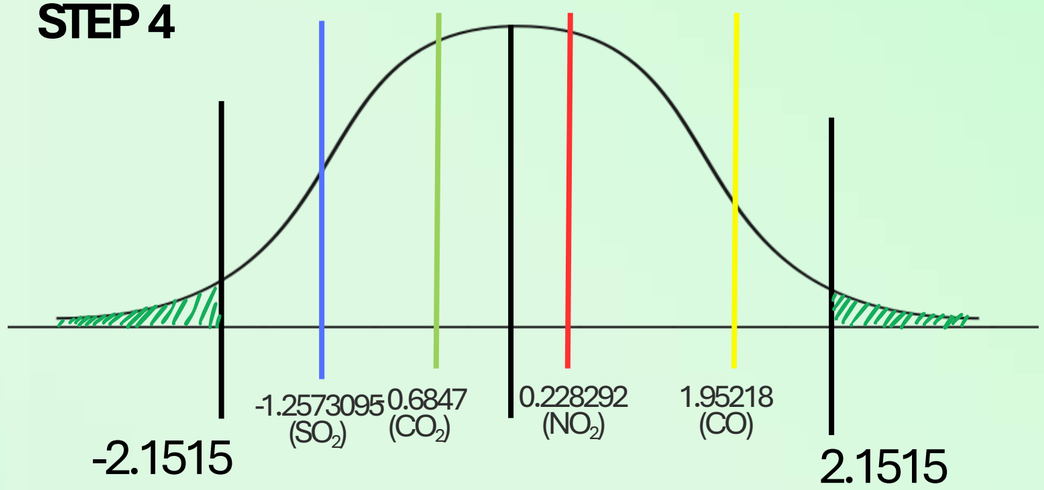
STEP 3

	1	2	3
CO2	-0.0887	-0.014	0.031

$\bar{D} = -0.0239$ $S_D = 0.06046097915$ $n=3$

$$t = \frac{-0.0239}{\frac{0.06046097915}{\sqrt{3}}} = -0.6847$$

STEP 4



STEP 5

H_o: do not reject (claim)

H_1: reject

There is enough evidence to support the claim

User Acceptance Test

	SCORING			
Questionnaire	**Strongly disagree - 1**	**Disagree - 2**	**Agree - 3**	**Strongly agree - 4**

Calculation for Air Quality Index

Formula

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}.$$

Where I_p = the index for pollutant p

C_p = the truncated concentration of pollutant p

BP_{HI} = the concentration breakpoint that is greater than or equal to C_p

BP_{Lo} = the concentration breakpoint that is less than or equal to C_p

I_{Hi} = the AQI value corresponding to BP_{Hi}

I_{Lo} = the AQI value corresponding to BP_{Lo}

These Breakpoints...							...equal this AQI	...and this category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	$PM_{2.5}$ ($\mu g/m^3$) 24-hour	PM_{10} ($\mu g/m^3$) 24-hour	CO (ppm) 8-hour	SO_2 (ppb) 1-hour	NO_2 (ppb) 1-hour	AQI	
0.000 - 0.054	-	0.0 – 9.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	9.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 125.4)[3]	255 - 354	12.5 - 15.4	[3] 186 - 304	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(125.5 - (225.4)[3]	355 - 424	15.5 - 30.4	[3] 305 - 604)	650 - 1249	201 - 300	Very unhealthy
0.201-([2])	0.405+	225.5+	425+	30.5+	[3] 605+	1250+	301+	Hazardous [4]

Calculation for Air Quality Index

Formula

These Breakpoints...							...equal this AQI	...and this category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	$PM_{2.5}$ ($\mu g/m^3$) 24-hour	PM_{10} ($\mu g/m^3$) 24-hour	CO (ppm) 8-hour	SO_2 (ppb) 1-hour	NO_2 (ppb) 1-hour	AQI	
0.000 - 0.054	-	0.0 – 9.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	9.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 125.4)[3]	255 - 354	12.5 - 15.4	[3] 186 - 304	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(125.5 - (225.4)[3]	355 - 424	15.5 - 30.4	[3] 305 - 604)	650 - 1249	201 - 300	Very unhealthy
0.201-([2])	0.405+	225.5+	425+	30.5+	[3] 605+	1250+	301+	Hazardous [4]

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}.$$

CO ppm value = 7.959 ppm

$BP_{LO} = 4.5$ $I_{LO} = 51$ $C_P = 7.959$

$BP_{HI} = 9.4$ $I_{HI} = 100$

$$\text{CO AQI} = \frac{100 - 51}{9.4 - 4.5} * (7.832 - 4.5) + 51$$

CO AQI = 84

Calculation for Air Quality Index

Formula

These Breakpoints...							...equal this AQI	...and this category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	$PM_{2.5}$ (µg/m³) 24-hour	PM_{10} (µg/m³) 24-hour	CO (ppm) 8-hour	SO_2 (ppb) 1-hour	NO_2 (ppb) 1-hour	AQI	
0.000 - 0.054	-	0.0 – 9.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	9.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 125.4)[3]	255 - 354	12.5 - 15.4	[3] 186 - 304	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(125.5 - (225.4)[3]	355 - 424	15.5 - 30.4	[3] 305 - 604)	650 - 1249	201 - 300	Very unhealthy
0.201-([2])	0.405+	225.5+	425+	30.5+	[3] 605+	1250+	301+	Hazardous [4]

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}.$$

1ppb = 0.001ppm

SO2 ppm value = 0.072 ppm

$BP_{LO} = 0.036$ $I_{LO} = 51$ $C_P = 0.072$

$BP_{HI} = 0.075$ $I_{HI} = 100$

$$SO2AQI = \frac{100 - 51}{0.075 - 0.035} * (0.071 - 0.075) + 51$$

SO2 AQI = 95

Calculation for Air Quality Index

Formula

These Breakpoints...							...equal this AQI	...and this category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	$PM_{2.5}$ (µg/m³) 24-hour	PM_{10} (µg/m³) 24-hour	CO (ppm) 8-hour	SO_2 (ppb) 1-hour	NO_2 (ppb) 1-hour	AQI	
0.000 - 0.054	-	0.0 – 9.0	0 - 54	0.0 - 4.4	0 - 35	0 - 53	0 - 50	Good
0.055 - 0.070	-	9.1 – 35.4	55 - 154	4.5 - 9.4	36 - 75	54 - 100	51 - 100	Moderate
0.071 - 0.085	0.125 - 0.164	35.5 – 55.4	155 - 254	9.5 - 12.4	76 - 185	101 - 360	101 - 150	Unhealthy for Sensitive Groups
0.086 - 0.105	0.165 - 0.204	(55.5 - 125.4)[3]	255 - 354	12.5 - 15.4	[3] 186 - 304	361 - 649	151 - 200	Unhealthy
0.106 - 0.200	0.205 - 0.404	(125.5 - (225.4)[3]	355 - 424	15.5 - 30.4	[3] 305 - 604)	650 - 1249	201 - 300	Very unhealthy
0.201-([2])	0.405+	225.5+	425+	30.5+	[3] 605+	1250+	301+	Hazardous [4]

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{HI} - BP_{Lo}}(C_p - BP_{Lo}) + I_{Lo}.$$

1ppb = 0.001ppm

NO2 ppm value = 0.04 ppm

$BP_{LO} = 0$ $I_{LO} = 0$ $C_P = 0.04$

$BP_{HI} = 0.053$ $I_{HI} = 50$

$$NO2AQI = \frac{50 - 0}{0.053 - 0} * (0.042 - 0) + 51$$

NO2 AQI = 40

Stress Testing

Expected Packet

$$\text{Expected Packets} = \frac{\text{Test Duration (seconds)}}{600 \text{ seconds}}$$

$$\text{Expected Packets} = \frac{172,800 \text{ seconds}}{600 \text{ seconds}}$$

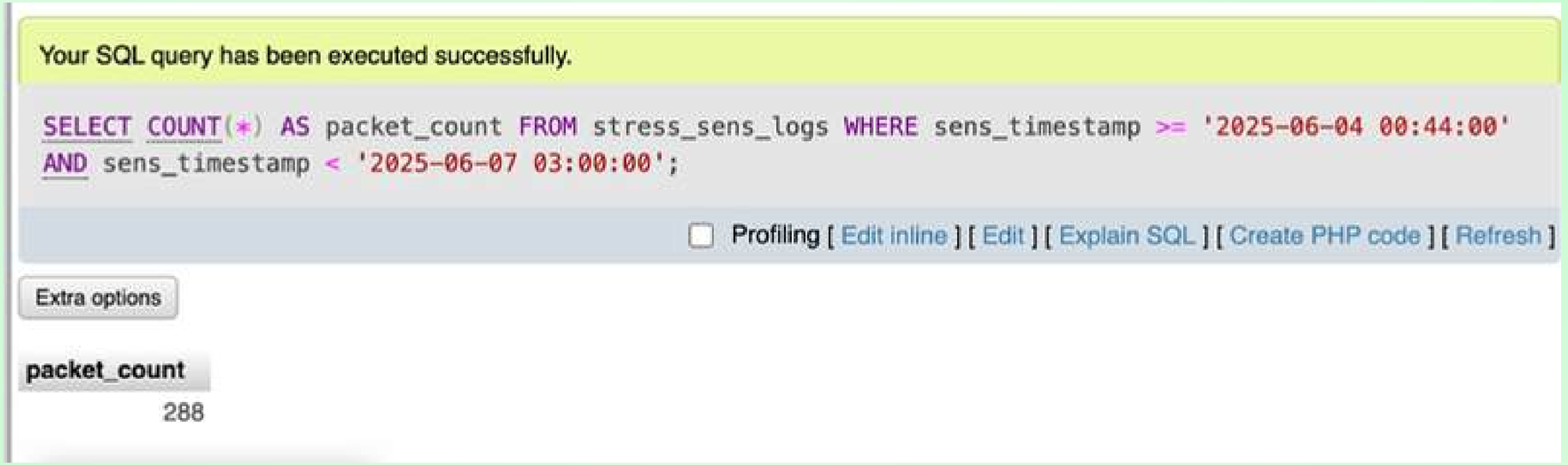
Test. Duration = 48 hours or 172,800 in seconds

Data Sent every = 10 minutes or 600 in seconds

= 288 Data Packets

Stress Testing

Actual Data Packets after the Stress Testing



Stress Testing

Actual Stress Testing

Table of Results for Actual Data Gathering

Table 13. Average concentration of Pollutants in Pulo Barangay Hall Intersection

Pollutants	Prototype Reading	Accepted Ambient Value	Remark
CO	7.959	9	ACCEPTABLE
CO_2	391.036	400	ACCEPTABLE
SO_2	0.072	0.07	ACCEPTABLE
NO_2	0.04	0.08	ACCEPTABLE

Table 14. Average concentration of Pollutants in Cabuyao Bayan Sidewalk

Pollutants	Prototype Reading	Accepted Ambient Value	Remark
CO	7.832	9	ACCEPTABLE
CO_2	372.560	400	ACCEPTABLE
SO_2	0.071	0.07	ACCEPTABLE
NO_2	0.042	0.08	ACCEPTABLE

Table 1. National Ambient Air Quality Guideline Values

Pollutants	Short Term[a]			Long Term[b]		
	µg/NCM	ppm	Averaging Time	µg/NCM	ppm	Averaging Time
Suspended Particulate Matter[c] –						
TSP	230[d]		24 hours	90		1 year[e]
PM-10	150[f]		24 hours	60		1 year[e]
Sulfur Dioxide[c]	180	0.07	24 hours	80	0.03	1 year
Nitrogen Dioxide	150	0.08	24 hours			
Photochemical Oxidants as Ozone	140	0.07	1 hour			
	60	0.03	8 hours			
Carbon Monoxide	35 mg/NCM	30	1 hour			
	10 mg/NCM	9	8 hours			
Lead[g]	1.5		3 months[g]	1.0		1 year

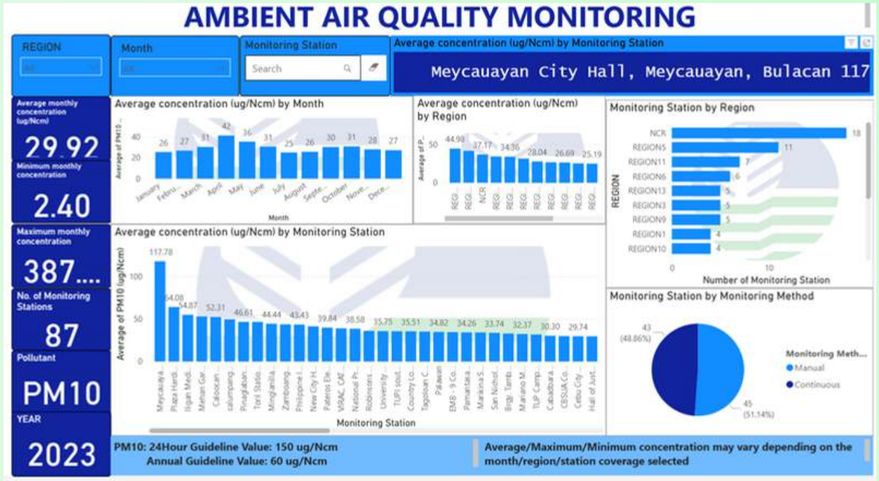
Table 5. Pollutant Specific Cautionary Statement for the General Public of CO2

Gas	OSHA Permissible Exposure Limit (PEL) Concentration in ppm	%	Cautionary Statement
Carbon Dioxide (CO_2)	400	0.04	The average outdoor air level.
	400 - 1,000	< 0.1	A typical level found in occupied spaces with good air exchange.
	1,000 – 2,000	< 0.2	A level associated with complaints of drowsiness and poor air.
	2000 - 5000	< 0.5	A level associated with headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
	5,000	0.5	This is the OSHA permissible exposure limit (PEL) for daily workplace exposures. It indicates unusual air conditions where high levels of other gases could also be present. Toxicity or oxygen deprivation could occur.
	40, 000	4.0	This level is immediately harmful due to oxygen deprivation.

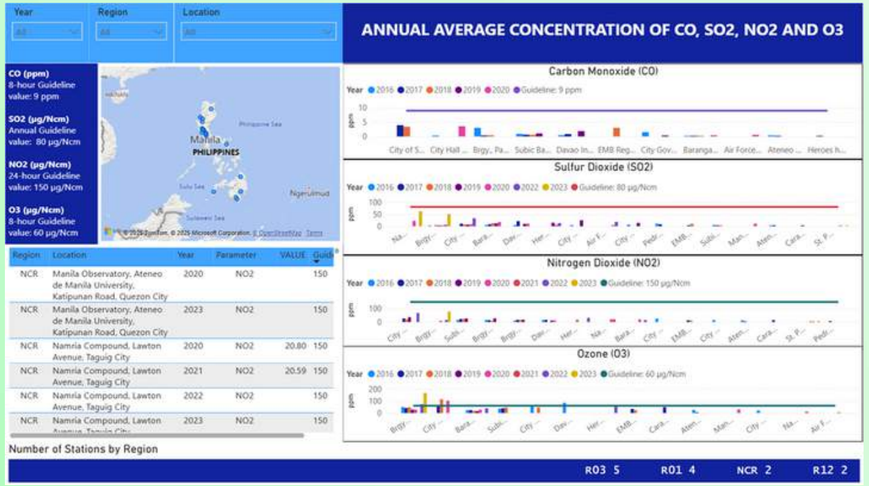
Source: Carbon Dioxide Health Hazard Information Sheet by fsis.usda.gov (OSHA Standards)

DENR-EMB AQI Website

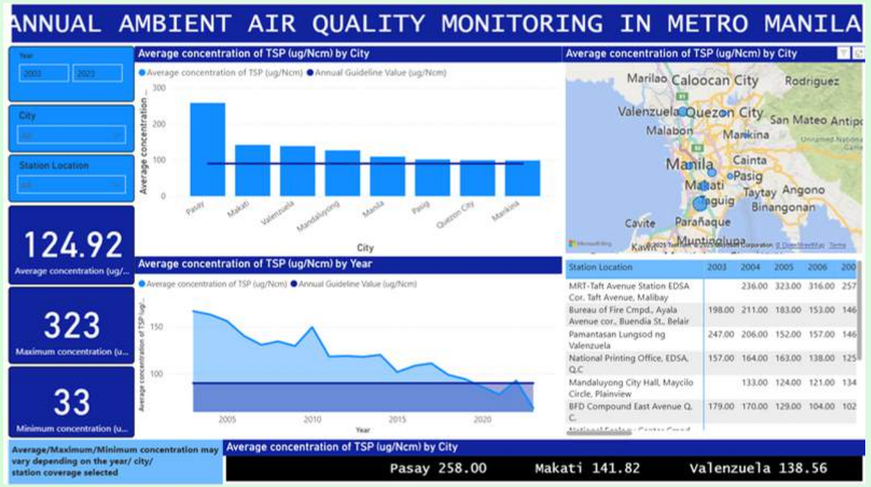
Air Quality Index Monitoring



Ambient Air Quality Monitoring (PM)



Annual Air Quality Monitoring (Gases)



Annual Ambient Air Quality Monitoring (Metro)

EXPERIMENTAL SETTING

System Architecture

Air Quality Monitoring System Architecture Diagram

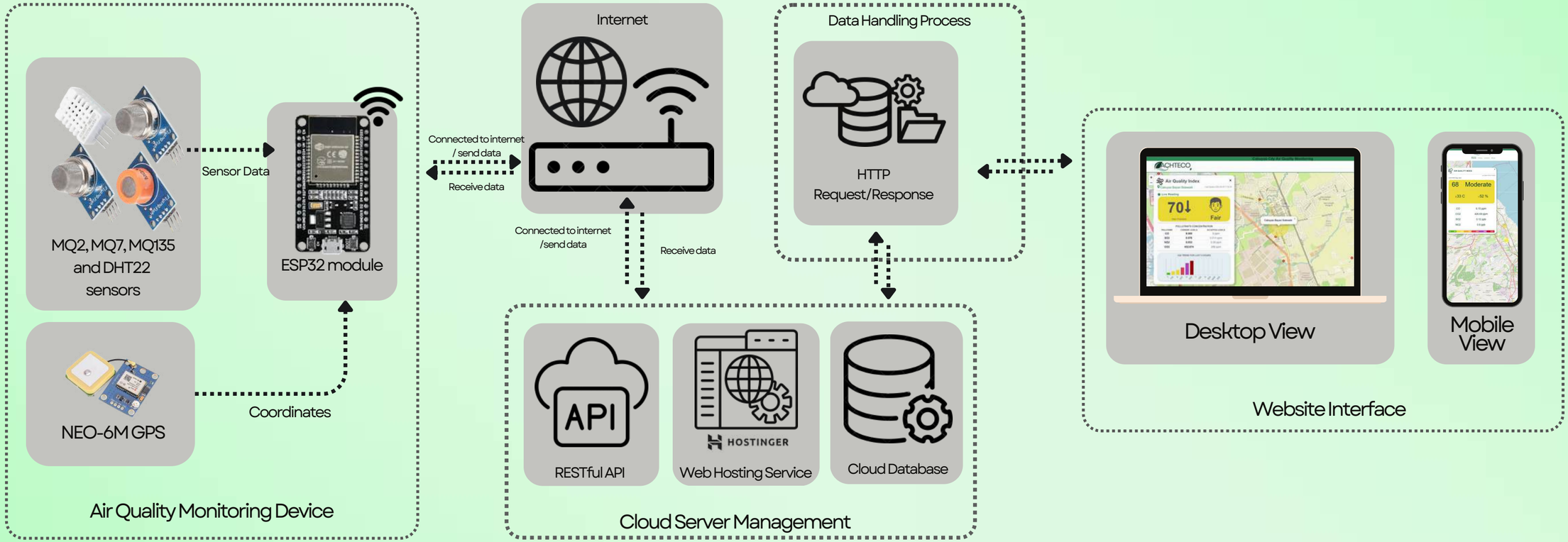
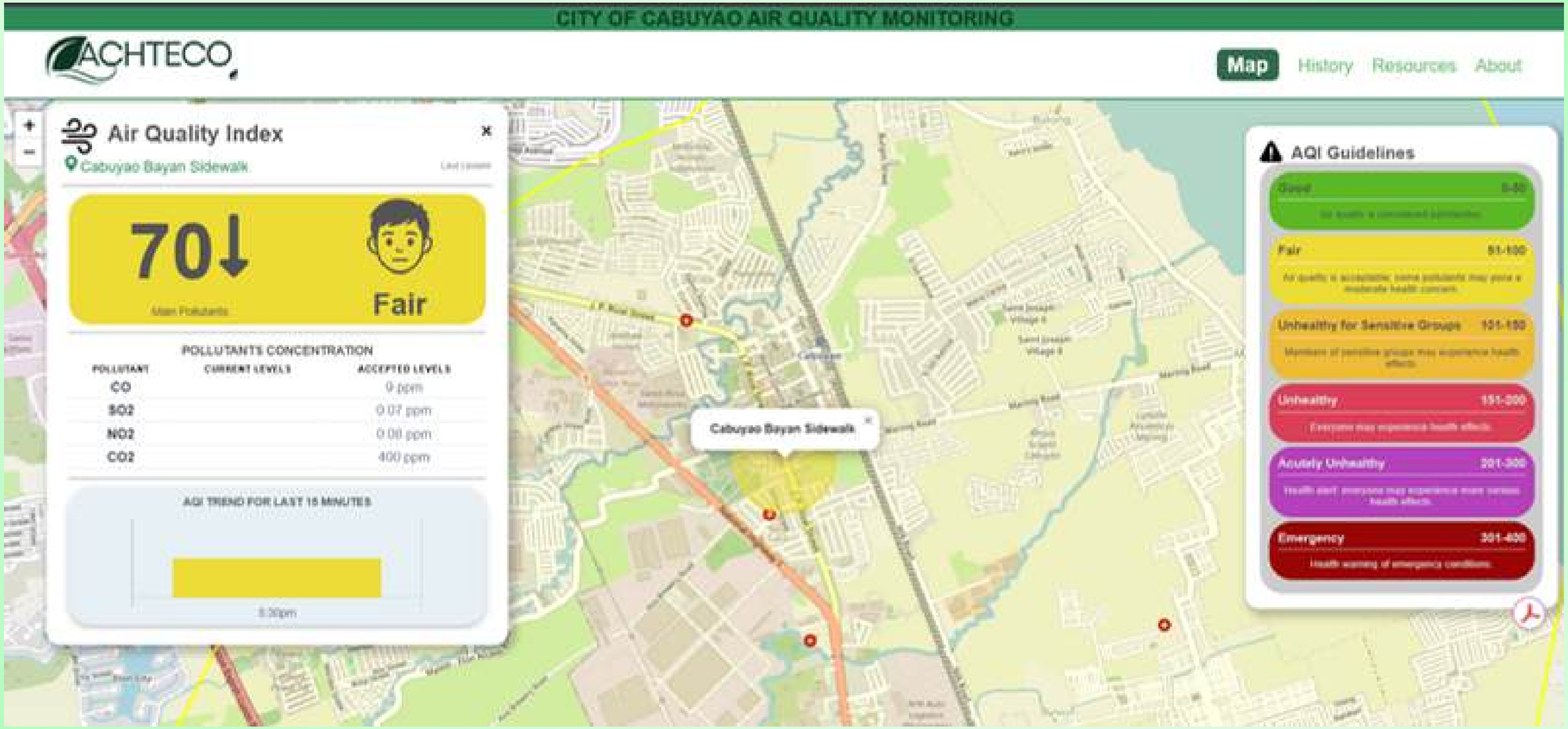


Figure 8. System Architecture (p.74)


CITY OF CABUYAO AIR QUALITY MONITORING
ACHTECO
Map
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Air Quality Index
Cabuyao Bayan Sidewalk
70↓
Main Pollutants
Fair
POLLUTANTS CONCENTRATION
POLLUTANT
CURRENT LEVELS
ACCEPTED LEVELS
CO
9 ppm
SO2
0.07 ppm
NO2
0.06 ppm
CO2
400 ppm
AQI TREND FOR LAST 15 MINUTES
5:30pm
Cabuyao Bayan Sidewalk
AQI Guidelines
Good
0-50
Fair
51-100
Unhealthy for Sensitive Groups
101-150
Unhealthy
151-200
Acutely Unhealthy
201-300
Emergency
301-400

CITY OF CABUYAO AIR QUALITY MONITORING

ACHTECO

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HISTORICAL AIR QUALITY INDEX

LOCATION: City of Cabuyao

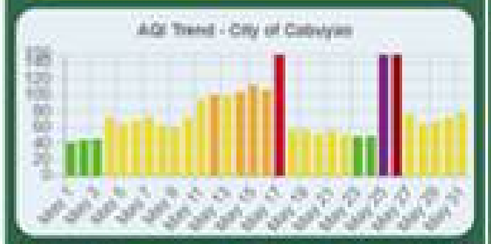
MONTHLY | YEARLY

SELECT DATE | SELECT LOCATION | CSV

AVERAGE AQI

AIR QUALITY INDEX
85
Fair

POLLUTANTS CONCENTRATION	
CO	7.51 ppm
SO2	0.19 ppm
NO2	2.86 ppm
CO2	449.83 ppm
Main Pollutant	CO 7.51 ppm
38°	62%



MONTHLY CALENDAR - AIR QUALITY

May 2025

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				May 1 42	May 2 44	May 3 45
May 4 73	May 5 65	May 6 69	May 7 73	May 8 63	May 9 61	May 10 72
May 11 95	May 12 100	May 13 99	May 14 104	May 15 113	May 16 107	May 17 161
May 18 57	May 19 56	May 20 52	May 21 57	May 22 52	May 23 49	May 24 49
May 25 204	May 26 304	May 27 77	May 28 65	May 29 68	May 30 73	May 31 78

May 17, 2025

161 Unhealthy

CO 7.48 ppm
38° 62%

POLLUTANTS CONCENTRATION

POLLUTANT	CURRENT LEVELS
CO	7.48 ppm
SO2	0.19 ppm
NO2	2.82 ppm
CO2	450 ppm

INSIGHTS

MOST & POLLUTED DAYS

MOST POLLUTED
2025-05-26
304

LEAST POLLUTED
2025-05-01
42

MOST & POLLUTED LOCATIONS

MOST POLLUTED
Cabuyao Bayan Sidewalk
86

LEAST POLLUTED
Pulo Intersection
84

CITY OF CABUYAO AIR QUALITY MONITORING

ACHTECO

Map History **Resources** About

Resources

This page is here to help you understand how air quality affects your health. We'll highlight the major pollutants affecting air quality, what they can do to your body, what AQI warnings mean, and what steps you can take to protect yourself and help reduce air pollution. Whether you're staying safe on high-pollution days or just learning the basics, this guide's got your back.

Health Concerns and Advisories

- **Breathing Difficulties**
- Cardiovascular Strain
- Allergy Reactions
- Nasal and Sinus Discomfort
- Lowered Immunity
- Chronic Respiratory Problems

Breathing Difficulties

Air pollution can trigger airway inflammation, leading to wheezing, chest tightness, and difficulty breathing.

DO'S:

- ✓ Limit outdoor activities when pollution levels are high.
- ✓ Use air purifiers to reduce indoor pollutants.
- ✓ Keep prescribed inhalers or breathing aids ready.
- ✓ Drink warm fluids to soothe airways.

DON'TS:

- ✗ Avoid intense outdoor exercise without protection like a mask.
- ✗ Stay away from smoky or dusty environments.
- ✗ Don't ignore persistent coughing or chest discomfort.