AIR UNIT

THE ENVIRONMENTAL MANAGEMENT AUTHORITY

Ambient Air Quality Monitoring Report

3rd Quarter 2020 (July – September)

NATIONAL AIR QUALITY INDEX

EMA environmental management authority

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EXECUTIVE SUMMARY

This ambient air quality monitoring report is prepared by the Air Unit of the Environmental Management Authority (EMA) to provide information on air quality for Trinidad and Tobago for the 3rd Quarter of 2020 (July – September, 2020). The report supports the EMA's mandate to promote a healthy environment by setting standards, monitoring and reporting on air quality to improve human health and the environment and to fulfill the goals and mandates set in Trinidad and Tobago's Environmental Management Act, Chapter 35:05, the National Environmental Policy (2018) and the Air Pollution Rules, 2014 (APR). It also supports the Government of the Republic of Trinidad and Tobago's (GORTT) commitment to achieving specific United Nations Sustainable Development Goals that relate to air quality.

The purpose of this report is to summarize ambient air quality data, collected from the Ambient Air Quality Monitoring Network (AAQMN), presenting average concentrations, comparisons and trends. Average concentrations are compared to Schedule 1, of the APR, 2014 for the following criteria pollutants:

- Particulate Matter [PM_{10} (≤10 micrometers), $PM_{2.5}$ (≤2.5 micrometers in diameter)]
- Carbon Monoxide (CO)
- Sulfur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)
- Ozone (O_3)

Monitoring these criteria pollutants is crucial as they cause acute and chronic impacts on human health. The criteria pollutants are measured using approved United States Environmental Protection Agency (US EPA) Federal Reference Methods (FRM) and Federal Equivalent Methods (FEM), to assess compliance with the standards listed in the APR. The data analysed for the third quarter of 2020 (July - September, 2020) demonstrates that the ambient air quality for Trinidad and Tobago, for the criteria pollutants, is acceptable. Elevated PM levels were observed on the days with Saharan dust, however, there were no exceedances of PM_{10} and $PM_{2.5}$. In addition, there were no days where the concentrations of NO_2, O_3, CO, exceeded the maximum permissible limits in the APR.

No changes occurred, in terms of station location or changes in analysers, to the Ambient Air Quality Monitoring Network during the third quarter of 2020.

Ambient air quality monitoring data was unavailable for the following parameters during the third quarter of 2020:

1. PM_{10} and $PM_{2.5}$ at the Signal Hill, Tobago monitoring location;
2. CO, NO_2, SO_2, O_3, $PM_{2.5}$ and PM_{10} at the Port-of-Spain, Trinidad monitoring location;
3. SO_2 at the Point Lisas, Trinidad monitoring location.

As a result of the restrictions imposed by the COVID-19 pandemic there were challenges with troubleshooting, maintenance and repairs due to the closure of offices internationally, resulting in delays with procuring and shipping parts and acquiring specialist skillsets for repairs. Data was recorded for NO_2, CO and SO_2 for Tobago. However, connectivity to the Tobago station to access the data has been a challenge due to internet service issues. The report will be updated to include Tobago's data when the internet connectivity issues are resolved.

1.0 INTRODUCTION

This report is prepared by the Air Unit of the Environmental Management Authority (EMA) to provide information on air quality for Trinidad and Tobago for the 3rd Quarter of 2020 (July – September, 2020). The report supports the EMA's mandate to promote a healthy environment by setting standards, monitoring and reporting on air quality to improve human health and the environment and to fulfill the goals and mandates set in Trinidad and Tobago's Environmental Management Act, Chapter 35:05, the National Environmental Policy (2018) and the Air Pollution Rules, 2014 (APR). It also supports the Government of the Republic of Trinidad and Tobago's (GORTT) commitment to achieving specific United Nations Sustainable Development Goals that relate to air quality.

The purpose of this report is to summarize ambient air quality data, presenting average concentrations, comparisons and trends. Ambient air is the outdoor, breathable air. The EMA sets ambient air quality standards/permissible levels for the criteria pollutants, as outlined in Schedule 1, of the APR. Criteria pollutants are the most common air pollutants found in the atmosphere, as a result of anthropogenic activity. They are thought to be the most common by-products of transportation and industrial activity that produce local, acute impacts on human health. The criteria pollutants are:

- Particulate Matter [PM_{10} (≤10 micrometers), $PM_{2.5}$ (≤2.5 micrometers in diameter)]
- Carbon Monoxide (CO)
- Sulfur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)
- Ozone (O_3)

The following meteorological parameters are also monitored at each site:

- Temperature
- Relative Humidity
- Barometric Pressure
- Wind Speed
- Wind Direction

Meteorological data is collected when pollutants are sampled to provide context for measurements and subsequently, trends that may emerge from them. This is particularly important, since meteorological conditions can affect the concentrations and behavior of air pollutants in the ambient environment. For example, high temperatures, calm winds and high levels of solar radiation catalyze reactions between Oxides of Nitrogen (NO_X) and Volatile Organic Compounds (VOCs) from automobile exhaust to produce ground-level O_3.

Ambient air monitoring is an integral part of the EMA's air quality management programme. The data collected can be used to:

1. Assess the extent of air pollution;
2. Provide information on air quality trends and air quality indices;
3. Provide data for use in air quality models;
4. Support the revision of air quality standards (Schedule 1 of the APR, Maximum Permissible Levels for Ambient Air);
5. Evaluate the effectiveness of emissions control strategies;
6. Conduct impact assessments of source(s) categories;
7. Evaluate the effectiveness/impacts of land-use planning on air quality;
8. Provide real-time air pollution data to the general public; and
9. Support research.

2.0 AIR QUALITY STANDARDS

The APR was developed under Sections 26, 27, 49, 50 and 51 of the Environmental Management Act, Chapter 35:05. The aim of the APR is to protect human health and the environment from the adverse effects of air pollution. This is achieved by identifying the activities that generate air pollutants (i.e., Schedule 3) and by setting permissible levels or standards for Point Sources/ Stack Emissions (i.e., Schedule 2) and Ambient Air (i.e., Schedule 1). Priority is given to meeting the permissible levels or standards for Schedule 1, ambient air [Sub-rule 19(2)].

The ambient air quality standards for the criteria pollutants are identified in Table 1 below.

TABLE 1: AMBIENT AIR QUALITY STANDARDS FOR CRITERIA POLLUTANTS

Parameter	**Short-Term Maximum Permissible Levels**		**Long-Term Maximum Permissible Levels**	
	Maximum Permissible Levels	Averaging Time	Maximum Permissible Levels	Averaging Time
PM_{10}	75 µg/m³	24 hours	50 µg/m³	1 year
$PM_{2.5}$	65 µg/m³	24 hours	15 µg/m³	1 year
Carbon Monoxide (CO)	100 000 µg/m³	15 minutes		
	60 000 µg/m³	30 minutes		
	30 000 µg/m³	1 hour		
	10 000 µg/m³	8 hours		
Nitrogen Dioxide (NO_2)	200 µg/m³	1 hour		
Sulfur Dioxide (SO_2)	500 µg/m³	10 minutes		
	125 µg/m³	24 hours		

Parameter	**Short-Term Maximum Permissible Levels**		**Long-Term Maximum Permissible Levels**	
	Maximum Permissible Levels	Averaging Time	Maximum Permissible Levels	Averaging Time
Ozone (O_3)	120 µg/m^3	8 hours		

The APR standards are classified as primary standards since they protect against adverse effects on the health of vulnerable populations such as persons with underlying health conditions e.g., heart disease and asthmatics. The standard for each pollutant may have different averaging times (e.g., hourly and 8-hour averages). These different forms of the standard are created and enforced to address varied health impacts that occur as a result of shorter, high-level exposure versus longer, low-level exposure. The data presented in Section 6, show air quality in Trinidad compared to the standards in Table 1 above, for the 3rd Quarter of 2020 (July- September, 2020). The Air Quality Index (AQI) (Section 7) is shown to aid interpretation of air quality, and are categorized by the level of health concern, with each category assigned a colour. Section 8 discusses analysis of PM samples obtained from filter tapes measurements for the second quarter period, information on Saharan dust occurences and trends observed during the third quarter of 2020.

3.0 HEALTH AND ENVIRONMENTAL IMPACTS OF MONITORED POLLUTANTS

3.1 Carbon Monoxide (CO)

Carbon Monoxide (CO) is a colourless, odourless gas emitted from combustion processes. Elevated levels of CO in ambient air can occur in areas with heavy traffic congestion, as internal combustion engines do not completely convert burnt fuel to Carbon Dioxide (CO_2) and water.

CO can cause harmful health effects by reducing oxygen delivery to the body's organs and tissues and can result in death at very high levels. People with cardiovascular disease or respiratory problems might experience chest pain and increased cardiovascular symptoms, particularly while exercising if CO levels are high. High levels of CO can affect alertness and vision even in healthy individuals. Its environmental effects include acid rain, which can corrode buildings and monuments after prolonged exposures or in high concentrations.

3.2 Nitrogen Dioxide (NO_2)

The term "NO_X" refers to Oxides of Nitrogen, which include nitric oxide (NO) and NO_2. NO_2 is used as the indicator for the larger group of oxides of nitrogen. NO_2 forms quickly from emissions from internal combustion engines e.g., cars, trucks, buses, and off-road equipment. Other sources include emissions from power plants.

NO_2 is linked with a number of adverse effects on the respiratory system. It can irritate the lungs and lower resistance to respiratory infections such as influenza. It may cause increased incidence of acute respiratory illness in children. NO_X react with ammonia, moisture, and other compounds to form small particles. These small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death. O_3 is formed when NO_X and VOCs react in the presence of heat and sunlight. Excessive O_3 in the air can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases in humans.

NO_X play a significant role in the formation of photochemical smog. It contributes to the greenhouse effect, and also plays a role in the depletion of the ozone layer and production of acid rain. It can adversely affect terrestrial and aquatic ecosystems and result in the eutrophication of coastal waters.

3.3 Ozone (O_3)

Ground level ozone (O_3) is not emitted directly into the air, but is formed by chemical reactions between NO_X and Volatile Organic Compounds (VOCs) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapours, and chemical solvents are some of the major sources of NO_X and VOCs.

Breathing O_3 can irritate the lungs and throat in both healthy adults and children and those with impaired respiratory systems (such as asthmatics). It reduces lung function and induces respiratory inflammation in normal, healthy people during periods of moderate exercise. Symptoms can include chest pain, coughing, nausea, and pulmonary congestion. Repeated exposure can cause permanent structural damage in the lungs. Studies have shown that it reduces visibility. In addition to its health effects, ground level O_3 can also have harmful effects on sensitive vegetation and ecosystems.

3.4 Sulfur Dioxide (SO_2)

Sulfur Dioxide (SO_2) is one of a group of highly reactive gases known as "Oxides of Sulfur". It is a colourless, reactive gas produced by burning fuels containing sulfur and by industrial processes. The largest source of SO_2 in the atmosphere is the burning of fossil fuels by power plants and other industrial facilities. Smaller sources of SO_2 emissions include, natural sources such as volcanoes, industrial processes such as, extracting metal from ore, ships and other vehicles and heavy equipment that burn fuel with a high sulphur content.

Current scientific evidence links short-term exposures to SO_2, ranging from 5 minutes to 24 hours, with an array of adverse respiratory effects, including bronchoconstriction and increased asthma symptoms. These effects are particularly important for asthmatics at elevated ventilation rates, for example, while exercising or playing. SO_2 emissions that lead to high concentrations of SO_2 in the air also lead to the formation of other Oxides of Sulfur (SO_X), which can react with other compounds in the atmosphere to form small particles. These particles contribute to Particulate Matter (PM) pollution and can penetrate deeply into sensitive parts of the lungs causing additional health problems. SO_2 is a precursor to sulphates which are associated with acidification of lakes, streams and soil.

3.5 Particulate Matter [≤10 micrometers (PM_{10}) and ≤2.5 micrometers ($PM_{2.5}$)]

Particulate Matter, also known as particle pollution or PM. is defined by the US EPA as a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals and soil or dust particles.

The size of particles is directly linked to their potential for causing health problems. The US EPA groups particle pollution into two categories:

- "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter.
- "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

Another source of PM in Trinidad and Tobago is Saharan Dust which results in elevated PM levels when present in the atmosphere.

PM_{10} includes both fine and coarse particles and can aggravate respiratory conditions such as asthma. Particles smaller than 2.5 micrometers in diameter or $PM_{2.5}$, generally come from wood burning, agricultural burning and vehicle exhaust including cars, diesel trucks and buses. Secondary sources include the formation of fine particulate in the atmosphere by complex reactions of chemicals such as SO_2 and NO_X, which are pollutants emitted from power plants, industries and automobiles.

PM exposure can lead to serious health effects since the particles can penetrate and lodge deep inside the lungs. Fine particles are most closely associated with increased respiratory disease, decreased lung function and even premature death. Older adults, children and people with respiratory illnesses are most sensitive and more likely to develop heart and lung problems associated with PM. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer. Small particulate pollution can have health impacts even at very low concentrations.

PM can make lakes and streams acidic. It causes changes in nutrient balances in coastal waters and large river basins, depletes nutrients in soil, and damages sensitive forests and farm crops.

4.0 MONITORING NETWORK

The distribution of ambient air quality monitoring sites throughout Trinidad and Tobago prioritizes areas that are close to sources, such as industrial areas and roadways; sensitive receptors, such as, schools, hospitals, and health centers; and areas with high population density. The siting of stations follows the requirements outlined in the United States Environmental Protection Agency (US EPA) 40 CFR Part 58 Appendix E: Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring. The distribution of commissioned ambient air quality monitoring equipment is summarized in Table 2.

TABLE 2: AMBIENT AIR QUALITY MONITORING STATION LOCATIONS

Location	Address	GPS Coordinates
TRINIDAD		
Port-of Spain	Water and Sewerage Authority's Beetham Waste Water Treatment Plant, East Sea Lots, Beetham Highway, San Juan	Datum: WGS84 UTM: Zone 20 X Coordinate (m): 664727.996 Y Coordinate (m): 1176857.003
Point Lisas	Point Lisas Industrial Port Development Corporation Limited (PLIPDECO) House, Orinoco Drive, Point Lisas Industrial Estate, Couva	Datum: WGS84 UTM: Zone 20 X Coordinate (m): 666970.000 Y Coordinate (m): 1151813.005
TOBAGO		
Signal Hill	Signal Hill Secondary Comprehensive School, Signal Hill Road, Signal Hill	Datum: WGS84 UTM: Zone 20 X Coordinate (m): 744611.001 Y Coordinate (m): 1236207.001

At each location meteorological and pollutant-specific parameters are monitored. The stations are owned, operated and maintained by the EMA. Best management practices are followed in the operation and maintenance of the AAQMS, and strict protocols for its operation are documented in the EMA's AAQMN Quality Assurance Project Plan, Standard Operating Procedures and the equipment manual.

Table 3 below, presents a summary of the monitoring stations and parameters monitored. Figures 1 and 2 illustrates the locations of the monitoring stations.

Criteria pollutants are measured using approved United States Environmental Protection Agency (US EPA) federal reference methods (FRM) and federal equivalent methods (FEM), to assess compliance with the standards listed in the APR. Table 4 lists the methods used for the various pollutants.

TABLE 3: MONITORING NETWORK

Area	PM_{10}	$PM_{2.5}$	O_3	NO_x	CO	SO_2	Met
Point Lisas, Trinidad	√	√	√	√	√	√	√
Port of Spain, Trinidad	√	√	√	√	√	√	√
Signal Hill, Tobago	√	√	√	√	√	√	√

Notes:
PM_{10} – Particulate Matter ≤10 micrometers NO_x – Oxides of Nitrogen O_3 - Ozone
$PM_{2.5}$ – Particulate Matter ≤2.5 micrometers CO – Carbon Monoxide
Met - Meteorological data SO_2 – Sulfur Dioxide

TABLE 4: MONITORING METHODS

Pollutant	Method	Units
Carbon Monoxide (CO)	Non-dispersive Infrared Radiation	ppm, ppb, µg/m^3, mg/m^3
Oxides of Nitrogen (NO_x)	Chemiluminescence	ppm, ppb, µg/m^3, mg/m^3
Ozone (O_3)	Ultraviolet Photometry	ppm, ppb, µg/m^3, mg/m^3
Sulfur Dioxide (SO_2)	Ultraviolet Fluorescence	ppm, ppb, µg/m^3, mg/m^3
Particulate Matter ≤10 micrometers (PM_{10})	Beta Ray Attenuation; Scattered Light Spectrometry	mg/m^3
Particulate Matter ≤2.5 micrometers ($PM_{2.5}$)	Beta Ray Attenuation; Scattered Light Spectrometry	mg/m^3

Notes:
ppm – Parts per million mg/m^3 - Milligrams per Cubic Meter
ppb – Parts per billion µg/m^3 - Micrograms per Cubic Meter

FIGURE 1: MAP SHOWING THE LOCATIONS OF THE AMBIENT AIR QUALITY MONITORING STATIONS

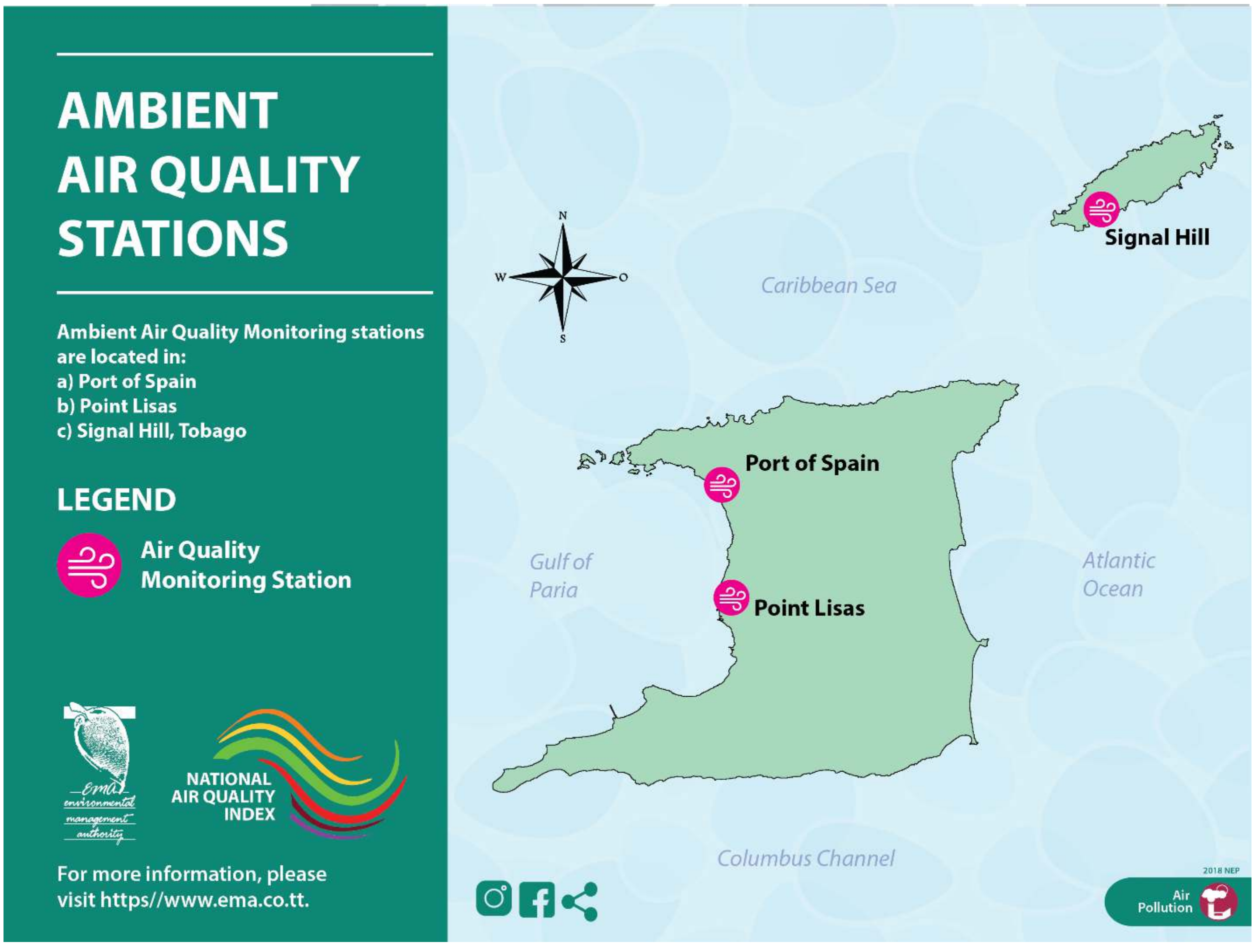


FIGURE 2: PICTURES OF THE AMBIENT AIR QUALITY MONITORING STATIONS

Port of Spain, Trinidad

Point Lisas, Trinidad

Signal Hill, Tobago

5.0 PRINCIPLE OF OPERATION

5.1 Particulate Matter (PM_{10} and $PM_{2.5}$)

5.1.1 Beta Attenation Mass Monitor

The Met One Instruments, Inc. Model BAM-1020 Beta Attenation Mass Monitor automatically measures and records hourly ambient particulate mass concentration using the principle of beta attenuation. The concentration is determined in units of milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$). The monitor consists of three (3) basic components: the central unit, the sampling pump and the sampling inlet hardware. Each component is self-contained and may be easily disconnected for servicing and replacement.

The inlet of the BAM-1020 can be configured for either PM_{10} or $PM_{2.5}$ measurement. For PM_{10} measurements, a 10-micron inertial impactor is installed on the top of the inlet. For $PM_{2.5}$ measurements, a 2.5 micron very sharp cut cyclone is installed in line between the 10-micron inertial impactor and the inlet tube.

Ambient temperature and pressure sensors are attached to the BAM-1020 monitors to meet the requirements of the applicable United States Environmental Protection Agency (USEPA) designated equivalent test methods.

5.1.2 Scattered Light Spectrometry

The Model T640 PM Mass Monitor is an optical aerosol spectrometer that converts optical measurements to mass measurements with sharp accuracy by determining sampled particle size via scattered light at the single particle level according to the Lorenz-Mie Theory.

Briefly, the sampling head draws in ambient air with different-sized particles, which are dried with the Aerosol Sample Conditioner (ASC) and moved into the optical particle sensor where scattered light intensity is measured to determine particle size diameter. The particles move separately into the T-aperture through an optically differentiated measurement volume that is homogeneously illuminated with polychromatic light. The polychromatic light source, an LED, combined with a 90° scattered light detection achieves a precise and unambiguous calibration curve, resulting in a large size resolution.

Each particle generates a scattered light impulse that is detected at an 85° to 95° angle where amplitude and signal length are measured; the amplitude (height) of the scattered light impulse is directly related to the particle size diameter.

The T-aperture and simultaneous signal length measurements eliminate border zone error, which is characterized by the partial illumination of particles at the border of the measurement range.

5.2 Carbon Monoxide (CO)

This component uses a high energy heated element to generate a beam of broad-band Infrared (IR) light with a known intensity at 4.7µm wavelength (measured during Instrument calibration). This beam is directed through a multi-pass cell filled with sample gas.

The sample cell uses mirrors at each end to reflect the IR beam back and forth through the sample gas to generate a 14-meter absorption path. Upon exiting the sample cell, the beam shines through a band-pass filter that allows only light at a wavelength of 4.7µm to pass. Finally, the beam strikes a solid-state photo-detector that converts the light signal into a modulated voltage signal representing the attenuated intensity of the beam.

5.3 Oxides of Nitrogen (NO_X)

The NO_x module utilises the principal of Chemiluminescence. The device measures the concentration of NO and NO_x in a gas sample and is able to calculate the concentration of NO_2 by subtracting the concentration of NO from the concentration of NO_x. NO_2 cannot be measured directly because it does not react with O_3. O_3 is fed into the reaction cell and reacts with NO; light at a specific wavelength is emitted due to the chemical reaction. The light intensity produced is measured by a Photomultiplier Tube (PMT) and is directly proportional to the concentration of excited molecules.

5.4 Sulfur Dioxide (SO_2)

The measurement principle is based on absorption or detection of photons. Within the SO_2 reaction cell the SO_2 molecules are excited by ultraviolet light of wavelength 214 nm generated by low pressure zinc vapor lamp, refer to the equation (1) below. The SO_2 molecules absorb this light energy which is in turn is emitted as a light pulse (photon), refer to equation (2). These photons have a wavelength of 330 nm and are recorded by a photomultiplier tube (PMT) detector which measures its fluorescence and sends an analog signal.

$SO_2 + h\upsilon \rightarrow SO_2^*$ (1)

$SO_2^* \rightarrow SO_2 + h\upsilon$ (2)

The optical design of the sample chamber optimizes the fluorescent reaction between SO_2 and Ultra Violet (UV) light ensuring that only UV light resulting from the decay of SO_2 into SO_2 is sensed by the instrument's fluorescence. The analyser uses two stages of optical filters to enhance performance:

1. Conditioning the UV light used to excite the 2 by removing frequencies of light that are not needed to produce SO_2, and
2. Protecting the PMT detector from reacting to light not produced by the SO_2 returning to its ground state.

Other measures/ design to assure the PMT only detects the light emitted by the decaying SO_2* include:

1. The pathway of excitation UV and field of view of the PMT are perpendicular to each other.
2. The inner surfaces of the sample chamber are coated with a layer of black Teflon to absorb light of other wavelengths.

5.5 Ozone (O_3)

The ozone analyser measures each of the variables: Sample Temperature, Sample Pressure, the intensity of the UV light beam with and without O_3 present, inserts known values for the length of the absorption path and the absorption coefficient, and calculates the concentration of O_3 present in the sample gas.

In the most basic terms, it uses a high energy, mercury vapor lamp to generate a beam of UV light. This beam passes through a window of material specifically chosen to be both non-reactive to O_3 and transparent to UV radiation at 254 nm and into an absorption tube filled with Sample Gas. Because ozone is a very efficient absorber of UV radiation, the absorption path length required to create a measurable decrease in UV intensity is short enough (approximately 42 cm) to pass the light beam only one time through the absorption tube. Therefore, no complex mirror system is needed to lengthen the effective path by bouncing the beam back and forth.

Finally, the UV passes through a similar window at the other end of the absorption tube and is detected by a specially designed vacuum diode that only detects radiation at or very near a wavelength of 254 nm. The selectivity of the detector is high enough that no extra optical filtering of the UV light is needed. The detector assembly reacts to the UV light and outputs a voltage that varies in direct relationship with the light's intensity. This voltage is digitized and sent to the instrument's central processing unit (CPU) to be used in computing the concentration of O_3 in the absorption tube.

5.6 Meteorological Parameters

The Wind Sensor (WS) family is a range of low-cost smart combination of weather sensors for the acquisition of a variety of measurement variables, as used for example for environmental data logging in road traffic management systems. The WS500 model has a combination of sensors for various measurement variables as follows:

- Wind Direction
- Wind Speed
- Air Temperature
- Relative Humidity
- Air Pressure
- Compass

Table 5 and 6 summarizes the principle of operation of the meteorological sensors for the stations.

TABLE 5: WS500 METEOROLOGICAL SENSORS AND MEASUREMENT DESCRIPTION AIRPOINTER STATION (TRINIDAD)

SENSOR	MEASUREMENT DESCRIPTION
Wind	The wind meter uses 4 ultrasonic sensors which take cyclical measurements in all directions. The resulting wind speed and direction are calculated from the measured run-time sound differential. The sensor delivers a quality output signal indicating how many good readings were taken during the measurement interval.
Compass	The integrated electronic compass can be used to check the north-south adjustment of the sensor housing for wind direction measurement. It is also used to calculate the compass corrected wind direction.
Air Temperature and Humidity	Temperature is measured by way of a highly accurate NTC-resistor while humidity is measured using a capacitive humidity sensor. In order to keep the effects of external influences (e.g., solar radiation) as low as possible, these sensors are located in a ventilated housing with radiation protection. In contrast to conventional non-ventilated sensors, this allows significantly more accurate measurement during high radiation conditions. Additional variables such as dew point, absolute humidity and mixing ratio are calculated from air temperature and relative humidity, taking account of air pressure.
Air Pressure	Absolute air pressure is measured by way of a built-in sensor (MEMS). The relative air pressure referenced to sea level is calculated using the barometric formula with the aid of the local altitude, which is user-configurable on the equipment.

Table 6: DESCRIPTION FOR WALK IN SHELTER (TOBAGO) METEOROLOGICAL SENSORS

SENSOR	MEASUREMENT DESCRIPTION
Wind	The wind speed and direction sensor measures via analog transmitters. The wind speed sensor propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed. Wind direction vane angle is sensed by a precision potentiometer. With known excitation voltage applied to the potentiometer, the output voltage is directly proportional to the vane angle.
Air Temperature and Humidity	Relative Humidity Sensor measures variance in the capacitance change of a one- micron thick dielectric polymer layer. This film absorbs water molecules through a metal electrode and causes capacitance change proportional to relative humidity. The thin polymer layer reacts very quickly, providing up to 90% of the final value of relative humidity in fewer than five seconds. The sensor's response is essentially linear, with small hysteresis, and negligible temperature dependence. The temperature sensor is a three element composite thermistor type with linear response over the range of -50°C to +50°C. The sensor is designed to be mounted in a radiation shield.
Rainfall	Rainfall is measured on a continuous basis. Water is not retained in the sensor. The tipping bucket is drained when it fills with 0.1 mm of rainfall. As the bucket tips overs and pours the water out the base of the sensor, a switch closure pulse is sent to a connected

	translator module or data logger for counting.
Air Pressure	The sensor measures absolute atmospheric pressure and converts it into a linear, proportional voltage, using digital computer technology. The pressure sensor uses an on board microcontroller and piezoresistive pressure sensor module. This module contains an analog-to-digital converter, a temperature sensor and non- volatile memory for storage of factory determined calibration coefficients. The microcontroller polls the senor module once per second. Measurements are temperature corrected, the calibration coefficients applied and the processed pressure measurement stored for output.

6.0 MONITORING RESULTS

6.1 Particulate Matter (≤10 micrometers and 2.5 micrometers)

FIGURE 3: PARTICULATE MATTER (PM_{10}) CONCENTRATIONS FOR POINT LISAS, JULY 2020

Daily 24-hour Average Concentrations versus Maximum Permissible Level (75 µg/m^3)

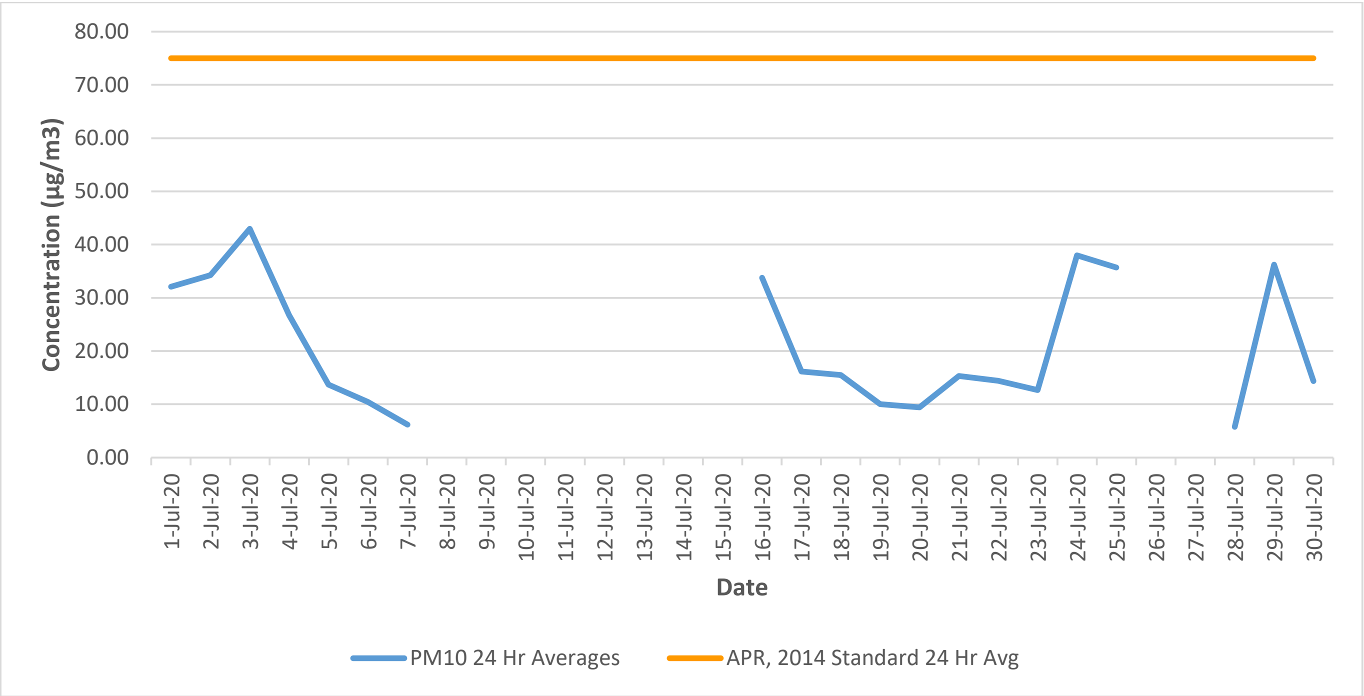


FIGURE 4: PARTICULATE MATTER (PM_{10}) CONCENTRATIONS FOR POINT LISAS, AUGUST 2020

Daily 24-hour Average Concentrations versus Maximum Permissible Level (75 µg/m^3)

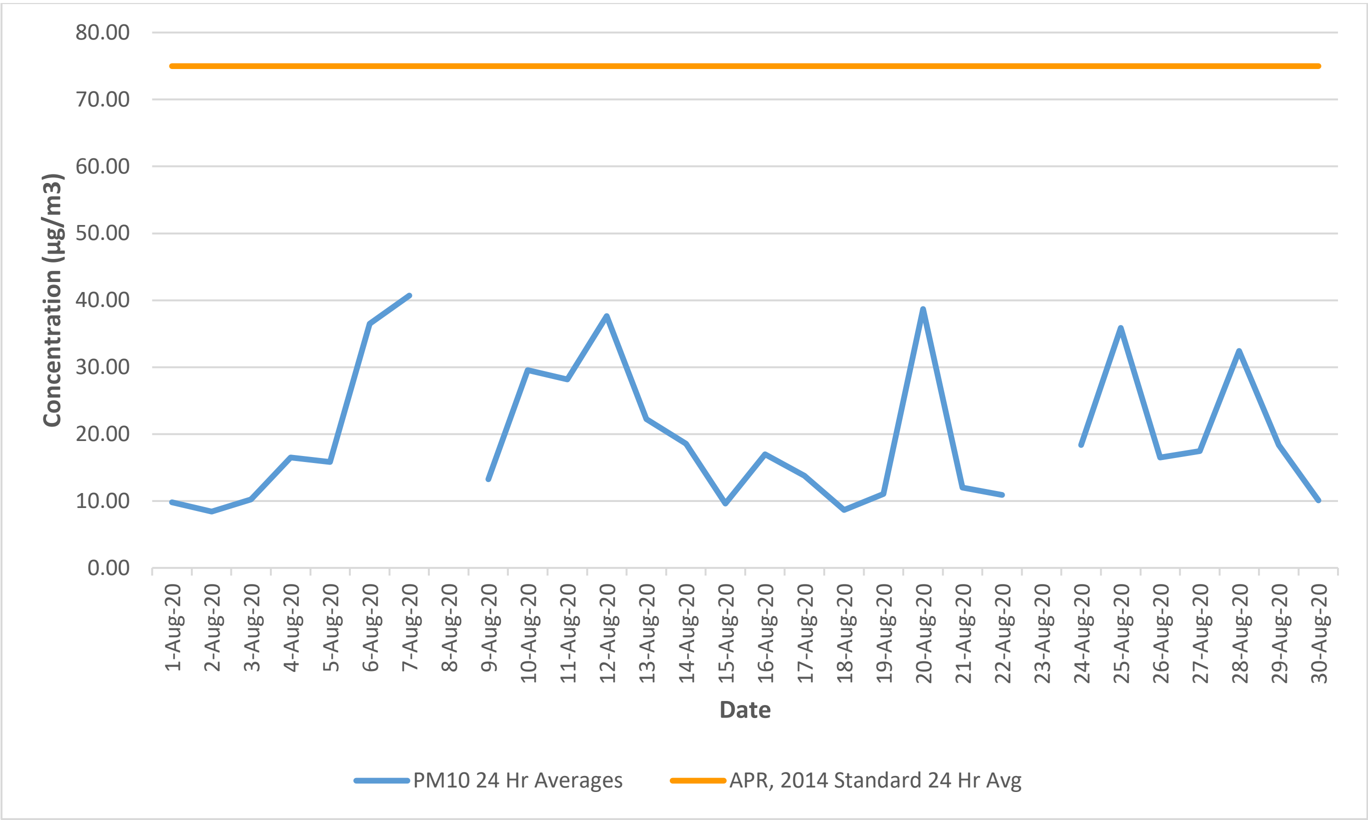


FIGURE 5: PARTICULATE MATTER (PM_{10}) CONCENTRATIONS FOR TOBAGO, SEPTEMBER 2020

Daily 24-hour Average Concentrations versus Maximum Permissible Level (75 µg/m^3)

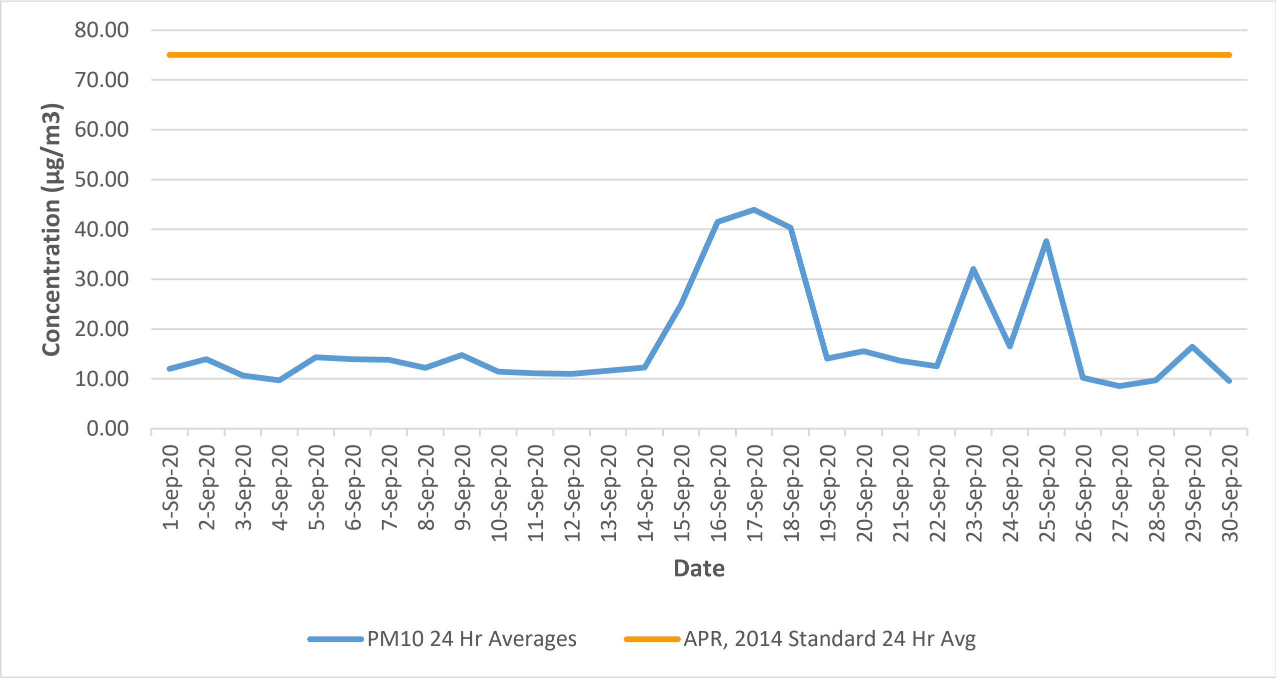


FIGURE 6: PARTICULATE MATTER ($PM_{2.5}$) CONCENTRATIONS FOR POINT LISAS, JULY 2020

Daily 24-hour Average Concentrations versus Maximum Permissible Level (65 µg/m^3)

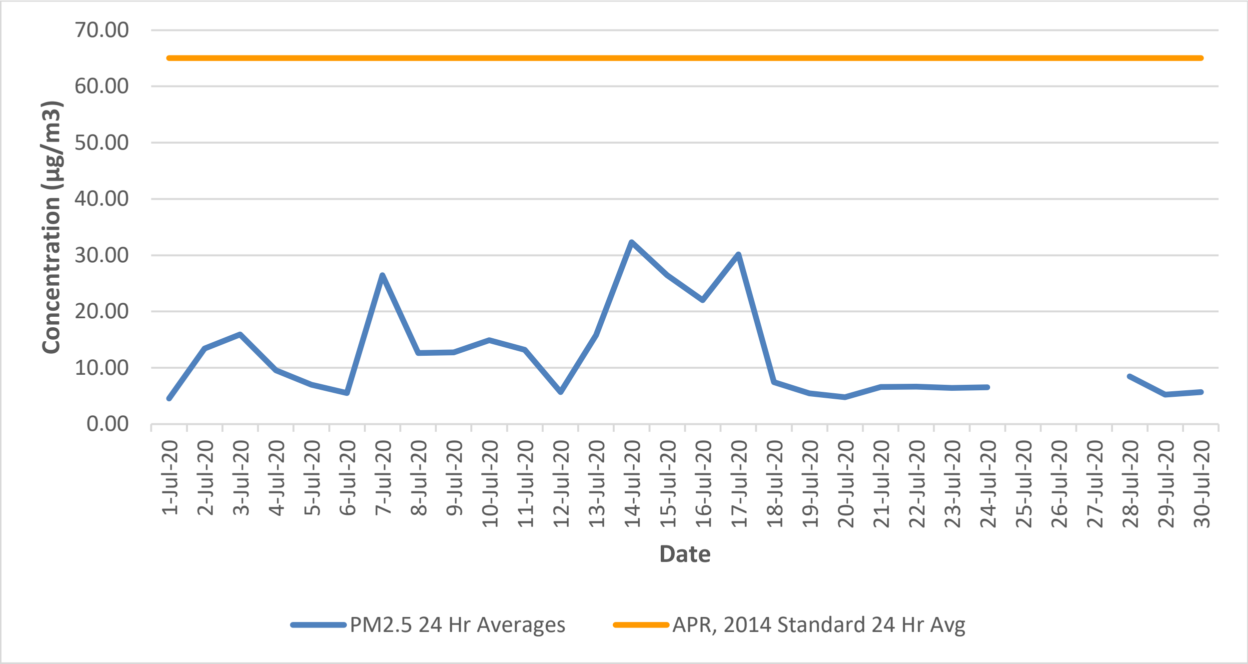


TABLE 7: MONTHLY SUMMARY FOR PM_{10} and $PM_{2.5}$

POINT LISAS, TRINIDAD							
Month	$PM_{2.5}$ µg/m^3				PM_{10} µg/m^3		
	Monthly 24-hr Average	Monthly 24-hr Max	Monthly 24-hr Min		Monthly 24-hr Average	Monthly 24-hr Max	Monthly 24-hr Min
July-20	12.04	32.30	4.54		20.78	42.95	5.74
August-20	n/a	n/a	n/a		19.58	40.70	8.44
September-20	n/a	n/a	n/a		17.33	43.97	8.56
No. of Exceedances with APR, 2014	0 days				0 days		
% of Q3 Valid Data	28.26%				78.26%		

Note: Point Lisas $PM_{2.5}$ data was unavailable for August and September due to a faulty air conditioning unit.

Data validity for PM_{10} at Point Lisas for July, August and September are 58%, 84% and 93% respectively. The combined data validity for the third quarter is 78.26%. Data for all months are presented in the table and graphs above. Data validity for $PM_{2.5}$ at Point Lisas for July was 84%. The combined data validity for $PM_{2.5}$ for the quarter was 28.26%. $PM_{2.5}$ data was not available for August and September therefore the data for these months were not presented in the graphs and table above.

PM_{10} and $PM_{2.5}$ data capture at Port-of-Spain was affected during Q3 due to a faulty compressor in the air conditioning system in both units which occurred as a result of wear and tear after continuous 24/7 operation for four years. Following the replacement of the compressors there were further issues with the compressors resulting in the units not being able to cool. Troubleshooting with anAC technician and the manufacturers has been on-going to resolve the issue.

The PM_{10} and $PM_{2.5}$ data for Signal Hill, Tobago, is currently unavailable for the period July - September, 2020 due to connectivity issues with the station. The report will be updated to include Tobago's data when the connectivity is restored.

6.2 Carbon Monoxide (CO)

FIGURE 7: CARBON MONOXIDE (CO) CONCENTRATIONS FOR POINT LISAS, SEPTEMBER, 2020

8-hour Average Concentrations versus the Maximum Permissible Level (10,000 µg/m^3)

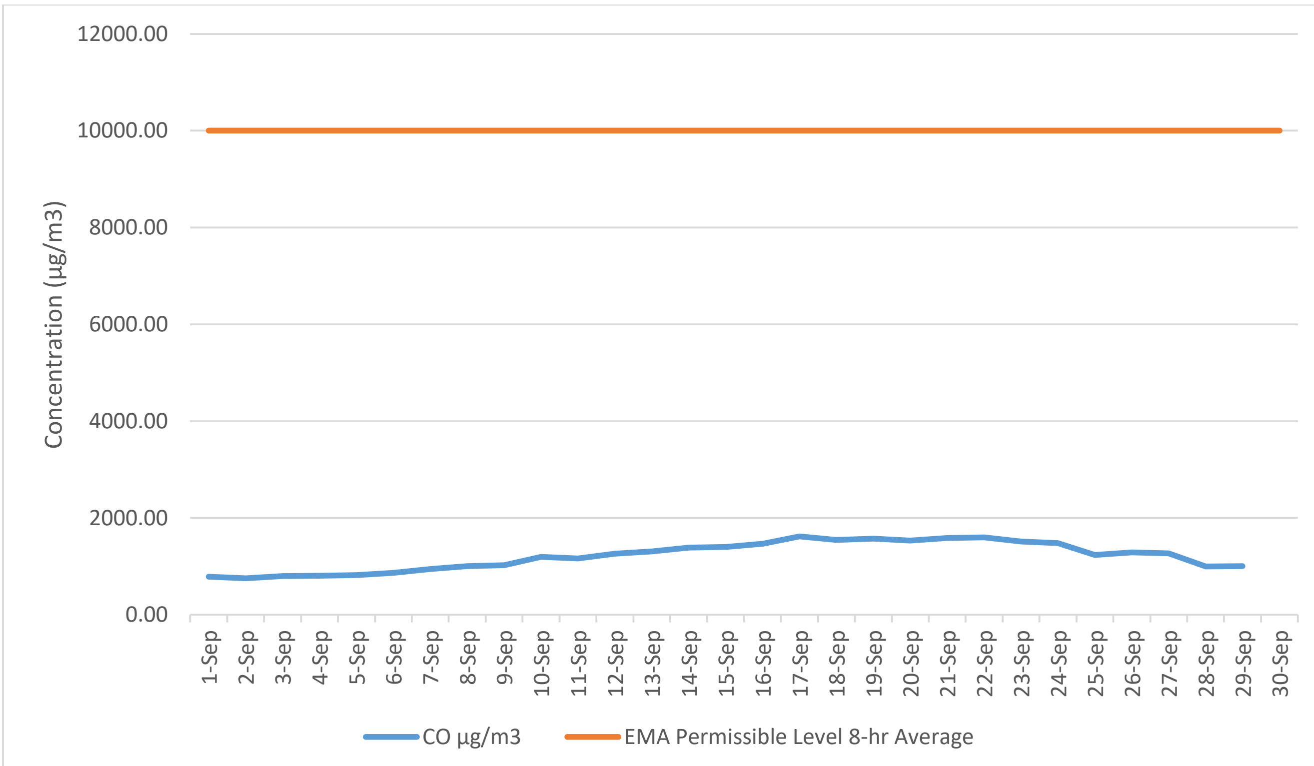


TABLE 8: MONTHLY SUMMARY FOR CO

POINT LISAS, TRINIDAD CO µg/m³			
Month	**Monthly 8-hr Average**	**Max 8-hr Average**	**Min 8-hr Average**
July-20	n/a	n/a	n/a
August-20	n/a	n/a	n/a
September-20	1255.75	1810.87	656.38
No. of Exceedances with APR, 2014	0 days		
% of Q3 Valid Data	32.25%		

Note: CO data was unavailable for July and August, 2020 due to challenges experienced with the internal span module of the analyser, resulting in analyser response issues

Data validity for July and August were both 0%, while September was 98.89%, therefore no data is presented in the table or graph above. The Q3 percent valid data is 32.25%.

Data for the CO analyser at Port-of-Spain, Trinidad, was not presented in this report, due to faulty compressors in the air condition units.

The CO data at Signal Hill, Tobago, is currently unavailable for the period July - September, 2020 due to connectivity issues with the station. The report will be updated to include Tobago's data when the connectivity is restored.

6.3 Nitrogen Dioxide (NO_2)

FIGURE 8: NITROGEN DIOXIDE (NO_2) CONCENTRATIONS FOR POINT LISAS, SEPTEMBER 2020

1-hour Average Concentrations versus the Maximum Permissible Level (200 µg/m^3)

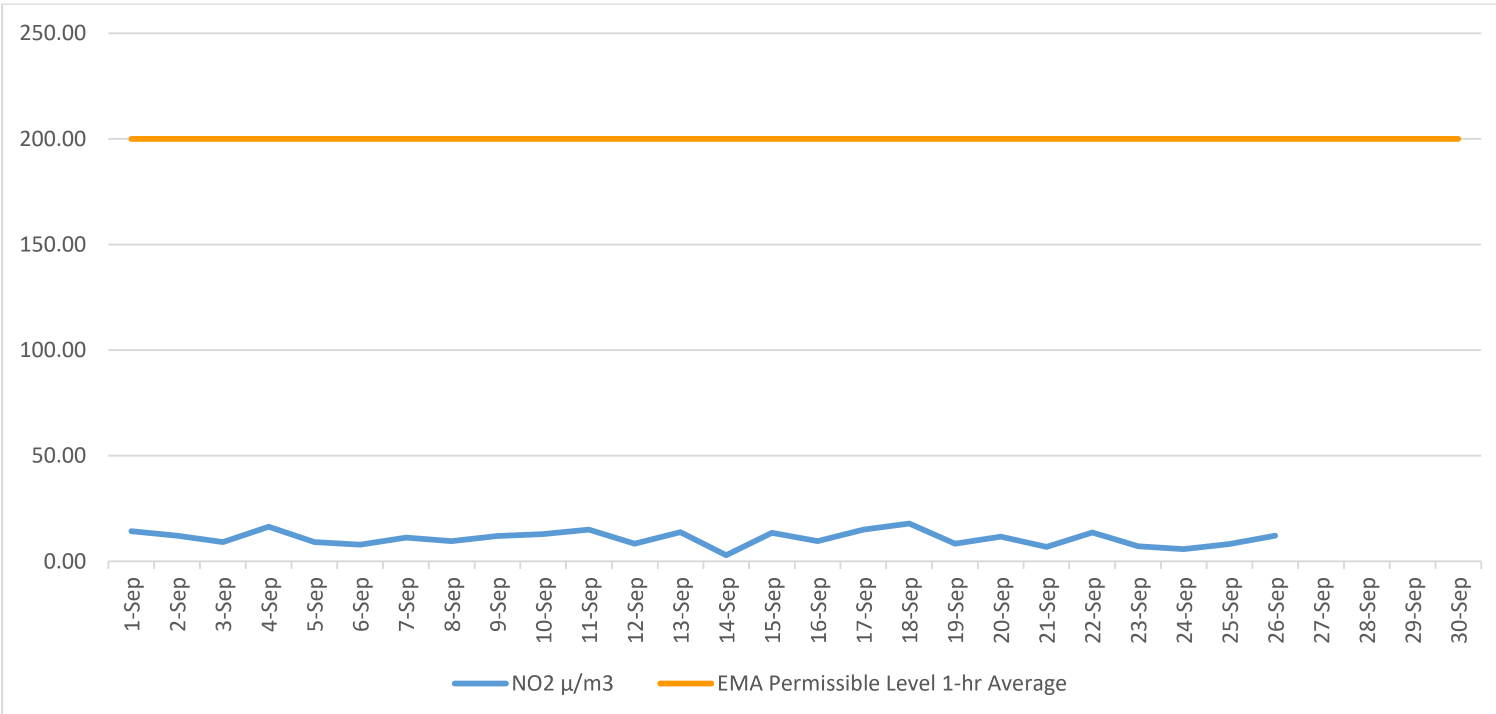


TABLE 8: MONTHLY SUMMARY FOR NO_2

POINT LISAS, TRINIDAD NO_2 µg/m³			
Month	**Monthly 1-hr Average**	**Max 1-hr Average**	**Min 1-hr Average**
July-20	n/a	n/a	n/a
August-20	n/a	n/a	n/a
September-20	13.65	23.84	1.17
No. of Exceedances with APR, 2014	0 days		
% of Q3 Valid Data	34.78%		

Note: NO_2 data was unavailable for July and August, 2020 due to issues experienced with the ozone generator of the analyser.

Data validity for July and August were 0% and 19.35%, while September was 86.67%. Less than seventy-five per cent (<75%) of valid data was available for July and August and as such are not presented in the table or graphs. The combined Q3 percent valid data for NO_2 is 34.78 %.

Data for the NO_2 analyser at Port-of-Spain, Trinidad, was not presented in this report, due to faulty compressors in the air condition units.

The NO_2 data at Signal Hill, Tobago, was unavailable for the period July - September, 2020 due to connectivity issues with the station. The report will be updated to include Tobago's data when the connectivity is restored.

6.4 Ozone (O_3)

FIGURE 9: OZONE (O_3) CONCENTRATIONS FOR POINT LISAS, TRINIDAD, JULY 2020

8-hour Averages Concentrations versus the Maximum Permissible Level (120 µg/m^3)

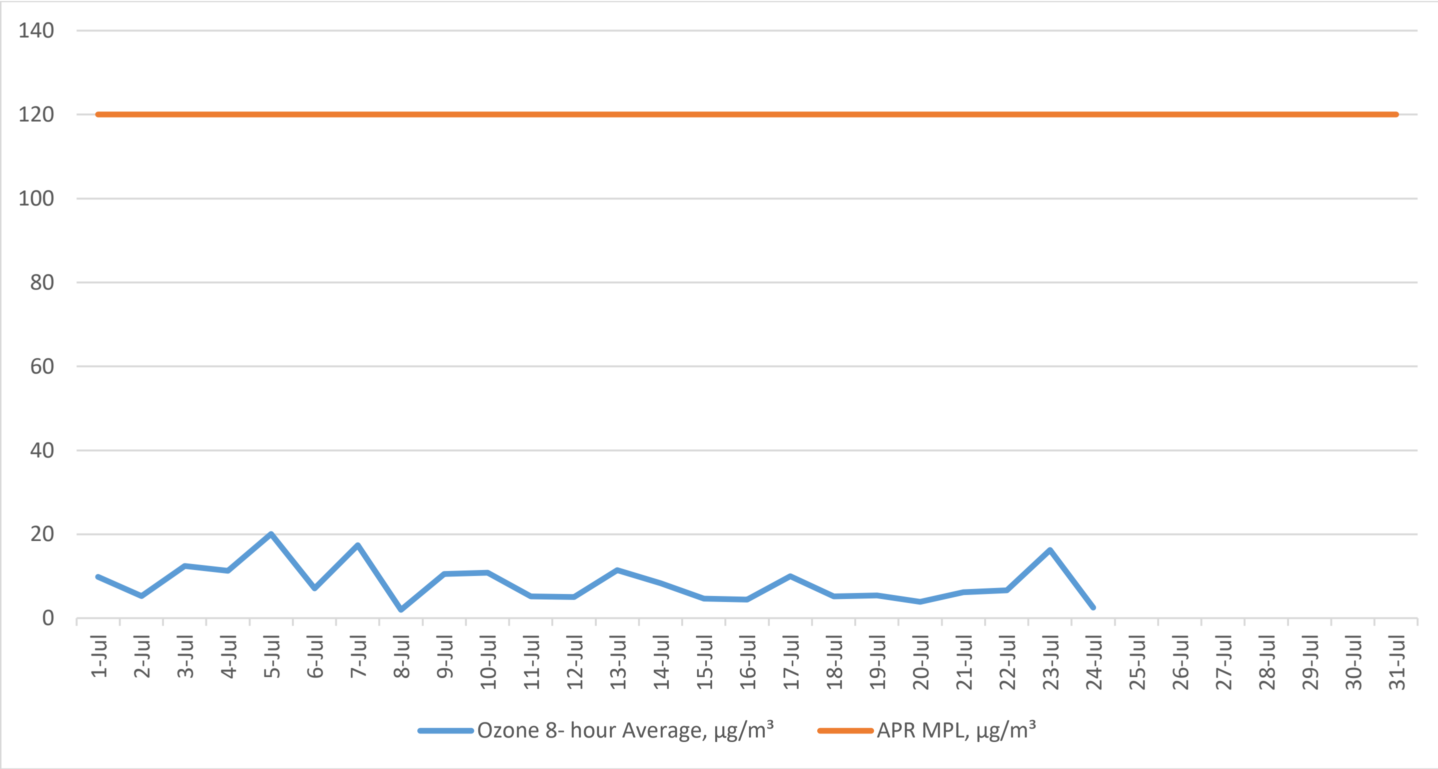


TABLE 9: MONTHLY SUMMARY FOR O_3

POINT LISAS, TRINIDAD O_3 µg/m³			
Month	**Monthly 8-hr Average**	**Max 8-hr Average**	**Min 8-hr Average**
July-20	12.70	32.90	2.01
August-20	n/a	n/a	n/a
September-20	n/a	n/a	n/a
No. of Exceedances with APR, 2014	0 days		
% of Q3 Valid Data	32.61%		

Note: O_3 data was unavailable for August and September, 2020 due to a faulty air conditioning unit.

Data validity for July was 96.77%, while August and September were both 0%, therefore no data is presented for August and September in the table or graphs above. The combined Q3 percent valid data is 32.61%.

Data for the O_3 analyser at Port-of-Spain, Trinidad, was not presented in this report, due to faulty compressors in the air condition units.

The O_3 data at Signal Hill, Tobago, was unavailable for the period July - September, 2020 due to connectivity issues with the station. The report will be updated to include Tobago's data when the connectivity is restored.

6.5 Sulfur Dioxide (SO_2)

Sulfur Dioxide data was unavailable for the third quarter of 2020 (July – September 2020) for Trinidad due to equipment downtime. The analysers at Port-of-Spain and Point Lisas, Trinidad were down due to faulty air condition units and data was recorded for the analyser at Signal Hill, Tobago, however due to connectivity issues to the station the data is currently unavailable.

7.0 AIR QUALITY INDEX

The Air Quality Index (AQI) is an index for reporting daily air quality. It gives an indication of how clean or polluted the air is in relation to the permissible levels. The generation of an AQI value involves a conversion of measured pollutant concentrations to a number on a scale of 0 to 500. The AQI values are categorized by the level of health concern, with each category assigned a colour. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little or no potential to affect public health, while an AQI value over 300 represents air quality so hazardous that everyone may experience serious effects. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant. AQI values at or below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy.

The AQI can be viewed on the EMA's Air Quality Management Information System (AQMIS) website using the following link: http://ei.weblakes.com/rttpublic or accessed from the EMA's website, www.ema.co.tt.

TABLE 10: POLLUTION CONCENTRATION BREAKPOINTS FOR EACH CATEGORY OF THE AQI

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air Quality is considered satisfactory and air pollution poses little or no risk
Moderate	51-100	Air Quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101-150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151-200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201-300	Health alert: everyone may experience more serious health effects.
Hazardous	>300	Health warnings of emergency conditions. The entire population is more likely to be affected.

TABLE 11: AQI SUMMARY FOR POINT LISAS, TRINIDAD FOR THE PERIOD JULY- SEPTEMBER, 2020

AQI Category	CO	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2
Good	44	30	22	68	29	n/a
Moderate	0	0	0	8	2	n/a
Unhealthy (Sensitive)	0	0	0	0	0	n/a
Unhealthy	0	0	0		0	n/a
Very Unhealthy	0	0	0	0	0	n/a
Hazardous	0	0	0	0	0	n/a
TOTAL	**44**	**30**	**22**	**76**	**31**	**n/a**

Note: SO_2 was unavailable due to faulty air conditioning unit.

8.0 SAHARAN DUST EVENTS

The Saharan Air Layer (SAL) is a mass of very dry, dusty air which forms over the Sahara Desert during the late spring, summer, and early fall and usually moves out over the tropical North Atlantic Ocean every 3-5 days. The National Oceanic and Atmospheric Administration (NOAA) states that the SAL extends between 5,000 to 20,000 feet (1.5 – 6 km) in the atmosphere and is associated with large amounts of mineral dust, dry air and strong winds (~10-25 m/s). These strong winds, or jets, are usually found between 6,500-14,500 feet (2 – 4.4 km) above the surface in the central and western North Atlantic and have a depth of ~1-2 miles.

Following the major Saharan dust events in June, 2020 the filter tapes from the Beta Attenuation monitors were retrieved from the Point Lisas station and analysed. A change in the colour of the filter tapes was observed subsequent to high Saharan dust days in June, 2020. The filter tapes were brownish/orange in appearance due to the high concentrations of Saharan dust in the atmosphere compared to the regular black or gray stamps on the tape due to combustion sources. A comparison of stamps recording the concentration of particulate matter is shown in the diagrams below, see Figure 10. The Environmental Management Authority has collaborated with the University of the West Indies to analyse the PM samples to determine the following:

- Mineral composition;
- Chemistry composition (e.g., metals, organics);
- Elemental analysis; and
- Electron microscope pictures.

A total of seventeen (17) days were selected for analysis: six (6) non-Saharan dust days (three $PM_{2.5}$ samples and three PM_{10} samples) and eleven (11) Saharan dust days (three $PM_{2.5}$ samples and eight PM_{10} samples) for comparison. The samples were digested and analysed for metal composition. The laboratory analyses of the samples were not completed at the time of this report submission. The results of the tests and study will be presented and discussed in a research paper and in a subsequent quarterly report.

FIGURE 10: FILTER TAPE COLOUR COMPARISON

For the third quarter of 2020, no exceedances with the APR, 2014 were observed for PM_{10} and $PM_{2.5}$, however, there were elevated levels of PM_{10} and $PM_{2.5}$ on days corresponding to days with Saharan dust occurrences (see Table 14). Table 14 also illustrates that on some days with Saharan dust occurrences, the AQI values were moderate. In Figure 11 below the graph illustrates how the PM levels were elevated during Saharan dust days, from September 16 -18, 2020.

TABLE 12: SAHARAN DUST OCCURANCES FOR THE THIRD QUARTER OF 2020 (JULY - SEPTEMBER, 2020)

Saharan Dust Events[1]	PM_{10} Concentrations µg/m³	$PM_{2.5}$ Concentrations µg/m³	AQI
	POINT LISAS	POINT LISAS	POINT LISAS
02/07/20	34.26	13.43	58 (PM10)
03/07/20	42.95	15.90	67 (PM10)
04/07/20	26.74	9.56	50 (PM10)
05/07/20	13.71	7.01	25 (PM10)
08/07/20	n/a	12.64	29 (PM2.5)
09/07/20	n/a	12.72	28 (PM2.5)
10/07/20	n/a	14.93	34 (PM2.5)
11/07/20	n/a	13.19	29 (PM2.5)
13/07/20	n/a	15.80	37 (PM2.5)
14/07/20	n/a	32.30	63 (PM2.5)
15/07/20	n/a	26.45	56(PM2.5)
16/07/20	33.79	21.99	49(PM2.5)
17/07/20	16.14	30.14	29(PM10)
21/07/20	15.29	6.58	28(PM10)
28/07/20	5.74	8.47	n/a
07/08/20	40.70	n/a	32(PM10)
10/08/20	29.56	n/a	54(PM10)
24/08/20	18.39	n/a	35(PM10)
25/08/20	35.89	n/a	27(PM10)
26/08/20	16.49	n/a	31(PM10)
27/08/20	17.44	n/a	33(PM10)
28/08/20	32.43	n/a	56(PM10)

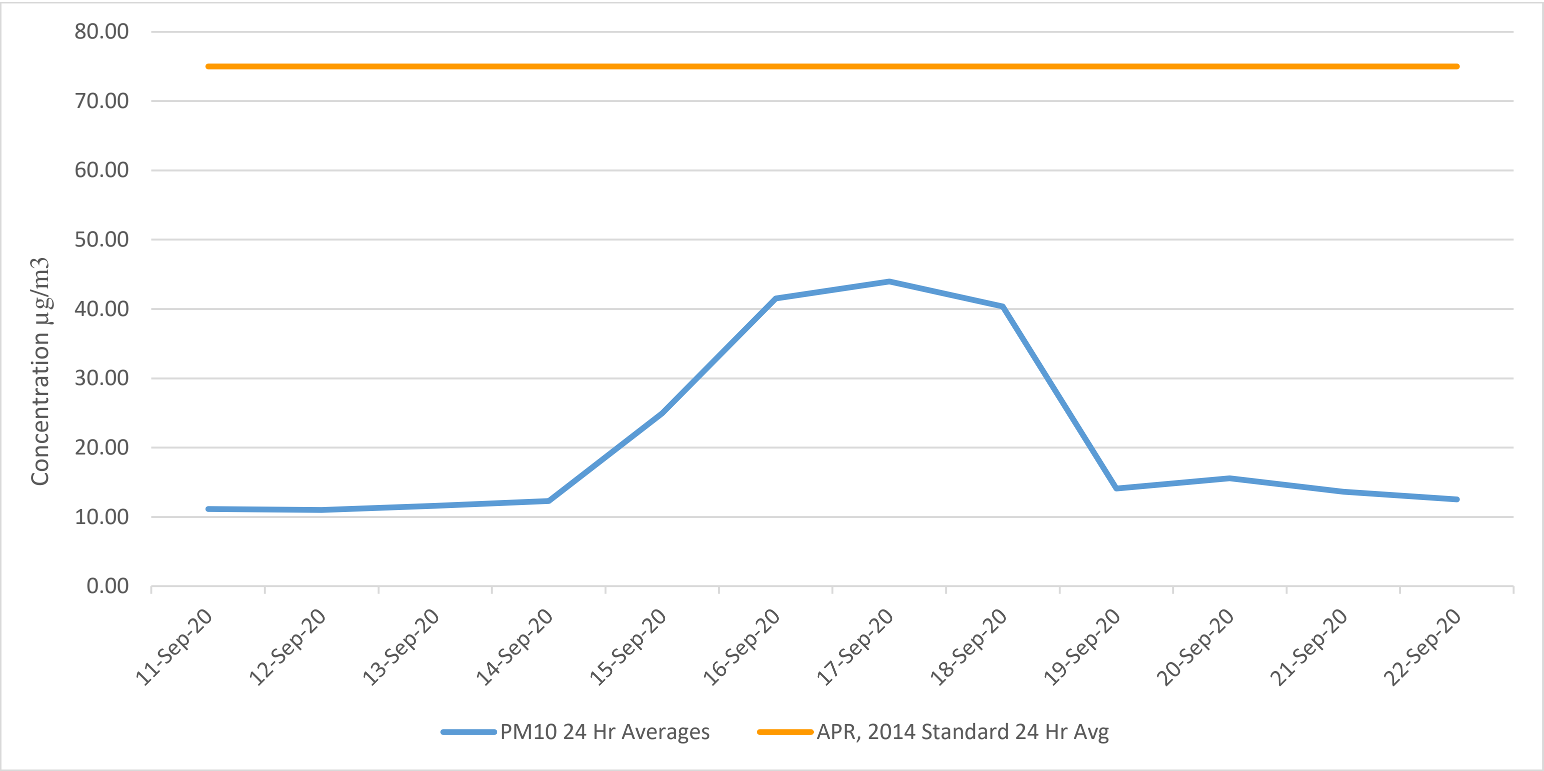
[1] Data provided by the Trinidad and Tobago Meteorological Services

29/08/20		18.38		n/a		34(PM10)
30/08/20		10.08		n/a		19(PM10)
16/09/20		41.50		n/a		64(PM10)
17/09/20		43.97		n/a		67(PM10)
18/09/20		40.37		n/a		63(PM10)
19/09/20		14.09		n/a		25(PM10)

Key:
n/a – insufficient data
APR, 2014 standard: PM10 - 75 µg/m^3 and PM 2.5 - 65 µg/m^3
0-50 – AQI Good
51-100 – AQI Moderate
101-150 – AQI Unhealthy for Sensitive Groups
151-200 - AQI Unhealthy
201-300– AQI Very Unhealthy
301-500 – AQI Hazardous

FIGURE 11: PARTICULATE MATTER (PM10) CONCENTRATIONS FOR POINT LISAS, TRINIDAD, SEPTEMBER 11-22, 2020

Daily 24-hour Average Concentrations versus Maximum Permissible Level (75 µg/m^3)



9.0 CONCLUSION

The data analysed for the third quarter of 2020 demonstrates that the ambient air quality for Trinidad and Tobago, for the criteria pollutants, is acceptable. There were no days during the period July – September, 2020 when concentrations for PM_{10}, $PM_{2.5}$, NO_2, O_3, CO exceeded the maximum permissible limits in the APR.

On days with Saharan dust occurrences, the AQI values were good and moderate. It is noted that the dust concentrations were lower than the recorded concentrations in the second quarter. The highest recorded AQI for period (July- September 2020) was on July 03, 2020, and September 17, 2020 with a moderate AQI value of 67; corresponding to a recorded PM_{10} value of 43 $\mu g/m^3$. There were ten moderate AQI values for the third quarter period at the Point Lisas Station.

No changes were made to the Ambient Air Quality Monitoring Network during the third quarter of 2020 (i.e., no relocation of stations or addition or removal of analysers).

Ambient air quality monitoring data was unavailable for the following parameters during the third quarter of 2020 (July - September, 2020):

- PM_{10} and $PM_{2.5}$ at the Signal Hill, Tobago monitoring location;
- CO, NO_2, SO_2, O_3, $PM_{2.5}$ and PM_{10} at the Port-of-Spain, Trinidad monitoring location;
- SO_2 at the Point Lisas, Trinidad monitoring location.

As a result of the restrictions imposed by the COVID-19 pandemic there were challenges with troubleshooting, maintenance and repairs due to the closure of offices internationally, resulting in delays with procuring and shipping parts and acquiring specialist skillsets for repair. Data was recorded for NO_2, CO and SO_2 for Tobago, however, there is no connectivity to the Tobago station to access the data.

The actions taken to resolve non-functioning units are shown in Table 13.

Table 13: ACTIONS TAKEN TO RESOLVE NON FUNCTIONING MODULES/UNITS

LOCATION	UNIT/MODULE	ACTION
Point Lisas	542 (CO and NO_2)	CO internal span disabled until repair conducted. Spares were ordered for NO_2 module.
	544 (SO_2 and O_3)	Trouble shooting conducted to resolve failed air conditioning unit, with no solution. New air conditioning unit to be purchased.
Port-of-Spain	543 (CO and NO_2)	Trouble shooting on air condition units.
	545 (SO_2 and O_3)	SO_2 optical filter ordered. Awaiting shipment.
Tobago		IT department is aware of the internet connectivity issue and is engaged in finding a solution.

10.0 REFERENCES

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