

Pollutant Standard Index and Air Quality Index of Wet Season Criteria Air Pollutants in Port Harcourt And its Environs, Niger Delta, Nigeria.

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Abstract: The Pollutant standards indices (PSI) is a sub air quality index (sub-AQI), a number which indicates the concentration level of each pollutant in the air. Pollutant standards indices (PSI) were computed using concentrations of criteria pollutants (SO₂, NO₂, CO, PM₁₀ and PM_{2.5}).

The concentration of air pollutants that present in the atmospheric air which exceeds the regulatory limits in Port Harcourt and its environs and with long time exposure constitute harm to human health and degradation of environments. Despite the global effort to curtail the discharge of air pollutants into the atmosphere, the tremendous increased in air pollution with rapid population growth and corresponding anthropogenic activities require developing of the air quality index model of our environment. The prime objective of this work is to study the air quality status of Port Harcourt city and its environs by developing pollutant standard index (PSI) and Air Quality Index (AQI) models. Results of AQI indicated that, Eleme, Obio/Akpor and Port Harcourt areas are more polluted than Oyigbo, Ikwerre and Etche in the wet season.

Keywords: Criteria air pollutants, Wet season, Air quality index, Pollutant standard index

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I. Introduction

Air pollution which has been a growing global problem in recent time is a product of natural and anthropogenic sources (Chelana, *et al.*, 2002; Longhurst, 2005; Efe, 2006; and Antai *et al.*, 2016a) and the impacts of this menace adversely affect man and his environment.

This trend of the air pollution could increase steadily if not properly assessed and effectively controlled by standard mitigation measures, Port Harcourt and its environs would be deterred due to air pollution. However, the daily reporting of the concentration of the air pollutants and the associated health implication in the environment is another challenge in air quality management but air quality index has often been used as an informative tool to represent or report daily air quality of the specific area to the public understanding and awareness (US EPA 2006). Air quality index is a chart with coded colour which each colour represents the daily air quality status and associated health implication of the specific area of study area (Antai *et al.*, 2016b). The degree of pollution in each of the study area in this research was therefore determined using pollutant standard index and air quality index models.

This study was designed specifically to assess the air quality status of Port Harcourt and its environs by developing its air quality index thus determine their quality changes.

STUDY LOCATION

Port Harcourt metropolis is located between latitudes 4°35' and 5°30' north and between longitudes 6°54' and 7°08' east. It covers an estimated area of 1811.6 square kilometers and is the capital of Rivers State. Port Harcourt was established in 1914 by the British colonial administration under Lord Lugard to meet the pressing economic needs of Europe. The metropolis lies at the heart of the Niger Delta, which is one of the world's richest wetlands. The Niger Delta is bounded on the south by the Atlantic Ocean, to the north by Imo and Abia States to the east by Akwa Ibom State and to the west by Bayelsa and Delta States. Some of the well-known residential areas in Port Harcourt and its environs include: Port Harcourt Town, Obio/Akpor, Eleme,

Oyigbo, Ikwerre and Etche Local Government Areas (Overview of Rivers State - Niger Delta Budget Monitoring Group,2005).

II. Materials And Methods

Sample and Sampling Techniques

The study primarily includes selection of sampling sites, field assessment/measurement, data reading, data storage, statistical data analysis, data interpretation and report writing. Hand held *in-situ* portable meters were used and application of standard ambient air quality assessment procedures were strictly adhered to. Field data measurement was done *in-situ* with the calibrated portable meters in accordance with the recommended standard procedures for environmental data collection in Nigeria FEPA, (1991), FMEnv, (2002), DPR, (2002) and WHO (2005) procedures for population density, topography, industrial cluster, and heavy traffic for site selection studies. The field data assessment of the air quality and meteorological parameters were sampled on hourly basis, three hours per sampling point (morning, afternoon and evening as peak, off peak and peak periods, respectively) for 26 days in the wet season.

Pollutant Standards Index (PSI) and Air Quality Index (AQI)

A type of air quality index known as Pollutant Standards Index was used to determine the level of pollutants in air. This was computed using the following equation and air quality index table (equation 1).

$$I_i = \frac{I_{i,j+1} - I_{i,j}}{X_{i,j+1} - X_{i,j}} (X_i - X_{i,j}) + I_{i,j} \quad (1)$$

for $X_{i,j} \leq X_i \leq X_{i,j+1}$

- Where X_i = Observed concentration for the i^{th} pollutant
 I_{ij} = PSI value for the i^{th} pollutant and the j^{th} breakpoint as given in the table
 I_{ij+1} = PSI value for the i^{th} pollutant and the $(j+1)^{\text{th}}$ breakpoint as given in the Table
 X_{ij} = Concentration for the i^{th} pollutant and j^{th} breakpoint as given in the table
 X_{ij+1} = Concentration for the i^{th} pollutant and $(j+1)^{\text{th}}$ breakpoint as given in the table

Concentrations of pollutants were expressed in terms of low, moderate, high and critical based on the computed values of EF and PSI (CPCB, 2006).

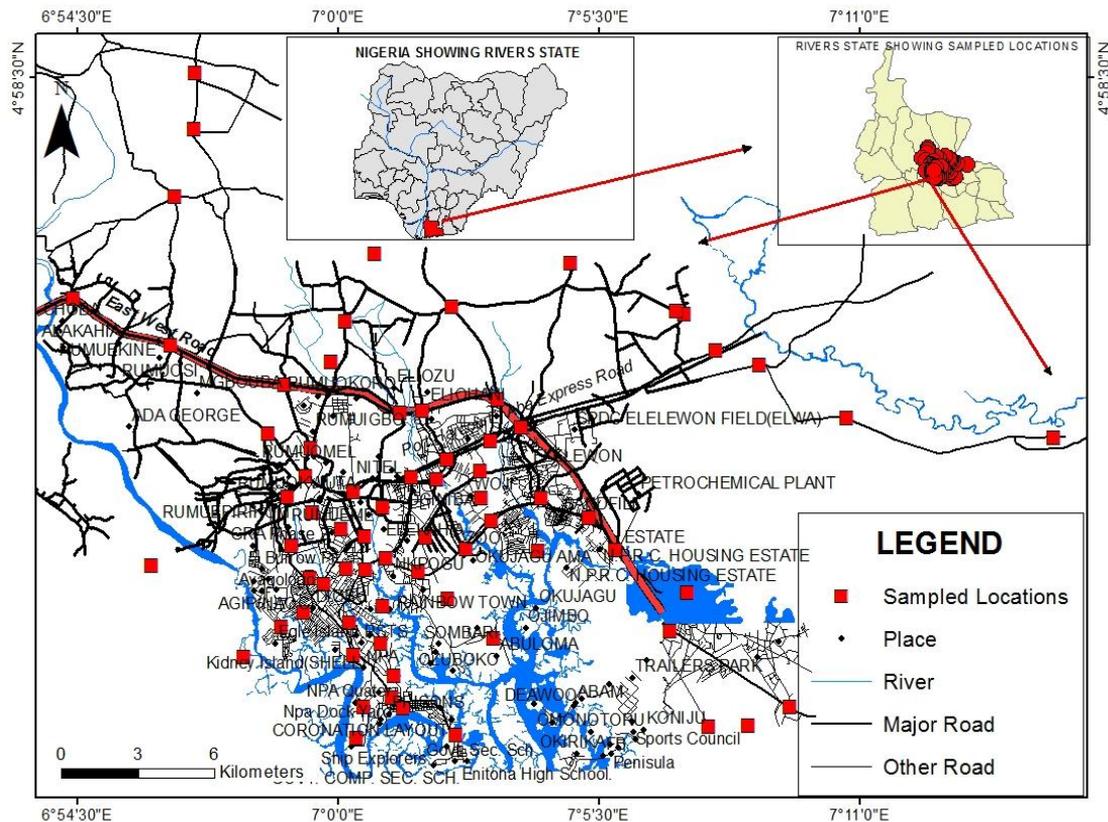


Figure 1:Port Harcourt and its Environs showing Sampling Points for the Study

III. Presentation Of Results And Discussion

The PSI is a sub air quality index (sub-AQI), a number which indicates the concentration level of each pollutant in the air. Pollutant standards indices (PSI) were computed using concentrations of criteria pollutants (SO₂, NO₂, CO, PM₁₀ and PM_{2.5}). The computed PSI for each pollutant in the wet season in Eleme area are shown in Figures 2 to 6, while plots of corresponding AQI are shown in Figure 7. Computed PSI showed high values of SO₂, NO₂ and PM_{2.5} (Figure 2 to 6). This implies that SO₂, NO₂ and PM_{2.5} are the main air pollutants prevailing in the Eleme area in the wet season. This may be as a result of industrial activities in the area.

The air quality indices computed in the wet season in Eleme area (Table 1 and Figure 7) indicated good air quality at station SP5 (between 0 – 50), and moderate air quality (51 – 100) at station SP2 (Table 1). These indicate that station SP5 has good and satisfactory air quality with minor or no health risk, while air quality at station SP2 is acceptable; however, SO₂ and PM_{2.5} pose some health concern for a very small number of sensitive people. Similarly, stations SP1 and SP4 showed unhealthy air quality (151 – 200), while stations SP3 and SP6 showed very unhealthy air quality (2001 – 300). This indicates that members of sensitive groups in stations SP1 and SP4 may experience more serious health effects, while there will be widespread effects among the general population and more severe effects in members of sensitive groups at stations SP3 and SP6. Station SP7 showed unhealthy air quality for sensitive groups (101 – 150), this may affect the health sensitive groups but may not affect the general public.

Table 1: Wet Season Pollutant Standard Index and Air Quality Index in Eleme area

Sampling Point	SO ₂ PSI	NO ₂ PSI	CO PSI	PM ₁₀ PSI	PM _{2.5} PSI	AQI	AQI Rating
SP1	499.5	266.5	45.5	45.6	74.1	186.2	Unhealthy
SP2	190.6	0.0	19.5	22.7	39.0	54.4	Moderate
SP3	499.5	266.5	219.9	56.3	78.3	224.1	Very Unhealthy
SP4	280.0	266.5	145.3	54.2	71.5	163.5	Unhealthy
SP5	0.0	0.0	19.1	41.1	62.2	24.5	Good
SP6	499.5	266.5	205.1	50.5	70.5	218.4	Very Unhealthy
SP7	499.5	0.0	22.1	37.3	57.8	123.4	Unhealthy for Sensitive Groups

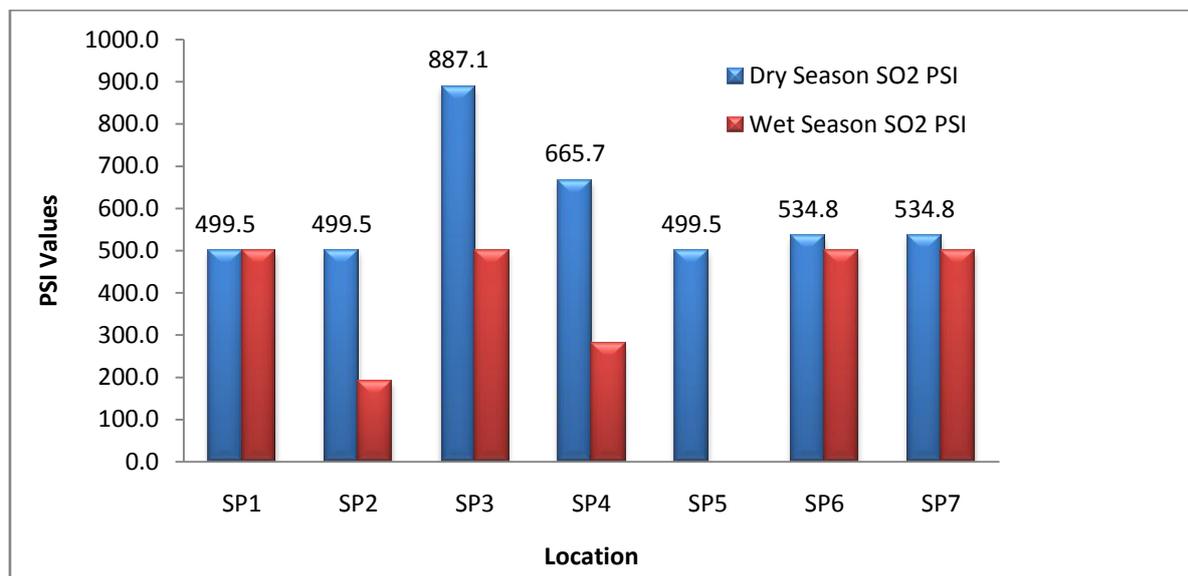


Figure 2: Computed Pollutant Standard Index of SO₂ around Eleme Area

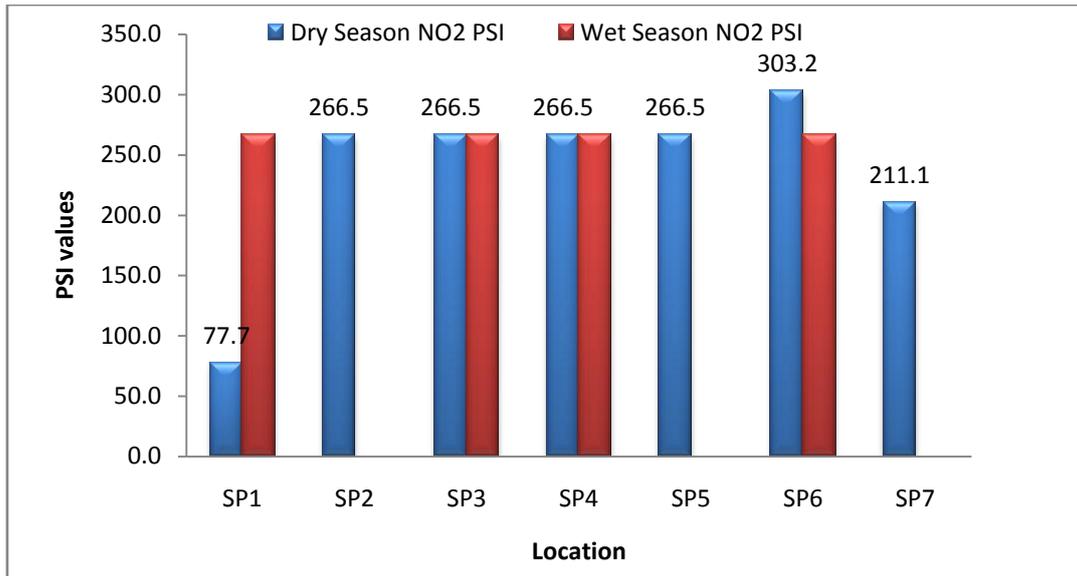


Figure 3: Computed Pollutant Standard Index of NO₂ around Eleme Area

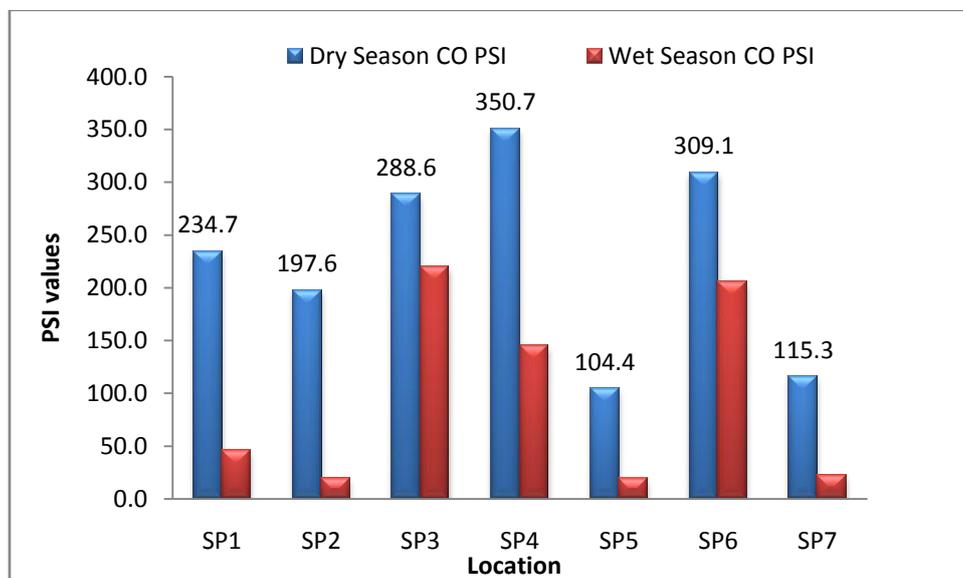


Figure 4: Computed Pollutant Standard Index of CO around Eleme Area

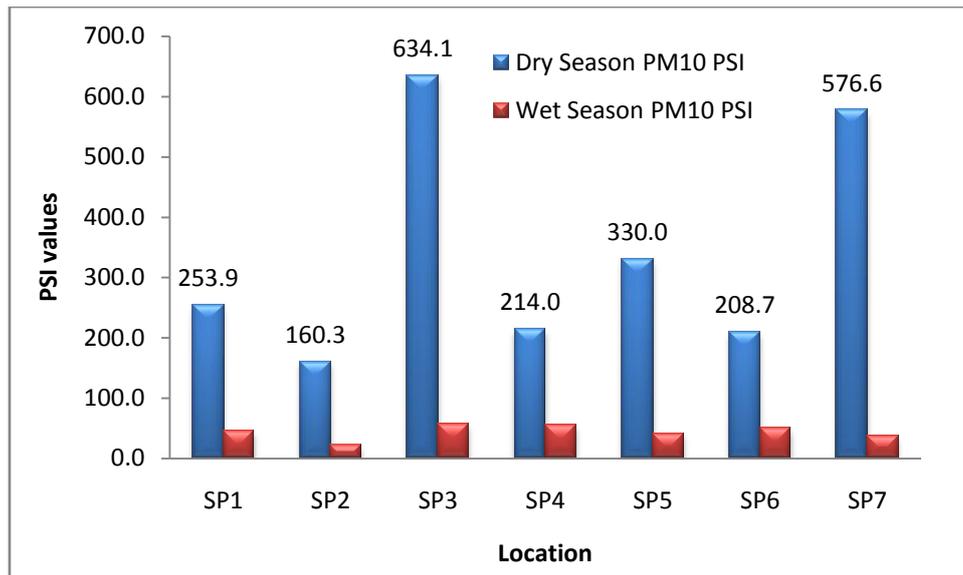


Figure 5: Computed Pollutant Standard Index of PM₁₀ around Eleme Area

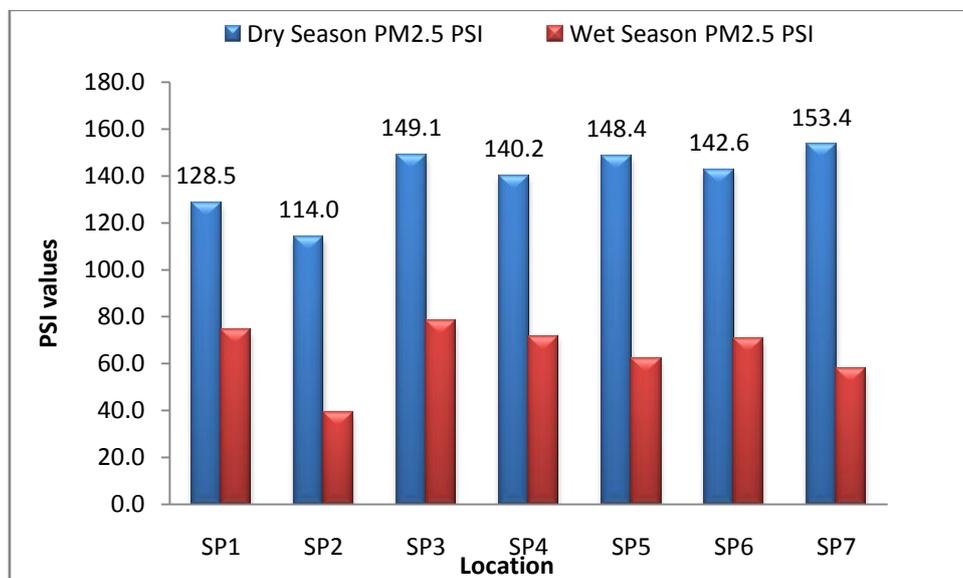


Figure 6: Computed Pollutant Standard Index of PM_{2.5} around Eleme Area

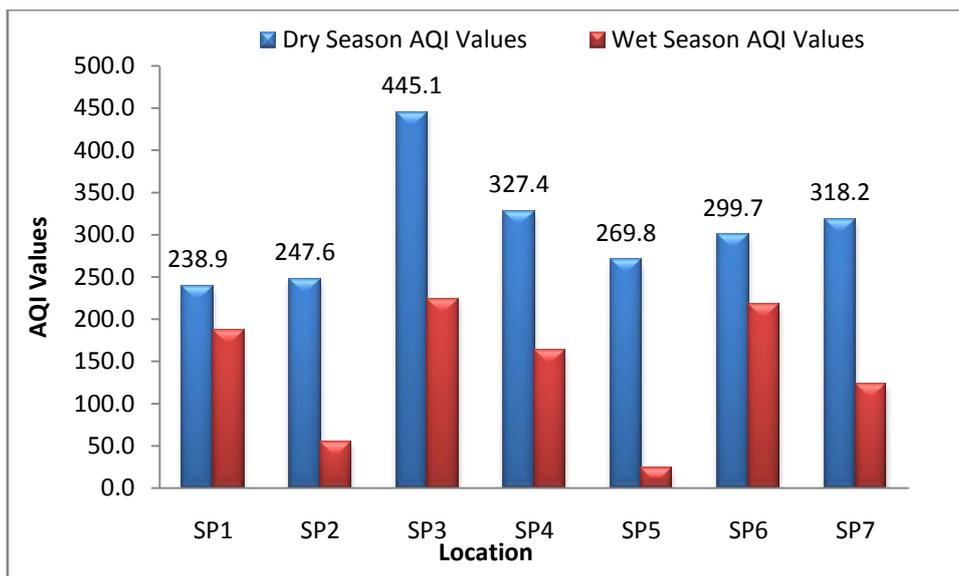


Figure 7: Computed Air Quality Index around Eleme Area

Assessment of Air Quality Index of Etche area

The computed PSI for each pollutant in the wet season in Etche area are shown in Figures 8 to 12, while plots of corresponding AQI values are shown in Figure 13. Computed PSI (Figure 8 to 12) showed that SO₂, NO₂ and PM_{2.5} are the main cause of pollution in wet season. This implies that SO₂, NO₂, PM_{2.5} are the main air pollutants prevailing in the Etche area in the wet season. This may be as a result of road construction activities and gas flaring in the area.

Computed air quality indices for Etche in the wet season (Table 2 and Figure 13) showed unhealthy air quality around station SP12 which may affect the health of everyone in the area especially those with respiratory problems. Station SP13 showed unhealthy air quality for sensitive groups which may affect a few number of people with respiratory symptoms; while station SP14 indicated a good air quality which may have no effect on the health of the people in the area

Table 2: Wet Season Pollutant Standard Index and Air Quality Index in Etche Area

Sampling Point	SO ₂ PSI	NO ₂ PSI	CO PSI	PM ₁₀ PSI	PM _{2.5} PSI	AQI	AQI Rating
SP12	499.5	266.5	25.5	43.6	65.4	180.1	Unhealthy
SP13	130.5	266.5	37.0	46.9	64.7	109.1	Unhealthy for Sensitive Groups
SP14	0.0	0.0	22.3	49.5	68.2	28.0	Good

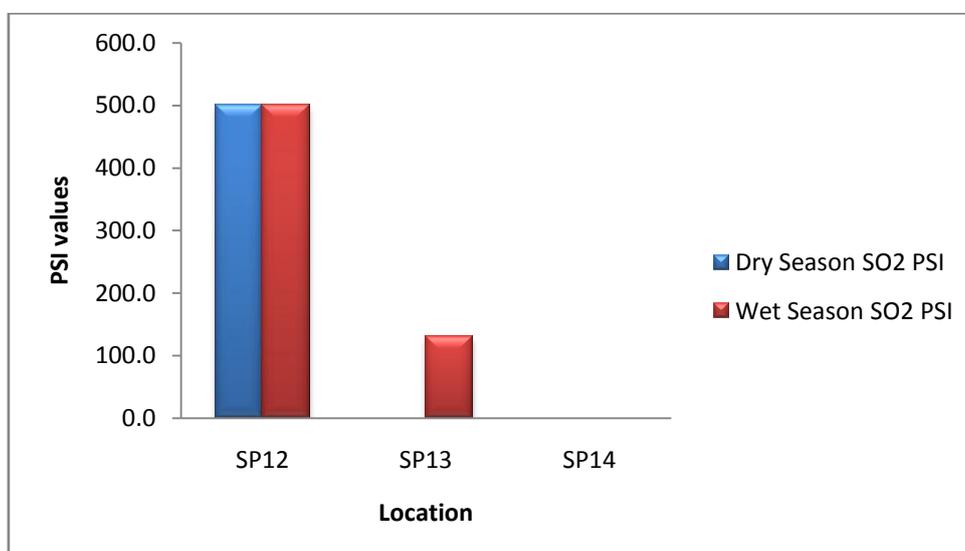


Figure 12: Computed Pollutant Standard Index of SO₂ around Etche Area

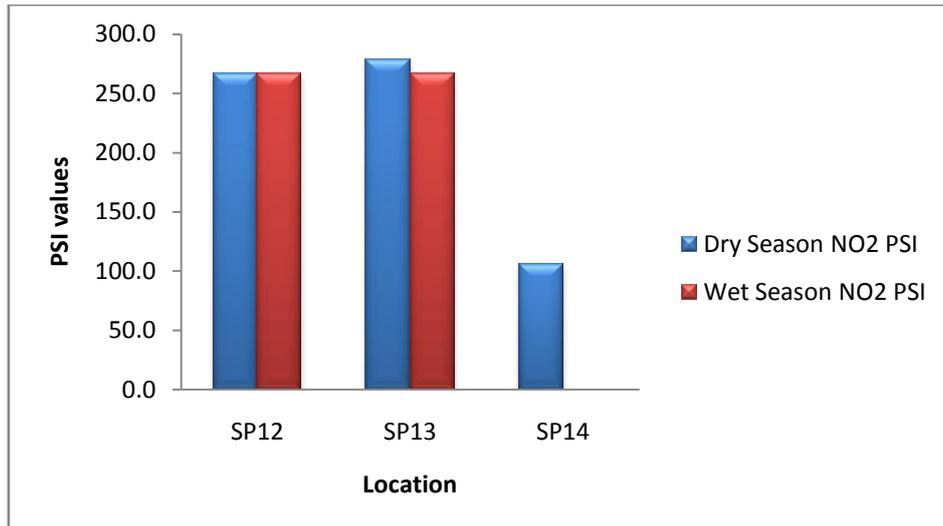


Figure 13: Computed Pollutant Standard Index of NO₂ around Etche Area

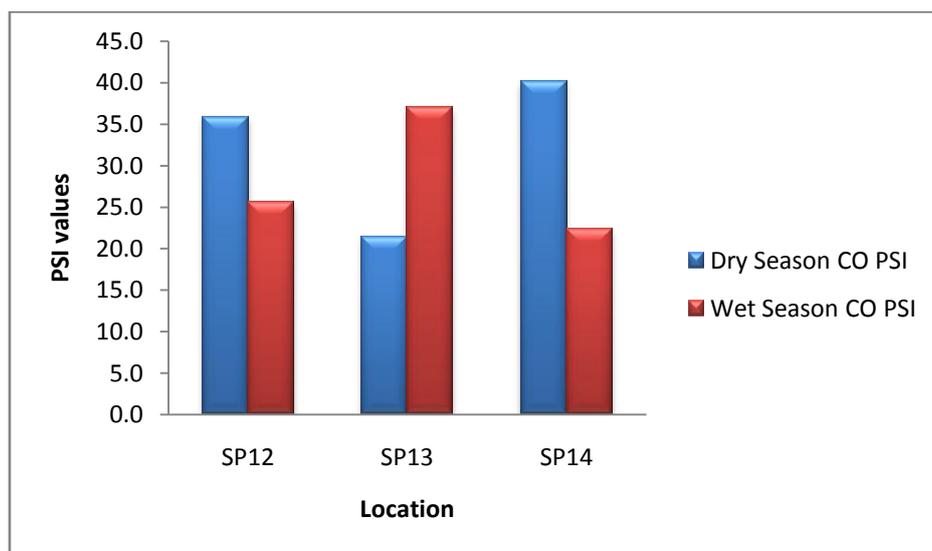


Figure 14: Computed Pollutant Standard Index of CO around Etche Area

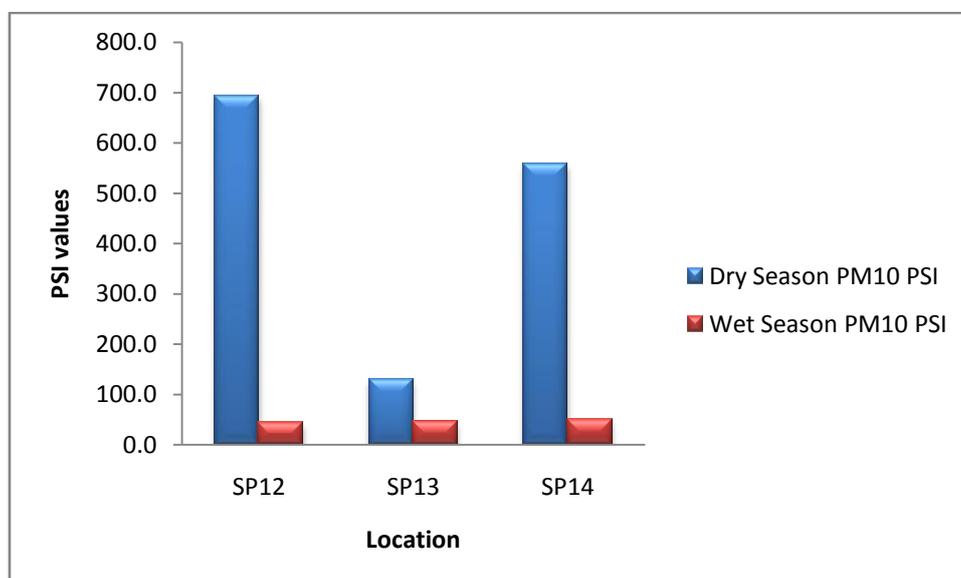


Figure 15: Computed Pollutant Standard Index of PM₁₀ around Etche Area

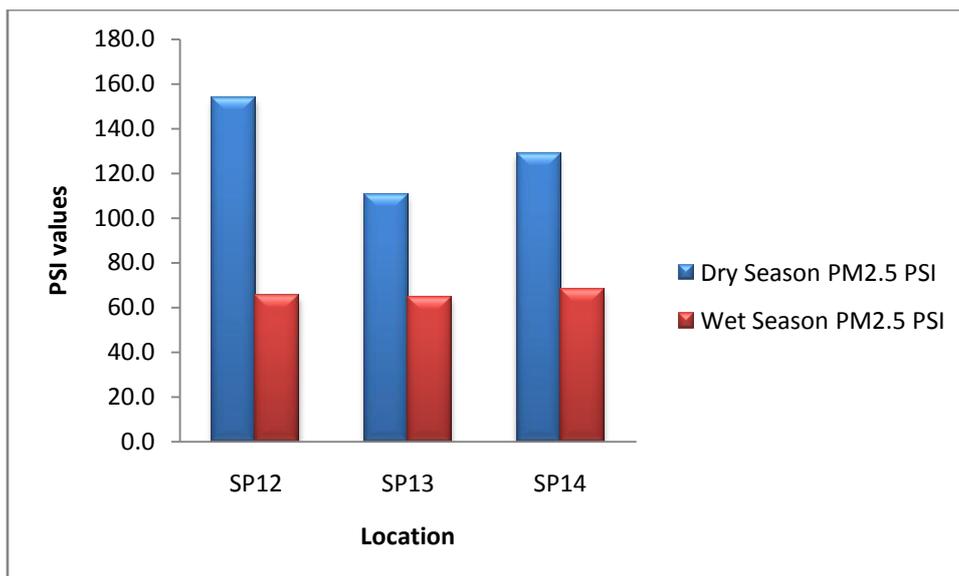


Figure 16: Computed Pollutant Standard Index of PM_{2.5} around Etche Area

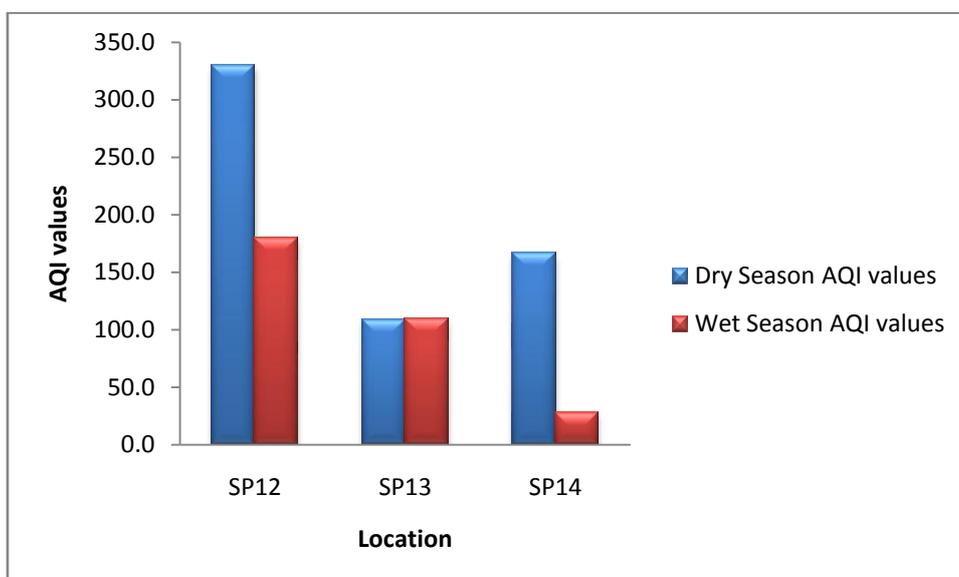


Figure 17: Computed Air Quality Index around Etche Area

Assessment of Air Quality Index of Ikwerre Local Government Area (LGA)

The computed PSI for each pollutant in the wet season in IkwerreLGA are shown in Figures 18 to 22, while plots of corresponding AQI values are shown in Figure 23. Computed PSI (Figure 18 to 22) showed low PSI values for all the pollutants in the wet season. This is responsible for the good and satisfactory air quality in the area in the wet season (Table 3).

Wet season computed air quality indices in IkwerreLGA (Table 3) indicated good air quality in all the sampling stations (SP25, SP26 and SP27). SP28 showed unhealthy air quality for sensitive groups in the wet season. This may affect only sensitive groups while the general public may not be affected. The air quality in the area in the wet season is therefore considered satisfactory and poses little or no health risk to the people.

Table 3: Wet Season Pollutant Standard Index and Air Quality Index in IkwerreLGA

Sampling Point	SO ₂ PSI	NO ₂ PSI	CO PSI	PM ₁₀ PSI	PM _{2.5} PSI	AQI	AQI Rating
SP25	0.0	0.0	33.2	32.8	51.0	23.4	Good
SP26	0.0	0.0	6.9	31.7	55.4	18.8	Good
SP27	124.4	0.0	16.8	32.5	51.4	45.0	Good
SP28	230.9	266.5	13.0	33.7	57.8	120.4	Unhealthy for Sensitive Groups

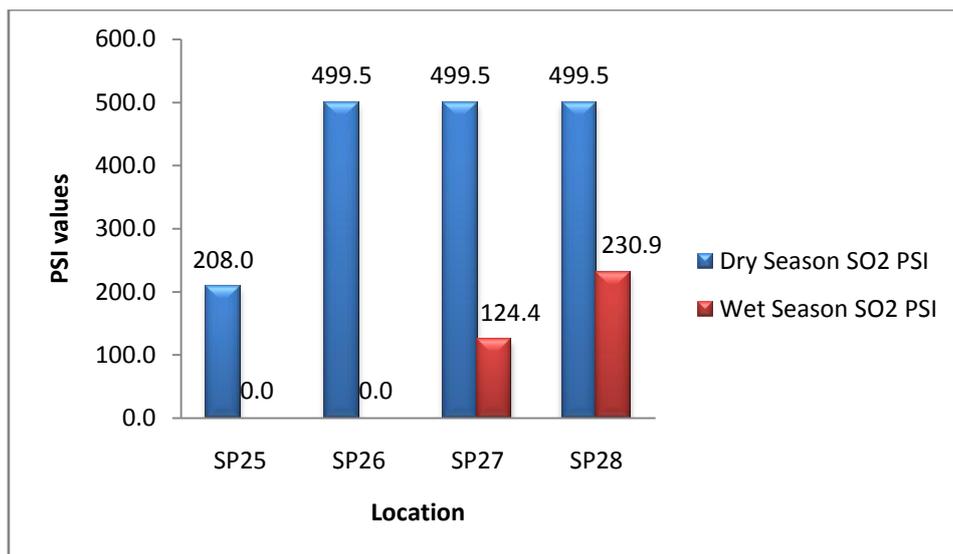


Figure 18: Computed Pollutant Standard Index of SO₂ around IkwerreLGA

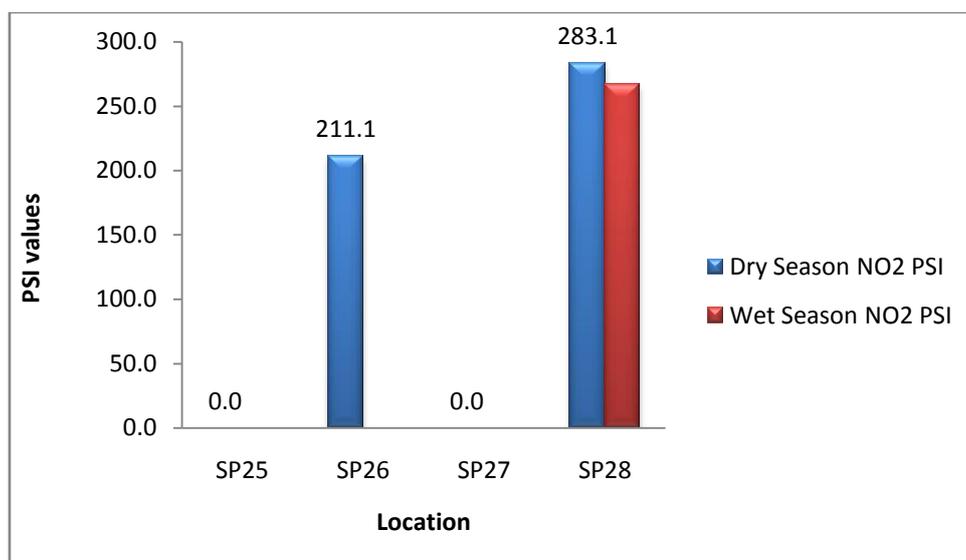


Figure 19: Computed Pollutant Standard Index of NO₂ around IkwerreLGA

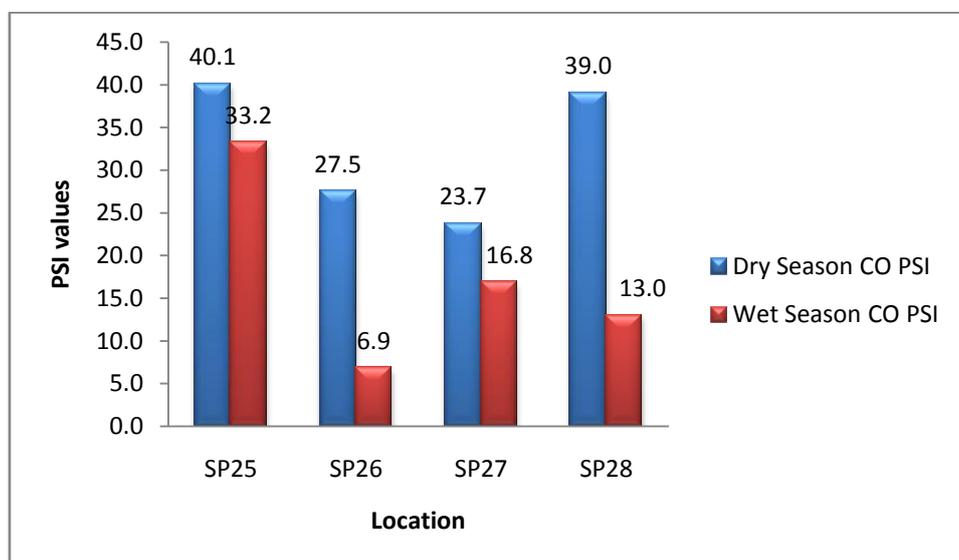


Figure 20: Computed Pollutant Standard Index of CO around IkwerreLGA

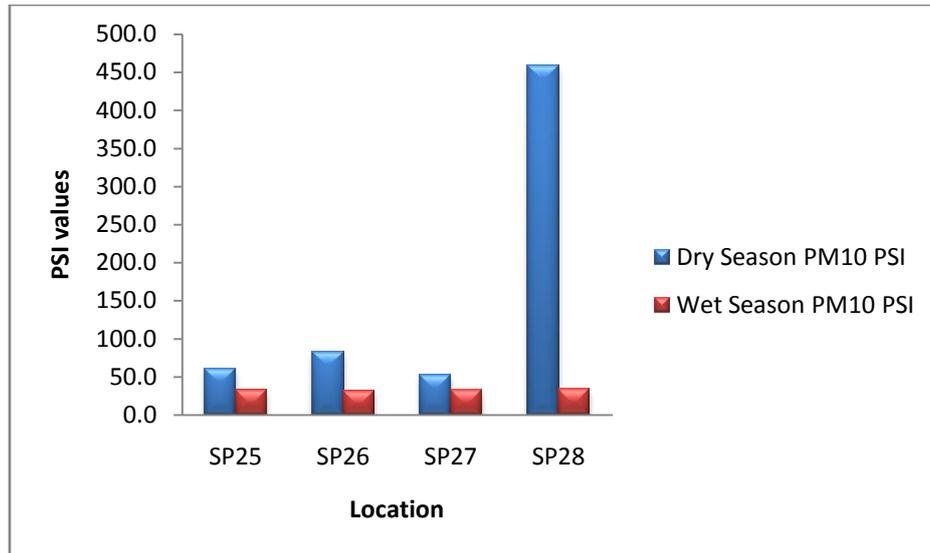


Figure 21: Computed Pollutant Standard Index PM₁₀ around IkwerreLGA

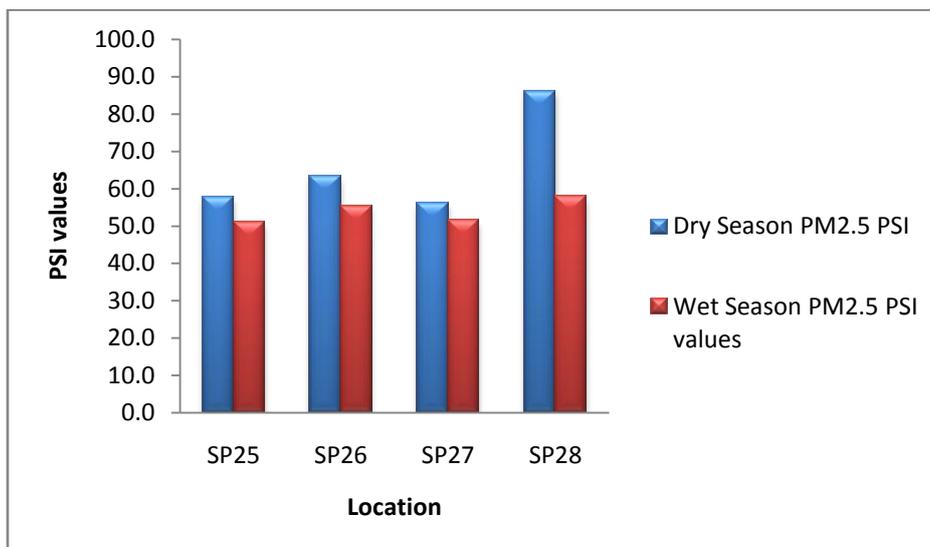


Figure 22: Computed Pollutant Standard Index PM_{2.5} around IkwerreLGA

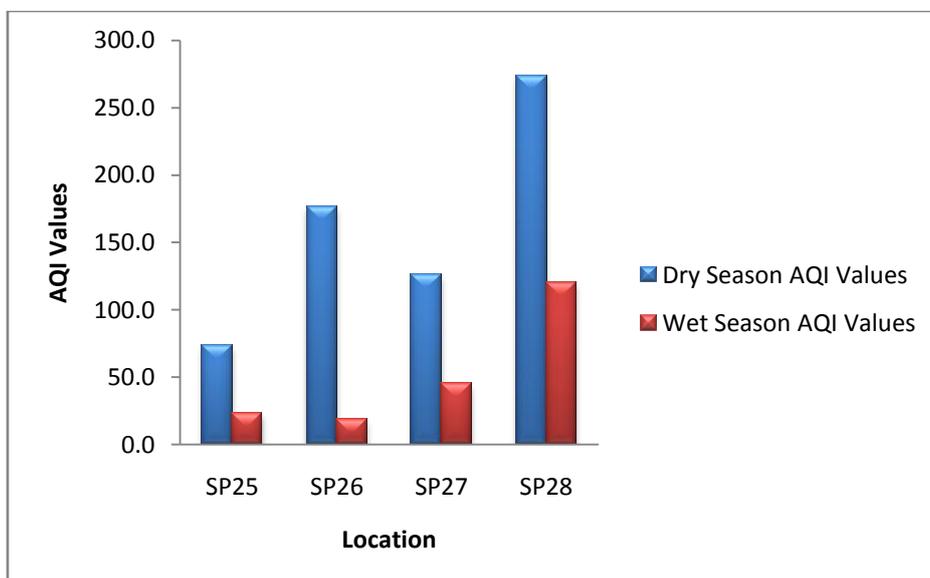


Figure 23: Computed Air Quality Index around IkwerreLGA

Assessment of Air Quality Index of Obio/Akpor Area

The computed PSI for each pollutant in the wet season in Obio/Akpor area are shown in Figures 24 to 28, while plots of corresponding AQI values are shown in Figure 29. Computed PSI (Figure 24 to 28) showed that SO₂, NO₂, CO, PM₁₀ and PM_{2.5} are the main cause of pollution in wet season in the area.

The wet season computed air quality indices for Obio/Akpor area (Table 4) showed very unhealthy air quality around stations SP32, SP46, and SP63. This may pose widespread health effects among the people in these areas, and members of sensitive groups may experience more serious effects. Stations SP29, and SP37 showed unhealthy air quality in the wet season (Table 4). Everyone in these stations may experience health effects; particularly sensitive people with respiratory symptoms may experience more serious health effects. Stations SP15, SP18, SP19, SP20, SP21, SP24, SP30, SP31, SP33, SP35, SP40, SP49, SP50, and SP62 showed moderate air quality in the wet season. This may affect few people and those who are unusually sensitive to particles pollution may experience respiratory symptoms. Stations SP16, SP17, SP22, SP23, SP28, SP36, and SP38 showed unhealthy air quality for sensitive groups in the wet season. This may affect only sensitive groups while the general public may not be affected. Also, stations SP34, SP47, SP48, and SP51 showed good air quality which poses minor or no health risk to the people.

Table 4: Wet Season Pollutant Standard Index and Air Quality Index in Obio/Akpor Area

Sampling Point	SO ₂ PSI	NO ₂ PSI	CO PSI	PM ₁₀ PSI	PM _{2.5} PSI	AQI	AQI Rating
SP15	106.4	0.0	52.0	64.2	90.3	62.6	Moderate
SP16	367.4	0.0	49.0	52.5	66.4	107.1	Unhealthy for Sensitive Groups
SP17	419.0	0.0	31.0	57.3	73.9	116.2	Unhealthy for Sensitive Groups
SP18	266.9	0.0	28.0	53.5	67.8	83.2	Moderate
SP19	0.0	266.5	74.0	52.3	67.4	92.0	Moderate
SP20	208.0	0.0	46.0	45.6	64.0	72.7	Moderate
SP21	166.5	0.0	52.0	43.2	68.8	66.1	Moderate
SP22	224.3	266.5	65.0	45.7	62.7	132.9	Unhealthy for Sensitive Groups
SP23	250.5	266.5	49.0	41.7	62.2	134.0	Unhealthy for Sensitive Groups
SP24	166.5	0.0	27.0	47.0	62.4	60.6	Moderate
SP29	304.6	266.5	121.4	45.6	64.2	160.5	Unhealthy
SP30	0.0	266.5	31.0	41.0	61.0	79.9	Moderate
SP31	283.2	0.0	40.0	42.1	60.1	85.1	Moderate
SP32	595.2	266.5	227.1	51.0	68.1	241.6	Very Unhealthy
SP33	296.3	0.0	25.0	39.7	53.9	83.0	Moderate
SP34	0.0	0.0	36.0	40.5	55.3	26.4	Good
SP35	196.6	0.0	38.0	42.5	57.4	66.9	Moderate
SP36	260.3	266.5	20.0	31.2	10.6	117.7	Unhealthy for Sensitive Groups
SP37	372.6	266.5	170.0	52.0	59.8	184.2	Unhealthy
SP38	208.7	266.5	27.0	27.2	11.4	108.2	Unhealthy for Sensitive Groups
SP40	196.6	0.0	44.0	39.7	57.6	67.6	Moderate
SP46	746.2	0.0	285.3	50.5	69.7	230.3	Very Unhealthy
SP47	0.0	0.0	54.0	25.9	50.3	26.0	Good
SP48	0.0	0.0	69.0	34.1	52.3	31.1	Good
SP49	315.1	0.0	61.0	43.8	52.1	94.4	Moderate
SP50	136.4	0.0	203.5	51.7	66.9	91.7	Moderate
SP51	204.7	0.0	8.0	16.3	9.4	47.7	Good
SP62	214.5	229.9	16.0	16.5	10.3	97.4	Moderate
SP63	403.9	266.5	247.1	45.7	59.9	204.6	Very Unhealthy

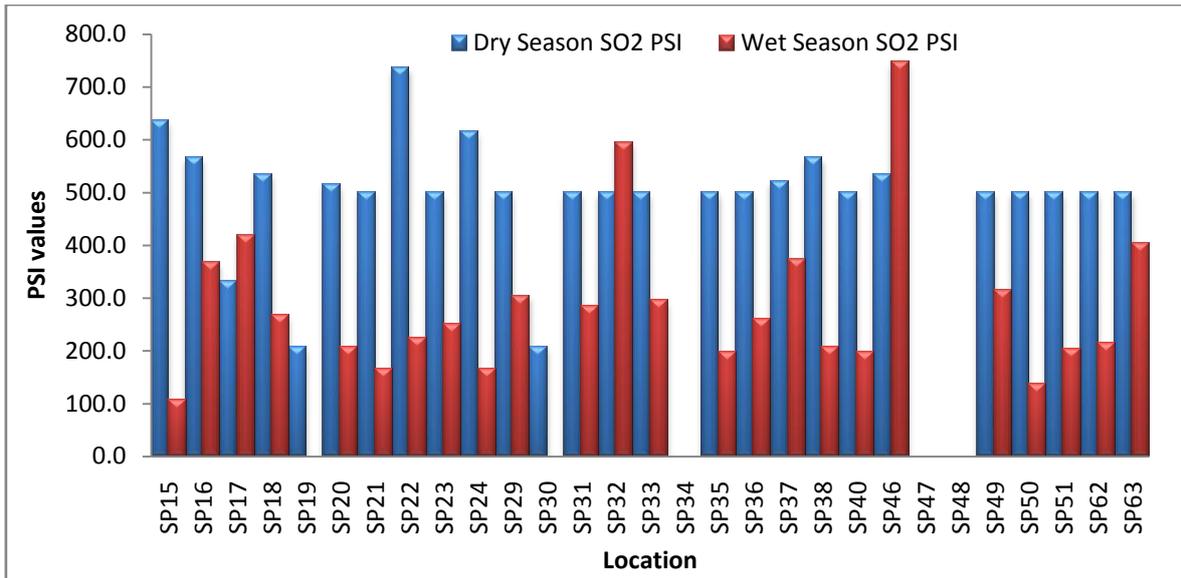


Figure 24: Computed Pollutant Standard Index of SO₂ around Obio/Akpor

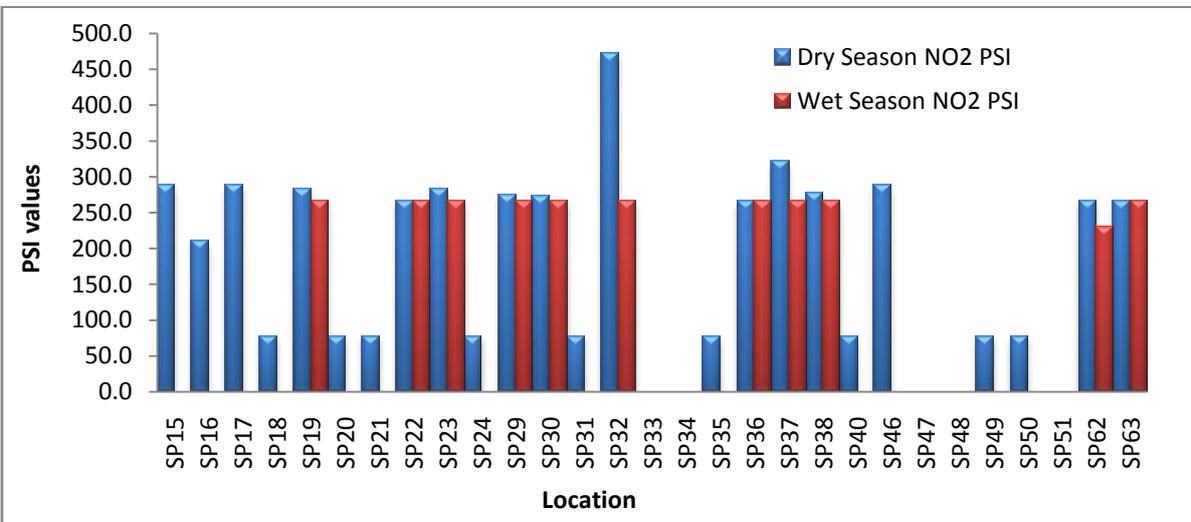


Figure 25: Computed Pollutant Standard Index of NO₂ around Obio/Akpor

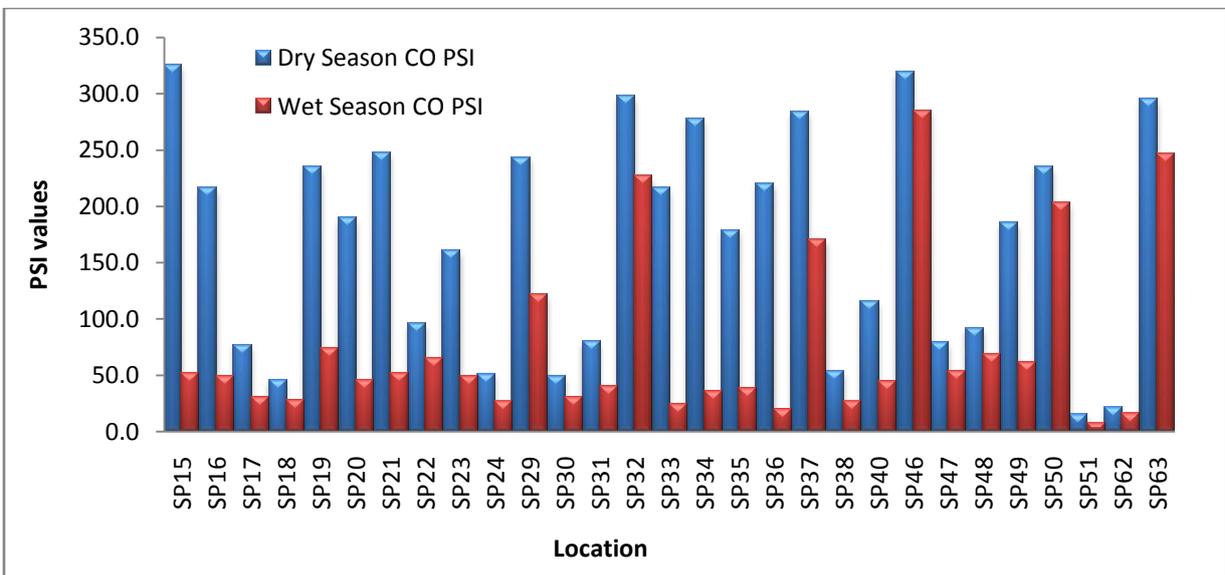


Figure 26: Computed Pollutant Standard Index of CO around Obio/Akpor

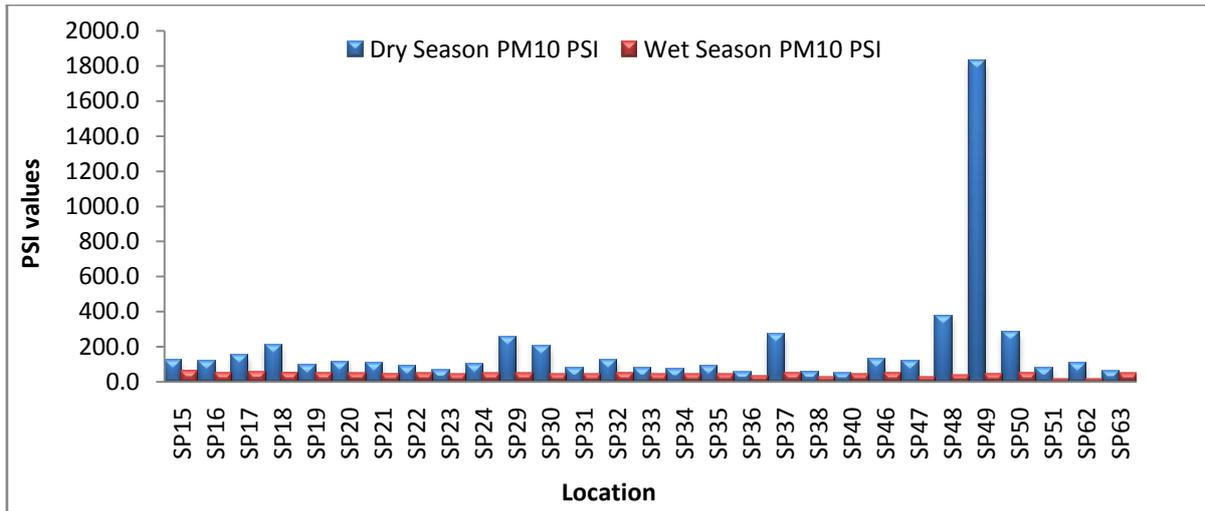


Figure 27: Computed Pollutant Standard Index of PM₁₀ around Obio/Akpor

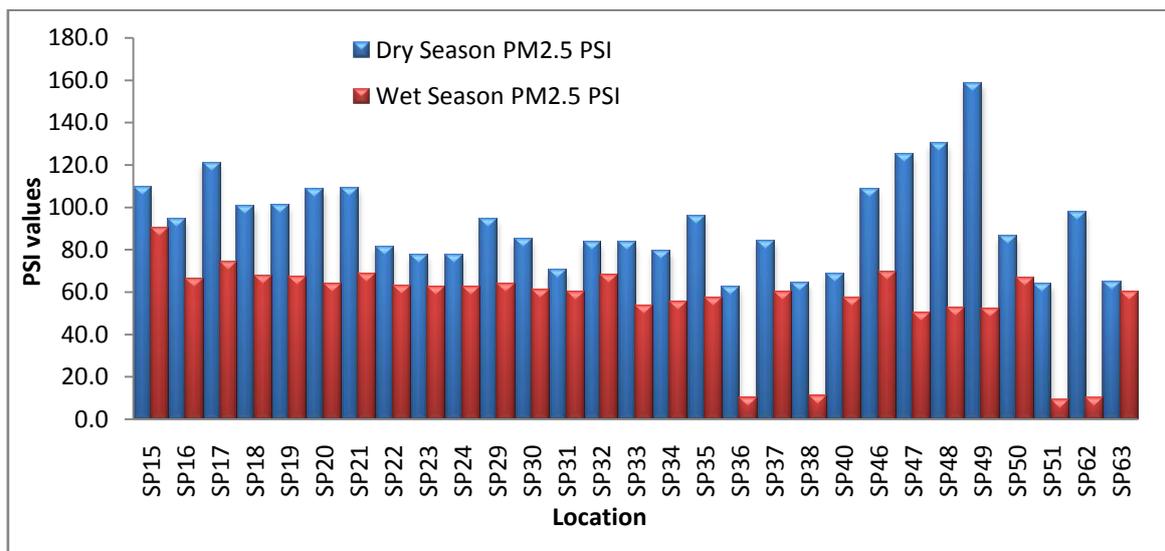


Figure 28: Computed Pollutant Standard Index of PM_{2.5} around Obio/Akpor

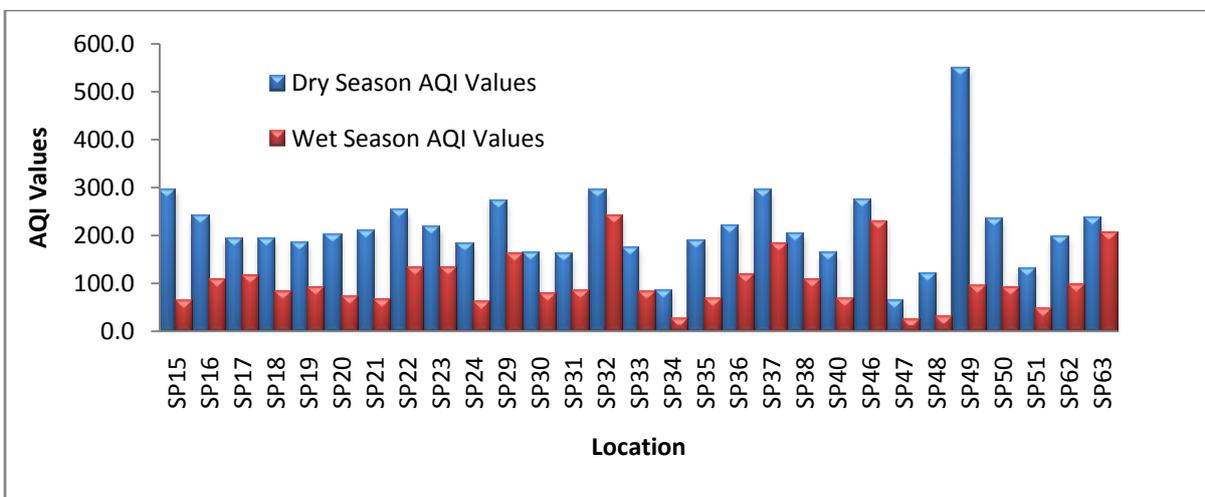


Figure 29: Computed Air Quality Index around Obio/Akpor

Assessment of Air Quality Index of Oyigbo Area

The computed PSI for each pollutant in the wet season in Oyigbo area are shown in Figures 30 to 34, while plots of corresponding AQI values are shown in Figure 35. Computed PSI (Figure 30to 34) showed that SO₂, NO₂ and PM_{2.5} are the main cause of pollution in wet season in the area, however, NO₂ and PM_{2.5} dominate the pollution levels in the wet season.

The wet season computed air quality indices for Oyigbo area (Table 5) showed moderate air quality around stations SP8, SP9 and SP10. This may affect few people and those who are unusually sensitive to particles pollution may experience respiratory symptoms. Also, station SP11 showed very unhealthy air quality in the wet season. This may pose widespread health effects among the people in these areas, and members of sensitive groups may experience more serious effects.

Table 5: Wet Season Pollutant Standard Index and Air Quality Index inOyigbo area

Sampling Point	SO2 PSI	NO2 PSI	CO PSI	PM10 PSI	PM2.5 PSI	AQI	AQI Rating
SP8	0.0	266.5	16.0	29.8	51.4	72.7	Moderate
SP9	0.0	266.5	17.0	30.8	54.1	73.7	Moderate
SP10	104.8	0.0	30.0	51.7	68.5	51.0	Moderate
SP11	534.8	266.5	117.1	54.3	84.1	211.4	Very Unhealthy

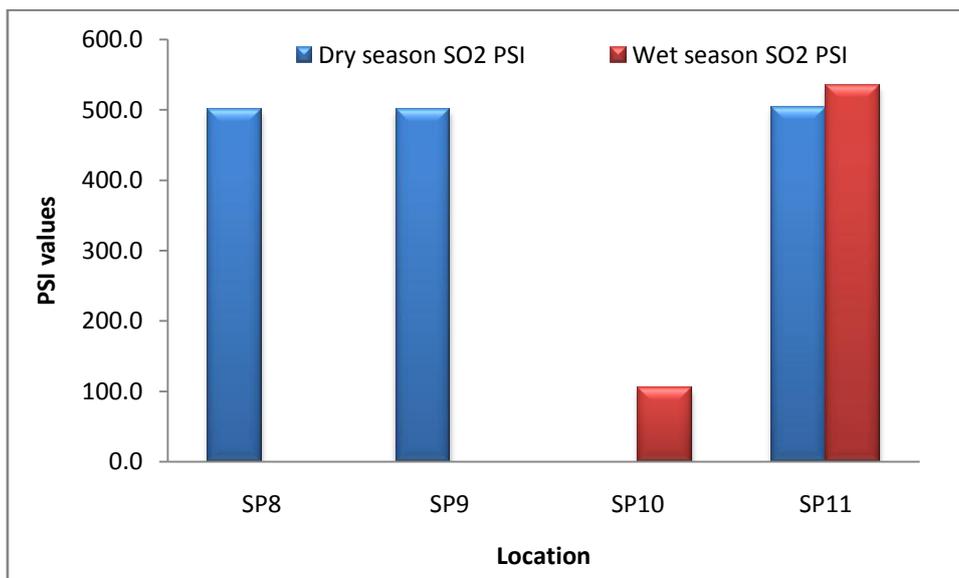


Figure 30: Computed Pollutant Standard Index of SO₂ around Oyigbo

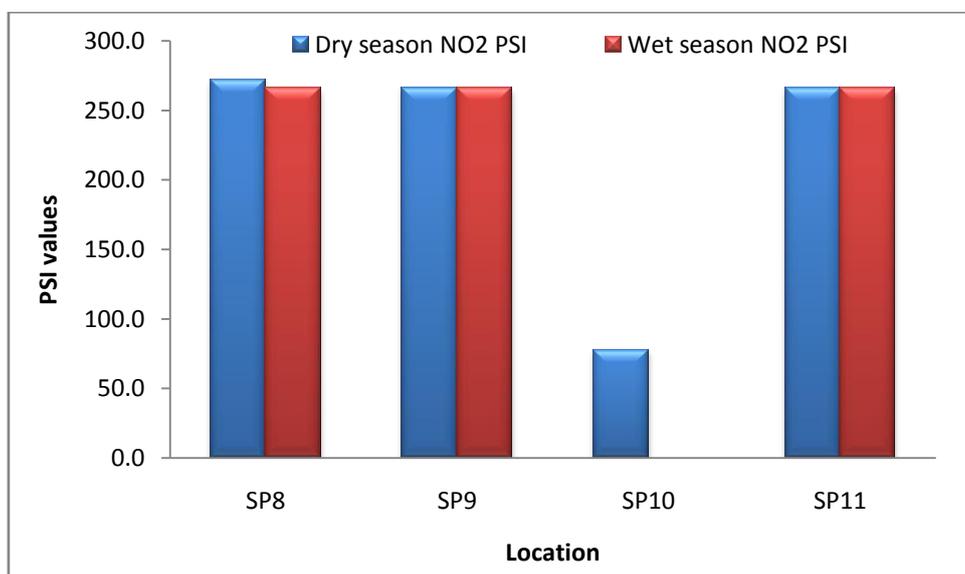


Figure 31: Computed Pollutant Standard Index of NO₂ around Oyigbo

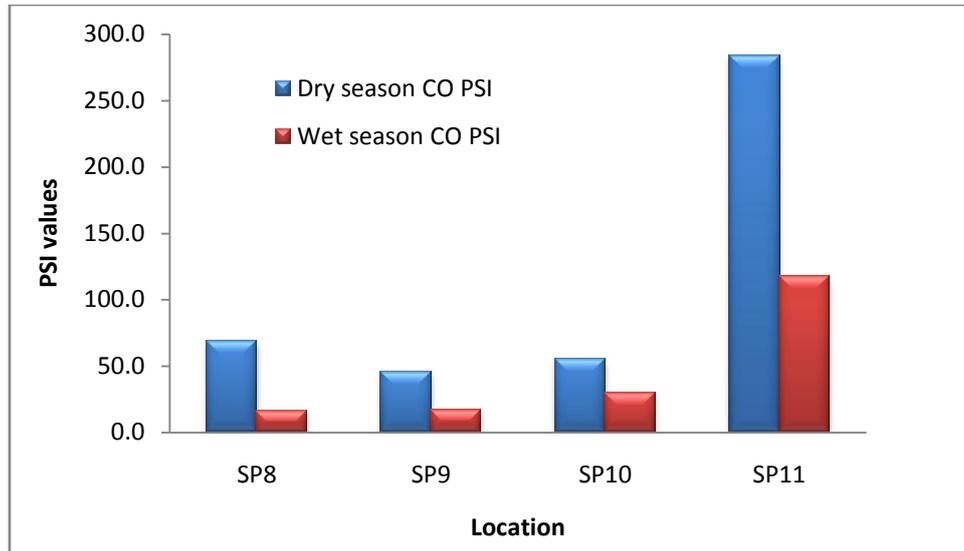


Figure 32: Computed Pollutant Standard Index of CO around Oyigbo

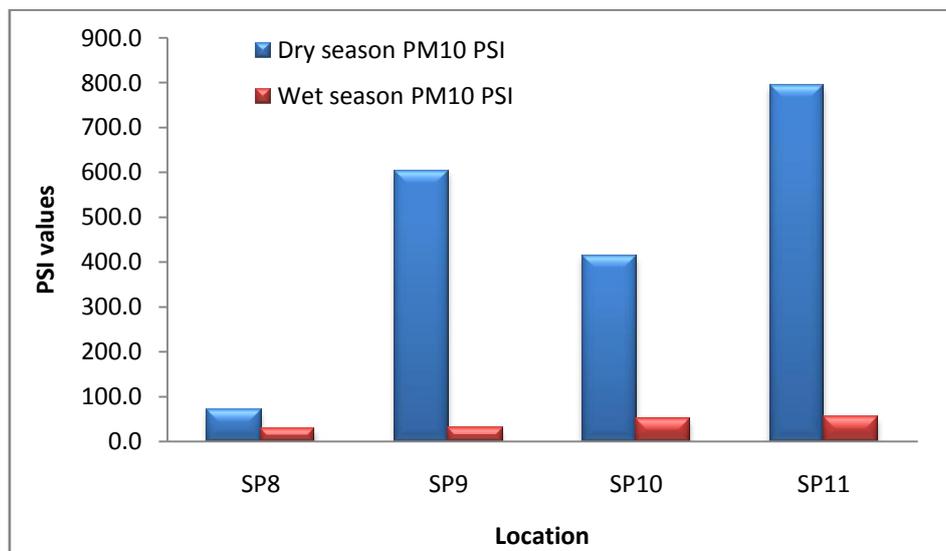


Figure 33: Computed Pollutant Standard Index of PM₁₀ around Oyigbo

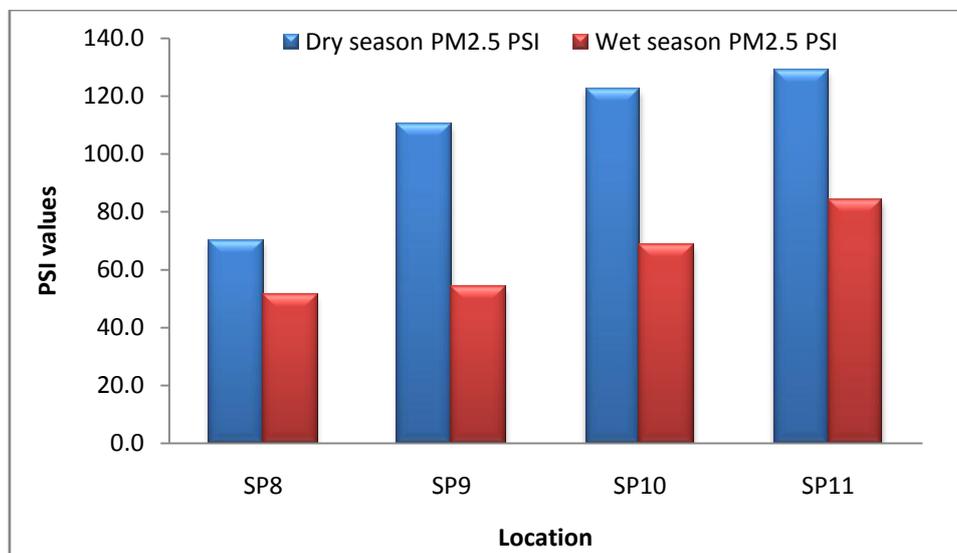


Figure 34: Computed Pollutant Standard Index of PM_{2.5} around Oyigbo

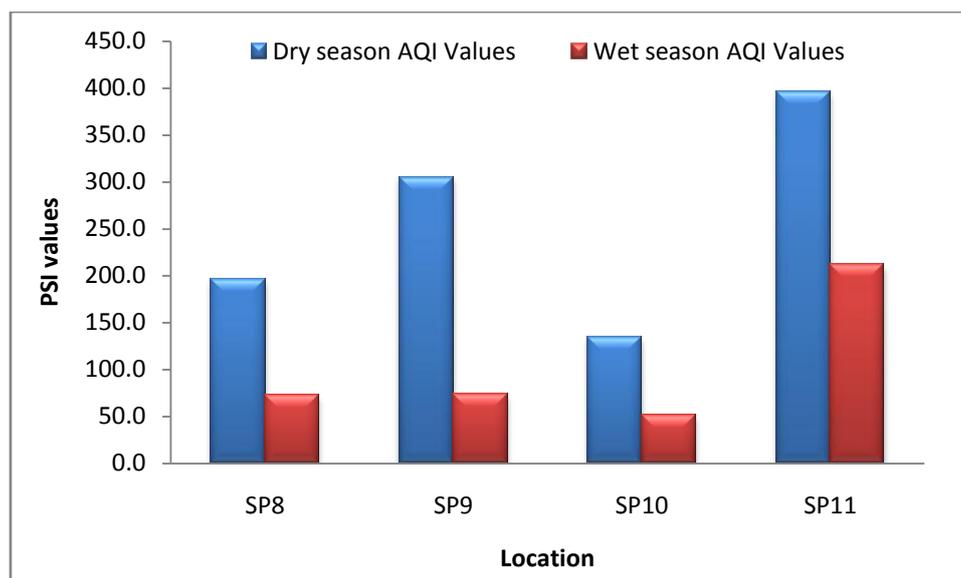


Figure 35: Computed Air Quality Index for Oyigbo

Assessment of Air Quality Index of Port Harcourt Area

The computed PSI for each pollutant in the wet season in Port Harcourt area are shown in Figures 36 to 40, while plots of corresponding AQI values are shown in Figure 41. Computed PSI (Figures 36 to 40) showed that SO₂, NO₂, CO, PM₁₀ and PM_{2.5} are the main cause of pollution in the wet season. This implies that there is high pollution in Port Harcourt which may be caused by vehicular exhaust emissions, gas flaring, oil and gas exploitation, industrial activities as well as road construction activities in the area.

The wet season computed air quality indices for Port Harcourt area (Table 6 and Figure 41) showed moderate air quality around stations SP42, SP43, SP44, SP54, SP55, SP58, SP59, SP61, SP64, SP67, SP69 and SP70. This may affect few people and those who are unusually sensitive to particles pollution may experience respiratory symptoms. Stations SP39, SP41, SP52, SP60, and SP71 showed good air quality which poses minor or no health risk to the people. Stations SP45, SP53, SP57, SP66 and SP68 showed unhealthy air quality for sensitive groups in the wet season. This may affect only sensitive groups while the general public may not be affected. Stations SP56 and SP65 showed unhealthy air quality in the wet season (Table 6). Everyone in these stations may experience health effects; particularly sensitive people with respiratory symptoms may experience more serious health effects.

Table 6: Wet Season Pollutant Standard Index and Air Quality Index inPort Harcourt Area

Sampling Point	SO ₂ PSI	NO ₂ PSI	CO PSI	PM ₁₀ PSI	PM _{2.5} PSI	AQI	AQI Rating
SP39	0.0	0.0	27.0	27.0	51.2	21.0	Good
SP41	0.0	0.0	43.5	42.7	55.9	28.4	Good
SP42	266.9	0.0	28.6	23.7	46.3	73.1	Moderate
SP43	190.6	0.0	28.6	36.6	56.2	62.4	Moderate
SP44	221.1	0.0	60.7	49.9	63.4	79.0	Moderate
SP45	286.5	266.5	82.5	46.7	67.0	149.8	Unhealthy for Sensitive Groups
SP52	0.0	0.0	26.3	35.8	58.8	24.2	Good
SP53	190.6	266.5	17.2	26.3	54.0	110.9	Unhealthy for Sensitive Groups
SP54	351.7	0.0	28.6	27.3	50.8	91.7	Moderate
SP55	383.1	0.0	24.0	29.8	51.7	97.7	Moderate
SP56	383.1	266.5	40.1	34.6	57.6	156.4	Unhealthy
SP57	398.8	183.2	16.0	27.1	50.6	135.1	Unhealthy for Sensitive Groups
SP58	289.8	0.0	29.8	29.7	53.5	80.6	Moderate
SP59	224.3	0.0	27.5	19.6	43.3	62.9	Moderate
SP60	0.0	0.0	26.3	17.8	39.6	16.7	Good
SP61	227.6	0.0	137.1	54.5	66.2	97.1	Moderate
SP64	293.0	0.0	24.0	20.1	50.5	77.5	Moderate
SP65	398.8	266.5	19.5	28.9	54.2	153.6	Unhealthy
SP66	304.6	0.0	201.0	31.9	62.6	120.0	Unhealthy for Sensitive Groups
SP67	211.2	0.0	90.5	25.6	53.8	76.2	Moderate
SP68	403.9	0.0	137.1	26.5	47.9	123.1	Unhealthy for Sensitive Groups
SP69	214.5	0.0	0.0	22.2	45.0	56.3	Moderate
SP70	211.2	0.0	84.7	23.8	45.0	73.0	Moderate
SP71	0.0	0.0	19.5	18.8	37.5	15.2	Good

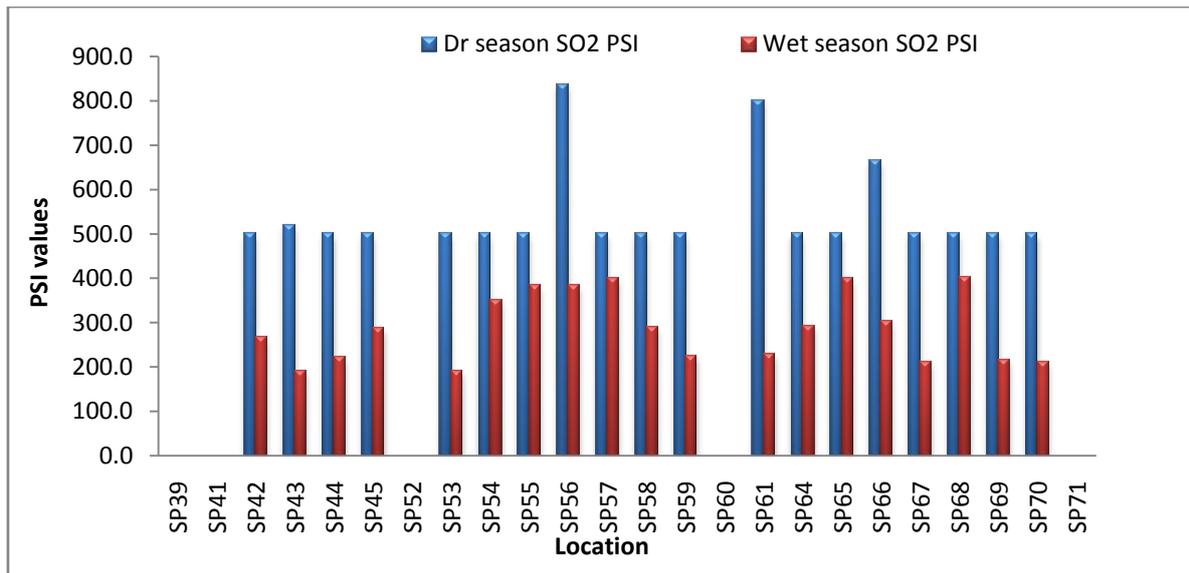


Figure 36: Computed Pollutant Standard Index of SO₂ around Port Harcourt Area

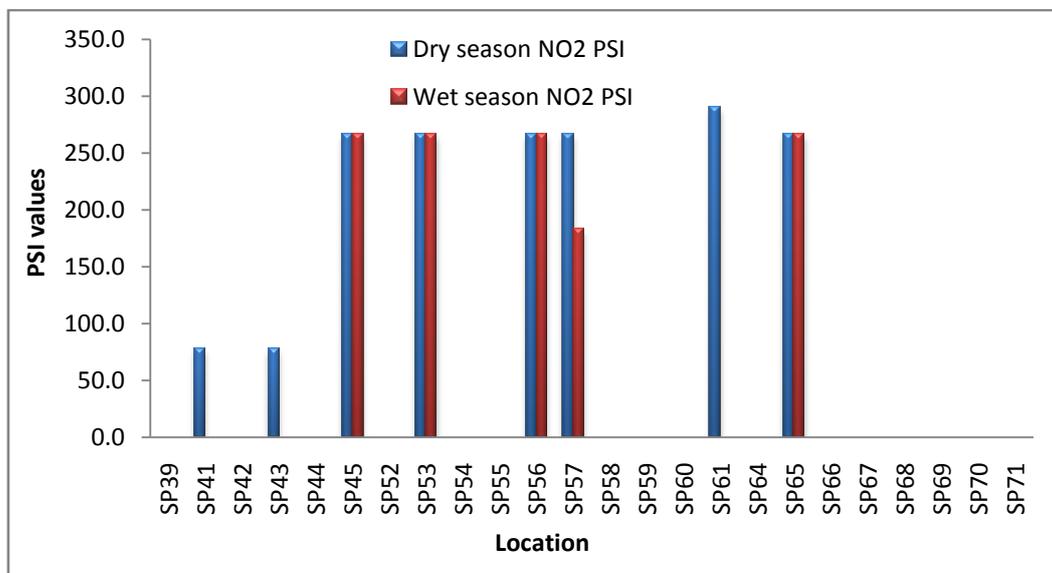


Figure 37: Computed Pollutant Standard Index of NO₂ around Port Harcourt Area

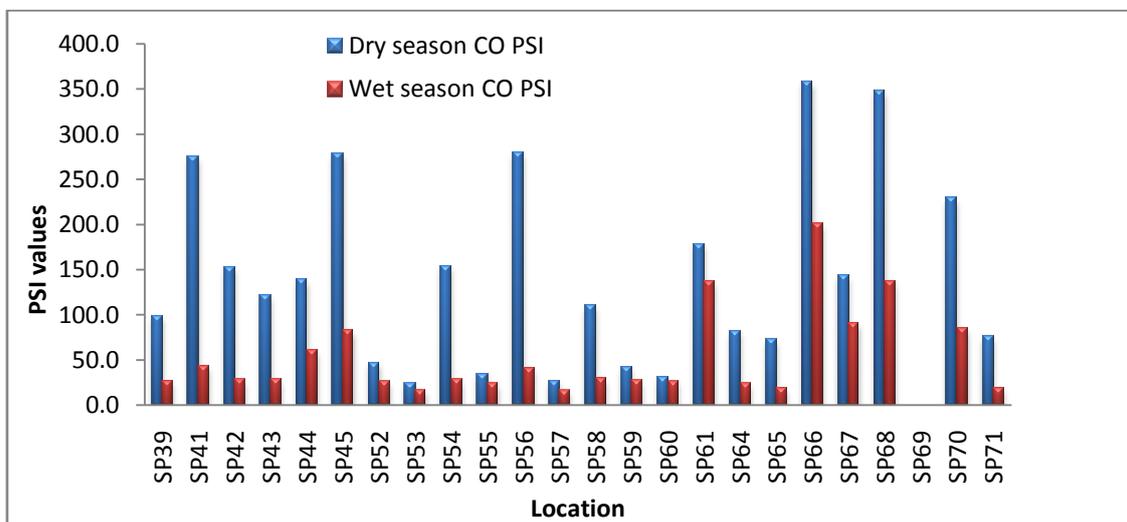


Figure 38: Computed Pollutant Standard Index of CO around Port Harcourt Area

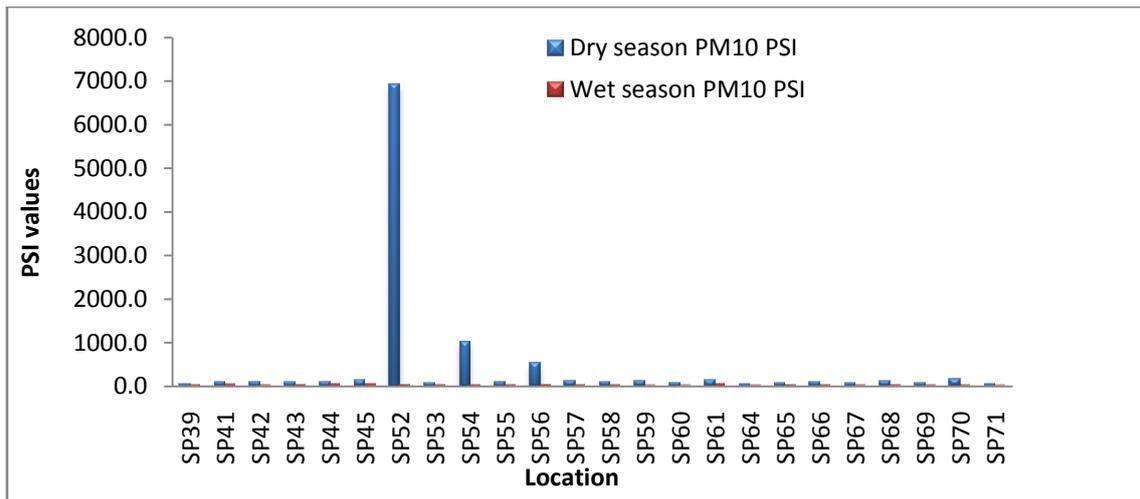


Figure 39: Computed Pollutant Standard Index of PM₁₀ around Port Harcourt Area

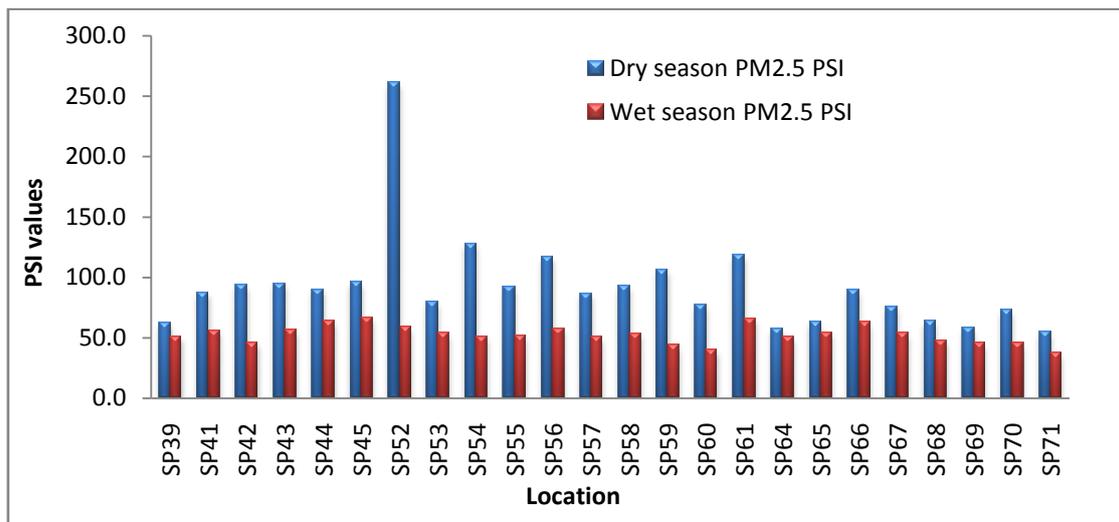


Figure 40: Computed Pollutant Standard Index of PM_{2.5} around Port Harcourt Area

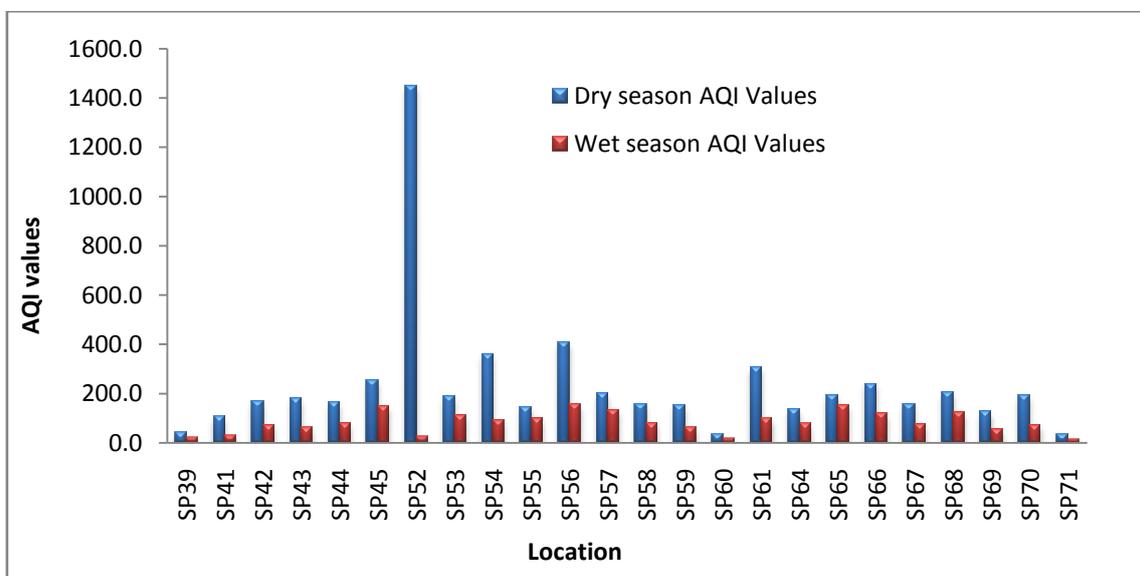


Figure 41: Computed Air Quality Index for Port Harcourt Area

IV. Conclusion

Computed PSI revealed that SO₂, NO₂, CO, PM₁₀ and PM_{2.5} are the prevalent air pollutants that cause pollution in the wet season. Results of AQI showed that, Eleme followed by Obio/Akpor and Port Harcourt areas are more polluted compared to Oyigbo, Ikwerre and Etche in the wet season.

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