Original Research Paper

EFFECTS OF SOME METEOROLOGICAL PARAMETERS ON VISIBILITY IN THE NIGER DELTA REGION OF NIGERIA

ABSTRACT:

Effects of meteorological parameters of relative humidity and wind direction on visibility in the Niger Delta, Nigeria (4.15˚N-7.17˚N, 5.05˚E-8.68˚E) for a period of 31 years (1981-2012) have been investigated. The data on visibility, relative humidity and wind direction were obtained from Nigerian Meteorological Agency (NIMET) and National Center for Environmental Prediction (NCEP) respectively. The visibility and meteorological data were analyzed to study the temporal variation of atmospheric visibility and its relationship with meteorological parameters in the region. The analysis was done using statistical techniques and the results show that cities in the Eastward (Calaber, Uyo and Port Harcourt) have more inverse correlation between Relative humidity and visibility while Westward cities (Owerri, Warri and Akure) are more directly correlated to visibility. Again it shows that visibility is more correlated with relative humidity in places of high hydrocarbon activities like Port Harcourt while it is better correlated with wind direction in places with less hydrocarbon activities like Akure.

Keywords: Meteorological, Parameters, Visibility, Niger Delta, Nigeria.

1: Introduction:

Due to increased urbanization and industrialization the Niger Delta of Nigeria is also included with other developing economies in the world to face air pollution problem. The aerosol is causing serious air pollution with large amount of land being exploited on the industrial scale, increased traffic, factories and workshops in the region (Okoro et al., 2014). Episodes of air pollution happen very often that they have aroused much concern to the government and the general public. Meteorological phenomena such as relative humidity and temperature are known to be natural causes of changes in aerosol extinction coefficient and decrease in atmospheric visibility. These meteorological parameters influence visibility through dispersion of aerosols or by changing their properties or formation and removal rate (Zhang et., al 2010). It is well known that the atmospheric visibility varies significantly with regions and season (Cuhadaroglu et al., 1997, Goyal et al., 2014). Visibility is directly affected by the anthropogenic air pollution on the other hand, it is influenced by the meteorological conditions (Deng et al., 2014). In addition to the air pollutants, the meteorological parameters (i.e., wind speed and direction, relative air humidity, air temperature, atmospheric pressure and precipitation) can also directly or indirectly affect atmospheric visibility as they influence the local and regional air quality in urban areas (Tai, et al., 2015; Du et al., 2013; Majewski et at., 2014; Chen et al.,2014).This study aimed to find out the important roles played by the meteorological parameters such as relative humidity and wind direction on the variation and evaluation of atmospheric visibility in the region over the period under investigation.

2: STUDY AREA:

Figure (1) shows the map of Nigeria indicating the Niger Delta states. The Niger Delta area in Nigeria is situated in the Gulf of Guinea between longitude (5.05°E-7.17°E) and latitude (4.15° N- 7.17°N). It is the largest wetland in Africa and the third largest in the world consisting of flat low lying swampy terrain that is cress crossed by streams, rivers and creeks. It covers 20,000km^2 within wetlands of 70,000km^2 formed primarily by sediment depositions. It records an average annual rainfall of 2400-4000mm. The area is influenced by the localized convection of the West African monsoon with less contribution from the mesoscale and synoptic system of the Sahel (Ba et al., 1995). The rainy (wet) season over the region starts in May, following the seasonal northward movement of the Intertropical Convergence Zone (ITCZ), with its cessation in October (Druyan et al., 2010; Xue et al., 2010). It has an equatorial monsoon climate influenced by the south west monsoonal winds (maritime tropical) air mass coming from the South Atlantic Ocean. It is home to 20 million people drawn from nine states of the federation namely Abia, Akwa-ibom, Bayelsa, Cross- River, Delta, Edo, Imo, Ondo and Rivers states with 40 different ethnic groups. This flood plain makes 7.5% of Nigeria's total land mass (Baird, 2010). The study is restricted to six states in the Niger Delta namely Warri, Owerri, Calabar, Akure, Uyo and Port Harcourt because there are no available data in the remaining stations at Yenegoa, Umuahia and Asaba (Nwokocha et al., 2016) as shown in Table 1.

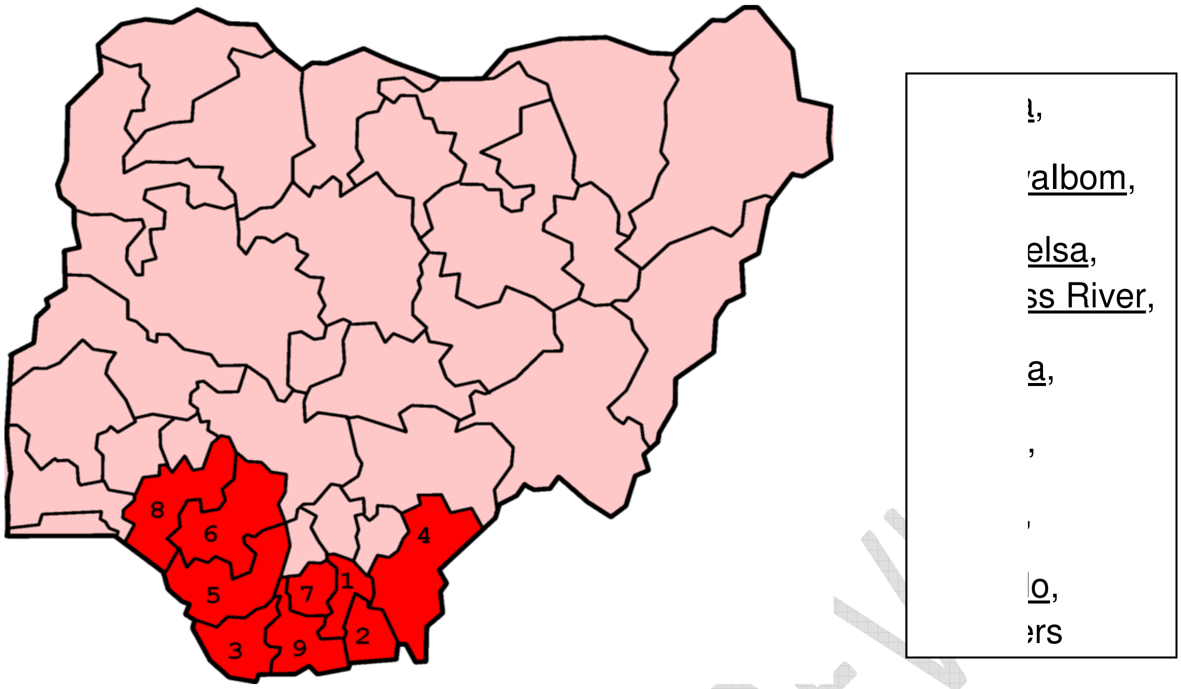


Fig 1: Map of Nigeria showing the Niger Delta region (5.05°E-8.68°E and latitude 4.15° N – 7.17 °N) shaded with colors.

Table 1: Coordinates of the study locations, their elevations and duration of study.

S/N	LOCATIONS	LAT(N)	LONG(E)	ELEVATION(M)	DURATION OF STUDY
1.	CALABAR	4.976	8.347	47.0	1981-2012
2.	UYO	5.038	7.909	65.0	1981-2012
3.	PORTHARCOURT	4.8156	7.0498	468.0	1981-2012
4.	OWERRI	5.483	7.0176	71.0	1981-2012
5.	WARRI	5.516	5.750	6.0	1981-2012
6.	AKURE	7.247	5.301	335.0	1981-2012

Data availability and Methodology

A 31 years record of mean horizontal visibility data for some coastal weather stations in the Niger Delta Region Nigeria between (1981-2012) for Calabar (8.32°E, 4.95°N), Uyo

(7.91°E,5.03°N), Port Harcourt (7.00°E, 4.75°N), Owerri (7.03°E, 5.48°N), Warri (5.75°E, 5.52°N, Akure (5.19°E, 7.25°N), was obtained from Nigerian Meteorological Agency Abuja (NIMET) which is the agency responsible for collecting and archiving meteorological data in Nigeria. The reanalysis data for wind direction and relative humidity for the period (1981-2012) was collected from the National Centre for Environmental Prediction (NCEP) and it is available online at (http://www.ncep.noaa.gov). These were extracted using Grid Analysis Display system (Grads) prepared on a resolution of 2.5° by 2.5° global grid (approximately 280km). However, being conscious of the limitations that visibility presents, analysis was carried out on the region using the following statistical criteria.

Anomaly:

In a bid to compare the capability of each of the dataset in spatial scales, the monthly visibility anomalies of the datasets were computed from the horizontal meteorological means using the following equation.

$$X' = X - \overline{X}$$

Where,

x = the monthly visibility data from each of the datasets and

$\overline{X}$ = the corresponding horizontal climatological mean for that month.

3.2.2. Normalization:

The monthly horizontal visibility anomalies were normalized with the aim of putting the datasets on the same scale for comparison as well as to eliminate the influence of location and spread in the various datasets. This is achieved by the following equation.

$$z = \frac{X' - \overline{X}'}{S_{X'}}$$

Where,

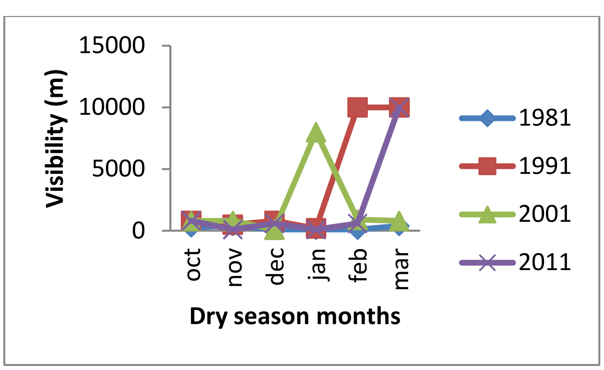
X' = the monthly horizontal visibility anomaly of each dataset,

$\overline{X}'$ = the mean of the total monthly horizontal visibility anomaly over the period and

S = the corresponding standard deviation from x′.

3: Results and Discussion

3.1: Impacts of Relative Humidity on Visibility



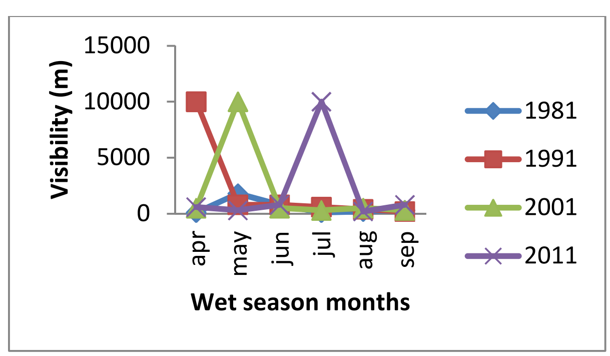


Figure 2 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for visibility in Calabar.

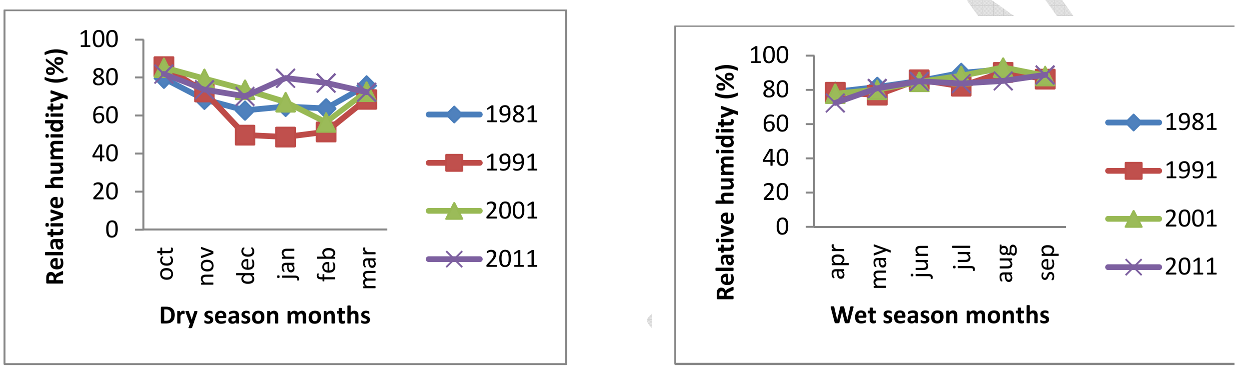


Figure 2 (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Calabar

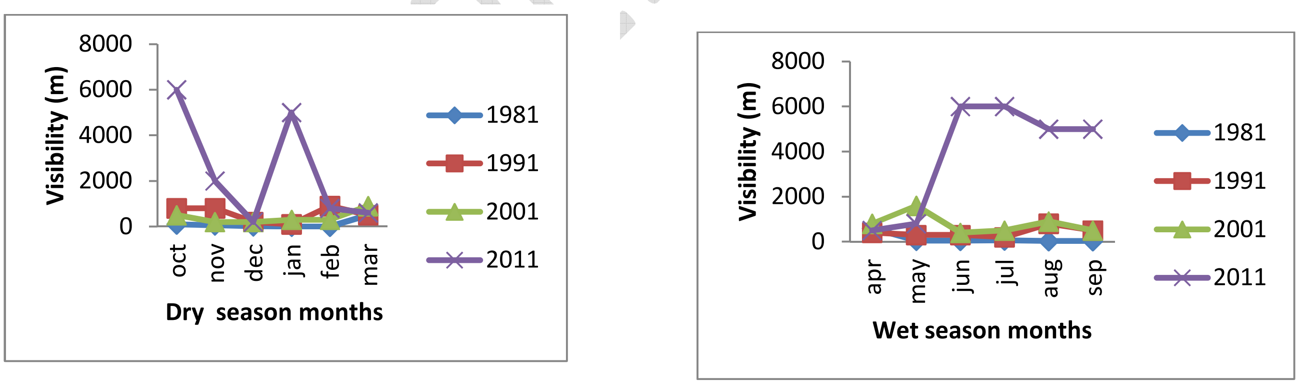


Figure 3 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Uyo.

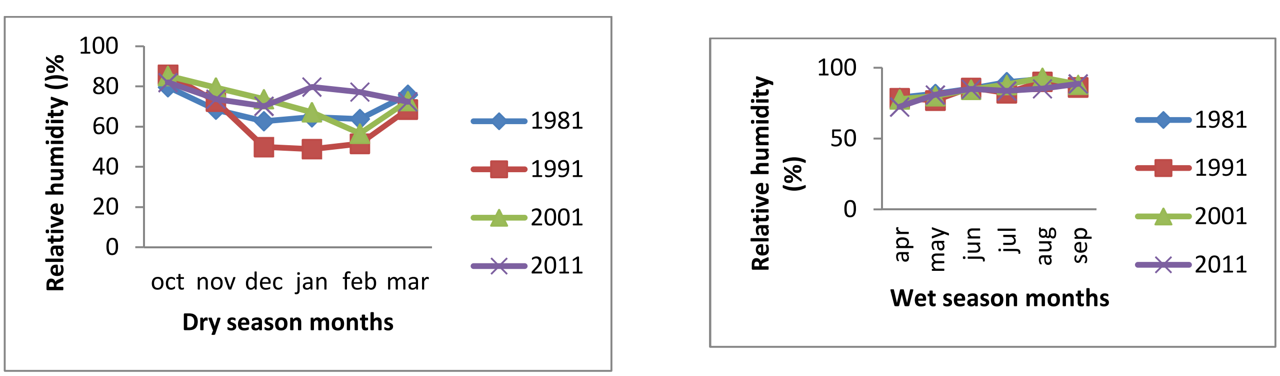


Figure 3 (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Uyo.

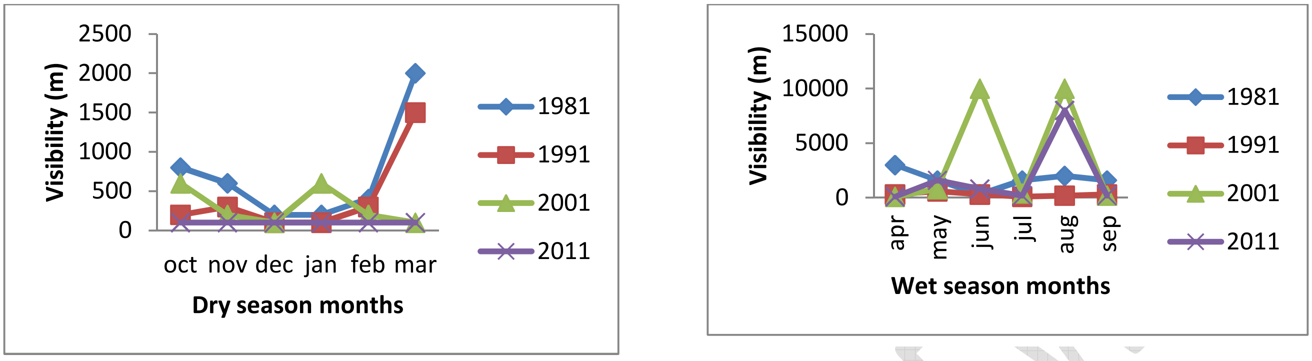


Figure 4 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Port harcourt.

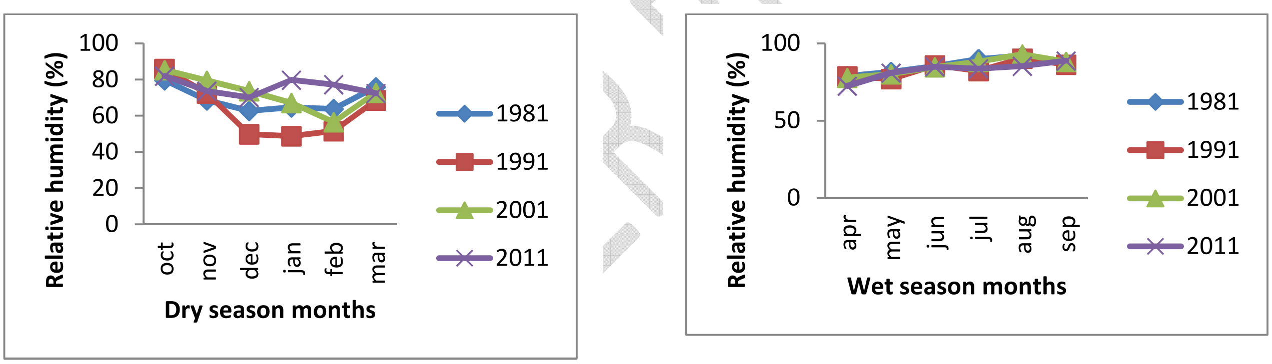


Figure 4. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Port harcourt.

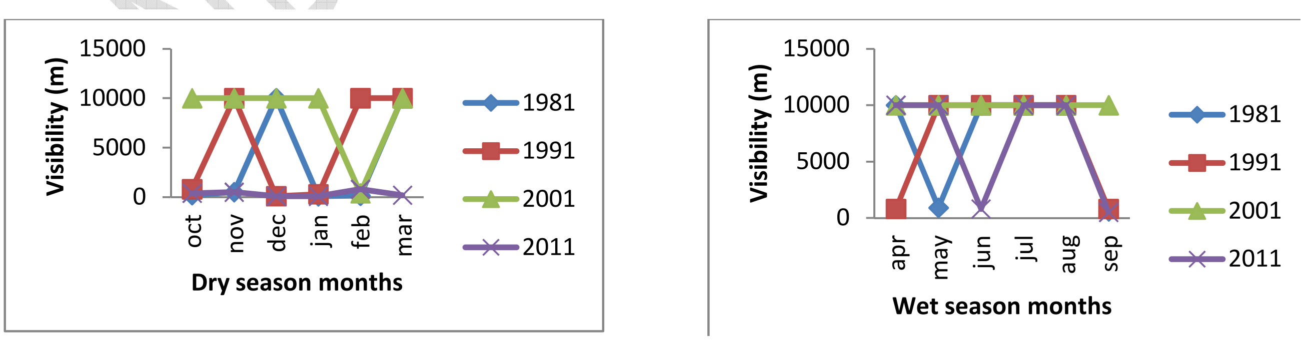


Figure 5 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Owerri.

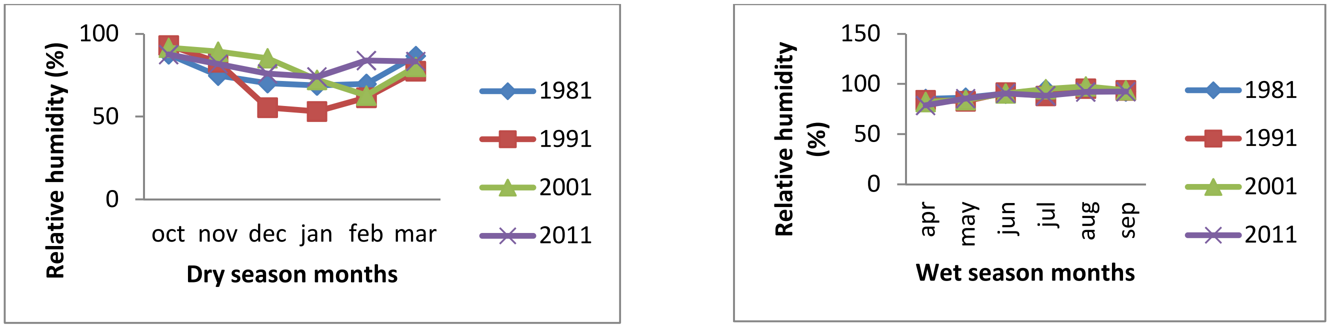


Figure 5 (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Owerri.

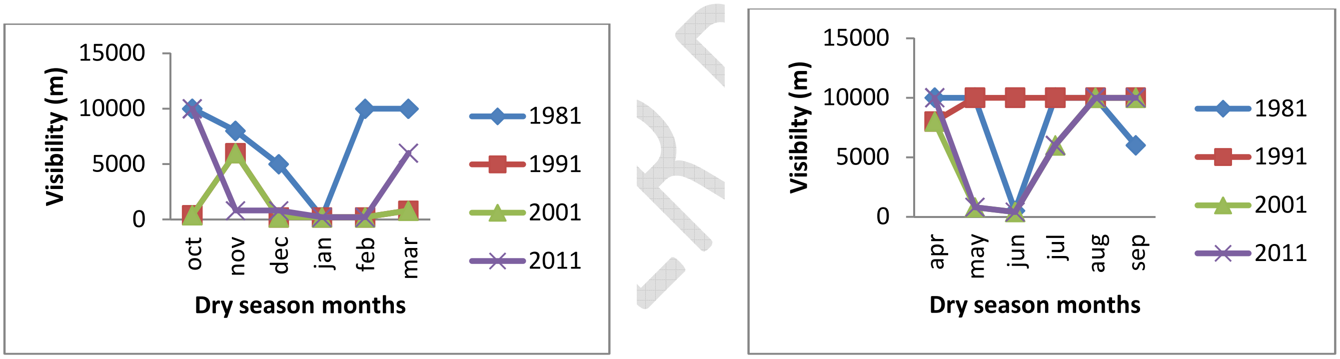


Figure 6 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Warri.

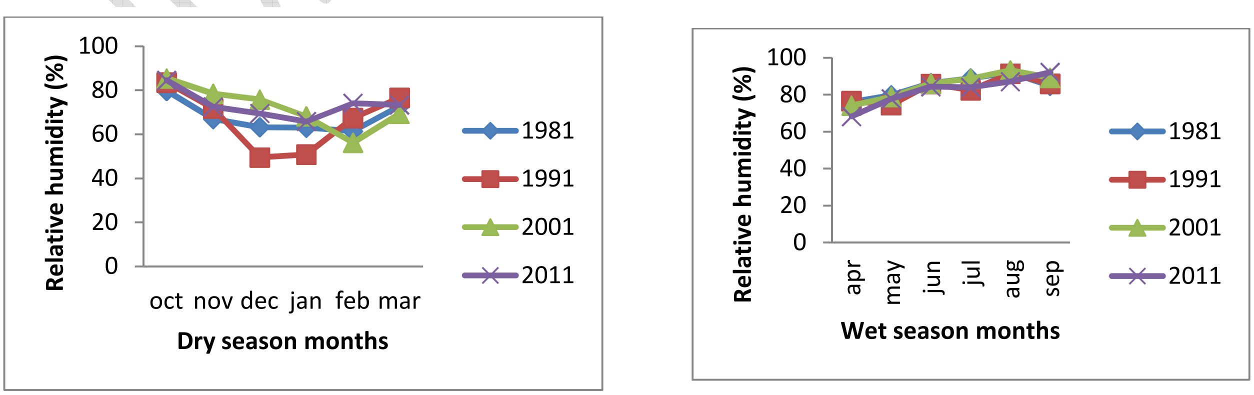


Figure 6. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Warri.

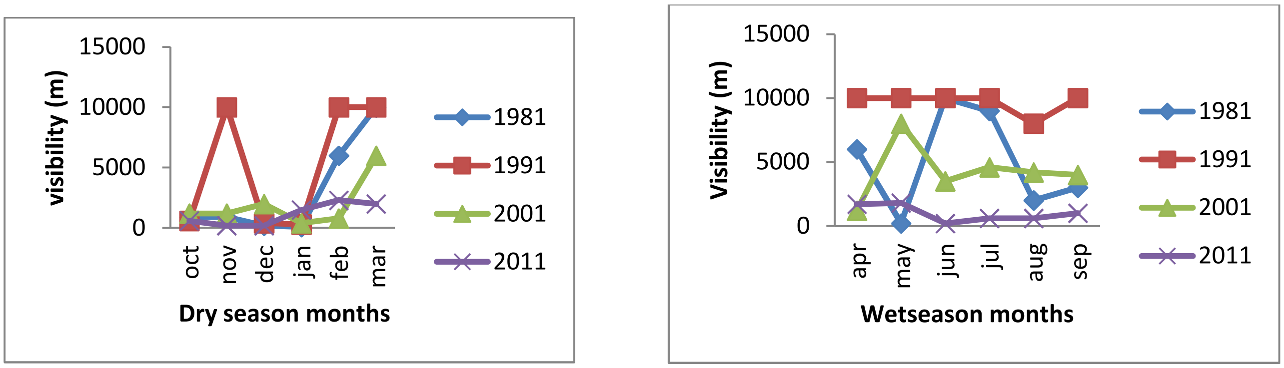


Figure7 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Akure.

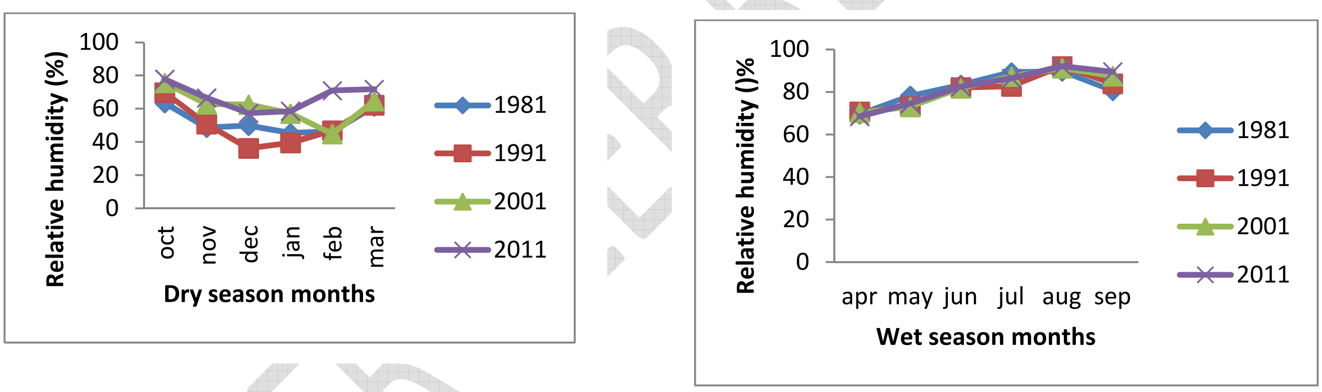


Figure 7 (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Relative humidity in Akure.

3.2: Impacts of Wind Direction on Visibility

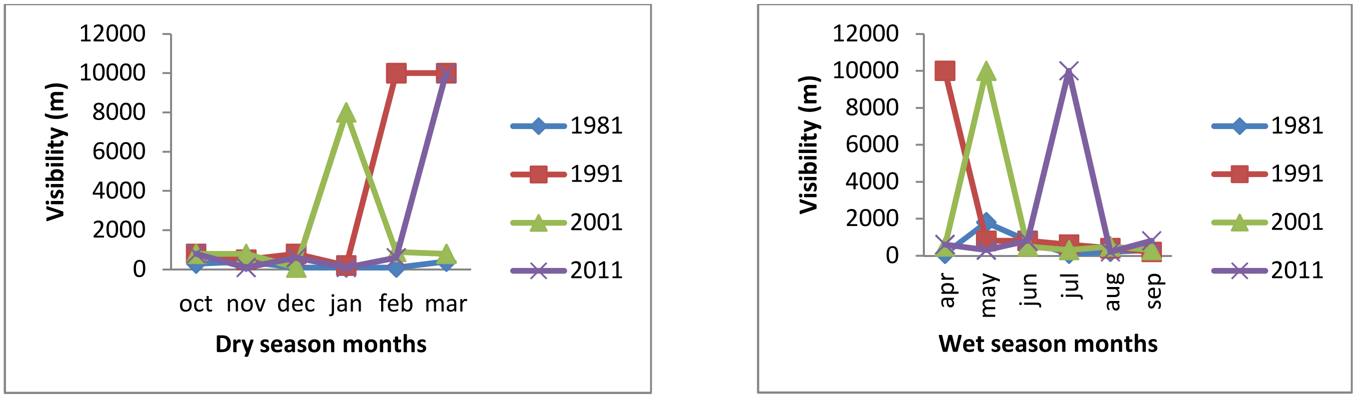


Figure 8 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Calabar.

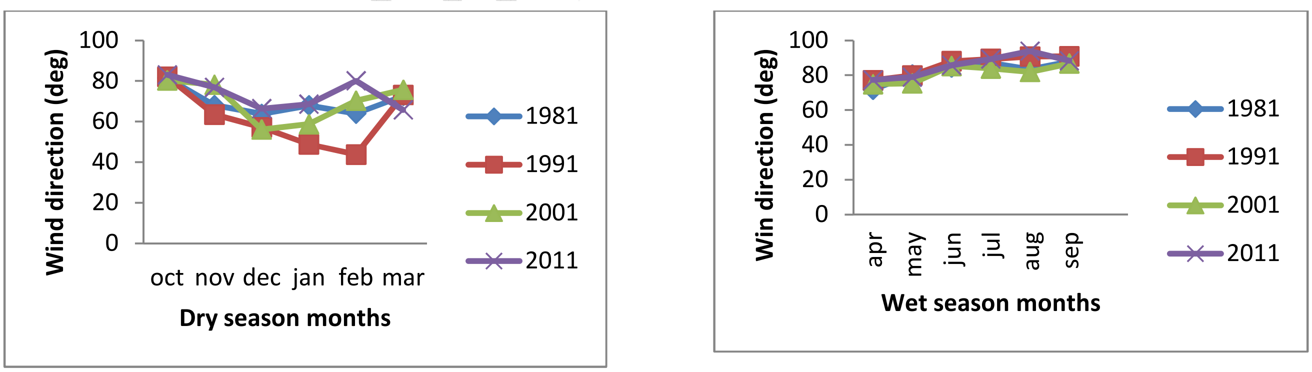
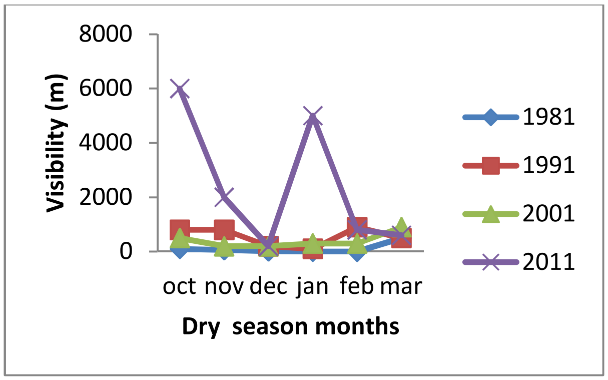


Figure 8. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Calabar.



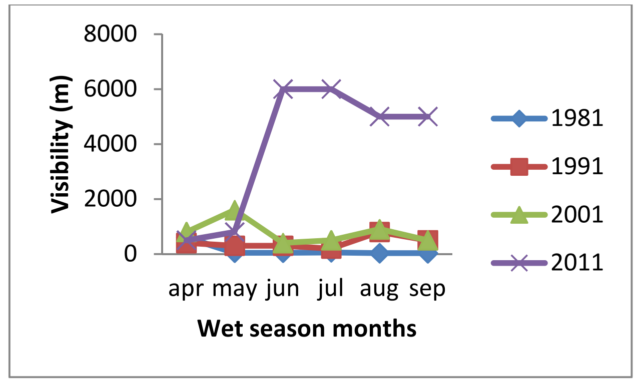
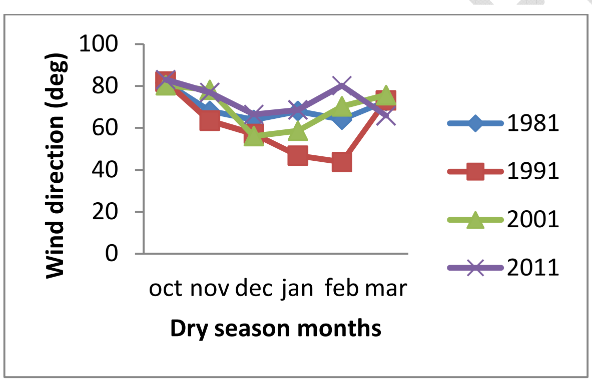


Figure 9 (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Uyo



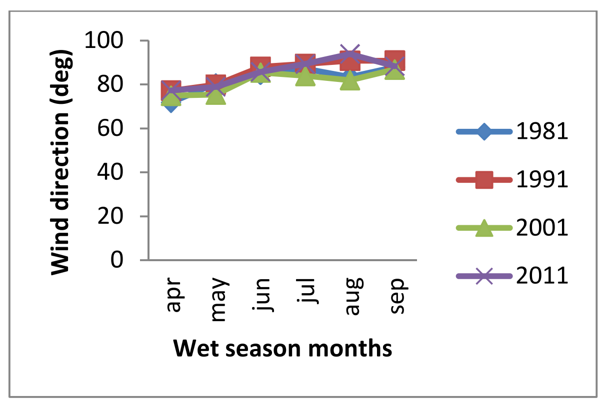


Figure 9. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Uyo.

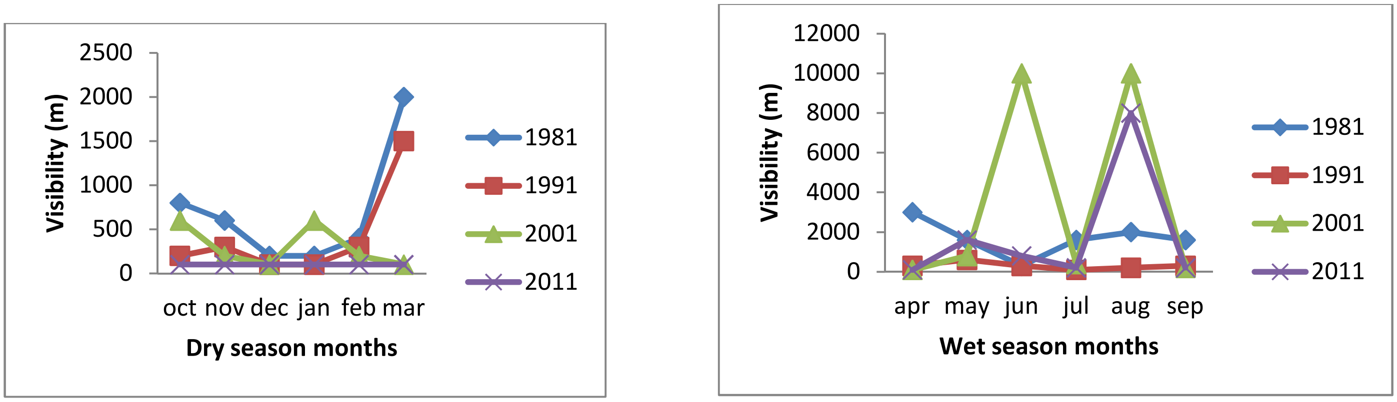


Figure 10. (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Port harcourt.

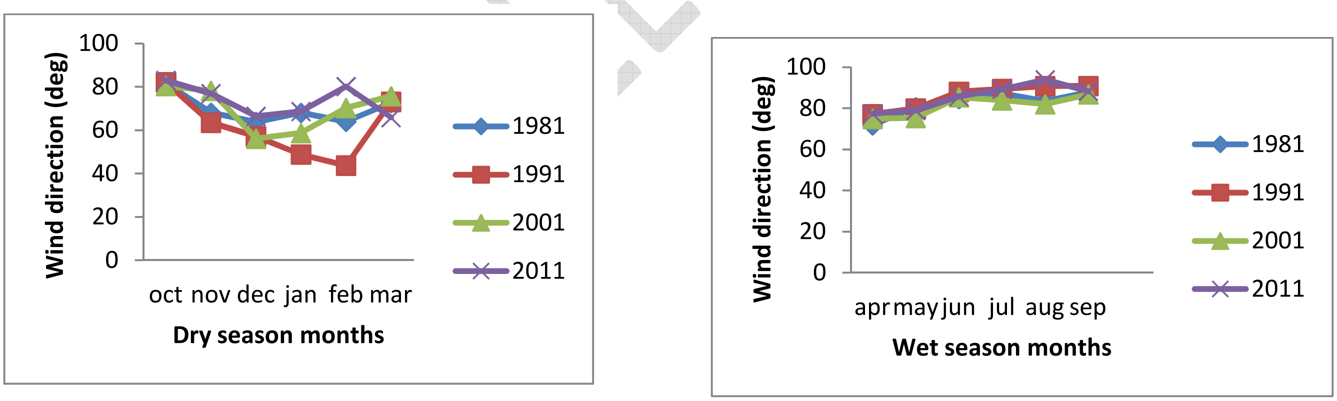


Figure 10. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Port harcourt.

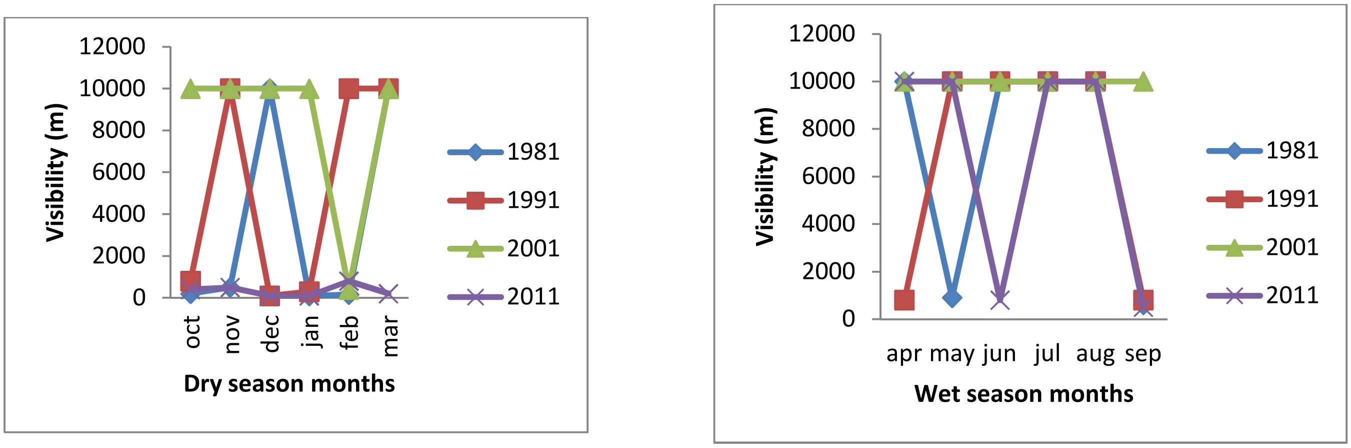


Figure 11. (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Owerri.

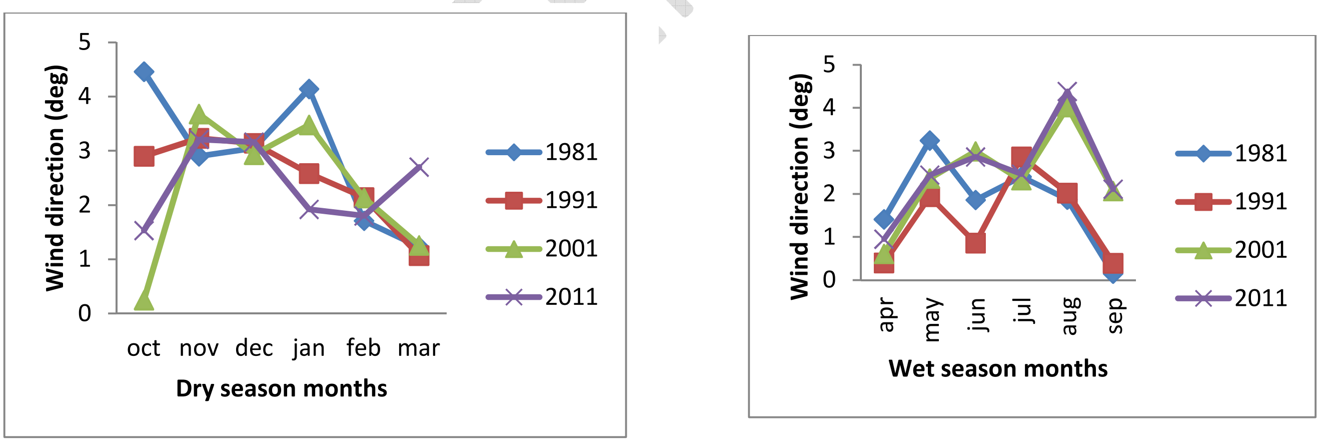


Figure 11. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Owerri.

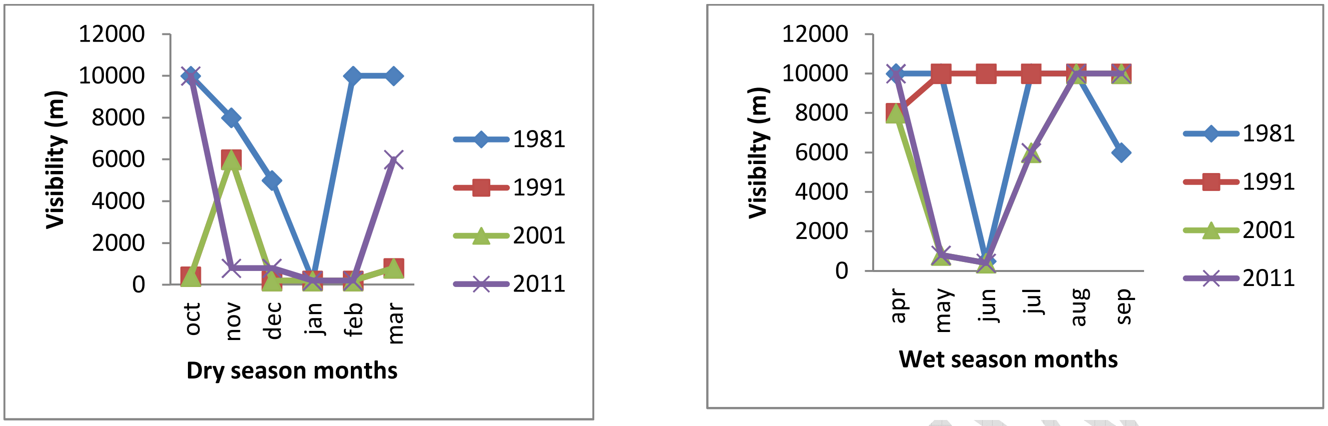


Figure 12. (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Warri.

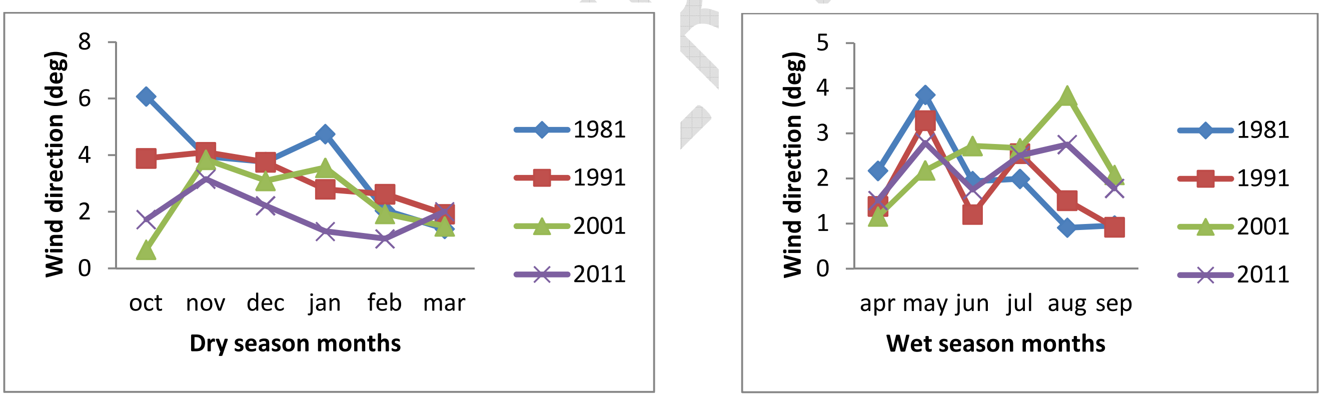


Figure 12. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Warri.

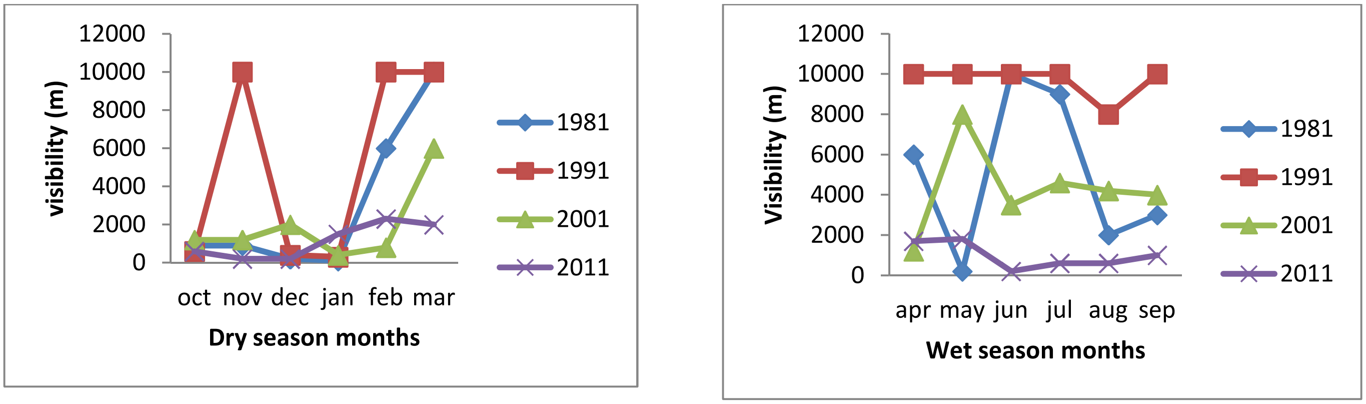


Figure 13. (a) Seasonal patterns for (i) dry season months and (ii) wet season months for Visibility in Akure.

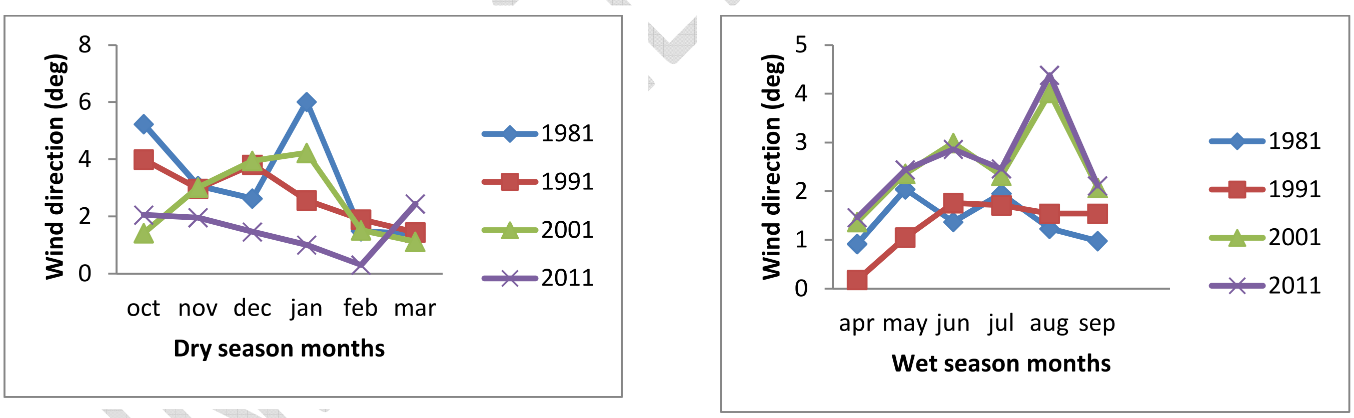


Figure 13. (b) Seasonal patterns for (i) dry season months and (ii) wet season months for Wind direction in Akure.

Due to the resolution of the Datasets, NCEP has a grid box representing each of Relative humidity and wind direction. Figures 2(a/b) to 7(a/b) shows the numerical graphic representation of Visibility and Relative humidity while figures 8(a/b) to 13(a/b) shows the numerical graphic representation of Visibility and Wind direction for Calabar, Uyo, Port Harcourt, Owerri, Warri and Akure respectively for the years 1981, 1991, 2001 and 2011. The graphs indicate that cities that are more Eastward (Calabar, Uyo and Port Harcourt) show more inverse correlation between Relative humidity and visibility. This result is expected because visibility is reduced when relative humidity is high and vice versa. This is because when relative humidity is low, water cannot condense to form low visibility. It is when water content in the atmosphere is high that condensation will take place to give rise to low visibility. Another important point here is that these cities are more or less in the area of high concentration of the hydrocarbon particles produced by industries. The high relative humidity in the atmosphere is able to dissolve the high concentration of hygroscopic particulate in the atmosphere that leads to worsening visibility. On the other hand, cities that are Westward (Owerri, Warri and Akure) the relative humidity in the region tends to be more directly correlated to the visibility in these cities. This relationship is also enhanced by the fact that these cities are not in the main center of the hydrocarbon hub and hence lacks hygroscopic particulate in the atmosphere which could combine with the relative humidity to foster the expected inverse relationship between relative humidity and Visibility. This is the reason why cities more westward tend to have direct correlation between relative humidity and visibility. This result obtained for the impact of relative humidity on visibility indicates a vital point that underscores the fact that relative humidity alone without the presence of hygroscopic particulates in the atmosphere (as it is in the westward cities of the Niger Delta Region) cannot influence visibility much; this is in line with result by Owoada et al (2012). The result shows that relative humidity alone does not affect visibility as much as when (water vapour) there is also the presence of hygroscopic particulates in the atmosphere.

There is an obvious inverse reaction observed between Wind direction and visibility throughout the cities in the Region. This means that as the wind direction increases the visibility reduces and vice versa. This result is also expected because there is a direct correlation between wind speed and wind direction and an inverse correlation between wind speed and wind direction, hence the relation between wind direction and visibility is an inverse correlation. This is because increasing wind direction will give rise to more dust which will be blown into the atmosphere to cause reduction in visibility. There was no observed difference between cities that are more eastward and those that are more westward but rather the following trend were noticed, Calabar had a better inverse relationship between wind direction and visibility followed by Akure, Owerri, Uyo, Warri in that order while Port Harcourt is with the least inverse correlation between wind direction and visibility. This could be due to the presence of heavy hydrocarbons particulate in the atmosphere which could have highly suppressed wind phenomena over Port Harcourt leading to equal values of indirect and direct correlation between wind direction and visibility (Nwokocha & Okujagu., 2016).

5: Conclusion

The impacts of Relative humidity and Wind direction on Visibility in the Niger Delta Region has been carried out with 31-years (1981-2012) period of horizontal visibility data from NIMET and re-analysis data from NCEP for Relative humidity and Wind direction for Calabar, Uyo, Port Harcourt, Owerri, Warri and Akure. The study shows that Visibility is not only influenced by concentrated air pollutants but also by complicated meteorological factors such as relative humidity, wind speed and atmospheric pressure.

This comparison does not provide all the uncertainties that would be found from each of the dataset over the Niger Delta but it’s a measure of the expected minimum uncertainty in the dataset which should guide scientists and researchers carrying out studies on regions of this scale.

Ethical: NA

Consent: NA

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