

METEOROLOGICAL VARIABLES THAT AFFECT VISIBILITY DEGRADATION AND THEIR SEASONAL TRENDS IN THE NIGER DELTA REGION OF NIGERIA

Abstract:

The study of visibility in the Niger Delta region is necessary because it reflects the atmospheric changes caused by economic expansion in Nigeria. Cities in the Niger Delta (especially Port Harcourt) are the most polluted cities in the country and therefore visibility degradation has become one of the major environmental challenges in Nigeria. Analysis of a 31 years (1981-2012) Horizontal visibility data and mean datasets of meteorological parameters such as relative humidity and wind direction obtained from Nigerian Meteorological Agency (NIMET) and the National Centre for Environmental Prediction (NCEP) for Calabar, Uyo, Port Harcourt, Owerri, Warri and Akure was done using regression analysis and statistical techniques. The results showed that visibility is more correlated with Relative humidity in places with high hydrocarbon activities leading to excess aerosol loading like Port Harcourt while it is better correlated with wind direction in places with less hydrocarbon activities like Calabar and Akure

The results of this study can assist policy makers and operators in establishing positive strategies to improve the air quality.

Keywords: Meteorological, Variables, Visibility, Degradation, Seasonal trends, Niger Delta.

Introduction:

Dramatic economic and industrial developments as well as vigorous urbanization in Nigeria have led to increased emission of pollutants from urban areas, making visibility degradation one of the severe environmental problems in such a rapidly changing country. Low visibility in Nigeria (especially in the Niger Delta region) is reported to cause 527,000 deaths annually according to World Health Organization (WHO).

The cities in the Niger Delta (especially Port Harcourt) are the most polluted cities in the country. Therefore visibility degradation has become one of the major environmental challenges in Nigeria, especially in the Niger Delta region that requires constant monitoring.

Studies according to Schichtel et al (2001), Doyle and Dorling (2002) and Molnar et al (2008) have evaluated long-term visibility observations and impacts of dominant air pollutants on local visibility. Also, the degree of visibility degradation in the Niger Delta Region has been found to be a function of season and region mainly due to the different concentrations of aerosols at different season and location owing to its variations of climates. The climate of Nigeria is usually characterized by two distinct seasons, namely; Summer (dry season) and Harmattan (cold-wet season), Kehinde, Ayodeji and Vincent (2012).

Another study by Zhao et al (2011) recognized dust haze as the principal pollutant in Nigeria and in the Niger Delta that causes low visibility.

This is due to the position of Nigeria in sub-Saharan West-Africa where dust aerosols are being transported regularly from Sahara desert. Dust aerosols are also emitted and circulated locally due to favorable weather conditions, especially in the northern part of Nigeria, even though, significant economic and population growth are obvious in Nigeria (<http://www.who.africa.org> (accessed on 28th March 2016). The authors added that contributions from industry and traffic emissions are also insignificant. The emission and transportation of these particles are increasing annually and seasonally with increasing number of hazy days. Low visibility has been reported to have adverse effects on traffic safety, economy, human health and many more in Nigeria (Kehinde et al 2012, Zheng et al 2015, Adefolalu, 1983).

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 (5.05E-7.17E 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 criss crossed by meandering and anastomosing streams, rivers and creeks. It covers 20,000km² within wetlands of 70,000km² formed primarily by sediment depositions. It constitutes about 7.5% of Nigeria's land mass with an annual rainfall total averaging from 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 country 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 Calabar, Uyo, Port Harcourt, Owerri, Warri and Akure because there are no available data in the remaining stations Yenegoa, Umuahia and Asaba as shown in Table 1 below.

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



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

Data/Method:

A 31 years record of observational data between (1981-2012) of mean horizontal visibility for some coastal weather stations in the Niger Delta Region Nigeria, Calabar (8.32E, 4.95N), Uyo (7.91E, 5.03N), Port Harcourt (7.00E, 4.75N), Owerri (7.03E, 5.48N), Warri (5.75E, 5.52N), and Akure (5.19E, 7.25N), were obtained from Nigerian Meteorological Agency Abuja (NIMET) which is the agency responsible for collecting and archiving meteorological data in Nigeria and reanalysis data for Relative humidity and Wind direction for the period (1981-2012) from the National Centre for Environmental Prediction (NCEP) and its available online at <http://www.ncep.noaa.gov> which were also extracted using Grid Analysis Display system (Grads) prepared on a resolution of 2.5° by 2.5° global grid (approximately 180km) . However statistical trend analysis has been followed.

Results and Discussion:

Relative humidity values and seasonal trends in the Niger Delta Region of Nigeria.

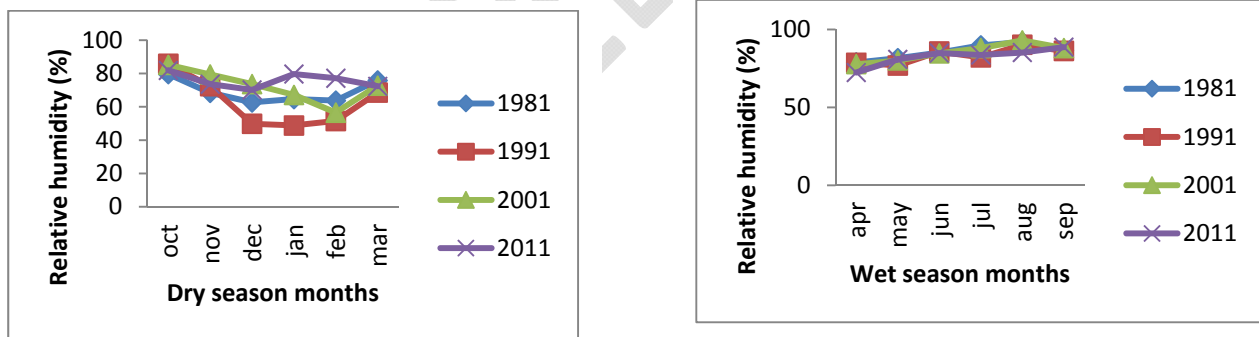


Figure 2 (a) Seasonal trends for (i) dry season months and (ii) wet season months for Relative humidity in Calabar..

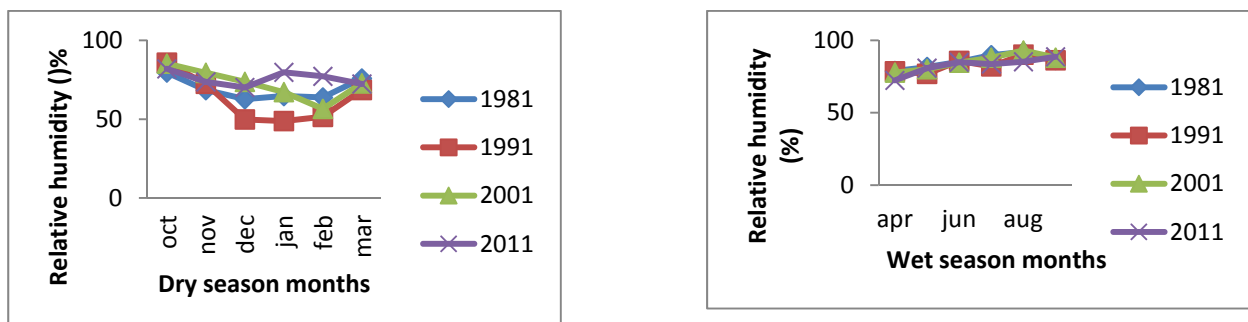


Figure 2 (b) Seasonal trends for (i) dry season months and (ii) wet season months for Relative humidity in Uyo.

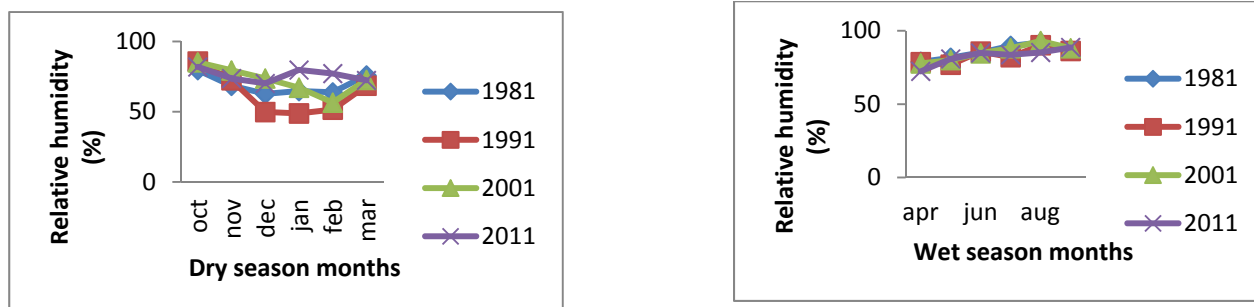


Figure 2 (c) Seasonal trends for (i) dry season months and (ii) wet season months for Relative humidity in Port Harcourt.

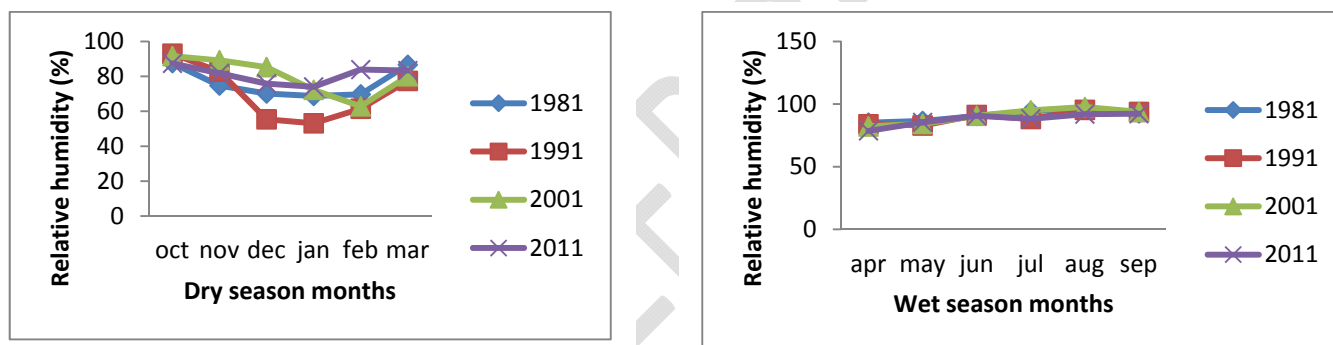


Figure 2 (d) Seasonal trends for (i) dry season months and (ii) wet season months for relative humidity in Owerri.

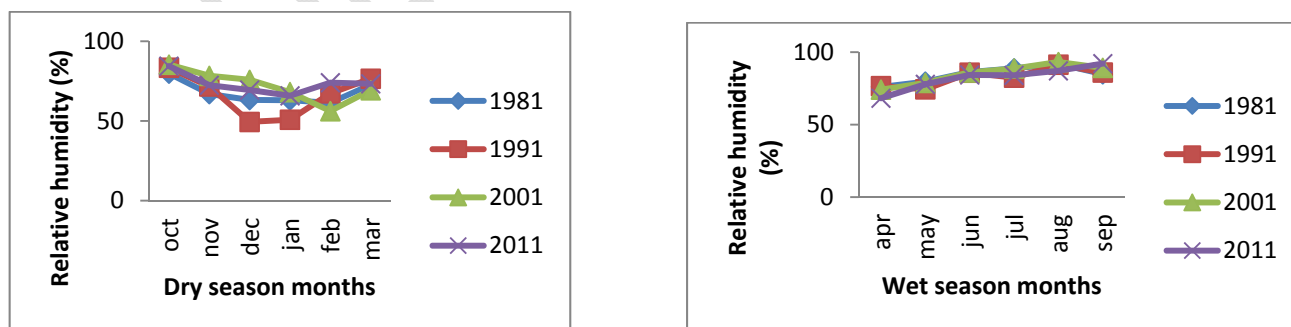


Figure 2 (e) Seasonal trends for (i) dry season months and (ii) wet season months for Relative humidity in Warri.

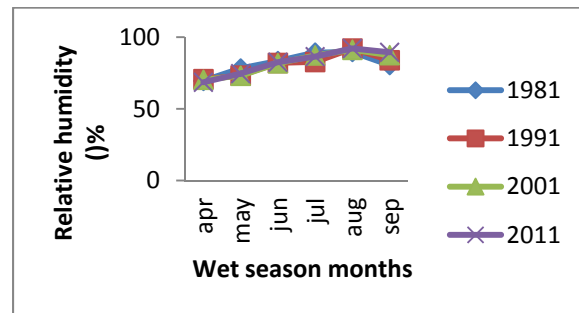
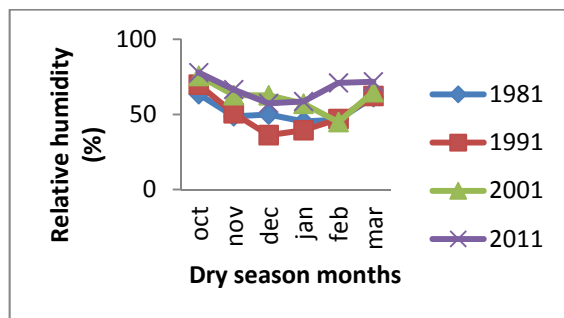


Figure 2 (f) Seasonal trends for (i) dry season months and (ii) wet season months for Relative humidity in Akure.

WIND DIRECTION VALUES AND SEASONAL TRENDS IN THE NIGER DELTA REGION OF NIGERIA.

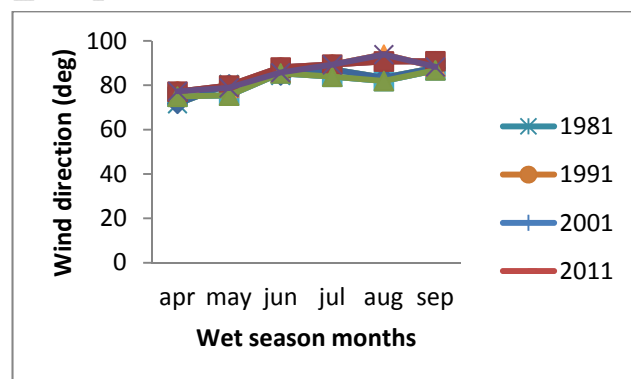
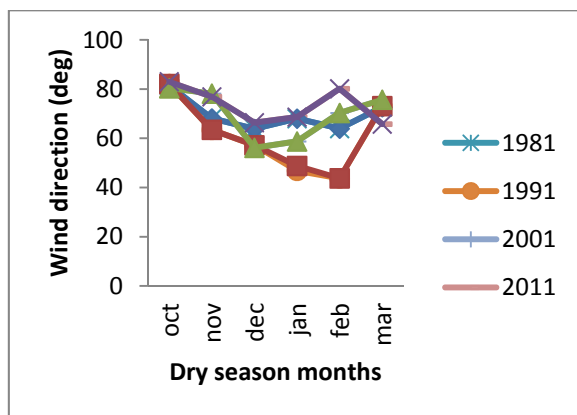


Figure 3 (a) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Calabar..

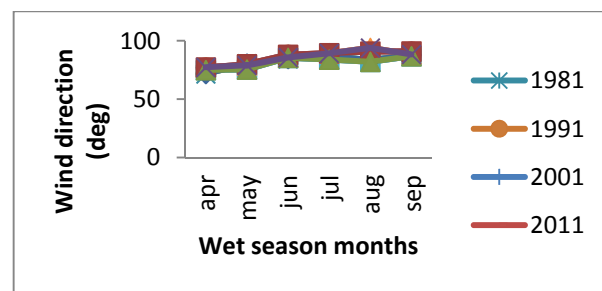
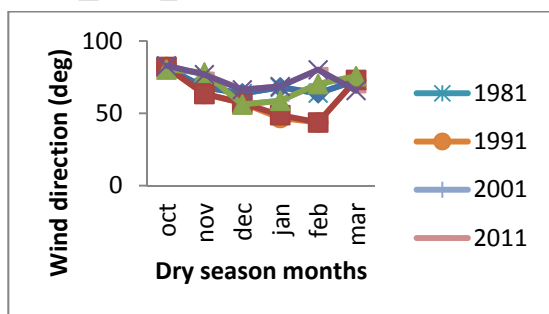


Figure 3 (b) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Uyo..

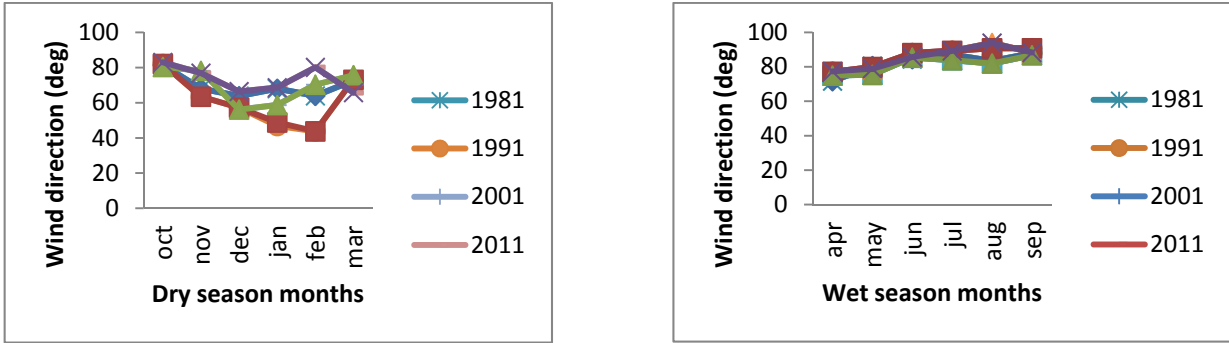


Figure 3 (c) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Port Harcourt..

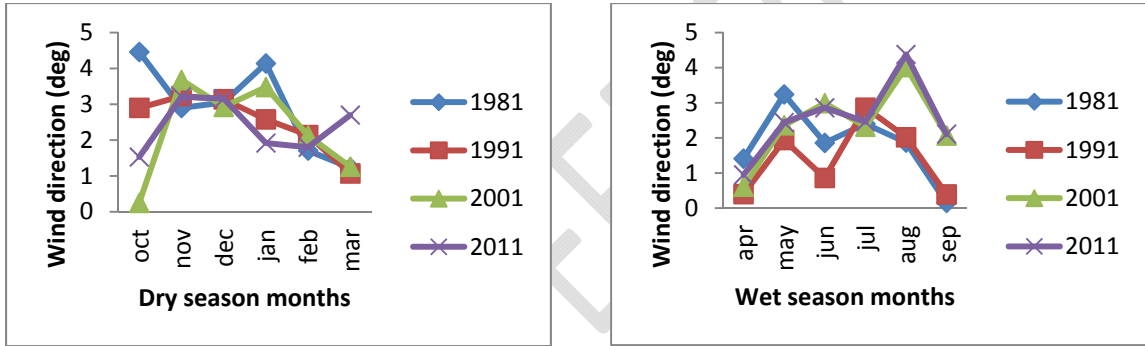


Figure 3 (d) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Owerri.

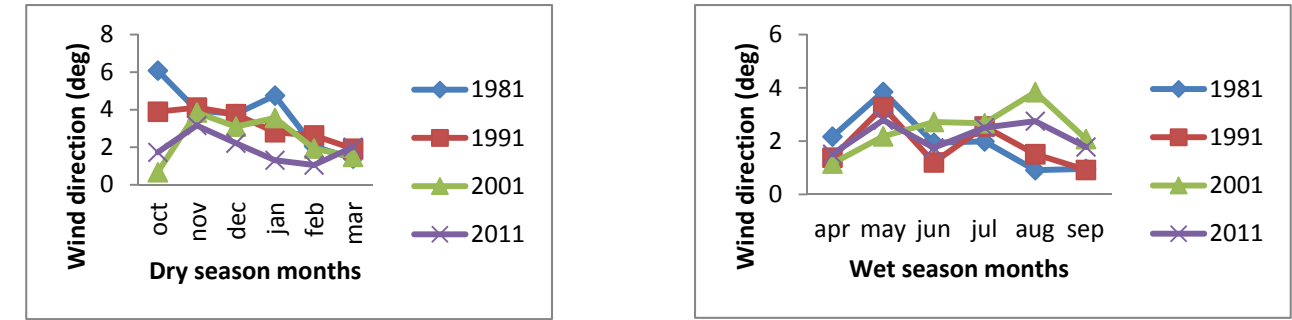


Figure 3 (e) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Warri.

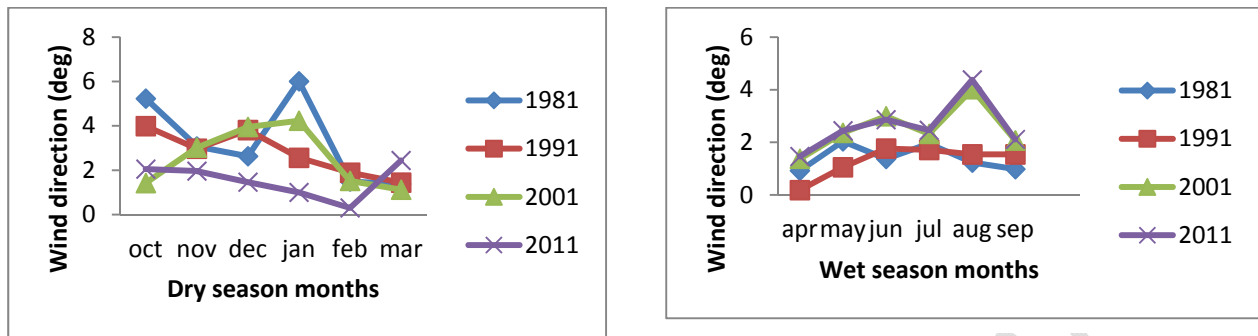


Figure 3 (f) Seasonal trends for (i) dry season months and (ii) wet season months for Wind direction in Akure..

Discussion:

Relative humidity is classified as follows for the purpose of the discussion in this work, namely below 70% is low to very low relative humidity ie the atmospheric water content (hygroscopic potential) is very low while above 70% is high relative humidity where the atmospheric water content (hygroscopic potential) is high to very high. Using this criteria, the performance of relative humidity for the months (season), years and cities are as presented.

A. Relative humidity trends in Dry season months (Oct, Nov, Dec, Jan, Feb, March).

Relative humidity values are generally low in dry season months of Nov, Dec, Jan, Feb and March. December and February are the months with highest cases of low RH for all the years considered?. Of the dry season months October has the fewest cases of low RH for all the stations and for all the years considered. This result show that dry season months generally has less moisture in the atmosphere as a result of the high evaporation and transport of water taking place on the earths surface to higher levels in the atmosphere.

B. Relative humidity trends in Wet season Months.(April, May,June,July,Aug,Sept).

The results in table 2 also shows wide spread of high relative humidity throughout all the wet months for all the years and cities under consideration. In addition the result shows that most cities and years in the wet season months recorded high relative humidity as well. This is indicative of the fact that relative humidity values in the Niger Delta Region are very high due to

the high moisture in the atmosphere as a result of its proximity to the Atlantic Ocean and the presence of rivers and creeks in the area.

Relative humidity is usually low from January through March, then it starts to improve from April through to September and even to October before dropping again. The months of high Relative humidity are those months when the region is under the influence of West African Monsoon as the inter-tropical convergence zone (ITCZ) moves up into the land areas of the region while the month of low relative humidity coincides with those months when the region is under the influence of the dry cold North-East Trade Wind from the sahel which dries the atmosphere which generally lowers the water content of the atmosphere in the Niger Delta region.

Relative Humidity Trends for the Cities in the Niger Delta

Table 2: Relative humidity analysis spread for the cities in the Niger Delta region.

City	Low RH values	High RH values
Cal	11	37
Uyo	11	37
PHC	10	38
Owerri	10	38
Warri	14	34
Akure	21	27

The analysis spread show that Calabar, Uyo, PHC and Owerri have high relative humidity values indicating that these cities are highly humid for most of the months as shown in table 2.

On the other hand, Warri and Akure have more low R-H values indicating that these cities have drier atmosphere for the years under consideration. The highest R-H values observed for Owerri, even higher than those in the cities of Cal, Uyo and PHC seem to be a misnomer to the expected values of R-H in Owerri for the years under consideration. Nevertheless, this seem to tally with the high visibility values also observed for Owerri when it is expected to have degraded visibility level.

SEASONALITY OF WIND DIRECTION VALUES IN THE NIGER DELTA REGION.

Wind direction values were found not to be uniform throughout the region. Three eastward cities namely Calabar, Uyo and Port Harcourt have very high wind direction values of mostly 40 and above. For these cities, the wind values have been classified as follows for the purpose of discussion in this work. Wind direction values of between 70 and 40 are considered low values while values above 70 are considered high wind direction values.

On the other hand, three westward cities namely Owerri, Warri and Akure that lie more to the west of the region have low wind direction values ranging from about 0 to 7. For these cities values of between 1 and 3 are considered low values of wind direction whereas values between 3 to 7 are considered high wind direction values. Using these criteria, the performance of wind direction is as presented respectively.

A. Wind Direction Trends for the Cities under Consideration

Table 3: Wind direction spread analysis for the Eastern and Western cities.

City	Eastern Cities		City	Western Cities	
	Low values	High Values		Low values	High Values
Calabar	13	35	Owerri	11	37
Uyo	13	35	Warri	14	34
Port harcourt	13	35	Akure	12	36

From the spread analysis above, it is obvious that all the Eastern cities of the region have uniform spread of high and low values of wind direction spread. Whereas the western cities (including Owerri) do not have uniform spread. Owerri has more high values of wind values. This is followed by Akure and then Warri. The spread does not also follow westerly trend as the values for Akure are higher than those for Warri.

Conclusion

The seasonal trends of Relative humidity and Wind direction as shown have their peaks in the dry season months October to March, the implication is that most of these dry season months are when most of the region is under the influence of the North Easterly winds which is cold, dry and brings dust from the desert especially cities which are in the heart of the hydrocarbon industry like Calabar, Uyo and Port Harcourt. Visibility degradation is not only influenced by concentrated air pollutants but also by complicated meteorological factors such as relative humidity, wind speed, atmospheric pressure and missing height.

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.

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