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Full Length Research Paper

Atmospheric visibility trends in the Niger Delta Region Nigeria 1981-2012

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Atmospheric pollution has been serious in the Niger delta region, as the hub of oil production in Nigeria due to the rapidly expanding economic and industrial activities which has significant impacts on visibility. Visibility is a highly relevant factor indicating the level of air quality and inversely related to the optical extinction coefficient caused by gas and particle phases. A 31 years Horizontal visibility data for some coastal weather stations in the Niger delta region acquired from the Nigerian Meteorological Agency (NIMET) Abuja Nigeria was analysed. In this study, atmospheric visibility trends for six Niger delta cities (Akure, Warri, Owerri, Uyo, Calabar and Portharcourt) in Nigeria were evaluated for the period 1981-2012 using statistical techniques. It was observed that the yearly seasonal indices for the mean visibilities for the stations, Warri, Owerri, Akure, Uyo, Calabar and Portharcourt are 2.056817, 1.523725, 0.988518,-3.87354, -0.08079, and -0.6144 km respectively. Akure, Owerri and Warri have experienced a significant increase in visibility during the entire time series while for other three cities/stations Phc, Uyo and Calabar shows decreasing visibility trends. The general dreadful conditions of visibility in these cities were probably due to the excess aerosol loading, oil exploration and exploitation in the region which leaves chunks of farmland, water bodies and the atmosphere severely polluted and degraded. Therefore, an urgent targeted reduction of atmospheric pollution may be needed to better air quality in the Niger delta region Nigeria.

Keywords: Visibility trends, Niger Delta, air quality, aerosol loading, Nigeria.

INTRODUCTION

Visibility degradation has been a thing of concern in Nigeria as evident in the Niger Delta region due to increased oil activities and development. It continues to be one of the most evident impacts of the formation of urban metropolis, with this in mind the study of the trends in visibility in the Niger Delta was necessitated. Visibility can be quite low at polluted sites mainly due to increased concentrations of anthropogenic aerosol particles (Husar et al., 1981). In a non-polluted atmosphere visibility would be in the order of 250km (leavey and Sweeney, 1990). Meteorological visibility can be said to be the greatest distance at which a black object of suitable dimension situated near the ground can be seen and recognized by the unaided eye when observed against a background fog or sky or in the case of night observations could be seen and recognized if the general illumination were raised to daylight level (WMO, 1971). Visibility can be influenced by meteorological factors, it increases with temperature and wind speed and decreases with relative humidity and atmospheric pressure (Tsai, 2005). Poor visibility has adverse effects on human lives, highway crowding and delays of airplane departures. Studies according to (schichtel et al, 2001,

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Doyle and Dorling, 2002, Molnar et al, 2008) have evaluated long term visibility observations and impacts of dominant air pollutants on local visibility. The study of visibility in the Niger delta is necessary and critical because it reflects the atmospheric changes caused by economic expansion in Nigeria and can assist policy makers in establishing positive strategies to improve the air quality. Important studies have been undertaking to examine visibility characteristics at regional, continental and global scales as recorded by (Doyle and Dorling, 2002; Mahowald et al, 2007). Urban areas with high population density and large scale economy exhibited worse visibility conditions than rural regions as recorded by (Tsai et al, 2007). The Niger delta is a developing industrialized area of the country as the home to Nigeria's oil industry. However this dramatic economic growth has led to severe air pollution and environmental degradation as recorded by (Isah, 2003).

According to other studies, dust aerosol is recognized as the principle pollutant in Nigeria 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. Though significant economic and population growth are obvious in Nigeria [http://www.who.africa.org (accessed on 28 March 2016) contributions from industry and traffic emissions are insignificant. The emission and transportation of these particles are increasing annually and seasonally with increasing number of hazy days. Low visibility has been reported (Kehinde, O.O.; Ayodeji, O.; Vincent, O.A. A., 2012, Zheng, S.; Pozzer, A.; Cao, C.X.; Lelieveld, J., 2015, Adefolalu, D.O 1983) to have adverse effects on traffic safety, economy, human health and many more in Nigeria (Kehinde, et al 2012, Adefolalu, D.O. 1983]. Therefore, visibility degradation becomes one of the major environmental challenges in Nigeria that requires constant monitoring and evaluation. The degree of visibility degradation in Nigeria especially in the niger delta region is a function of season and region mainly due to different concentration of aerosols at different season and location owing to variations of climate. The climate of Nigeria is usually characterized by two distinct seasons' summer and Harmattan (Kehinde, O.O.; Ayodeji, O.; Vincent, O.A. A., 2012).

Previous studies (Zhao, P.; Zhang, X.; Xu, X.; Zhao, X, 2011., Mahowald et al., 2007., Lin,et al, 2012., Deng et al, 2014., . Huang et al, 2009) have revealed an increasing interest in visibility study globally.

Adimula et al. 2008 reported the monthly cycle of visiblity at Ilorin Nigeria. In Usman et al. 2013, the authors uses meteorological data of Sokoto state, Nigeria for the estimation of visibility. Coordinated research focusing on visibility characteristics, trends and variability on the Niger delta region as the hub of oil production in Nigeria is lacking. As such this paper seeks to fill in this gap using the recent 31 years horizontal visibility data obtained from the Nigerian Meteorological Agency Abuja Nigeria (NIMET). The information obtained in this study will enable us to gain an insight as well as scientific understanding of changing patterns and extent of visibility degradations in the Niger Delta region Nigeria which is vital in our aviation industries. It can also be used in the evaluations of the effectiveness of the control strategies already in place in Nigeria as well as in model development.

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 cress crossed by meandering and anatomizing streams, rivers and creeks. It covers 20,000km^2 within wetlands of 70,000km^2 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 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 region warri, Owerri, Calabar, Akure, Uyo and Portharcourt because there are no available data in the remaining stations Yenegoa, Umuahia and Asaba as shown in Table 1.

DATA AND 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

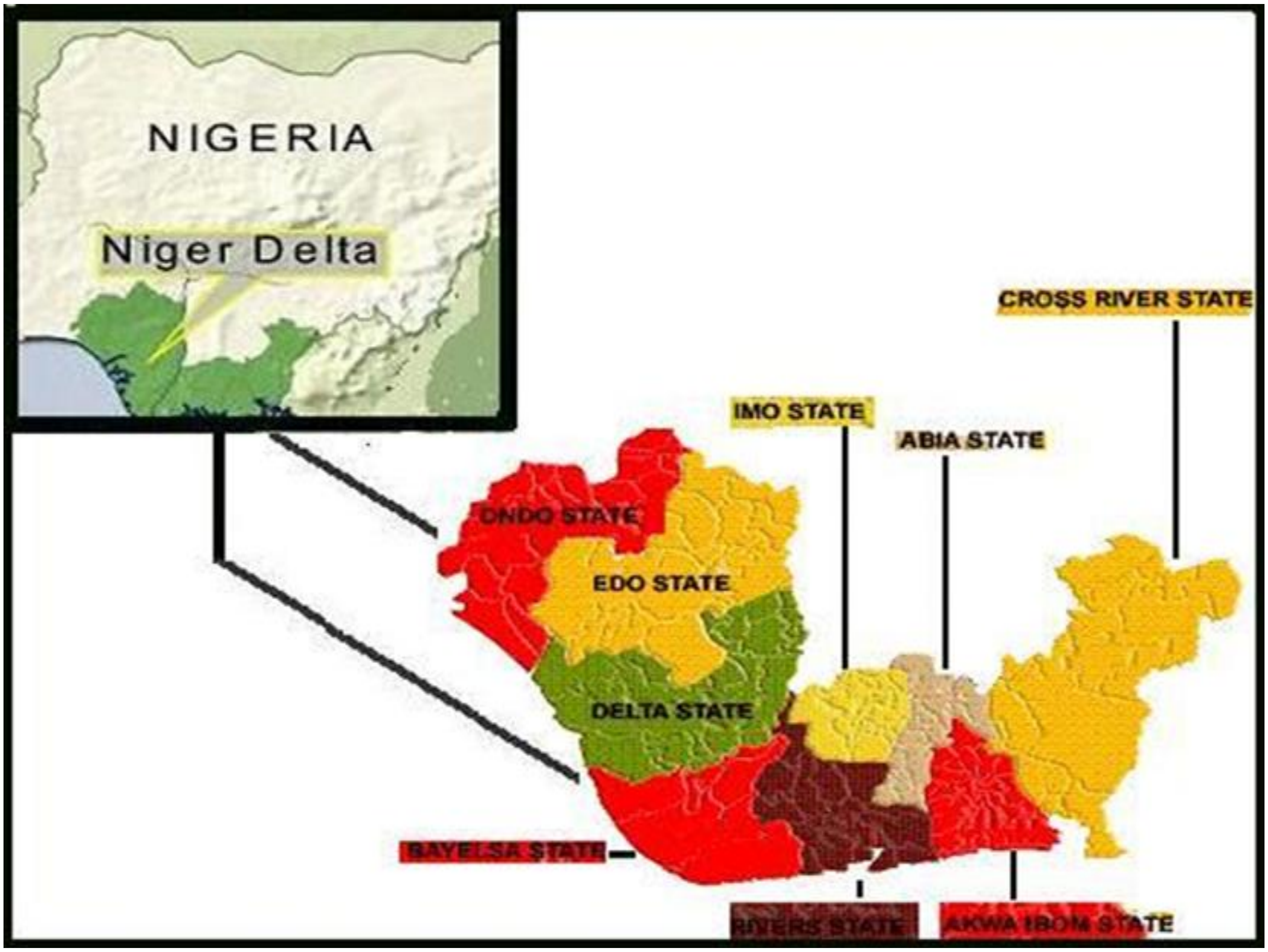

Figure 1. Map of Nigeria showing the Niger Delta region (5.05E-7.17E and latitude 4.15 N – 7.17 N) shaded with colors.

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

Stations/Locations	Lat(N)	Long (E)	Elevation (M)	Duration
Akure	7.247	5.301	335.0	1981-2012
Calabar	4.976	8.347	63.0	1981-2012
Owerri	5.483	7.033	91.0	1981-2012
Portharcourt	4.750	7.016	18.0	1981-2012
Warri	5.516	5.750	8.0	`1981-2012
Uyo	5.038	7.909	196.0	1981-2012

Nigeria, Warri (5.75E, 5.52N), Owerri (7.03E, 5.48N), Calabar (8.32E, 4.95N), Akure (5.19E, 7.25N), Uyo (7.91E,5.03N) Portharcourt (7.00E, 4.75N) were obtained from Nigerian Meteorological Agency Abuja (NIMET) which is the agency responsible for collecting and archiving meteorological data in Nigeria. However being conscious of the limitations that visibility represents, analysis was carried out on the region and the following statistical criteria for the analysis have been followed.

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.

$$x^{'} = x - x^{-} \quad (1)$$

Where, x is the monthly visibility data from each of the datasets and

x is the corresponding horizontal climatological mean for that month.

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.

$$z = \frac{x' - x^{-\prime}}{s_{x'}} \quad (2)$$

Where, $x^{'}$ is the monthly horizontal visibility anomaly of each dataset, $x^{-\prime}$ is the mean of the total monthly horizontal visibility anomaly over the period and s is the corresponding standard deviation from $x^{'}$.

Visibility variability index:

In order to show the ability of the dataset to represent the standardized visibility departure of the annual time series at different climates, the interannual visibility variability index is computed using the equation.

$$\delta_k = \left(\frac{R_k - R}{S_R}\right) \quad (3)$$

Where, K is the year, R is the total annual visibility, $R \ and \ S_R$ are the mean annual visibility and standard deviation respectively for the period of study.

RESULTS AND DISCUSSIONS

Trends in Atmospheric Visibility

The trends of the yearly means and standard deviation got from the table of the original visibility data for different regions in the Niger Delta Nigeria as shown in figure 2 depicts that there is no significant appreciable increase or decrease in the seasonal means which implies that the additive model is the most appropriate.

The least square method was used to estimate the trend values using the model, the trend values were gotten and the graph of the trend is shown in figure 3. From figure 3 it was observed that there is a positive upward movement of the time plot which suggests the presence of upward trend and the presence of peaks and troughs indicates that there is variation in the graph. Hence the trend is positively sloped.

The seasonal indices were estimated using the mean detrended series which comply with the fact that the sum of the seasonal effect of an additive model over a complete cycle is equal to zero (0). The seasonal indices for the state capitals Warri, Owerri, and Akure are 2.056817, 1.523725, and 0.988518 respectively which implies that there is an increase in visibility while the state's capital; Uyo, Calabar, and PHC are -3.87354, -0.08079, and -0.6144 respectively, indicating a decrease in visibility over the years under study (1981-2012).

CONCLUSIONS

The atmospheric visibility trend over the Niger Delta has been investigated in this paper using a 31 years (1981-2012) period horizontal visibility data. There was significant increase and decrease in the trends for some locations more obvious between Warri, Akure and Owerri. It was concluded that these locations have similar pattern in economic development, weather and regional anthropogenic activities leading to homogenous aerosol emission.

Visibility deterioration has been observed to be caused by serious atmospheric pollution in the Niger Delta region due to increased rates of industrialization and increased number of vehicles. The long term visibility change trend in the six locations in the Niger Delta were studied in this work. The mean annual visibility for the six locations

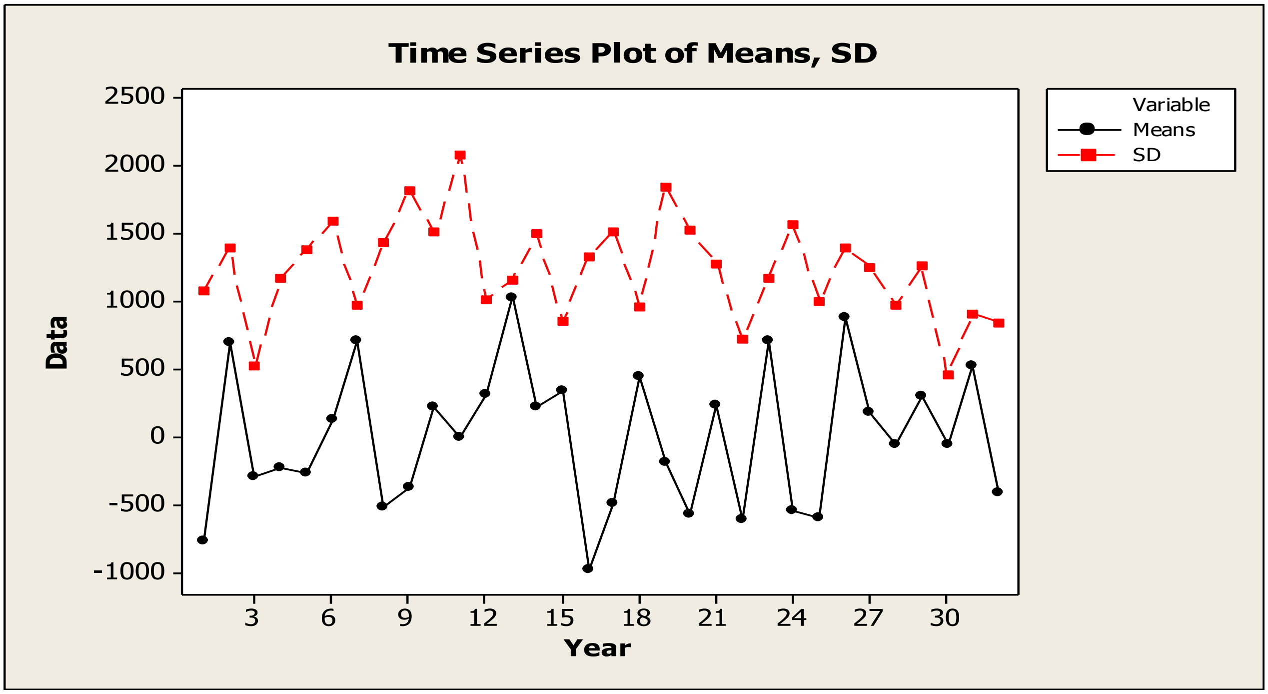

Fig 2. Graph of the yearly means and standard deviation for visibility 1981-2012.

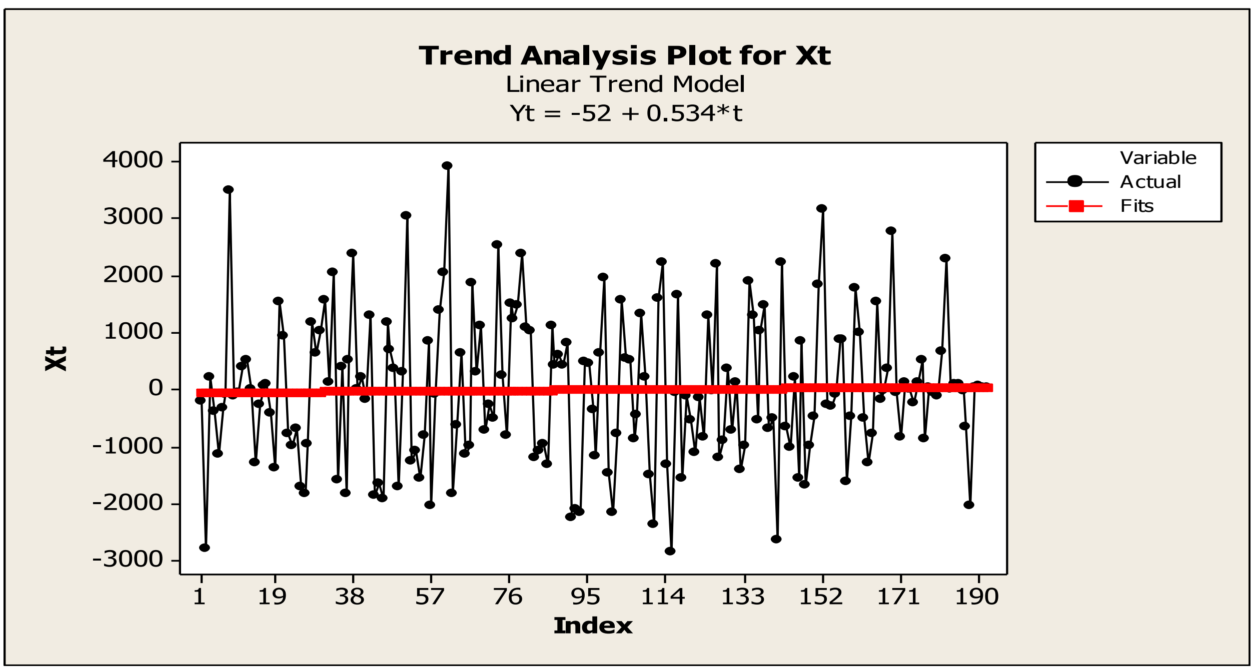

Fig 3. Graph of the visibility Data with the trend lines.

(Warri, Owerri, Akure, Uyo,Calabar and Portharcourt) generally showed significant increasing and decreasing trends with Warri (2.056817km), Owerri (1.523725)km, Akure (0.988518km) having increased visibility respectively and Uyo (-3.87354)km, PhC (-0.6144km) and Calabar (-0.08079km) with decreasing visibility respectively over the years under study.

These observations show that visibility is not only

Table 2. Seasonal Effects of visibility over the Niger Delta Region.

location	WARRI	OWERRI	AKURE	UYO	CALABAR	PHC	Total
S.I	2.056817	1.523725	0.988518	-3.87354	-0.08079	-0.6144	0.00

influenced by concentrated air pollutants but also by complicated meteorological factors such as relative humidity, wind speed, atmospheric pressure and missing heights. Also visibility reduction in the Niger Delta has been attributed largely from the high concentrations of aerosol particles from coal combustion, automobile exhaust, industrial activities and some natural factors like, dust storms, fog, haze, mist, sea salt aerosols which are major aerosol emission sources. However further studies are needed to evaluate the seasonal trends of horizontal visibility for the Niger Delta region, evaluate the effects of aerosol particles on visibility and analyze the specific emission sources in each location.

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