CORRELATION OF ATMOSPHERIC VISIBILITY AND METEOROLOGICAL VARIABLES IN NIGERIA: THE NIGER DELTA.

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ABSTRACT: The air pollution problem has been serious in the Niger Delta due to the rapidly expanding economic, industrial and vehicular developments. It has significant influences on atmospheric visibility, whose degradation dominates in urban areas. Increased air pollution in urban area may lead to the atmospheric reactions, resulting into the formation of secondary pollutants similar to cloud condensation processes. Therefore, atmospheric visibility and meteorological variables such as wind direction and relative humidity for the Niger Delta (4.15N-7.17N, 5.05E-8.68E) for a period of 31 years (1981-2012) from the Nigerian Meteorological Agency (NIMET) and the National Center for Environmental Prediction (NCEP) were correlated with a view to establish the potential influence of these parameters on visibility. A statistical software minitab was used for the analysis and pearsons correlation analysis was performed for the correlation. The results showed the mean visibilities for the stations warri, owerri, akure, uyo, calaber and portharcourt as 2.0568km, 1.5237km, 0.9885km, -3.8735km, -0.0807 and -0.6144km respectively, relative humidity 0.006192, 0.003715, 0.001239, -0.00124km, -0.00372km and -0.00619km respectively and wind direction as 2.056817km, 1.523725km, 0.988518km -3.87354km, -0.08079km and -0.6144km respectively. The annual visibility variability indexes from (NIMET) shows significant correlation with the (NCEP) datasets for R/humidity at $r = 0.1334$ and Wind direction at $r = 0.1210$ respectively at 90% confidence level from t-test. This study concluded that the relationship of the atmospheric visibility and meteorological factors are closely related. The study therefore, will guide researchers in carrying out studies independently over the Niger Delta region Nigeria.

Keywords: Correlation, Atmospheric visibility, Meteorology, Variables, Niger Delta, Nigeria.

1: INTRODUCTION:

Meteorological parameters such as relative humidity and wind speed/direction are natural causes of changes in visibility in the atmosphere and our environment. Manmade pollutants from combustion, construction, mining, agriculture and welfare are increasing by day thereby causing pollution. Atmospheric pollution due to coal combustion, vehicle exhaust and industry, which are known as the primary emission sources of particles over urban areas were considered to be the main cause of visibility degradation (Baird, 2010). Subsidence caused by the predominant subtropical high over the region leads to tropospheric stability, high temperatures, and high solar radiation for the broad summer season, yielding suitable conditions for enhanced photochemical processes. These photochemical processes originate from local and distant anthropogenic precursor emissions along the Mediterranean coasts and generate secondary pollutants, such as ozone, leading to photochemical haze and thus affecting visibility in such region. Recently, clear sky visibility has been found to decrease over land globally from 1973 to 2007 (Wang et al., 2009). Understanding the temporal variation of the atmospheric visibility and the factors affecting it is important in a mega-city because poor visibility has significance for not only human health but also air and ground transportation. Meteorological parameters of various weather patterns including relative humidity and wind direction plays important roles on the reduction of visibility in Nigeria especially the Niger delta. The concentration of particulate matter varies and it is majorly influenced by weather pattern, wind speed and direction, relative humidity, precipitation and topography (Ghim, et al, 2001). There are two broad seasonal patterns, namely the dry season (November-April) and rainy season (May-October) experienced in the study area. The dry season features brief spells known locally the harmattan period when cold and dust laden North-east trade winds from the Sahara desert keep the atmosphere heavily loaded with dust for many days. The other periods are usually dry with high solar radiation and clear sky conditions, moderate air temperature and no precipitation. Between April and mid-October, the near surface flow is dominated by the South-Westerly winds originating from the Atlantic. The weather is mainly characterized by moderate to heavy rainfall and highly humid conditions. The presence of convective clouds is mainly responsible for the marked reduction of intensity of solar radiation during the rainy season (Ogunjobi, et al 2002). The impairment of visibility is attributed primarily to the

scattering and absorption of visible light by suspended particles, as well as by gaseous pollutants (e.g. NO_2) in the atmosphere (Appel et al., 1985; Hodkinson, 1966; Groblicki et al., 1981; Latha and Badarinath, 2003). Among them, particulate light scattering has often been reported to be the dominant cause of light extinction in urban areas (Chan et al., 1999). Previous studies revealed that the size, chemical composition, and mass concentration of airborne particles substantially affect visibility (Conner et al., 1991; Malm and Pitchford, 1997). Fine particles, generally characterized as PM2.5, are believed to be mostly responsible for the scattering of visible light and to cause the degradation of visibility (Sloane et al., 1991). Although the extinction of visible light from gaseous species can also impair visibility, such species have a much weaker influence (Chan et al., 1999; Dzubay et al., 1982). Meteorological factors, especially humidity, could also contribute to the degradation of visibility (Tang et al., 1981; Tsai and Cheng, 1999). Due to increased urbanization and industrialization the Niger Delta joins other developing economies in the world to face air pollution as a common problem facing the globe and also one of those in Nigeria in which the aerosol is causing serious air pollution with large amount of land being exploited on the industrial scale, decreased traffic and vigorously developed township factories and workshops in the region, episodes of air pollution happen very often that they have aroused much concern in the government and the general public.

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 (5.05E-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 Niger Delta namely warri, Owerri, Calabar, Akure, Uyo

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and Portharcourt because there are no available data in the remaining stations Yenegoa, Umuahia and Asaba as shown in Table 1.

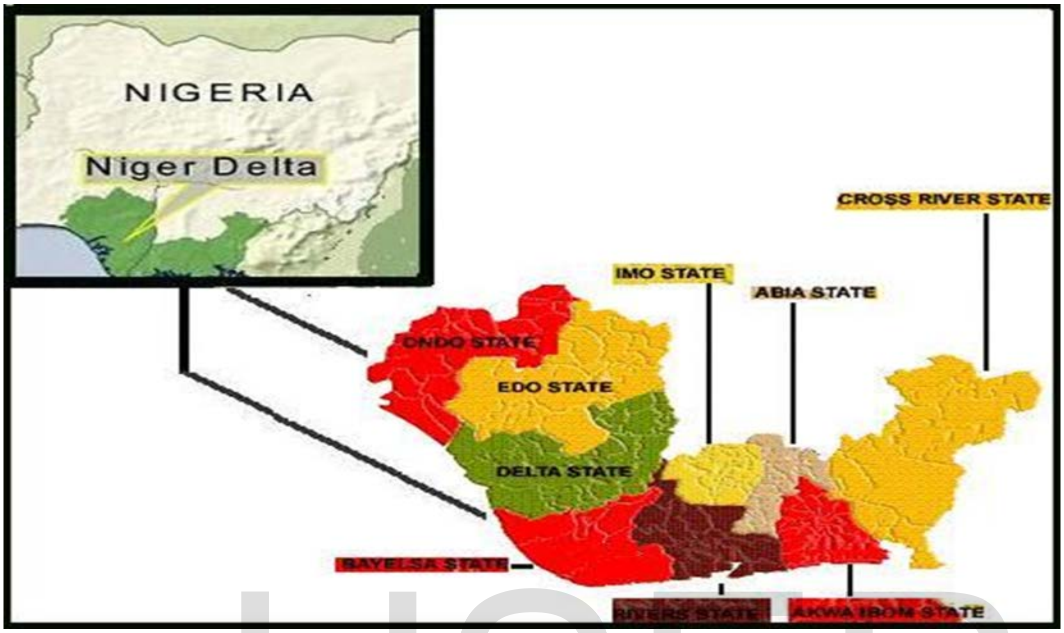

Fig 1: Map of Nigeria showing the Niger Delta region (5.05E-7.17E and latitude 4.15 N – 7.17 N) shaded with colors.

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*

3. 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 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 and reanalysis data for wind direction and relative humidity 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 $2.5^{\bullet}$ by $2.5^{\bullet}$ global grid (approximately 180km) . However a statistical software Minitab was used for the analysis.

3.1. DISCRIPTION OF MINITAB.

Minitab, originally intended as a tool for teaching statistics, is a general-purpose statistical software package designed for easy interactive use. **Minitab** is well suited for instructional applications but is also powerful enough to be used as a primary tool for analyzing research data. **Minitab** is a statistics package developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L. Joiner in 1972. It began as a light version of OMNITAB, a statistical analysis program by NIST; the documentation for OMNITAB was published 1986 and there has been no significant development since then.

4. RESULTS AND DISCUSSION:

4.1. Similarity and differences on Visibility, Relative Humidity and Wind Direction.

Due to the resolution of the Datasets, NCEP has a grid box representing each of Relative humidity and wind direction. Figures 2 (a-b), 3 (a-b) and 4(a-b) shows the normalized time

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series of atmospheric horizontal visibility, relative humidity and wind direction and normalized time series trend analysis of anomalies from the three datasets at each of the locations. The relative humidity and wind direction shows similarities to visibility dataset at each location which is evident in the coefficient of correlation values. However the correlation values were

higher with the (NCEP) datasets relative humidity than wind direction. The linear regression equation for the three datasets indicates that the monthly variability for the three locations showed positive upward movements for the stations.

The trends of the three datasets confirm increment in the monthly variability over the region with varying magnitudes. The coefficient of correlation of the normalized areal average shows that the variability from NIMET has significant relationship with NCEP datasets Relative humidity $(r = 0.1344)$ and Wind direction $(r = 0.1210)$ respectively both at 90% confidence level from t-test. The seasonal indices and seasonal effect of Visibility, Relative humidity and Wind direction over the locations in the study area were estimated using the mean detrended series which complies with the fact that the sum of the seasonal effect of an additive model over a complete cycle equals to zero. The seasonal indices as estimated shows that visibility recorded increase in Warri, Owerri and Akure of 2.056817km, 1.523725km, 0.988518km respectively and a corresponding decrease in Uyo, Calabar Portharcourt at -3.87354km, -0.08079km, -0.6144km respectively. Relative humidity has a positive upward movement and presence of peaks and troughs which indicate variation and the seasonal indices of (0.006192km, 0.003715km, 0.001239km) for Warri, Owerri and Akure respectively and (-0.00124km, -0.00372km, -0.00619km) for Uyo, Calaber and Portharcourt respectively. The Wind direction also recorded increase in Warri, Owerri and Akure at (2.056817km, 1.523725km, 0.988518km) respectively and decrease in Uyo, Calaber and Portharcourt at (-3.87354km,-0.08079km, -0.6144km) respectively. The atmospheric visibility is positively related to prevailing wind direction of the place of observation and one can say that atmospheric visibility improves if the wind speed becomes high and vice versa, reason being that if wind speed is high it will carry away the air pollutants with it and thus helps in improving the visibility of a place and relative humidity of a place is negatively related to atmospheric visibility such that when humidity increases there will be formation of tiny droplets suspended in air which reduces the atmospheric visibility by inhibiting the solar radiations reaching the earth surface.

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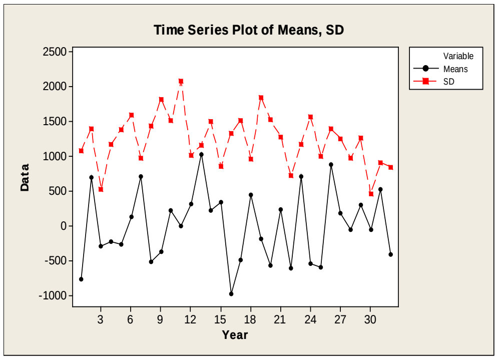

Fig 2a: Normalized time series of visibility

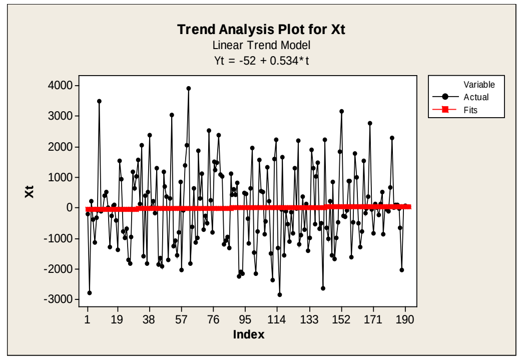

Fig 2b: Normalized time series trend analysis of visibility anomalies.

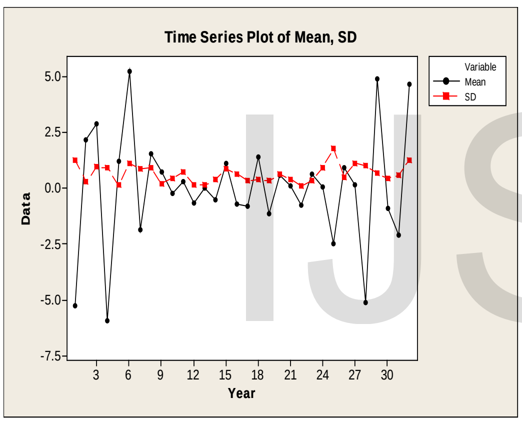

Fig 3a: Normalized time series of Relative Humidity.

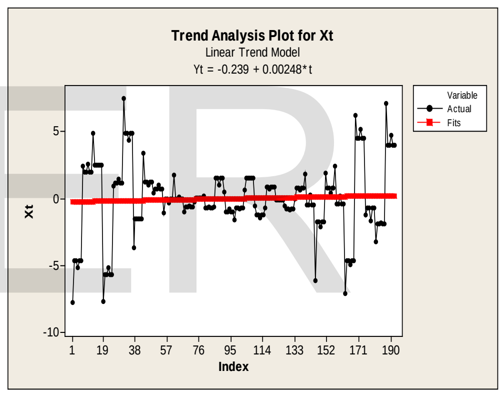

Fig3b: Normalized time series trend analysis of relative humidity anomalies.

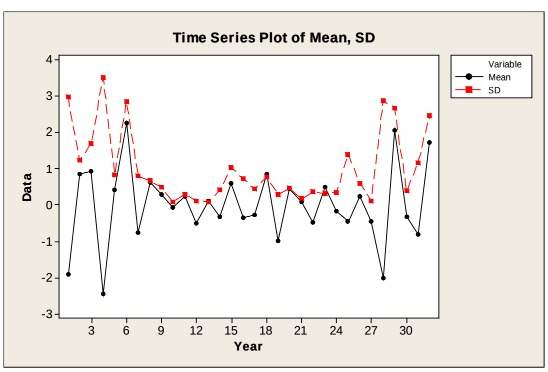

Fig 4a: Normalized time series of Wind direction.

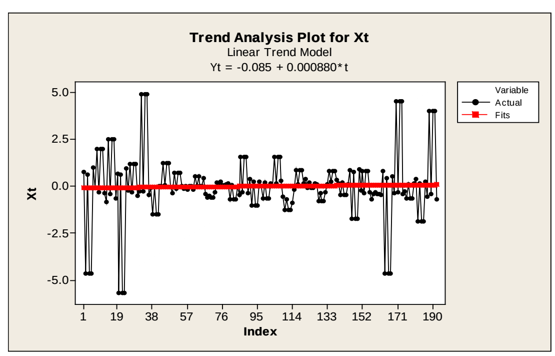

Fig4b: normalized time series trend analysis of wind direction.

Table 2: showing the seasonal indices for visibility

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

Table 3: showing the seasonal indices for relative humidity

City	WARRI	OWERRI	AKURE	UYO	CALABAR	PHC	Total
S.I	0.006192	0.003715	0.001239	-0.00124	-0.00372	-0.00619	0.00

Table 4: showing the seasonal indices for wind direction

City	WARRI	OWERRI	AKURE	UYO	CALABAR	PHC	Total
S.I	0.0022	0.001321	0.000439	-0.00044	-0.00132	-0.0022	0.00

5. CONCLUSION:

This study has compared the similarities and differences between horizontal visibility and measured meteorological parameters (Relative humidity and wind direction) this was carried out in six locations over the Niger Delta region of Nigeria for the period of 31 years. Since the NCEP datasets are products of different interpolation techniques, whereas the visibility datasets from NIMET are presented as observed, differences and similarities are anticipated from the output. The results of the correlation analysis indicate that there is a good measure of agreement between atmospheric horizontal visibility (NIMET) dataset and NCEP dataset at each of the location as well as on the areal averages over the region. The correlation between the areal averaged monthly datasets of both NIMET and NCEP at each location shows the signature of the sets at each location. Though the three datasets show increment in the trend for Akure, Owerri and Warri and a corresponding decrease for Porharcout, Uyo and Calabar respectively. This correlation does not provide all the uncertainties that would be found from each of the datasets over the Niger Delta Region but it's a measure of the expected minimum uncertainties in the datasets which should guide researchers and scientists carrying out research and studies on regions of this scale. However further investigation into the implications of using other meteorological parameters within the region should be considered.

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