Analysis of Temporal Variability of Atmospheric Transparency in Akwa Ibom State International Airport , Nigeria.

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Abstract
The investigation of meteorological variables to understand atmospheric transparency is importance for safe air traffic. This is due to constant poor visibility that normally cause shift and delay in the take-off of flights in Akwa Ibom international Airport. This was accomplished by obtaining information on temperature, pressure, visibility, wind, relative humidity and cloud cover from an automatic meteorological station where both the camera and station are located near the optical receiver site. Atmospheric variables were obtained on three hours daily duration ranging from 0600z,0700z and 0800z between 2008- 2012 . Results from the observations indicated that, there was an increase in atmospheric water vapour leading to high relative humidity forming fog and mist from Nsit- Atai lake within the airport and proximity to Atlantic Ocean . Poor visibility was observed due to weak wind force from SWTW caused be obstruction by tall palm trees and other plant species around the airport. This led to the formation of low clouds like OVC and BKN that further impaired visibility in the morning hour between 0600z - 0800z, with an improvement later due to sunshine . Based on these, the following suggestions are made: prune down trees surrounding the Airport, install heat blower, précised weather forecasting be and measurement done on regular basis and experienced air traffic controllers be trained for simulation using Terminal Area Parallel Procedures Research (TAPPR) in the Airport.

Keywords: Atmosphere, transparency. Temporal, variability, airport

1.0 INTRODUCTION:

Atmospheric visibility is a measure of the distance at which an object or light can be clearly discerned, and it is usually reported within surface weather observation and metar code either in meters or kilometer of status, depending upon the country (Charlon et al, 1978; Charlon, 1979), and visibility affects all forms of traffic: road, rail, sailing and aviation . Meteorologically, visibility is refers to transparency of air; in dark,

meteorological visibility is still the same as in day light for the same air. Because visibility involves human perception of the environment, do instrument truly measure visibility (Malm, 1979a). The transparency of the atmosphere become impede due to some atmospheric phenomenon observed like, dust haze, rain, fog, mist etc. (kopeika et al, 1998).

According to FAA statistics, weather is the cause of approximately 70 percent of the delays in the National Airspace System (NAS) (TCWF,2001). In addition, weather continues to play a significant role in a number of aviation accidents and incidents. While National Transportation Safety Board (NTSB) reports most commonly find human error to be the direct accident cause, weather is a primary contributing factor in 23 percent of all aviation accidents. The total weather impact is an estimated national cost of $3 billion for accident damage and injuries, delays, and unexpected operating costs (Gloria, 2012). Low ceiling and poor visibility are not just a safety issue. They can also severely degrade the efficiency of commercial and military aviation. Reduced ceiling and/or visibility can severely reduce the capacity of an airport and lead to airborne or ground delays that result in diversions, cancellations, missed connections, and extra operational costs (TCWF,2001). Low ceiling and reduced visibility are safety hazards for all types of aviation. The NASDAC study of NTSB statistics indicated that ceiling and visibility were cited as contributing factors in 24 percent of all general aviation accidents (Gloria, 2012). Also meteorological condition largely determine the extent and speed within which pollutants disperse, and thus have a major effect on visibility include wind speed and direction, mixing height, and relative humidity, solar illumination and cloud cover (Rachelle , 2012).

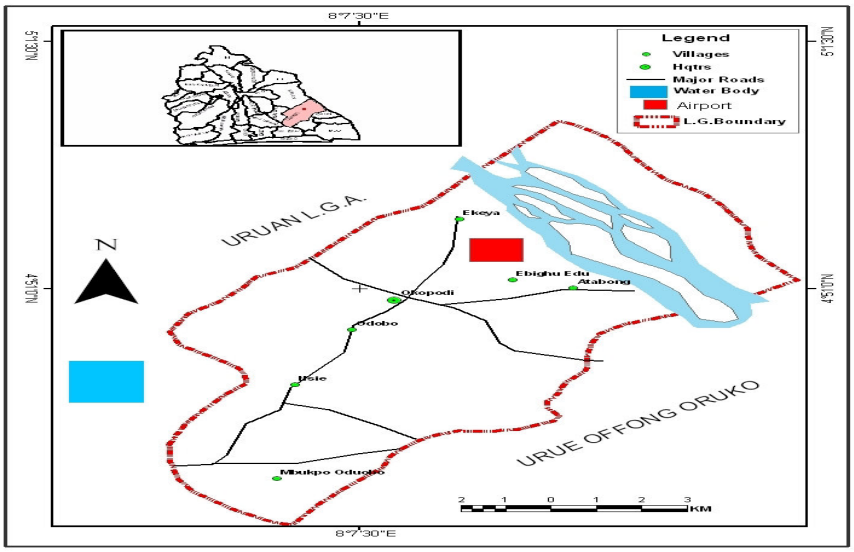
The study of atmospheric visibility is of great practical importance for all kinds of transportation (visibility of road signs, landing fields, and so forth), for topography (visibility of triangulation signs), for aerial photography, and in military affairs. Fluctuations in atmospheric visibility are closely related to the weather. For this reason meteorological stations conduct systematic observations of the atmospheric visibility and give its magnitude in weather forecasts. This research therefore focus on meteorological variables that are responsible for the continual alteration of flight schedule in Ibom International Airport in order to forestall environmental hazards in aviation industries that constantly occurring in Nigeria and world at large.

1.2 Geographical Setting:

Trigonometrically, Akwa Ibom State lies between latitude 4^0 32' and 5^0 53' North; and Longitudes 7^0 25' and 8^0 25' East, covers a total land area of 8,412 km2, encompassing the Qua Iboe River Basin, the western part of the lower Cross River Basin and the Eastern part of the Imo River Basin. With an ocean front which spans a distance of 129 kilometers from Ikot Abasi in the west to Oron in the east (Ubuoh, 2012). The mean annual temperature of the state lies between 26^0 C and 28^0 C, while mean annual rainfall ranges from 2000 mm to 3000 mm, depending on the area. Naturally, maximum humidity is recorded in July while the minimum occurs in January. Thick cloud cumulonimbus type is commonly experienced in the months of March to November. Evaporation is high with annual values that range from 1500 mm to 1800 mm.

Though visibility ranges varied from one airport to another. For example, at malam Aminu Kano International Airport (MAKIA), the minimum visibility range for landing mid take-off is 800meters, at Nnamdi Azikiwe International Airport (Abuja), the minimum visibility range is also 800 meters, while in Akwa Ibom International Airport (AKIA), the minimum range is 2500 meters and above (ICAO, NCAA, 2005). The implication of this visibility reduction requires careful watch in Akwa Ibom International Airport (AKIA) where daily variation of visibility reduction is recorded around the airport runway between 0600Z-0800Z (NIMET,2011). On account of environmental disposition and peculiarity, this is caused by the presence of mist and fog observed

in the atmosphere during this hour (NIMET, 2011). Also, it has been observed that Akwa Ibom International Airport (AKIA)is sited close to a pond known as Nsit Atai lake and the coast of the state along the Atlantic Ocean. The runway of AKIA is located facing the pond and the ocean from the southern direction at the angle of 135^0SE to 225^0SW. The airport occupies 2,500 hectares (spanning Nsit Atai, Okobo and Uruan LGAs) (Ubuoh, 2012) (Fig.1).



OKOBO L.G.A

Fig. 1:Okobo L. G. A. Showing Location of Ibom International Airport

1.3 Methodology

1.3.1 Methods of Measurement of the Meteorological Variables:

Meteorological conditions were identified by means of video camera images and data obtain from an automatic meteorological station. Both the camera and station are located near the optical receiver site. The automatic meteorological station is equipped with VAISALA sensors for the measurement of temperature, humidity and air pressure, wind velocity and direction and two tipping bucket rain gauge with different collector area for measurement of rain intensities. The VAISALA PWD 11 equipment measured visibility (MOR) up to 2000m using forward scattered light at an angle of 45^o The distance between the transmitter and the receiver of the visibility detector was about 0.5m, hence the measurement was local. Meteorological conditions during fading event were recorded. The calibrated RSSI signal was continuously recorded. Three hours daily duration (0600z,0700z and 0800z) of meteorological weather observation data on (temperature, wind, pressure, visibility, relative humidity and clouds) for a period of 5 years (2008-2012) was collected for the purpose of these research. Meteorological data were determined and recorded as follows:

1.3.1.1 Temperature: Daily minimum and maximum temperature was obtained from a thermometer partially exposed to the atmosphere in a Stevenson screen. The temperature was measured in degree Celsius (° C).

1.3.1.2 Pressure: Daily pressure data was obtained from kew pattern Barometer corrected to mean sea level value in Hectopascal (Hpa (NIMET, 2012).

1.3.1.3 Visibility: The visibility in the airport was recorded by automated scopograph . Here specific distance was measured from a reference point to a direction indicating North, South, East and West. The unit of measurement of visibility used is in meters (m) (NIMET, 2012).

1.3.1.4 Wind: The Direction and speed of wind were measured with parallel wind dial instrument .The direction is measured in degrees and speed in knots (NIMET, 2012).

1.3.1.5 Relative Humidity: Relative humidity was measured with automated installed instrument called Hair hygrograph mounted in the Airport, and the result in percentages (%) (NIMET, 2012; .(Michell, 2012).
1.3.1.6 Clouds: Information on cloud height and coverage were calculated using temperature depression with some derive constants in meters (m) while the amount of cloud coverage was measured with eye observation by estimation recording as: FEW (1-2 oktas), SCT (3-4 oktas), BKN (5-7 oktas) and OVC (8 oktas) according to WMO (2012) as :

(i) FEW (1-2) equals FEW cloud coverage in the sky
(ii) SCT (2-4) equals scattered cloud coverage in the sky
(iii) BKN (5-7) equals Broken cloud coverage in the sky
(iv) OVC (8) equals overcast cloud coverage in the sky

1.4 Atmospheric Transparency:

Below is the representation of the present visibility ranges as categorized by the international civil aviation organization (ICOA), adopted by the Nigerian civil aviation agency (NCAA) for safe operation in Nigeria aviation industry. The ranges are as follows:

Very Poor Visibility	Zero (0) -	< 1000 Meters
Poor Visibility	1000 -	< 2000 Meters
Moderate Visibility	2000m -	< 7km
Good Visibility	7km -	< 10km
Very Good Visibility	10km -	< 30km
Excellence Visibility	>30km	

Source: International Civil Aviation Organization (ICAO,2012)

1.5 RESULTS AND DISCUSSION

For interpretation of the raw data from Akwa Ibom International Airport, this chapter is committed to data presentation and discussion of the results.

1.5.1 TEMPERATURE VARIATION

When the temperature is high, transparency of the atmosphere increases but, when the temperature is low transparency reduces (NIMET, 2011). The result of temperature variations of the airport between 2008 – 2012 is indicated in Table 1.

Table1: **Showing Minimum and Maximum temperature variability in Akwa Ibom International Airport between (2008 - 2012).**

MONTHS	MAXIMUM TEMP(^{0}C)	Depression Value	MINIMUM TEMP.(^{0}C)
Jan	32	9	23
Feb	33	9	24
Mar	33	9	24
Apr	32	8	24
May	31	7	24
Jun	30	6	24
Jul	28	5	23
Aug	27	4	23
Sep	28	5	23

Oct	30	6	24
Nov	31	8	23
Dec	32	10	22
Mean	**31**	**7**	**24**

SOURCE: AUTHORS WORK 2012.

From Table 1 , it is observed that the mean minimum temperature recorded 24^{o}C, with the lowest minimum temperature of 22^{o}C during the month of December indicating the effect of North East Trade Wind that is dust laden, while the mean maximum temperature is 31^{o}C , with the least maximum temperature of 27^{O} C during the month of August, indicating the effect of heavy rainfall on temperature reduction (Ubuoh, 2012), with the depression value of 7^{0}C that capable of increasing water vapour for the formation of mist and fog that reduces atmospheric transparency .Fog and mist suspension in the atmosphere continue to increase as vapour pressure increase for continual reduction in visibility over the Airport(Gloria,2012). This is similar to a report carried out by the International Civil Aviation organization(ICAO) due to incessant demonstration of fog at Pearl River Delter at Hong Kong International Airport.

1.5.2 Relative Humidity :

Relative humidity is a term used to describe the amount of water vapour in a mixture of air and water vapour (Global Nest, 2012). Relative humidity significantly increases has an effects on visibility that leads to the reduction on atmospheric transparency (EPA, 2012). The result of relative humidity is shown in Table 2

Table 2: Showing Mean Relative Humidity in Akwa Ibom International Airport.

MONTH	2008-2012 (%)
Jan	97
Feb	97
Mar	97
Apr	97
May	97
Jun	98
Jul	98
Aug	97
Sep	97
Oct	96
Nov	96
Dec	96

SOURCE: AUTHORS Field WORK , 2012.

From Table 2, it is observed that relative humidity is on the value of 97% between January to December. This signifies that the atmosphere at these period is always supersaturated in which 97% is a prerequisite for reporting of fog in Meteorological Aerodrome Report (METAR) (WMO, 2012). This implies that visibility reduction will always prevail with a relative humidity of such intensity . The level of visibility reduction caused by this magnitude of atmospheric saturation has the ability of affecting almost all the major Airports operation in Akwa Ibom International airport This is consistent with the finding of Malm (1979b); Gloria (2012) who reported that high relative humidity has the ability of affecting all forms of traffic flow both on the earth and within the atmosphere.

1.5.3 Variability of Wind Direction and Speed in the Airport

Wind is one of the atmospheric phenomena and it is defined as air in motion (NIMET 2010). Wind is said to be calm when the wind value is zero (0) (WMO, 2012). When the wind is calm in most cases, visibility is always poor due to suspension of pollutants in the atmosphere but, with increase in force of wind, visibility improves in the direction of the prevailing wind especially when the wind is blowing high temperature over warm surface (WMO, 2012).

Table 3: Showing the Wind distribution in the Airport

Month	AVG.MAX. WIND DIRECTION (^{0}C) AND FORCE (KNOT)					
	0600Z (7am)		0700Z (8am)		0800Z (9am)	
Jan.	3	**SW**	2	**SW**	3	**SE**
Feb.	CALM	**S**	2	**NE**	5	**NW**
Mar.	CALM	**SW**	2	**SW**	4	**NW**
Apr.	2	**SW**	2	**S**	6	**S**
May	CALM	**N**	3	**SW**	4	**SW**
Jun.	2	**NE**	3	**S**	4	**SW**
Jul.	2	**SW**	2	**S**	5	**SW**
Aug.	2	**SW**	2	**SW**	4	**SW**
Sep.	3	**S**	3	**SW**	6	**NW**
Oct.	2	**S**	4	**SW**	6	**SW**
Nov.	2	**NW**	2	**W**	4	**SE**
Dec.	2	**NW**	3	**SW**	6	**SE**

SOURCE: AUTHORS FIELD WORK , 2012.

From 3, it is observed that the wind dominating the airport are the moisture leaden winds (South Westerly winds) . At 0600Z (7:00am) the wind force is mostly 2 knots or calm which cannot push the suspended polluted relative humidity leading to impairment of the atmospheric transparency (Fig.2). It is also observed that, by 0700Z (8:00am) the wind force begins to increase as sun set in to the atmosphere (Fig. 3). But at 0800Z (9:00am), the intensity of the sun increased the more which caused an increase in wind force to push away the suspended pollutants in the atmosphere (Fig.4). This is the hour that the relative humidity in the atmosphere drastically reduced given way for a better transparency of the atmosphere over the Airport. The overall result shows that, weak winds with speed between 2knots to 5knots are the wind prevailing over Airport leading to poor visibility at the Airport especially during early hour of the day. This is suspected to be the cause of delay in the take -off and landing of the aircrafts in the port.The result is consistent with the finding of Gloria (2012).

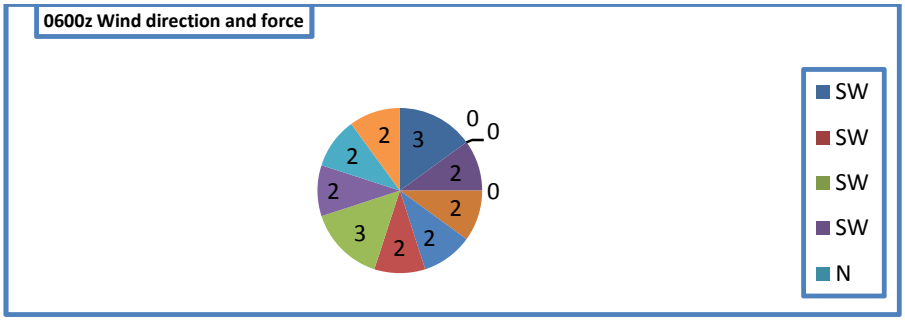


Fig2. Wind Rose during 0600z in the Airport

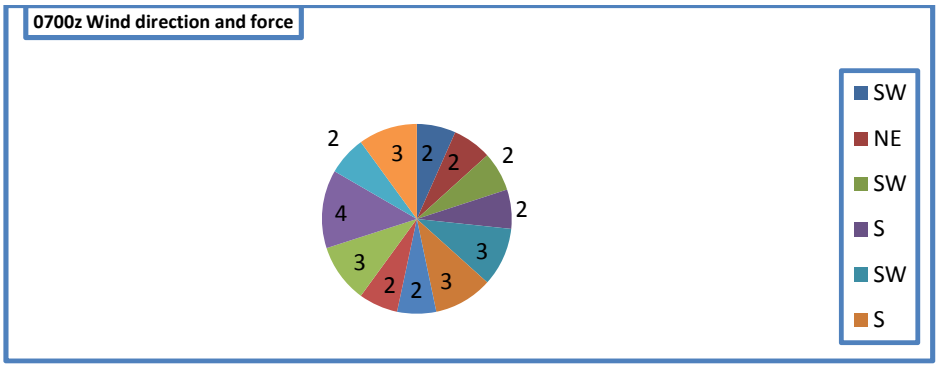


Fig3. Wind Rose during 0700z in the Airport

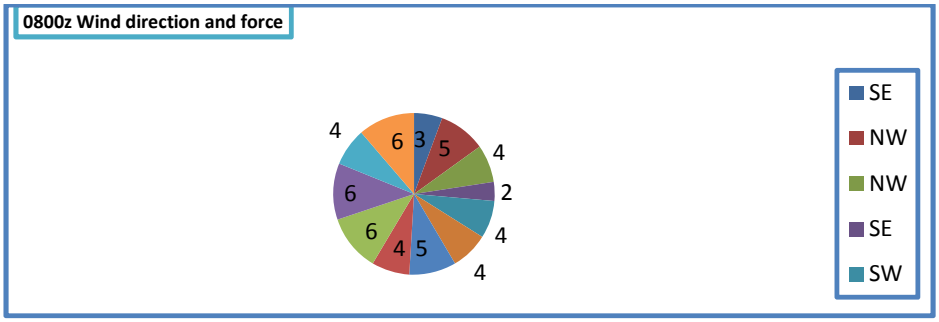


Fig4. Wind Rose during 0800z in the Airport

1.5.4 Variability of Cloud Coverage in Airport: Cloud is a suspended particle of water in the atmosphere which falls as rain after proper condensation and saturation (NIMET,2010). Cloud coverage and the type of cloud at a particular time determines the transparency of the atmosphere (Obasi, 2000). The important of cloud height and cloud coverage cannot be over emphasized in aviation industry especially, when it has to do with low clouds like Cumulonimbus (CB) clouds that releases electric charges (NIMET, 2010).

Table4: Showing Cloud types, Height and Coverage in the Airport.

MONTH	0600Z (7:00AM)			0700Z (8:00AM)			0800Z (9:00AM)		
	CL	CM	COVERAGE	CL	CM	COVERAGE	CL	CM	COVERAGE
Jan	210	1500	BKN	240	2100	SCT	300	2700	SCT
Feb	210	1500	BKN	240	2100	SCT	300	2700	SCT
Mar	240	2100	BKN	270	2400	FEW	300	2400	SCT
Apr	240	2100	BKN	270	2400	SCT	330	2400	SCT
May	270	2400	BKN	300	300	FEW	270	2100	BKN
Jun	240	2100	OVC	270	2400	SCT	300	2100	SCT
Jul	240	2100	BKN	270	2400	BKN	300	2400	SCT
Aug	240	2100	BKN	270	2400	BKN	300	3000	FEW
Sep	270	2400	OVC	300	3000	SCT	330	3000	FEW
Oct	270	2400	BKN	300	3000	BKN	360	2700	SCT
Nov	240	2100	BKN	270	2400	SCT	360	3000	FEW
Dec	210	1500	SCT	240	2100	BKN	330	2700	SCT

KEY: CL=LOW CLOUD, CM=MEDIUM CLOUD, OVC=OVERCAST, BKN=BROKEN, SCT=SCATER, FEW=FEW

SOURCE: AUTHORS FIELD WORK, 2012.

From Table 4 above, it is observed that more than half of the sky is always covered with clouds as represented with OVC and BKN that ranged between 240 (2100)cm - 270 (2400)cm and 240 (2100)cm-360 (27000cm respectively. This may be responsible for the reduction in the transparency of the atmosphere as the cloud coverage limits the illumination from the sun. It is also been observed that the height of low cloud can be as low as 210m, this is very dangerous as this clouds would limits the visibility of a pilot from seeing the run way clearly for proper alienation of the aircraft while descending for landing. Low clouds of height below 240meters are dangerous as it prevent pilot from seeing the runway while descending for proper alienation of air craft for landing. It is also risky for aviation operation when these low clouds are formed on the surface in which it is term as "FOG" (Gloria, 2012). The fog can reduce the horizontal visibility to less than 500meters, thereby making all forms of aviation operation very challenging (NIMET, 2010). From the result the Airport is dominated with low clouds of height below 240meters with overcast and broken cloud coverage at most time of day throughout the year especially at early morning hours that has heavier atmospheric density require for optimal operation of heavy duty aircraft, Example, Cargo aircrafts. Flying at low level, i.e. below safety altitude, in conditions of frontal fog and low cloud can quickly become extremely hazardous if visual flight rules cannot be maintained. Attempting to fly between layers of Stratus, so-called "letter boxing", can result in impact with terrain CFIT if forward visibility and Situational Awareness is lost (*SKYbrary, 2012).*

1.5.5 Variability of Atmospheric Pressure in Akwa Ibom International Airport:

Atmospheric pressure is the force per unit area exerted into a surface by the weight of air above that surface in the atmosphere of Earth or that of another planet (WIKIPEDIA, 2012). Pressure is also define as the weight of the atmosphere exerted on the surface of the earth by gravity (WMO, 2010). The variation of atmospheric pressure is proportional to temperature (NIMET, 2010). The global time for pressure variation is 4:00am , 10:00am , 4:00pm and10:00pm (WMO, 2012). Every aircraft require QNH (mean sea level pressure) for setting of Altimeter, of which without, no aircraft can land with optimal safety (NIMET, 2010).

TABLE 5: Mean variation of Atmospheric Pressure in the Airport between (2008-2012)

MONTHS	MEAN PRESURE(HPA)
Jan	1011
Feb	1011
Mar	1012
Apr	1013
May	1012
Jun	1013
Jul	1014
Aug	1015
Sep	1015
Oct	1014
Nov	1012
Dec	1011
MEAN(HPA)	**1012**

Source: AUTHORS FIELDWORK, 2012

From table .5 above, it is observed that lowest mean pressure value ranged between 1011- 1015Hpa obtained around January, February and August, September respectively . The high pressure signifies the

high relative humidity in the atmosphere, leading to reduction in atmospheric visibility in the Airport. This is suspected to be caused by the excessive evaporation of the lake from the Airport and moisture laden wind from the Atlantic Ocean. Supersaturated atmosphere is always the atmosphere with high pressure due to high gravitational forces acting on denser atmosphere. Pressure varies with temperature and height. Akwa Ibom International Airport located between latitude $4^0$32' and longitude $5^0$32' is associated with high atmospheric density and low temperatures. The airport vicinity dominating with weak winds supports poor visibility, as the weight of the atmospheric phenomena that impairs visibility is greater than the wind force that suppose to be the atmospheric clearing agent (Ubuoh et al, 2010b).

1.5.6 Variability of Atmospheric Transparency in the Airport.

Reduced visibility because of fog may result in restrictions on movements at an airport, reduced capacity (because of procedural increased separation between aircraft take-offs and landings in order to maintain safety), and may lead to the closure of the airport (Malm, 1979a; SKYbrary, 2012).

TABLE 4.6: S Variability of mean visibility observation in Airport between (2008-2012).

MONTH	0600Z(7:00AM) METERS	0700Z(8:00AM) METERS	0800Z(9:00AM) METERS
Jan.	900	1200	2900
Feb.	800	1500	2500
Mar.	800	1200	2300
Apr.	1200	1800	3600
May	1000	1600	3200
Jun.	900	1600	3400
Jul.	1000	1800	4500
Aug.	1100	2100	3200
Sep.	1000	3300	3700
Oct.	1000	2300	4100
Nov.	500	1500	2800
Dec.	500	1400	2500
MEAN	**900**	**1800**	**3200**

SOURCE: AUTHORS FIELDWORK, 2012

From Table 6, it observed that the lowest visibility is always prevails at 0600Z (7:00AM), with a better improvement in visibility prevails at 0800Z (9:00am). Also, it observed that the value of the lowest visibility is 500 meters while the highest visibility value is 4500 meters obtained during the months of November, December and July respectively. Visibility is very important because pilot would have to see the horizontal direction above 2,500meters for safe landing or take-off. Poor visibility will always prevails where there are, weak wind forces e.g 2knots to 5knots, low or moderate temperatures, supersaturated atmosphere (high relative humidity), high coverage of clouds amount etc. Visibility observer must be free from any form of eye defect to ensure an acceptable accuracy.

1.6 CONCLUSION

In addition to safety, convective weather poses a problem for the efficient operation of the airport in Akwa Ibom. The Akwa Ibom International Airport is on a continuous influenced of Nsit Atai Lake and Atlantic Ocean, this increased domination of weather clouds (low clouds) of low height and large coverage that support formation of fog and mist during terrestrial radiation to reduced visibility in the Airport. Also the closeness of the airport to the Atlantic Ocean has seems to result from poor visibility due to the prevailing

wind (SETW) which is moisture laden wind is another factor (Ubuoh, 2012a) . Temperature ranges that prevails over the Akwa Ibom International Airport are low temperature that supported the availability of vapour pressure for incessant fog and mist formation with high percentages of relative humidity causing super-saturation for continuous fog formation that reduced visibility in the morning hour that impairs take-off of the aircraft. This worsen by large oil plantation that breaks the force of wind before getting to the Airport for dispersion of the pollutants. The atmospheric region of Akwa Ibom International Airport is of a denser density, these atmosphere is difficult to be push by weak winds that is agent for pollutant clearance in the atmosphere invariably, sustaining poor visibility. The result has further shown that the visibility in Akwa Ibom International Airport , at early morning hours are always less than (<) 2500meters which is the approved minimum visibility ranges for Air operation (landing and take-off) (ICAO, 2008). Low ceiling and poor visibility are not just a safety issue. They can also severely degrade the efficiency of commercial and military aviation. Reduced ceiling and/or visibility can severely reduce the capacity of an airport and lead to airborne or ground delays that result in diversions, cancellations, missed connections, and extra operational costs (Gloria, 2012).This then call for measures for weather clemency in the airport.

1.7 RECOMMENDATION:

Base on the conclusion of the research work above, the following recommendations are made:

[1] The palm tree plantation surrounding the Airport should be removed to allowed free flow of air mass across the Airport at all times with increase wind force that will limit the activities of Fog and Mist.

[2] Installation of heat blower around the runway is advisable, the warm air released by the blower will help to dissolved Fog and Mist around the runway to give way for an improved visibility.

[3] Well equip meteorological weather forecast office with Up to date facilities should be established, which should be operated by well train and certified meteorological personnel for daily forecast of this weather phenomena for smooth Airport operation.

[4] Experienced air traffic controllers should participate in a simulation using Terminal Area Parallel Procedures Research (TAPPR) in the Airport. [5] The location of the second runway should be taken to the end of first runway to the north (runway 21) to be horizontally sited so that the two ends will be parallel to east and west. Above all, in poor visibility situations Airport Operations should perform the following : [a] Crews and controllers should exercise additional caution during low visibility operations - loss of situational awareness is a major contributory factor in Runway Incursion events. [b] Airports should ensure that collaborative decision making arrangements to maximize airport capacity involve met service providers.

[c] Flight crews should anticipate longer taxiing times in low visibility operations and carry additional fuel accordingly.

ACKNOWLEDGEMENT: I wish to acknowledge Mr. Ime Apkan and Mr. William Timothy , staff of NIMA, who are in-charge of Meteorological Centre in Akwa Ibom State who supplied the necessary information required for the assessment of the weather conditions of the airport between 2008 – 2012 . This will help in operational efficiency as well and value change in the airport.

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