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Investigation of the periodic hyrometeorological characteristics of Anambra-IMO river basin of Nigeria

Obi Lawrence E
Department of civil engineering, IMO state university, P.M.B. 2000, Owerri, IMO, Nigeria

Abstract
Global warming has been a source of concern in recent times due to its devastating effects on human life, water bodies, earth resources and vegetation. This results from the changes in climate elements of temperature, rainfall, sunshine hours, humidity and evaporation. In response, this research engaged the method of empiricism to determine the numerical values of most climate variables to enhance the understanding of climate conditions in Anambra – Imo River Basin within the periods of October to December 2011. In the research, it was discovered that the rainfall amounts were very small with high variability while the temperatures were very high. With this, further continuous periodic monitoring of the climate variables will create massive hydrometeorological data which will bridge the gap in the paucity of data in this area of study.

Keywords: hydrometeorology, rainfall, climate, weather

1. Introduction
The hydrometeorological characteristics of an area are direct effects of global warning. This is to say that the knowledge of the hydrometeorological characteristics gives a fair understanding of the consequences of global warning and provides the needs for an urgent mitigation or otherwise. Effective monitoring of the hydrometeorological characteristics of an area has been inevitable especially at this time when the ozone layer has been greatly depleted due to fossil fuel burning and huge industrial activities which release significant amounts of carbon monoxide into the atmosphere.
Hydrometeorological elements include rainfall, precipitation, wind, velocity, humidity, climate, weather, temperature, pressure, evapouration etc. and these elements are important signals that pre-determine the condition of the planet earth. When the temperature of an area becomes extra-ordinarily high, this condition suggests that there is ample evaporation from surface water and transpiration from the leaves of plants. This suggests also that the vegetation, plants, water resources crops and even human beings are highly predisposed to harm and danger.
This paper tends to solve the problems associated with global warning by trying to investigate the hydrometeorological characteristics of Anambra – Imo River Basin which consists of the Southern Eastern geopolitical zone of Nigeria.

1.1 Temperature
South Eastern geo-political zone which consists of the Anambra – Imo River Basin is a part of Nigeria located in the tropics. The rainy season brings in cooler weather as a result of increased cloud cover, which acts as a blockage to the intense sunshine by shielding much of the sun rays during the rainy season. This in turn cools the land and the winds above the ground remains cool thereby making for cooler temperatures during the rainy season. But afternoons during the rainy season can be hot and humid - a feature of tropical climates. During the rainy season, it is damp and the rain falls are much.
There is greater temperature during the dry season as there is little or no rain at this time. There is little cloud in the Anambra Imo River Basin during the dry season. The sun shines through the atmosphere with little obstructions from the clear skies making the dry season a period of warm weather conditions. There is haze in the atmosphere during the December period because the sun is partially obscured from shining. The activities of the wind lower temperatures considerably thereby saving the inhabitants from the scorching heat of the sun. The temperatures run up to 44^0C (111.2^0f) in some parts of the country.

1.2 Hydrometeorology
Meteorology is the study of atmospheric phenomena and it is gotten from the Greek word "meteor" which means "high in the air". Meteors have three main categories namely: (a) hydrometeors e.g. precipitation, (b) tithometoers e.g. smokes, dust and haze (i.e. condensation nuclei) (c) electrometers e.g. thunder and lightning. Weather and climate atmospheric phenomena interact to affect the environment and life on earth. Weather is the current state of atmosphere while climate is the average weather over the course of a 30- year time. The sun heats the surface of the earth through its rays. The wind and air with the ocean current redistribute the heat around the globe. Hydrometeorology is a branch of meteorology that deals with problems involving the hydrologic cycle, the water budget and rainfall statistics of storms.

1.3 Precipitation
Precipitation is the condensation of water vapour from the atmosphere and its falling to the earth's surface. This occurs mostly as rainfall, but also snowball and hail are all forms of precipitation. Precipitation is the basic source of water that evaporates or else moves to the streams and rivers or else seeps into the ground and emerges into groundwater. The understanding of these processes is vital for the management of surface water and groundwater resources.
The boundaries of hydrometeorology are not clear cut and the problems of the hydrometeorologist overlaps with those of the climatologist, hydrologist, cloud physicist and the weather

forecaster. It deals with measurement, analysis and modeling of atmospheric and land surface processes tied to the hydrologic cycle. These analyses often serve as the bases for the design of flood – control and water usage structures primarily dams and reservoirs. The hydrometeorologist concerns himself further with determination rainfall probabilities, the space and time distribution of rainfall and evaporation, the recurrence interval of major storms, now melt and runoff and probable wind tides and waves in reservoirs.

1.4 Weather

Weather is defined as the state of atmosphere at any given time. Some places on the globe see little change in weather daily. The meteorologist sees the weather as the accurate measurements of temperature, humidity, rainfall, pressure etc. The desire to forecast has been the habit of man from the biblical Noah's days. The methods of weather forecasting can be put into three namely: Point Forecasting, Pattern Forecasting and Numerical Weather Prediction.

1.4.1 Point Forecasting

Point Forecasting involves analysis of historical time services which establishes a correlation between a present observation and future occurrence. This may be of the same variable or a completely different variable. Most forecasting rules depend on animal or plant sensitivity to subtle changes in the atmosphere that suggest a coming change in the atmosphere. Other rules apply changes in cloud or wind patterns that humans can observe directly. Some of the approaches are globally applicable both spatially and in time.

1.4.2 Pattern Forecasting

Since the time that observations could be exchanged in real-time due to the invention of the electric telegraph in 1840, weather forecasting agencies were made to collect observations and develop maps of them for specific times. This approach was successful in middle latitudes where travelling depressions would be clearly identified in pressure observations and could be followed up daily. The recognition of structures within these pressure patterns such as warm and cold fronts, further enhanced the value of forecasts produced by this means. Further exploration of the upper air and the recognition of streams were both highly coherent in time and provided a guide to the evolution of surface depressions, led to the full flourishing of synoptic forecasting method in the mid-20th century.

1.4.3 Numerical Weather Forecasting

There were huge advances in the understanding of the atmosphere as a gaseous fluid in the 19th century. The gaseous fluid was observed to behave according to the principles of the Newtonian physics. In 1904, Whilhelm Ekerknes proposed that this knowledge can be used directly to predict future weather condition. Sequel to this, the attempt by hand calculation by L.F. Richardson in 1910s precipitated a successful progress to the coming invention of programmable computers during the Second World War The first successful forecasts were generated in the early 1950s and the method had become a valuable phenomenon to solving forecasting problems by the 1970s. Further developments in computer use and applications in the areas of satellite observations and in meteorology has made this method the most successful approach to weather forecasting, with useful skill to forecast for five days ahead on average (sometimes much more) and forecasts on the first day are often too accurate in their detail down to weather features of a few tens of kilometers across.

This numerical weather prediction is actually based on the application of computer models that describe the way the atmosphere changes using mathematical equations. This requires fast communications that gather the observations and very fast computers to carry out the large number of calculations needed. A practical numerical weather forecasting involves an observation capture, data assimilation, prediction, uncertainly and risk assessment and communication. Observation capture relies on the knowledge of the current state of the atmosphere and this is obtained by observations and measurements with this, the whole world can be captured through the exchange of weather observations among the nations of the world by the instrumentality of fast communication links.

Data assimilation is the input of data from the observation capture into the computers which can stimulate the behavior of the atmosphere extremely well. This yield approximate results and it uses a branch of mathematics called inverse modeling. This is the most difficult and expensive part of the numerical weather forecasting. These observations are made by satellites and these satellites are able to send huge volumes of data back to the earth.

The prediction involves the application of a mathematical model which is derived from the equations of physics that describe the acceleration of air due to pressure gradients resulting from variations in the density of the air. Even though the equations are relatively simple, the calculation is complex due to the effects of the rotation of the earth, irregularity of the earth's surface, and the effects of water as it changes between its states of vapour, liquid or ice, makes it complex. Uncertainty is involved because the equations of the atmosphere are highly non-linear and small features will grow exponentially in some parts of the forecast domain and as such the forecast must be represented by a probability distribution.

Risk assessment and communication portray the impact of the predicted weather on the people and the choice of the communication tool for its announcement. A forecast has value when people take it serious and adjust their behavior due to it. For low impact weather, simple broadcast styles of communication may be used but when large impacts are involved, whether to life, or properties, ensuring correct understanding of the risk is paramount.

1.5 Climate

This describes the average weather over a period of time. It includes not just the average but the variability and extremes, as these can have great impacts. Climate is usually described for different seasons, months, and averaged over a period of 30 years. Long time series of observations are important in detecting the changes in our climate.

Climate change is very much involved with energy and most commonly in the form of heat energy. Radiation comes from the sun in the form of solar radiation at short wave lengths and people radiate proportionally to the fourth power of absolute temperature and this makes the inhabitants of earth surface, and atmosphere to radiate at infrared wavelengths. Weather and climate on earth are determined by the amount and distribution of incoming radiation from the sun. Incoming

radiant energy may be scattered and reflected by clouds or aerosols (dust or pollution) or absorbed in the atmosphere. The transmitted radiation is then absorbed or reflected at the earth's surface. Radiant solar (short wave) energy is transformed into sensible heat (related to temperature), latent energy (involving different water bodies), potential energy (gravity and height), and kinetic energy (involving motion) before being emitted as long-wave infrared radiant energy. Energy may be stored, transported in various forms and converted among different types, giving rise to a rich variety of weather or turbulent phenomena in the atmosphere and ocean.

Climatic change has been a source of concern not necessarily because of its inherent fascination but because of its huge and adverse effects on the planet earth which may even lead to its extinction. Global warming occurs when carbon dioxide (CO_2) and other our pollutants and greenhouse gases collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface. Normally, this radiation would escape into space but those pollutants, which can last for years to centuries in the atmosphere, planet trap the heat and cause the planet to get hotter. This is known as greenhouse effect. Efforts geared towards curbing dangerous climatic changes require very deep cut in emission, as well as the use of alternatives to fossil fuels globally.

1.6 Humidity

This is the amount of water vapour present in the air. Water vapour is the gaseous state of water and it is invisible to human eye. Humidity shows the possibility of precipitation, dew or fog. Humidity when high reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. This effect is calculated in a heat index table or humidity. The amount of water vapour that is needed to achieve saturation increases as the temperature increases.

There are three main measurements of humidity namely: absolute, relative and specific humidity. Absolute humidity is the water content of the air expressed in g/m^3. Relative humidity is expressed in percentage and it measures absolute humidity relative to the maximum for that temperature. Specific humidity is the ratio of the mass of water vapour to the total mass of the most air parcel. The absolute humidity is given by the formular,

$$AH = \frac{M\ (H_2O)}{V_{net}}$$

Humidity is a climate variable and it interacts with other climate variables. It is affected by winds and rainfalls. Humidity affects the energy budget and influences temperatures in two major ways. The water vapour in the atmosphere contains "latent" energy and during transpiration or evaporation the latent heat is removed from surface thereby cooling the earth's surface. This is the biggest non-radiactive cooling effect at the surface. It compensates for roughly 70% of the average net radiactive warming at the surface.

2. Materials and methods

2.1 Materials

In this research, equipment were used to determine such climate and weather parameters as rainfall, humidity, evaporation, temperature, wind velocity and the intensity of the sun. The equipment used in the work include rain-gauge, dry and wet bulb thermometer, piche evaporimeter, and sunshine recorder and they were used to measure rainfall, temperature, humidity, evaporation, and the intensity of the sun respectively.

2.2 Methods

The method used in this research was empirical as equipment were used to measure the various climate and weather variables. The results of the measurement were collected and tabulated. The data collected covered the period of October, November and December of 2011.

2.3 Data Analysis

The data collected were analyzed using the various statistical method and graphs.

3.0 Result Presentation and Analysis

3.1 Result Presentation

The results of measurements carried out on the climate variables of rainfall, temperature, relative humidity, evaporation, sunshine hours and wind speeds for the months of October, November and December, 2011 are presented in Table 3.1, table 3.2 and table 3.3 respectively.

Table 1: Hydro- meteorological Data of Study Area, For October, 2011

DAY	RAINFALL (mm)	TEMPERATURE (°C)			RELATIVE HUMIDITY (%)	PICHE EVAPORATION (ml)	SUNSHINE HOURS (hrs)	WIND SPEED (Knots)
		MAX	MIN	MEAN				
1	23.00	33.50	25.00	29.25	72.50	0.80	3.00	6.38
2	NR	33.50	23.00	28.25	78.00	0.90	2.00	6.76
3	1.00	28.00	23.00	25.50	76.00	1.10	4.00	6.83
4	NR	33.50	24.00	28.75	80.50	1.00	5.00	16.66
5	3.00	33.50	24.00	28.75	85.00	1.40	4.00	15.89
6	21.50	33.50	23.00	28.25	85.50	0.10	0.00	10.90
7	5.80	33.50	22.00	27.75	79.00	0.60	4.30	2.32
8	NR	30.60	22.00	26.30	81.00	1.60	3.00	6.28
9	90.50	33.50	23.00	28.25	75.00	1.00	4.00	5.32
10	8.00	35.50	23.00	29.25	79.00	0.30	3.00	1.55
11	85.00	37.00	26.00	31.50	82.00	0.40	4.00	4.63
12	NR	36.00	25.00	30.50	84.50	0.40	2.40	4.35
13	11.00	36.00	23.00	29.50	68.00	0.40	7.20	4.60
14	35.20	36.00	23.00	29.50	72.00	1.10	6.00	3.82
15	56.00	36.00	21.00	28.50	75.50	0.40	0.00	5.14
16	NR	37.50	28.00	32.75	67.50	0.90	7.00	4.32
17	NR	34.50	25.00	29.75	78.00	1.00	6.00	4.40
18	3.40	34.50	25.00	29.75	80.50	1.90	3.00	10.00
19	NR	34.50	23.00	28.75	79.00	1.10	5.50	0.00
20	7.20	34.50	23.00	28.75	82.00	0.50	0.00	1.47
21	NR	34.50	24.00	29.25	68.50	0.50	3.45	0.00
22	46.10	34.70	22.00	28.10	81.00	0.30	2.00	0.00
23	7.80	34.20	22.00	28.10	69.50	0.60	6.00	1.77
24	5.50	32.00	23.00	27.50	77.00	0.20	2.45	2.68
25	30.00	32.00	21.00	26.50	79.00	1.00	0.00	0.00
26	0.50	32.00	25.00	28.50	82.00	0.80	3.30	0.00
27	5.60	32.00	22.00	27.00	85.00	3.00	7.30	0.03
28	NR	32.00	24.00	28.00	80.00	3.00	6.30	2.93
29	NR	32.00	22.00	27.00	84.50	1.30	8.50	0.00
30	NR	32.00	23.00	27.50	87.00	0.90	2.30	0.00
31	NR	31.00	24.00	27.50	85.00	1.10	3.45	0.00
Mean	**23.48**	**33.66**	**23.42**	**28.53**	**78.68**	**0.95**	**3.82**	**4.16**
Max	**90.50**	**37.50**	**28.00**	**32.75**	**87.00**	**3.00**	**8.50**	**16.66**
Min	**0.50**	**28.00**	**21.00**	**25.50**	**67.50**	**0.10**	**0.00**	**0.00**
Sum	**446.10**							

** NR - No Rainfall*

Table 2: Hydro-meteorological Data of Study Area for November, 2011

DAY	RAINFALL (mm)	TEMPERATURE (°C)			RELATIVE HUMIDITY (%)	PICHE EVAPORATION (ml)	SUNSHINE HOURS (hrs)	WIND SPEED (Knots)
		MAX	MIN	MEAN				
1	NR	31.00	23.00	27.00	85.00	0.90	6.00	0.00
2	75.00	31.00	22.50	26.75	80.00	1.00	0.10	0.00
3	NR	31.00	23.00	27.00	80.50	1.00	5.00	0.00
4	NR	31.00	23.00	27.00	82.00	0.30	6.00	1.58
5	23.50	31.00	23.00	27.00	84.50	0.20	5.00	0.00
6	NR	28.00	22.00	25.00	87.00	0.10	5.30	1.50
7	NR	32.00	24.00	28.00	90.00	1.00	6.00	0.60
8	NR	30.00	22.00	26.00	87.50	0.80	4.35	1.20
9	NR	28.00	19.00	23.50	86.50	0.70	5.20	0.90
10	NR	29.00	21.00	25.00	84.00	1.20	6.00	0.10
11	NR	28.00	22.00	25.00	87.00	1.00	5.00	0.00
12	NR	29.00	18.50	23.75	85.50	1.40	7.00	0.00
13	NR	30.00	21.00	25.50	82.50	0.90	4.00	0.50
14	NR	34.00	24.50	29.25	80.00	1.00	5.00	0.06
15	NR	30.00	24.00	27.00	87.50	1.00	4.00	0.14
16	NR	33.00	23.00	28.00	87.50	0.40	5.00	0.05
17	NR	33.00	22.00	27.50	82.00	1.70	7.00	0.01
18	NR	29.00	23.00	26.00	84.50	1.10	6.00	0.09
19	NR	30.00	25.00	27.50	92.50	1.00	5.30	0.01
20	NR	31.50	23.00	27.25	86.50	0.80	6.00	0.02
21	NR	30.00	24.00	27.00	84.00	0.20	7.00	0.70
22	NR	34.00	24.00	29.00	81.00	0.70	6.00	0.90
23	NR	30.00	23.00	26.50	85.00	1.60	6.00	0.11
24	NR	29.00	25.00	27.00	79.50	1.42	5.45	0.12
25	NR	39.00	26.00	32.50	75.00	2.30	5.30	0.13
26	NR	37.00	28.00	32.50	77.00	2.40	8.00	0.00
27	NR	39.00	27.00	33.00	76.50	1.10	7.30	0.02
28	NR	40.50	13.00	26.75	77.50	1.50	5.00	0.08
29	NR	40.50	13.00	26.75	77.50	1.40	8.30	0.02
30	NR	41.00	13.50	27.25	78.50	2.00	6.40	0.31
31								
Mean	**49.25**	**32.32**	**22.17**	**27.24**	**83.13**	**1.07**	**5.60**	**0.31**
Max	**75.00**	**41.00**	**28.00**	**33.00**	**92.50**	**2.40**	**8.30**	**1.58**
Min	**23.50**	**28.00**	**13.00**	**23.50**	**75.00**	**0.10**	**0.10**	**0.00**
Sum	**98.50**							

** NR - No Rainfall*

Table 3: Hydro-meteorological Data of Study Area for December, 2011

DAY	RAINFALL (mm)	TEMPERATURE (°C)			RELATIVE HUMIDITY (%)	PICHE EVAPORATION (ml)	SUNSHINE HOURS (hrs)	WIND SPEED (Knots)
		MAX	MIN	MEAN				
1	NR	40.50	12.00	26.25	73.00	3.50	8.45	2.44
2	NR	37.80	8.50	23.15	65.00	4.70	7.50	4.64
3	NR	41.50	21.50	31.50	61.00	2.20	7.40	1.50
4	NR	35.00	9.00	22.00	60.00	2.40	8.30	1.39
5	NR	30.00	19.00	24.50	60.50	1.50	5.00	0.29
6	NR	31.00	18.00	24.50	72.50	1.70	6.00	1.90
7	NR	33.00	21.00	27.00	76.00	2.00	6.30	3.80
8	NR	31.00	11.00	21.00	69.00	4.20	8.00	2.30
9	NR	37.00	22.00	29.50	60.50	3.50	5.30	2.20
10	NR	32.00	18.00	25.00	61.50	2.40	7.45	1.90
11	NR	34.00	19.00	26.50	69.50	4.00	6.30	5.00
12	NR	39.00	18.50	28.75	65.00	0.61	6.00	4.13
13	NR	37.50	17.50	27.50	61.57	4.50	3.00	7.81
14	NR	37.00	9.50	23.25	65.00	7.34	8.00	0.75
15	NR	40.00	11.00	25.50	72.00	2.50	5.30	10.87
16	NR	39.00	11.00	25.00	70.50	3.75	7.00	8.39
17	NR	28.00	13.00	20.50	69.00	3.20	7.45	3.50
18	NR	31.00	18.50	24.75	67.00	0.80	6.00	6.20
19	NR	39.00	15.00	27.00	60.00	0.60	6.50	0.05
20	NR	34.00	21.00	27.50	61.50	0.90	6.45	7.30
21	NR	37.50	13.00	25.25	69.50	1.80	7.00	0.21
22	NR	38.50	17.00	27.75	75.00	2.20	6.00	7.70
23	NR	37.00	12.00	24.50	69.00	2.20	6.30	0.87
24	NR	41.00	19.00	30.00	60.50	0.50	6.00	6.02
25	NR	39.00	14.00	26.50	65.00	4.90	8.00	10.60
26	NR	30.00	27.00	28.50	61.50	0.70	7.00	1.18
27	NR	28.00	25.00	26.50	71.00	2.90	6.00	2.59
28	NR	28.00	26.00	27.00	69.50	0.50	7.45	1.00
29	NR	30.00	19.00	24.50	65.50	2.00	8.00	0.86
30	25.00	33.00	23.00	28.00	65.00	3.00	6.00	1.97
31	46.00	36.00	31.00	33.50	69.00	3.00	7.00	0.41
Mean	**35.50**	**35.01**	**17.42**	**26.21**	**66.47**	**2.58**	**6.65**	**3.54**
Max	**46.00**	**41.50**	**31.00**	**33.50**	**76.00**	**7.34**	**8.45**	**10.87**
Min	**25.00**	**28.00**	**8.50**	**20.50**	**60.00**	**0.50**	**3.00**	**0.05**
Sum	**71.00**							

** NR - No Rainfall*

The daily variations of the rainfall, sunshine hours, mean temperatures, maximum and minimum temperatures, evaporation, relative humidity and wind speed for the month of October, 2011 are presented in figures 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 and 3.7 respectively.

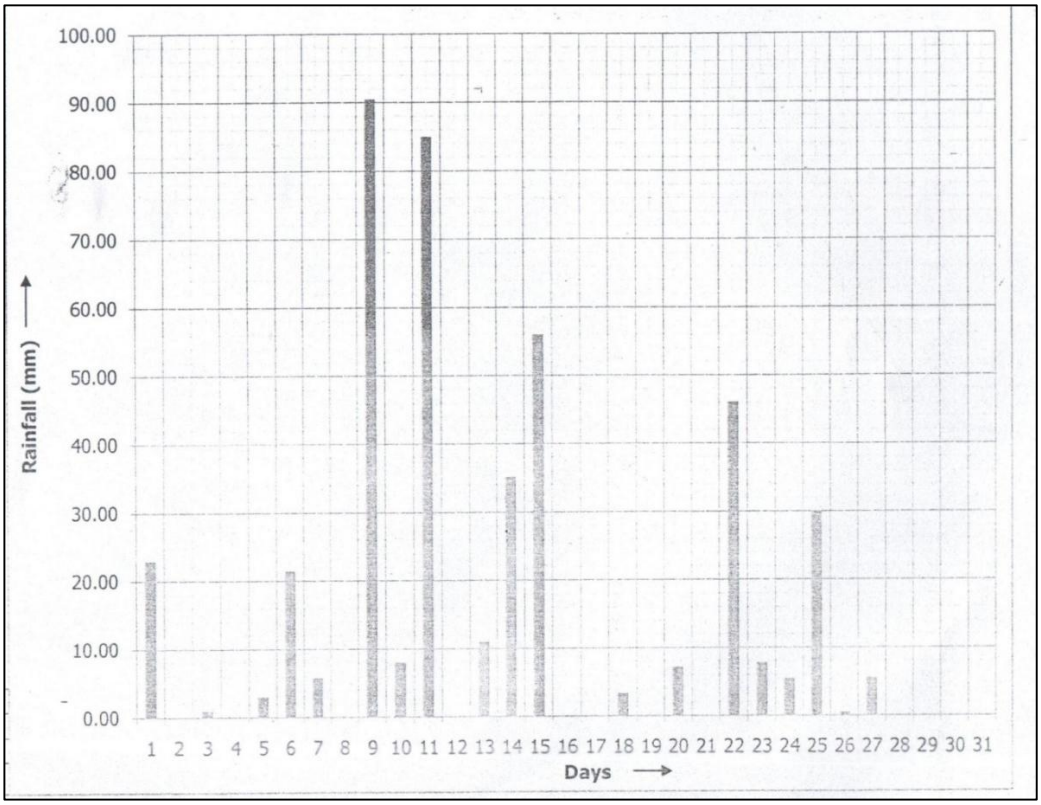

Fig 1: Variation in Rainfall for October, 2011

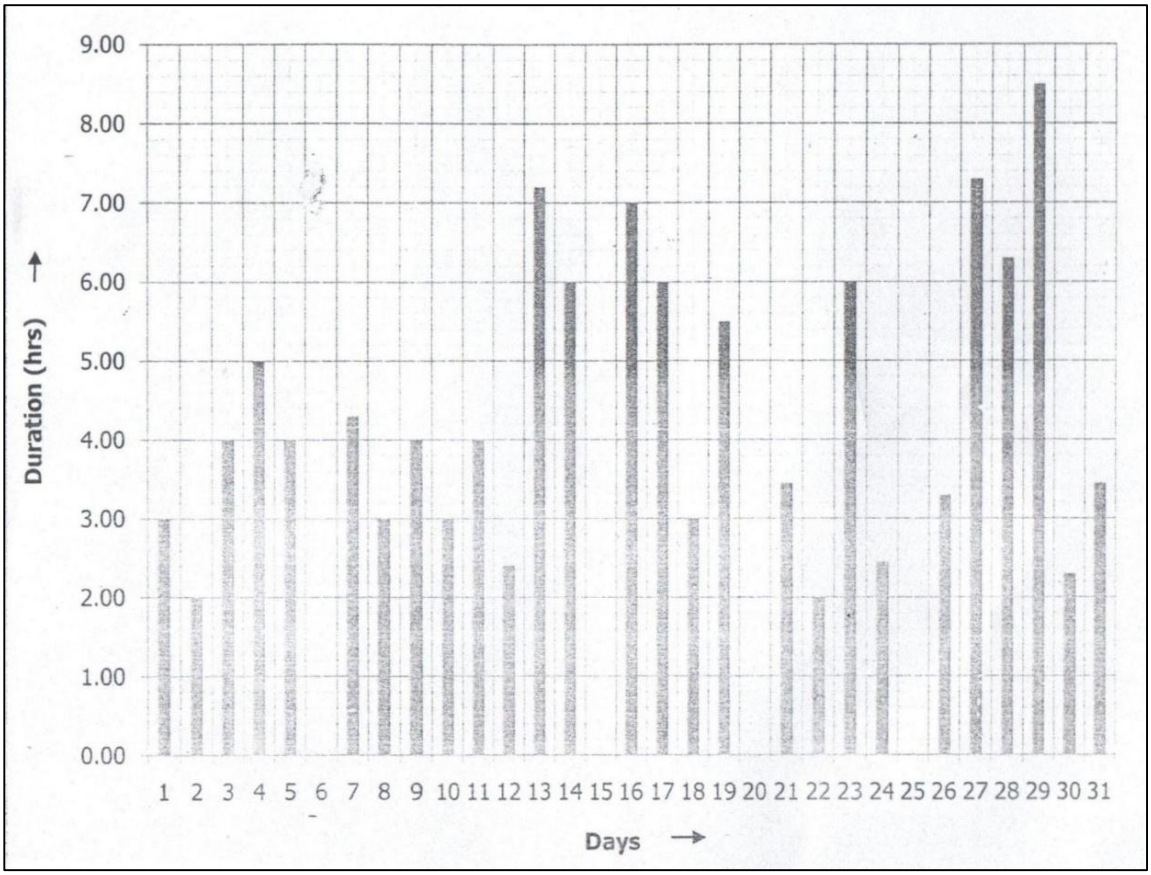

Fig 2: Variation in Sunshine Hours for October, 2011

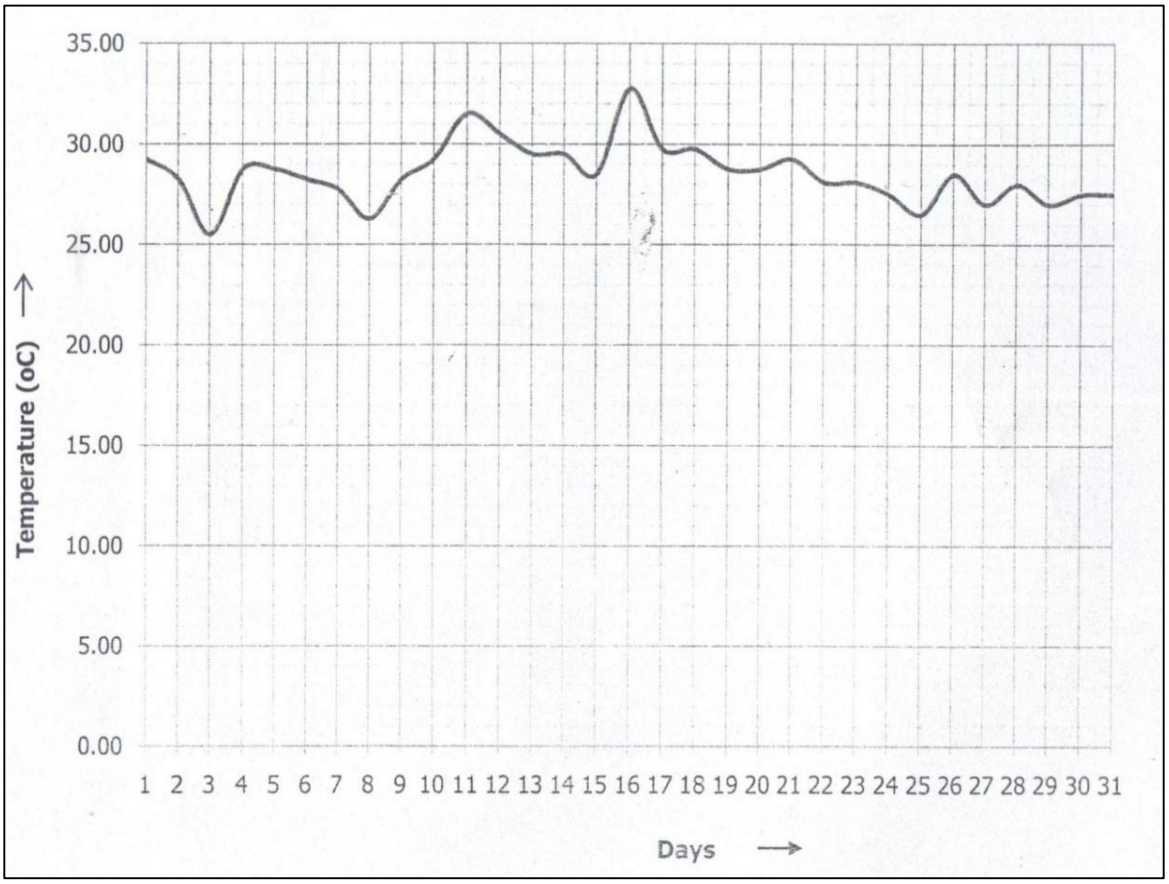

Fig.3.3: Variation of Mean Temperature for October, 2011

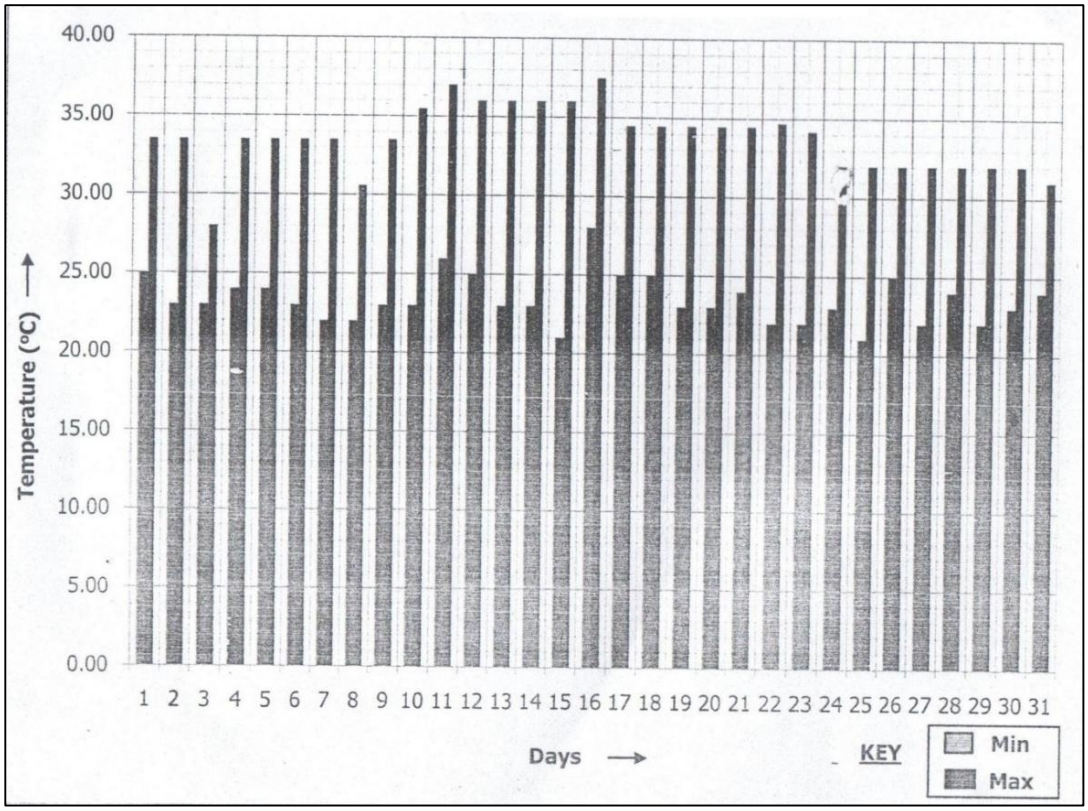

Fig 4: Variation of Maximum and Minimum Temperature, 2011

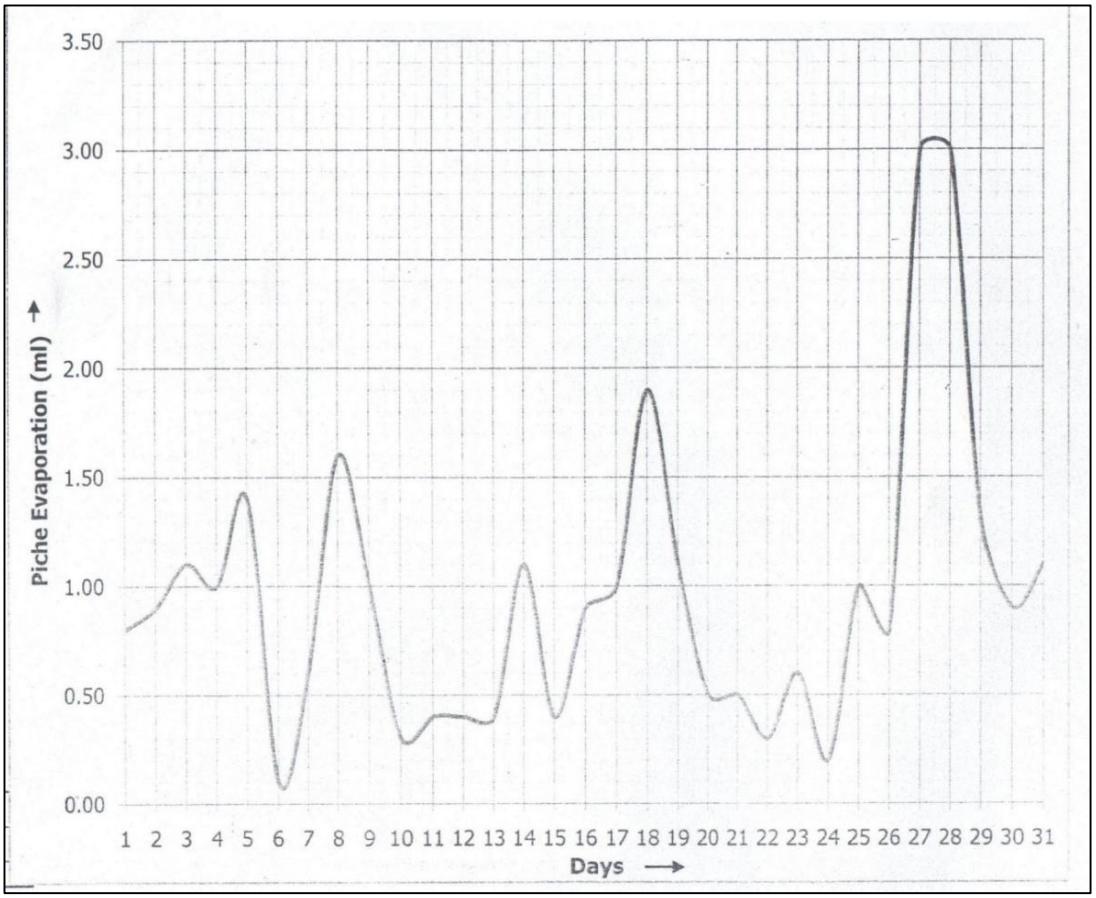

Fig 5: Variation of Evaporation for October, 2011

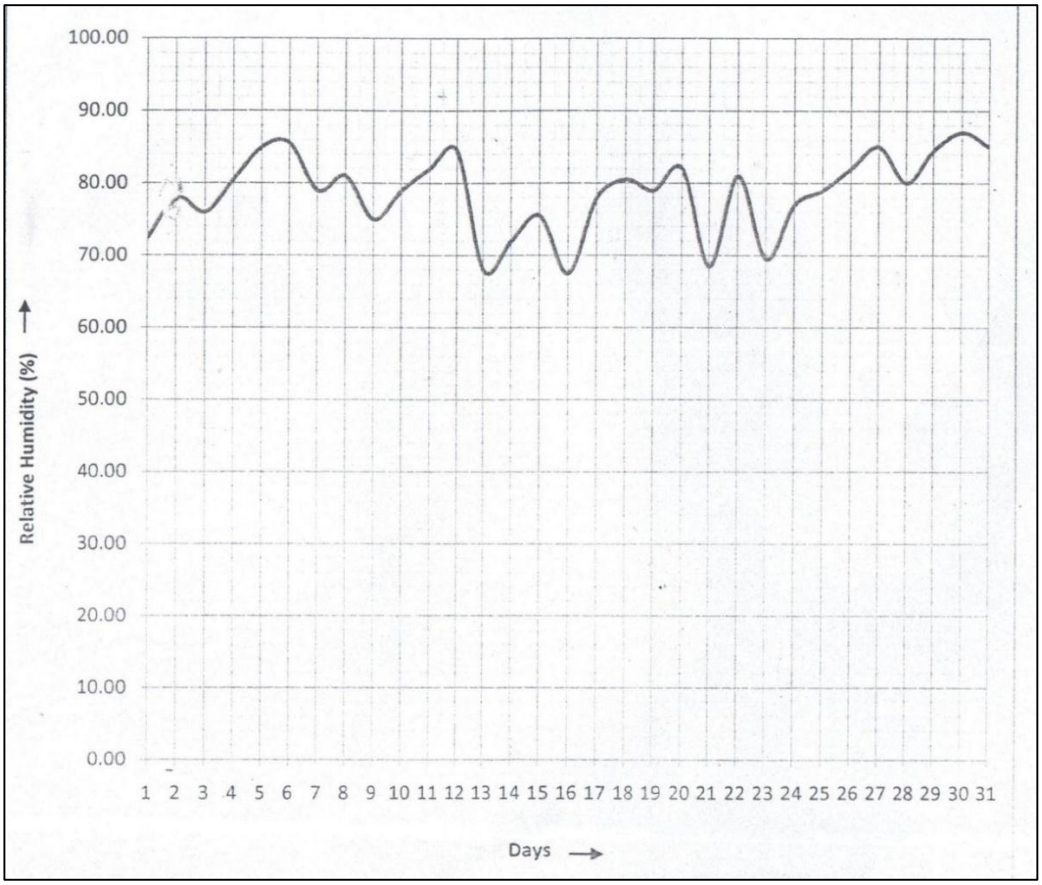

Fig 6: Variation of Relative Humidity for October, 2011

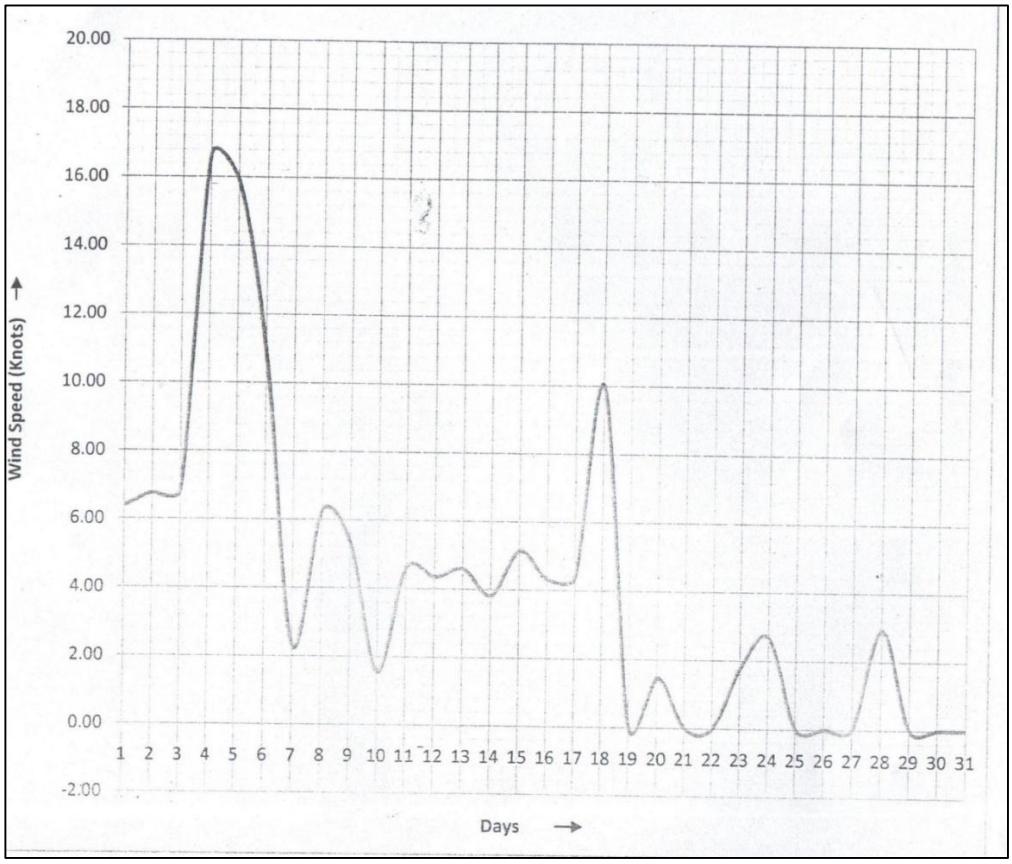

Fig 7: Variation of Wind Speed in October

3.2 Analysis of results

Tables 3.1, 3.2 and 3.3 show that the highest average temperatures for the period under review are 28.53^0C, 27.24^0C and 26.21^0C. Within the period there was high temperature as there was little cloud in the sky to protect much solar rays from reaching the area. Dryness is enhanced in the area with high mean piche evaporation of 0.75ml, 1.07ml and 2.58ml. The average wind speeds of 4.16 knots, 0.3 knots and 3.54 knots played a significant roles in moderating the high temperatures and reducing the scorching effects of the sun as they distribute the prevailing heat around the area. There were low mean amounts of rainfalls resulting to rainfall amounts of 23.48mm, 49.25mm and 35.50mm and this also encouraged dryness during that period.

In hydrometeorological analysis, the interest in the analysis lies on the extremities and their variabilities. In line with this, it can be understood from the work that maximum rainfall amount for October is 90.50mm while the minimum rainfall for the same period was 0.50mm. Generally, it can be deduced from fig. 3.1, that the variability of rain within the period was very high. The high variability in rainfall is also applicable to the months of November and December as can be seen in tables 3.2 and 3.3 respectively.

4. Conclusion

Climate change is a prelude to global warming and this demands that adequate attention should be given to all the variables of the climate which include rainfall, temperature, humidity, evaporation, wind speed, sunshine hours, etc. Obviously, empiricism is the most viable option to undertake the determination of the numerical values of these variables and the continuity of the approach periodically is tantamount to monitoring development in the climate elements. It is true that global warming originates from the human activities of industrialization but its effects concentrate on the climate and the earth's water resources and vegetation. This is to say that the understanding of the climate will help to guide the activities on the study area. This paper therefore has played a critical role in developing numerical values for rainfall, temperature, humidity, evaporation, wind speed and sunshine hours thereby closing the gap in the dearth of hydrometeorological data in Anambra – Imo River Basin. From this work, it is believed that there will be a continuation and continuous monitoring of the climate variables through empiricism.

4. References

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