Int. J. Pure Appl. Sci. Technol., 28(2) (2015), pp. 63-76

International Journal of Pure and Applied Sciences and Technology

ISSN 2229 - 6107

Available online at [***www.ijopaasat.in***](http://www.ijopaasat.in)

Research Paper

An Examination of Trends and Variation of Monthly Mean Relative Humidity Data in Nigeria from 1950 – 2012

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(Received: 9-4-15; Accepted: 16-5-15)

Abstract: *This paper analyzed the spatial and temporal variations of surface relative humidity in Nigeria in the context of climate variability and change. The study is based on the data collected from the Nigerian Meteorological Agency, Oshodi, Lagos Nigeria for the period ranging from 1950 – 2012 with variations in data length across the stations. Basic data consist of monthly mean daily relative humidity values expressed in percent at 0900 hours GMT from 20 meteorological stations spread across different ecological zones and climate belts in Nigeria. Statistical techniques used for the analyses include time series plots, correlation analysis, descriptive statistics, Mann-Kendall's rank correlation tests, bar charts and the least square linear fitting of the linear regression model. These analyses were executed using MATLAB 2008, SPSS version 17 and the 'R' programming language software packages. The descriptive statistics indicate that the mean and the coefficient of variation show latitudinal dependence. The Mann-Kendall's tests results show that 4 stations (representing 20%) show significant downward trends while 3 stations (representing 15%) show significant upward trends at the 1% and 5% levels with no discernible pattern across latitudinal bands. The inter station correlation as revealed by the Pearson's product moment correlation coefficients show strong positive correlations significant at the 1% level across all station pairs. The bar charts show more marked seasonal variations in the north than in the south with peak values from June to October and minimum extending from November to March across Nigeria. The results suggest that the spatial variability of surface relative humidity is impacted by some local processes and local clouds as the spatial and temporal trends are not consistent with the increasing global temperatures based on positive feedback of water vapour on surface temperature in model simulations.*

Keywords: Relative Humidity, Trends, Variations, Mann-Kendall, Least Squares Regression, Nigeria.

1.0 Introduction

Recently, attention has been given to climate variability and its effect on the hydrological cycle and water supply. Many of the researches perceive climate changes, trends and variability in many parts of the world, using some climatic parameters such as air temperature, rainfall, evapotranspiration, wind speed, sunshine duration, surface specific humidity and surface relative humidity among others.

This study is undertaken to examine the trends and variations of monthly mean relative humidity data using statistical tools. Most practical effects of trends and variations in climate do not involve a single climatic element but are synergistic result of many climatic elements. Relative humidity is recognized by its important role as a determinant in weather and climate. The atmospheric water vapour provides the single largest greenhouse effect on the earth's climate system (Dai, 2006).

Relative humidity is a measure of the water content of the air at a given temperature. The amount of water vapour in the air is compared with the maximum amount that the air can contain (required to saturate the air) at the same temperature expressed as a percentage. In other words, it is a measure of the actual amount of water vapour in the air compared to the actual amount of water vapour that the air can contain at its current temperature. At the surface, relative humidity is an important meteorological and climatic variable that affects human comfort. Humans are very sensitive to humidity because the human skin relies on the air to get rid of moisture. The process of sweating is the body's attempt to keep cool and maintain its current temperature. When the air is at 100% relative humidity, sweat will not evaporate into the air. As a consequence, people feel much hotter than the actual temperature when the relative humidity is high. When the relative humidity is low, people feel much cooler than the actual temperature because their sweat evaporates easily, thereby cooling them off.

According to Dai *et al*, (2001), all climate models predict increased water vapour in the air and small changes in relative humidity as the temperature increases due to increased CO_2 and other greenhouse gases accumulation. The water vapour feedback mechanism is the most powerful positive feedback on surface temperature in the earth's climate system. According to Dai (2006), this water vapour positive feedback is the main cause of increased precipitation at mid and high latitudes in model simulations. It is therefore justifiable to study and monitor the changes in the moisture content of the atmosphere for detecting global warming and climate change on the one hand, and for validating the large water vapour feedback observed in climate models.

Long-term variations in surface specific humidity and surface relative humidity have been studied at various spatial and temporal scales. Dai, (2006) observed relatively small variations in surface relative humidity over the oceans but considerable variations over the continental United States for the period 1975 – 2005. Dessler and Davis (2010) examined the trends in tropospheric humidity from reanalysis systems resulting from decadal climate fluctuations between 1973 and 2007. Smirnov and Moore (2001) examined the transport of water vapour through the Mackenzie River Basin for the period 1979 – 1993 and discovered that the transport of water vapour through the Mackenzie Basin showed high spatial and temporal variability. Shenbin *et a*l, (2006) analysed the potential evapotranspiration trends in the Tibetan Plateau from 1961 – 2000 and observed a downward trend for all seasons. Chakraborty *et al*, (2013) analyzed reference evapotranspiration variability and trends in the Seonath River basin, Chhattisgarh from 1960 – 2008 using Mann-Kendall's and Spearman's rho statistics. They observed more pronounced increasing trends than decreasing trends. In Nigeria, Akinnubi *et al*, (2007) studied the characteristic variation of relative humidity and solar radiation for 48 months (1999

– 2001) over Ibadan using the average monthly values of each parameter. Ewona and Udo (2008) and Ogolo and Adeyemi (2009) examined the relative humidity variations for Calabar (1985-1994) and Ibadan (1988-1997) respectively.

In this study, we examined the relative humidity trends and variability from 1950 – 2012 in 20 meteorological stations spread across different ecological and climatic zones in Nigeria using the robust Mann-Kendall's rank correlation test and other statistical tools.

2.0 Study Area

Nigeria co-ordinates on latitude 10.00^{o}N and Longitude 8.00^{o}E and lies between latitude 4^{o}N and 14^{o}N, and between longitude 2^{o}E and 15^{o}E. It has a total area of 923.77km^{2} and land mass coverage of 910.77km^{2}. It comprises various ecotypes and climatic zones. The climate is equatorial at the southern coast; humid tropical in the south; dry tropical in the north; and sahelian towards the Lake Chad in the North East. The Nigerian climate is mostly dominated by the north-south oscillation of the Inter Tropical Discontinuity (ITD). The ITD is marked by the convergence of the north – easterly monsoon and the south westerly trade winds. The seasonal north – south migration of the ITD dictates the weather pattern of Nigeria. Fig 1 is the map of Nigeria showing the 20 meteorological stations used in the study.

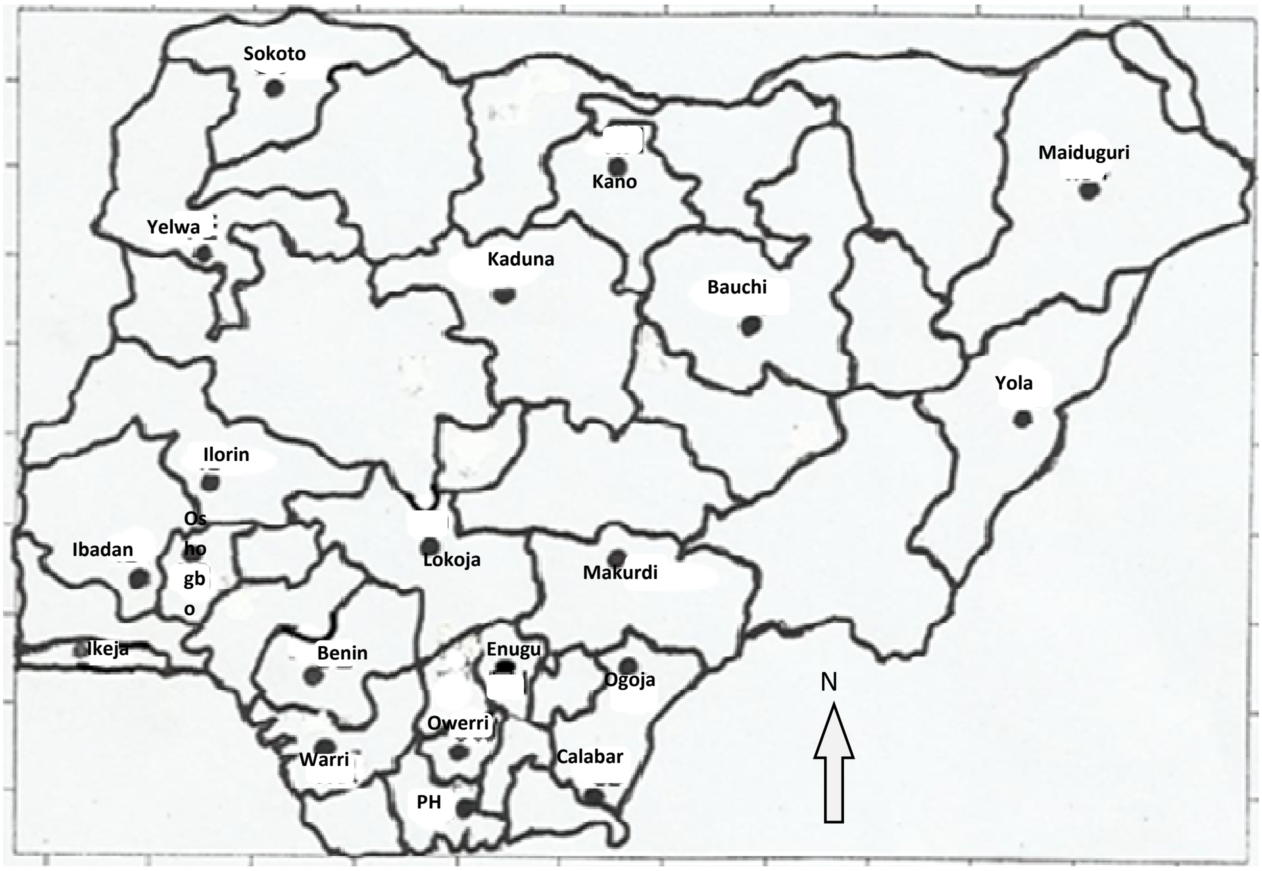


Fig. 1: Map of Nigeria showing the relative humility stations used in the study

3.0 Data and Methodology

3.1 The Data

Monthly mean daily relative humidity at 0900 hours GMT during 1950 – 2012 at 20 meteorological stations in Nigeria were obtained from the archives of the Nigerian Meteorological Agency, Oshodi, Lagos Nigeria. Table 1 gives the information of relative humidity data used in the study.

Table 1: Summary information of the relative humidity (R.H) data used in the study

Station No.	Station Name	Latitude (^{o}N)	Longitude (^{o}E)	Altitude (m)	Period	Sequence length	% of missing data
1.	Yelwa	10.53	4.45	244	1950-2012	756	0.00
2	Sokoto	12.55	5.12	351	1950-2012	756	0.00
3	Kaduna	10.42	7.19	645	1950-2012	756	0.00
4	Kano	12.03	8.32	476	1960-2012	636	0.00
5	Bauchi	10.17	9.49	591	1950-2012	756	0.00
6	Maiduguri	11.51	13.05	354	1950-2012	756	0.00
7	Ilorin	8.26	4.30	308	1961-2012	624	0.00
8	Yola	9.16	12.26	191	1950-2012	756	0.00
9	Ikeja	6.35	3.20	40	1950-2012	756	0.00
10	Ibadan	7.22	3.59	234	1961-2012	624	0.00
11	Oshogbo	7.47	4.29	305	1961-2012	624	0.00
12	Benin	6.19	5.36	77.80	1950-2012	756	0.00
13	Warri	5.31	5.44	6.00	1950-2012	756	0.00
14	Lokoja	7.48	6.44	113	1950-2012	756	0.00
15	Port Harcourt	5.01	6.57	18	1950-2012	756	0.00
16	Owerri	5.25	7.13	91	1974-2012	468	7.69
17	Enugu	6.28	7.34	142	1961-2012	624	15.38
18	Calabar	4.58	8.21	62	1961-2012	624	0.00
19	Makurdi	7.42	8.37	113	1961-2012	624	4.00
20	Ogoja	6.40	8.48	117	1976-2012	444	0.00

3.2 Data Quality Check

The data were subjected to a range of quality checks (0% - 100%). The quality checks were intended to exclude outliers that could result from errors in measurements, data transmission and other sources. The remainder of the random errors in the data were significantly reduced during the averaging to derive the monthly mean data from daily observations because the data is large overall stations. No attempt was made at addressing potential systematic errors and biases that could result from changes in instrumentation, instrument heights and positions, and other factors because metadata for these changes were unavailable. Dai (2006) noted that statistical tests for non-climatic changes without any metadata are not very effective for relatively short length durations. Missing records were observed (table 1). The missing data were not replaced because of dearth of relative humidity data stations in the country such that nearby stations from where to reconstruct the missing data are nonexistent. Shongwe *et al* (2006)had recommended the use of data from the stations with missing records not exceeding 5% for data scarce regions. However Enugu and Owerri stations recorded missing data that exceeds 5%. Ngongondo *et al*, (2011) adopted a more flexible 10% maximum threshold recommended by Hosking and Wallis (1997). Still, Helsel and Hirsch (1992) in National Nonpoint Source Monitoring Programme (NNSMP) (2011) recommended that monotonic trend analysis could be applied if the data gap does not exceed one-third of the total data length. This recommendation is based on the use of the robust non-parametric tests that are robust against large data gaps. This is adopted in this research. This conveniently accommodates the Enugu data with 15.38% missing record. A preliminary step in analysis of homogeneity is to plot the time series of the original data on a linear scale.

This was done in this case and visual inspection of the plots revealed that the data are homogeneous. The plots also revealed long-term fluctuations and trends embedded with considerable month-to-month variation, which are within the non-randomness characteristics of series of climatological observations.

3.3 Methodology

3.3.1 Processing Software Packages

The descriptive statistics of the distribution was evaluated using the SPSS version 17 computer package. The SPSS V.17 package was also used to evaluate the Mann-Kendall's (M-K) rank correlation tests and the Pearson's product moment correlation coefficients. The non-parametric M-K test was used to detect direction and significance of the trends and the time trend coefficients. The trend magnitudes were estimated using the least squares regression which was executed using the MATLAB 2008 software package. The time series plots with the trend lines (not shown) were done using the MATLAB 2008 software package. The R Programming Language was used to plot the bar charts to indicate seasonal variations in the relative humidity record.

3.3.2 Trend Analysis

The Mann-Kendall's (M-K) rank correlation test was used to determine the direction and significance of the trends. The M-K test also indicates the trend coefficients. The significance of the trends were tested at the 1% and 5% levels. Detailed discussion of M-K trend tests abound in the literature (e.g Turkes, 1999, Turkes *et al*, 2009; Zhihua *et al*, 2013; De Luis *et al*, 2000; Rai *et al*, 2010; Amadi *et al*, 2014a; Amadi *et al*, 2014b). To perform the M-K test, the difference between the earlier and the later measured values $(y_j - y_i)$ where j >i are computed. Values of +1, 0, and -1 are assigned to the positive differences, zero differences, and negative differences respectively as ranks. The test statistic, S, is then computed as the sum of the integer values,

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sign\ (y_j - y_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Sign $(y_j - y_i)$ is equal to +1, 0 or -1.

When S is a large positive number, later measured values tend to be greater than earlier measured values and a positive (upward) trend is indicated. When S is a large negative number, earlier values tend to exceed later values and a negative (downward) trend is indicated. If the absolute value of S is small, no trend is indicated.

The null hypothesis H_o is that the variable is independent and randomly distributed, i.e, no trend exists. The alternative hypothesis H_1 is that there is existence of trend.

The test statistic τ (Kendall's *tau b*) can be determined as:

$$\tau = \frac{S}{n(n-1)/2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

τ is the time trend coefficient and has a range of -1 to +1, analogous to the correlation coefficient in regression analysis. The null hypothesis H_0 is rejected if τ is significantly different from zero ($p<\alpha$) where α is the chosen significance level (0.01 and 0.05 in this study). The M-K tests were executed using SPSS version 17. Even though the M-K test gives the time trend coefficients, it cannot estimate the trend magnitudes.

The trend magnitudes were estimated based on the linear regression model using the method of least squares linear fitting.

The linear regression model is expressed thus:

$$\overline{y} = \beta_1 \overline{x} + \beta_o \quad \ldots\ldots\ldots\ldots (3)$$

The null hypothesis is that the slope coefficient $\beta_1 = 0$ (lack of linear dependence). The alternative hypothesis is that the slope coefficient $\beta_1 \neq 0$ (linear dependence exists). If β_1 is significantly different from zero, the null hypothesis is rejected and it can be concluded that there is linear trend in y over time with the rate = β_1. The values of β_1 (slope) and β_o (vertical intercept) were determined on the basis of the following equations:

$$\beta_1 = \frac{\sum_{i=1}^{n} (x_i - \bar{x}).(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \quad \ldots\ldots\ldots\ldots (4)$$

$$\beta_o = y - \beta_1 . x \quad \ldots\ldots\ldots\ldots (5)$$

where n = sample size; y_i = value of next observation i of y variable; x_i = value of next observation i of x variable; y is the arithmetic mean of y variable, x is the arithmetic mean of x variable. Regression analysis were executed using MATLAB 2008.

4.0 Results and Discussion

Table 2 shows the descriptive statistics of the relative humidity data. The table indicates that the average of the monthly mean daily relative humidity for the period shows latitudinal dependence, decreasing with latitude. In otherwords, the mean of the relative humidity values decreases from South to North. The coefficient of variation also shows latitudinal depdence increasing from South to North. These results are to be expected because the South is dominated by humid tropical climate and equatorial climate along the coast adjoining the Atlantic Ocean while the north is dominated by the dry tropical climate and the Sahelian climate at the far north-east region. This shows that more moisture is evaporated into the atmosphere in the South than in the North as air temperature rises. The values of the coefficients of variation implies that relative humidity is more stable in the South and suffers less variation compared with the North.

Table 3 is the result of the M-K trend tests along with the *p*-values of the test stastic, the trend coefficients, τ and trend magnitudes. 50% of the stations (10 stations) show downward trends with only 4 stations indicating significant downward trends. These are Kaduna, Ikeja, Calabar and Ogoja. Also, 10 stations (representing 50%) show upward trends with only 3 stations indicating significant upward trends. These are Bauchi, Port Harcourt and Owerri.

The Pearson's product moment correlation matrix is shown in table 4. The table clearly indicates positive correlations significant at the 1% level in all the station pairs.

Table 2: Descriptive Statistics for Relative Humidity (R.H)

Station Name	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Range**	**C.V. (%)**
Yelwa	756	14	98	59.99	19.640	84	32.74
Sokoto	756	8	90	44.04	24.090	82	54.70
Kaduna	756	11	90	54.54	24.981	79	45.80
Kano	636	8	90	45.78	22.828	82	49.86
Bauchi	756	7	87	46.31	23.269	80	50.25
Maiduguri	756	5	96	39.23	21.960	91	55.98
Ilorin	624	23	98	74.55	11.999	75	16.10
Yola	756	10	90	52.35	23.223	80	44.36
Ikeja	756	41	97	83.81	5.100	56	6.09
Ibadan	624	27	97	80.33	7.695	70	9.58
Oshogbo	624	37	97	81.81	8.129	60	9.34
Benin	756	55	94	83.95	5.290	39	6.30
Warri	756	46	98	84.53	4.066	52	4.81
Lokoja	756	40	87	73.38	8.379	47	11.42
Port Harcourt	756	40	94	82.23	6.758	54	8.22
Owerri	432	12	93	70.13	20.300	81	28.95
Enugu	528	18	89	73.68	11.622	71	15.77
Calabar	624	50	94	84.50	5.513	44	6.52
Makurdi	600	10	93	68.38	15.483	83	22.64
Ogoja	444	25	90	72.60	14.030	65	19.33

Table 3: Mann-Kendall's test results and estimates of trend magnitudes of relative humidity

Station No.	**Station Name**	**Kendall's *tau b* (τ)**	***p* values**	**Trend estimates**		
				% per month	**% per year**	**%per decade**
1.	Yelwa	0.007	0.765	0.0056	0.0672	0.672
2	Sokoto	-0.014	0.565	0.0131	0.1572	1.572
3	Kaduna	-0.057*	0.020	0.0086	0.1032	1.032
4	Kano	0.024	0.379	0.003	0.036	0.36
5	Bauchi	0.059*	0.017	0.0048	0.0576	0.576
6	Maiduguri	0.001	0.982	0.0101	0.1212	1.212
7	Ilorin	0.020	0.463	0.0042	0.0504	0.504
8	Yola	-0.003	0.898	0.00140	0.0168	0.168
9	Ikeja	-0.226**	0.000	0.002	0.024	0.24
10	Ibadan	0.008	0.764	0.0039	0.0468	0.468
11	Oshogbo	0.024	0.388	0.0037	0.0444	0.444
12	Benin	-0.001	0.962	0.0012	0.0144	0.144
13	Warri	-0.016	0.537	0.0011	0.0132	0.132
14	Lokoja	-0.027	0.269	0.0024	0.0288	0.288
15	Port Harcourt	0.066**	0.008	0.0093	0.1116	1.116
16	Owerri	0.294**	0.000	0.0482	0.5784	5.784
17	Enugu	0.054	0.068	0.0025	0.03	0.3
18	Calabar	-0.135**	0.000	0.0088	0.1056	1.056
19	Makurdi	-0.022	0.436	0.0097	0.1164	1.164
20	Ogoja	-0.064*	0.047	0.0075	0.09	0.9

**Correlation is significant at the 0.01 level (two-tailed). * Correlation is significant at the 0.05 level (Two-tailed).

Table 4: Correlation coefficients for **Relative Humidity** across the stations

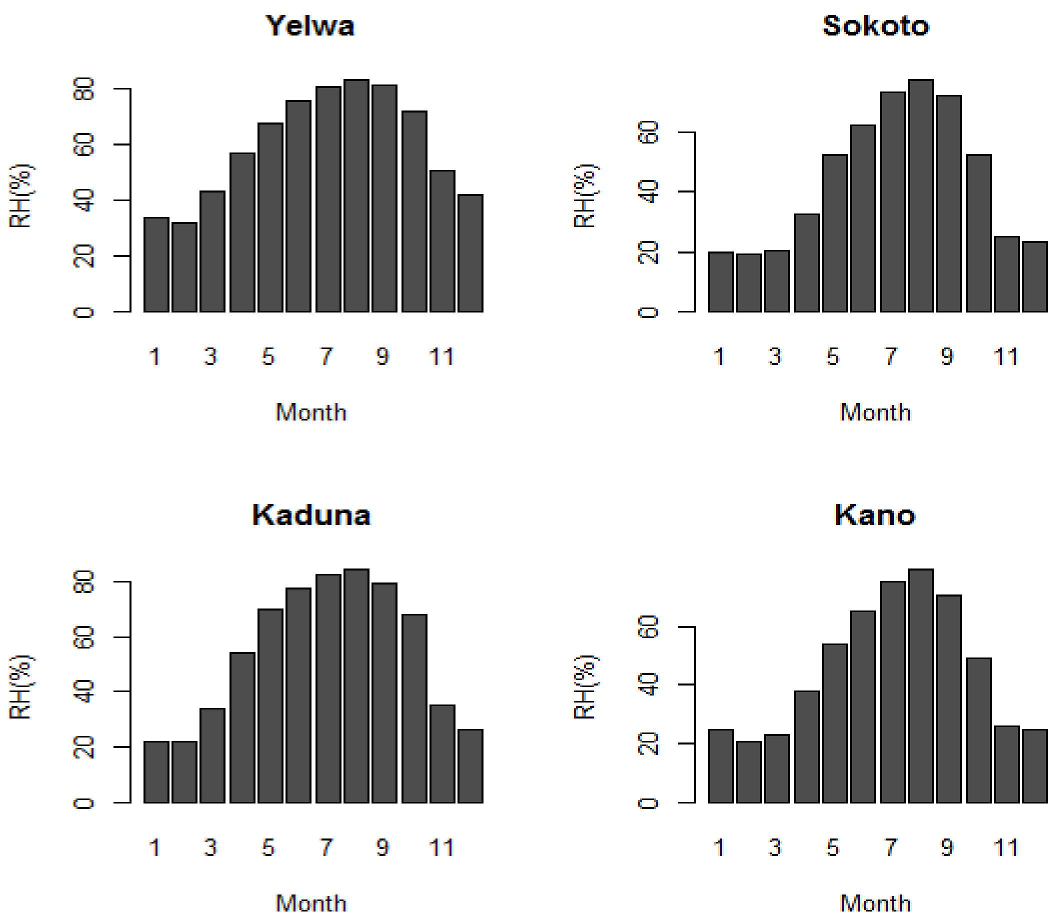
	Stations																			
Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1																			
2	.845**	1																		
3	.920**	.877**	1																	
4	.863**	.907**	.907**	1																
5	.908**	.883**	.922**	.913**	1															
6	.825**	.844**	.829**	.869**	.875**	1														
7	.773**	.718**	.783**	.714**	.717**	.679**	1													
8	.851**	.814**	.874**	.818**	.848**	.791**	.720**	1												
9	.396**	.383**	.386**	.422**	.363**	.408**	.547**	.381**	1											
10	.656**	.615**	.663**	.623**	.605**	.584**	.855**	.620**	.595**	1										
11	.709**	.668**	.724**	.666**	.642**	.602**	.835**	.646**	.517**	.847**	1									
12	.635**	.611**	.628**	.632**	.611**	.615**	.801**	.592**	.560**	.832**	.760**	1								
13	.229**	.332**	.231**	.404**	.280**	.335**	.412**	.249**	.377**	.497**	.462**	.534**	1							
14	.749**	.731**	.758**	.749**	.713**	.680**	.786**	.736**	.538**	.773**	.796**	.717**	.394**	1						
15	.579**	.487**	.573**	.506**	.560**	.554**	.722**	.534**	.408**	.697**	.675**	.587**	.279**	.502**	1					
16	.488**	.476**	.413**	.428**	.481**	.374**	.425**	.413**	.224**	.333**	.376**	.399**	.189**	.375**	.283**	1				
17	.776**	.679**	.785**	.697**	.699**	.643**	.905**	.706**	.559**	.821**	.819**	.798**	.370**	.771**	.750**	.480**	1			
18	.654**	.584**	.639**	.603**	.605**	.597**	.742**	.585**	.601**	.716**	.688**	.719**	.387**	.688**	.673**	.298**	.757**	1		
19	.783**	.692**	.792**	.712**	.713**	.679**	.828**	.727**	.493**	.752**	.759**	.698**	.328**	.759**	.632**	.352**	.852**	.694**	1	
20	.785**	.687**	.804**	.709**	.706**	.659**	.874**	.717**	.605**	.783**	.795**	.775**	.445**	.760**	.746**	.425**	.916**	.796**	.836**	1

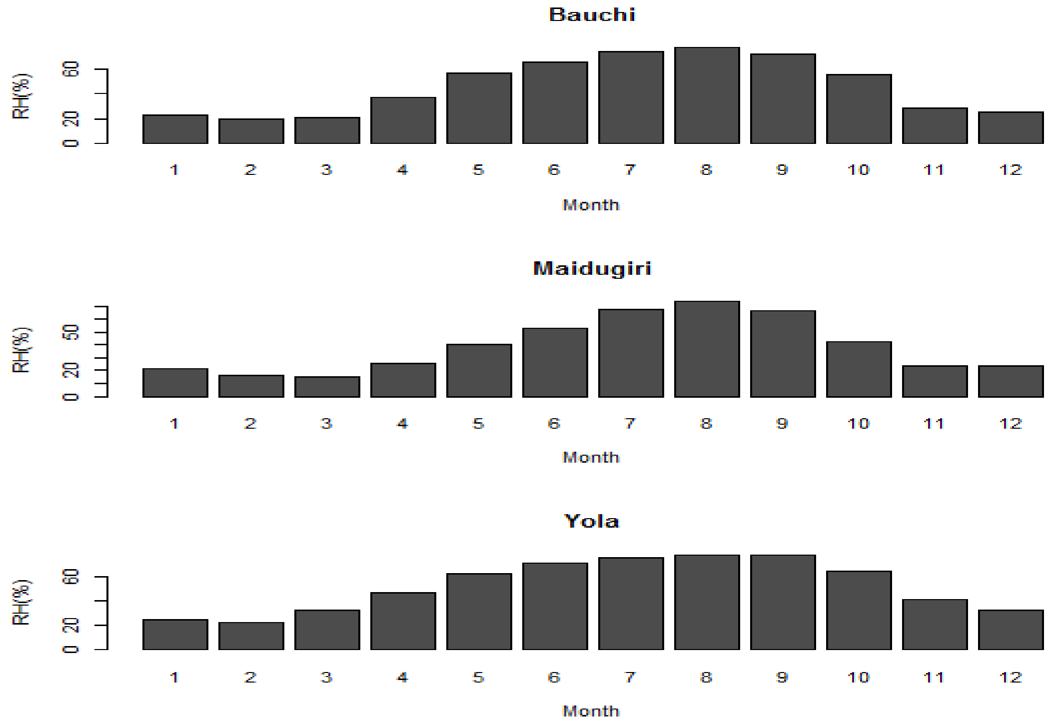
** Correlation significant at 1% (two taired) *Correlation significant at 5% (two tailed).

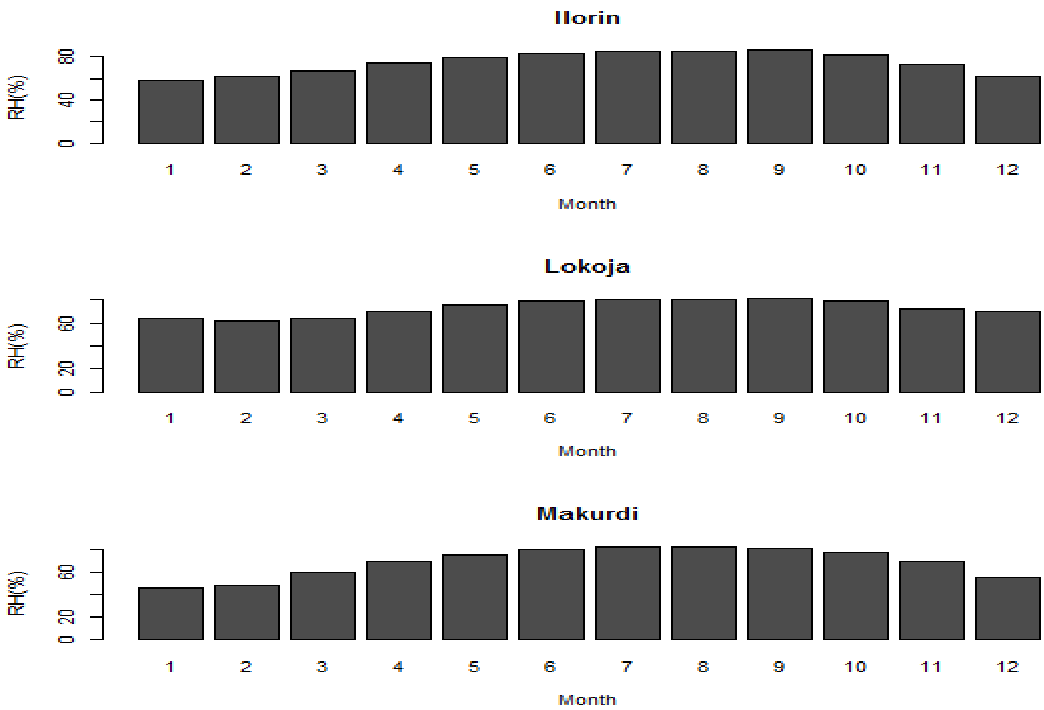
Fig 2 are the bar charts depicting the seasonal variations of relative humidity in the stations. The figures clearly show that relative humidity suffers marked seasonal variations in the north (at higher latitudes). Highest values are recorded in the months of July, August and September in the north (exceeding 80%) with peak values occuring in August. Lowest values are recorded from November to March, (oscillating around 20%). Down south, the distributions are more uniform ranging from 70% and above. Thus, the southern part of the country indicate small variations in relative humidity across the seasons. However, peak values are observed in the months of June to October while minimum values are recorded from November to March.

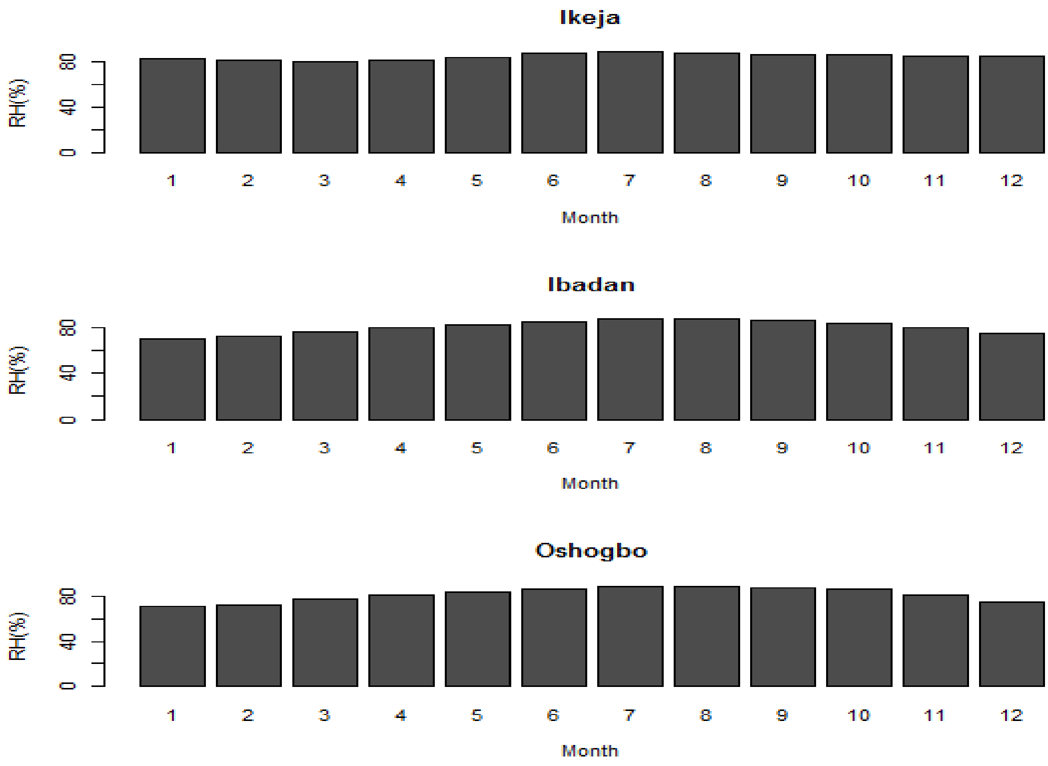
In as much as the relative humidity distribution pattern here strongly follows the divides of the ecological zones and climatic regions as expected, there are, nonetheless, some deviations as observed in table 3. The trends observed in table 3 corroborate the fact that surface relative humidity is controlled by a number of processes such as atmospheric circulation, vertical mixing, surface evaporation, wind speed, moisture and solar heating. Other factors include greenhouse gases accumulation, sulphate aerosols, ozone, volcanic and solar forcing.

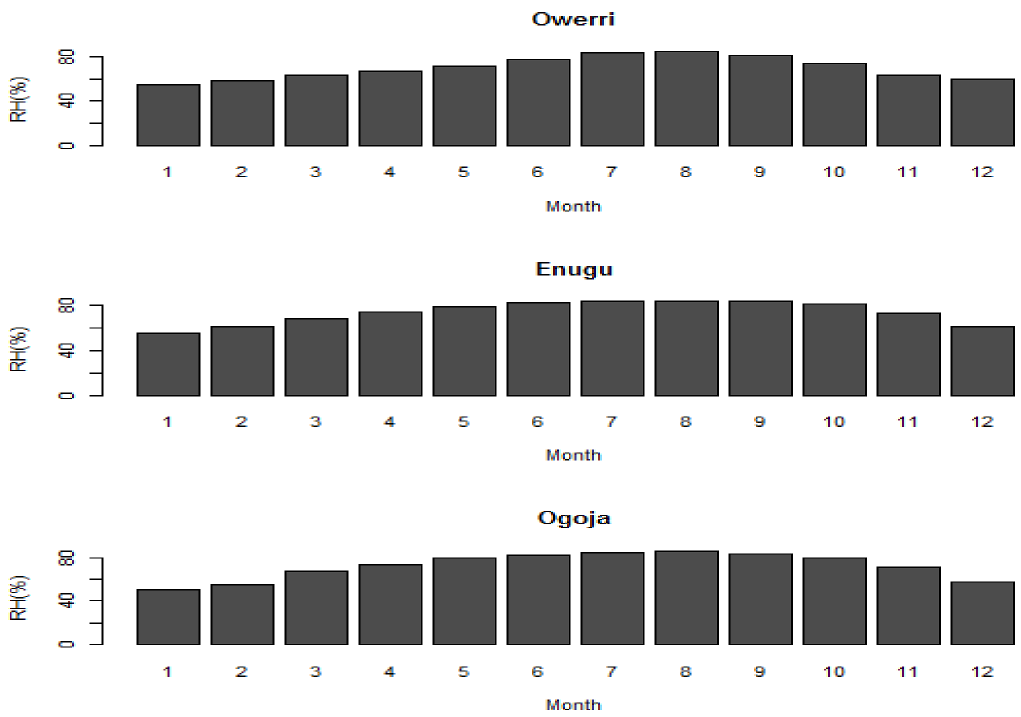
The observed large latitudinal variation in relative humidity is expected. This is suggestive of the drying effects of dry soils on surface humidity. The positive feedback of water vapour suggests that surface temperature should largely control surface humidity. The control of surface temperature on surface humidity is also implied by the relatively invariant seasonal distributions of surface relative humidity over the sourthern part and marked seasonal variations in the northern part of Nigeria. Fig. 2 shows that relative humidity is around 60% to 80% over most southern stations, whereas it is around 20% to 80% over most northern stations. The fact that relative humidity attains a maximum at about 80% in both the southern and northern parts could imply that there is a limit to which water can evaporate into




Bauchi
RH(%)
0 20 60
1 2 3 4 5 6 7 8 9 10 11 12
Month
Maidugiri
RH(%)
0 20 50
1 2 3 4 5 6 7 8 9 10 11 12
Month
Yola
RH(%)
0 20 60
1 2 3 4 5 6 7 8 9 10 11 12
Month


Ilorin
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month
Lokoja
RH(%)
0 20 60
1 2 3 4 5 6 7 8 9 10 11 12
Month
Makurdi
RH(%)
0 20 60
1 2 3 4 5 6 7 8 9 10 11 12
Month


Ikeja
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month
Ibadan
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month
Oshogbo
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month


Owerri
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month
Enugu
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month
Ogoja
RH(%)
0 40 80
1 2 3 4 5 6 7 8 9 10 11 12
Month

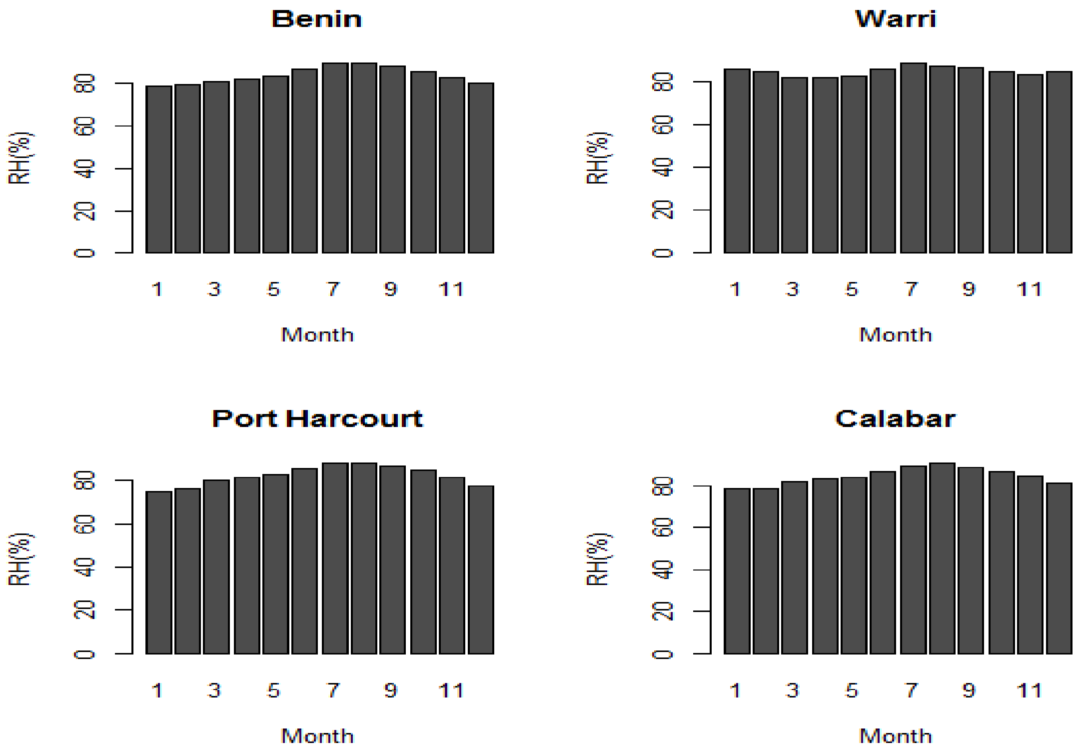


Fig. 2: Seasonal variation relative humidity in the stations

the Nigerian atmosphere. Because atmospheric water vapour provides a strong positive feedback to greenhouse gas induced global warming, suface humidity is expected to increase with the observed increase in global surface temperature. This is because as air temperature increases, the air would accommodate more moisture (ie more water vapour would be needed to saturate the air) and vice-versa. However, the surface relative humidity is expected to correlate negatively with temperature over dry areas with weak or negative surface specific humidity – temperature correlation. This is expected because surface evaporation over these regions is limited by soil wetness, and it often cannot meet atmospheric demand to maintain a constant relative humidity as air temperature increases. Type of soil is also a factor because some soils (e.g clay) can retain water more than others (e.g sandy),and even in terms of capillary actions of the soil formation. In dry regions, dry soil and atmospheric subsidence have large impact on surface specific humidity, leading to its weak or negative correlation with temperature. These assertions (observations) could explain the indicated significant upward and downward trends shown in table 3. The results also suggest that the spatial variability of surface relative humidity is closely associated with local clouds. In addition, the magnitude of surface relative humidity trends is sensitive to the time period considered here, especially given the relatively short length of records in some stations.

The results of this study agree to a large extent with the results of Ogolo and Adeyemi, (2009), which observed significant increasing trends in the monthly mean series of relative humidity values and non-significant increasing trends in the annual mean series for Ibadan, Nigeria, between 1988 and 1997 using M-K and Spearman's test. The results of this study equally agree with observed seasonal variations in relative humidity values at 0900 hours GMT between 1985 and 1994 as reported by Ewona and Udo (2008) for Calabar which peaked between July and September. However, the trend results of this study disagree with the trend results of Ewona and Udo (2008) that indicated increasing trends in relative humidity at 33% rate for Calabar, Nigeria, between 1985 and 1994, even though that study did not indicate the trend significance. The difference is atributed to the differences in data length used and the staitiscal tests applied. This is because time series plots usually reveal long-term fluctuatons and trends which are embedded with considerable month-to-month, or year-to-year variations as the case may be, depicting existence of short term (interval) trends in the series. In addition, these results here agree with Akinnubi *et al*, (2007), which observed peak values of relative humidity in August for Ibadan from 1999 – 2001.

Furthermore, at the international level, the results of this study agree with Dai, (2006) that observed significant long-term trends comprising significant increasing and decreasing trends from over 15,000 weather stations across the world between 1975 to 2005. The results of this study is further supported by the observed relatively large relative humidity variations of 0.5% to 2.0% per decade over the central and Eastern United States, India and Western China as reported by Dai (2006).

5.0 Conclusion

The trends and variability of relative humidity (R.H) in Nigeria has been analysed for the period 1950-2012. The mean and the coefficient of variation of relative humidity show latitudinal dependence. While the mean increases from north to south, the coefficient of variation decreases from north to south. The M-K tests results indicate that only 7 stations representing 35% of the stations show significant trends; 4 stations indicating significant downward trends and 3 stations indicating significant upward trends. The trends and variations in R.H as observed in the result is due to impacts of processes such as surface temperature, greenhouse gases accumulation, atmospheric wind speed, soil moisture, solar heating, soil type and atmospheric subsidence etc. Inter station correlation coefficients indicate strong positive correlations significant at the 1% level across all the station pairs. The R.H shows more marked seasonal variations in the north (where dry tropical climate is dominant) than in the south and central parts that are dominated by humid tropical and equatorial climates. Across Nigeria, high values of R.H are recorded in the months of June to October with a peak in August while minima are recorded from November to March. The south shows weak seasonal variations relative to the north. The inability of the observed temporal trends to show latitudinal dependence suggests that the spatial variability of surface R.H is closely associated with local clouds, local atmospheric circulation and a range of other processes as enumerated in the preceding statements. Furthermore, the magnitude of the surface R.H trends is sensitive to the time period considered here, and given the relatively short length of records in some stations.

These results have implications for the country's hydrological cycle and water supply which appear to be impacted by some local processes as earlier mentioned. Nevertheless, the results bring to bear the need for monitoring surface R.H trends for prompt actions in the areas of policy formulation and implementations especially with regards to hydrological cycle and water supply.

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