STATISTICAL ANALYSIS OF THE HOURLY RELATIVE HUMIDITY DATA OF SOKOTO AND PORT HARCOURT IN NIGERIA AND ITS IMPLICATION ON AGRICULTURE

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Abstract

Hourly relative humidity (RH) for Sokoto and Port Harcourt in Nigeria were obtained from the Nigerian Meteorological Agency, Oshodi for the years 1995 to 2009. Statistical analyses were carried out on the data to obtain average hourly relative humidity for each month and then the average monthly relative humidity. Probability density functions were developed from the hourly relative humidity data for the two cities. The results show that Sokoto and Port Harcourt have their lowest average relative humidity of 19.39% and 74.72% in March and January respectively. While the highest average relative humidity occurs in August and were found to be 78.7% and 89.93% for Sokoto and Port Harcourt respectively. The number of hours that relative humidity is below 60% is high in Sokoto while the number of hours that relative humidity is above 60% is high in Port Harcourt. The implication of these results on the practice of agriculture is that drying and storage of some crops could be achieved better under atmospheric conditions in Sokoto than Port Harcourt. Equally the practice of poultry keeping involving incubation and brooding for which moderate relative humidity id required will pose a challenge most of the month of the year for the two cities. For Sokoto, there will be need to increase it to appropriate level and slight reduction will be required for Port Harcourt. It is therefore recommended that more attention should be paid to Agriculture practices in these locations considering the weather-related areas of strength. Silos should be built for storage of grains and storage facilities for fruits should be built in Port Harcourt. This will improve the agricultural capacities in the country.

Key words: relative humidity, agriculture, storage

Introduction

In Nigeria the occupation of the rural dwellers is predominantly agricultural practices. They engage in planting of crops such as potatoes, vegetables and some other food crops. A major problem in planting is post harvest losses during drying and storage which depends largely on the humidity of the environment.

Two cities in Nigeria considered in this study are Sokoto and Port Harcourt. Sokoto is in Northern Nigeria and lies on the geographical coordinates of 13° 3' 5" N, 5° 13' 53" E. Port Harcourt located in Southern Nigeria, a Coastal City lies on the geographical coordinates of 4° 47' 21" N, 6° 59' 54" E**.**

Agriculture is practiced in the two cities as described in Wikipedia (2013), Ademiluyi and Puyate(2013), Etukudoh et al(2013) in various capacities and areas.

In one report on Sokoto, it was said that over eighty percent (80%) of the inhabitants practice one form of agriculture or the other from which crops such as millet, guinea corn, maize, rice, potatoes, cassava, groundnuts and beans for subsistence and produce are obtained.

Air humidity is a very important factor that influences the success of processing and preservation of farm products. It has been found that some crops require high humidity in storage whereas some others require low humidity (Igbeka, 2013). Non growth of fungi on food crop is aided by air of relative humidity of 60% or less (ASHRAE, 2005). Thorpe (1986) found that it is possible to use ambient air for drying of paddy without supplementary heating if the relative humidity of the air is less than 70%. Recommended storage conditions for some fruits are depicted in the Table below.

Table 1: Fruits storage conditions (Ohio State University extension, 2013)

Product	Temperature range (°C)	Relative humidity (%)
Sweet potatoes	18-21	85-90
Watermelon	18-21	85-90
Pears (for ripening)	18-21	85-90
Tomatoes, mature green	18-21	85-90
Yams	18-21	85-90

In the work of Ademiluyi (2013) on drying of ground fermented cassava in Port Harcourt, it was reported that to achieve a working condition of 80% relative humidity in one of the experimental work, an air conditioning system was employed.

The objectives of this work are to do statistical analysis on the hourly relative humidity data obtained from Nigerian Meteorological Agency, NIMET to obtain the probability density function and compare these with what is needed for optimum agricultural practice in the area of harvesting, post harvesting and poultry keeping processes.

Analysis of the data

The statistical analysis described in this work was done using Microsoft Excel 2007 version. The relative humidity data for 15 years for both Sokoto and Port Harcourt were collected from Nigerian Meteorological Agency, NIMET, Oshodi, Nigeria. The data were recorded on hourly basis using the standard time of Greenwich Meridian Time (GMT). Hourly averages of the 24 hours of the day were computed. The Standard deviations were computed for each month of the year. The average daily range was calculated, this is the difference between the average maximum and average minimum for each of the month.

Monthly average daily relative humidity for the two cities was computed. The maximum monthly daily relative humidity for Sokoto and Port Harcourt occurs in August. The minimum relative humidity occurs in the months of March for Sokoto and January for Port Harcourt.

Probability Density Function

The probability density function of a variable describes the range over which a variable is distributed and how the variable is distributed over its range of values.

The Probability density function for the relative humidity was developed from the measured data. A bin width of 5% was used. The equation (Ariyo, 1997) below was used to calculate the bin width for each month for both cities.

$$\Delta = r \times (1+3.3\log_{10}N)^{-1} \qquad (1)$$

Where Δ is a reasonable interval, r is the range of data and N is the number of data points.

The computed bin width varied from 3.85% to 6.68% for Sokoto and from 2.94% to 6.26% for Port Harcourt. The averages of the calculated bin width for both Sokoto and Port Harcourt were 5.26% and 4.44% respectively.

Therefore a bin width of 5% was chosen for convenience in the development of the probability density function for each city. The number of hours that the relative humidity is within an interval is resolved by the product of the number of hours in the month and the integral of the probability density function over that defined range of relative humidity in the interval.

Results

The results of the average monthly relative humidity, standard deviation and range for each city are presented in Table 2 for Sokoto and Port Harcourt.

TABLE 2: AVERAGE MONTHLY RELATIVE HUMIDITY, STANDARD DEVIATION AND RANGE OF RELATIVE HUMIDITY FOR SOKOTO AND PORT HARCOURT

		Sokoto			**Port Harcourt**		
S/No	**Month**	**Mean RH**	**STD**	**Range**	**Mean RH**	**STD**	**Range**
1	January	25.36	8.86	16.72	**74.72**	20.29	42.75
2	February	21.09	7.55	16.72	75.34	20.09	43.58
3	March	**19.39**	8.91	13.12	80.88	14.76	34.00
4	April	29.92	15.88	22.36	83.83	11.80	27.51
5	May	46.01	16.88	33.10	85.68	11.02	25.33
6	June	57.13	15.62	34.32	88.05	9.64	21.18
7	July	70.01	14.32	31.33	89.47	8.81	18.47
8	August	**78.70**	12.23	27.62	**89.93**	8.43	17.50
9	September	74.58	13.63	32.11	89.91	8.64	18.66
10	October	53.43	20.69	40.83	88.04	9.64	21.99
11	November	28.79	10.54	22.78	85.14	12.17	29.28
12	December	28.16	8.82	18.53	80.29	16.84	38.83

The compiled bin data from the fifteen years hourly data are shown in Tables 3 and 4 for Sokoto, while Tables 5 and 6 show the results for Port Harcourt. The value in each of the

bin interval gives the number of hours the relative humidity was in that bin. The sum of the hours in all the bins in a month gives the sum of the hours in that month.

TABLE 3: MEASURED AMBIENT AIR RELATIVE HUMIDITY BIN DATA OF 0-50% FOR SOKOTO (HOURS)

Month	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Jan	0.00	17.42	92.20	135.08	149.63	141.23	109.82	58.55	27.07	11.05
Feb	0.27	45.63	132.40	157.89	149.06	116.95	54.99	16.46	3.28	0.67
Mar	0.00	2.77	98.46	173.98	172.84	147.83	86.17	31.75	10.73	6.68
Apr	1.64	48.18	86.84	99.89	102.27	89.06	70.26	54.25	45.31	34.80
May	0.15	3.45	7.19	24.57	40.64	60.37	82.52	86.92	82.01	71.22
Jun	0.00	0.00	0.43	1.50	3.85	10.91	34.73	62.34	77.67	80.95
Jul	0.00	0.00	0.00	0.00	0.16	0.16	1.69	8.68	19.13	42.93
Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	5.15
Sep	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.75	5.60	17.02
Oct	0.00	0.00	7.20	36.55	38.73	36.71	43.18	52.80	64.93	62.91
Nov	0.08	1.94	49.96	127.31	139.06	108.04	112.60	89.02	45.48	23.42
Dec	0.00	1.53	41.92	123.44	143.68	139.98	134.44	92.60	45.38	15.90

TABLE 4: MEASURED AMBIENT AIR RELATIVE HUMIDITY BIN DATA OF 50-100% FOR SOKOTO (HOURS)

Month	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Jan	1.61	0.28	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.67	0.20	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	3.62	3.34	2.42	2.27	0.36	0.50	0.28	0.00	0.00	0.00
Apr	31.11	21.34	15.10	7.47	5.34	3.04	2.05	0.98	1.07	0.00
May	73.94	65.58	45.84	33.45	23.11	18.19	12.25	8.51	3.67	0.44
Jun	78.53	73.18	70.11	68.68	55.70	44.01	29.31	18.62	8.20	1.28
Jul	63.99	77.25	76.21	83.36	78.30	86.34	78.38	72.27	47.75	7.40
Aug	18.43	46.94	67.76	72.62	71.39	82.49	99.18	123.99	135.52	19.95
Sep	46.27	68.74	75.38	67.40	68.44	79.11	88.67	100.83	88.67	12.84
Oct	60.24	56.76	52.24	49.57	44.96	45.77	41.56	36.55	12.53	0.81
Nov	9.72	6.76	4.31	0.85	0.76	0.51	0.17	0.00	0.00	0.00
Dec	3.85	0.72	0.16	0.40	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 5: MEASURED AMBIENT AIR RELATIVE HUMIDITY BIN DATA OF 0-50% FOR PORT HARCOURT (HOURS)

Month	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Jan	0.00	0.00	0.00	2.50	12.00	20.43	18.57	17.22	13.79	20.22
Feb	0.00	0.00	1.47	8.28	13.96	9.75	7.75	9.29	13.56	17.90
Mar	0.00	0.00	0.00	1.73	2.14	1.67	2.34	3.80	4.27	8.81
Apr	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.13	0.33
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov	0.00	0.00	0.00	0.00	0.07	0.00	0.29	0.50	1.64	3.57
Dec	0.00	0.00	0.00	0.21	2.00	6.21	9.14	11.07	9.29	12.71

TABLE 6: MEASURED AMBIENT AIR RELATIVE HUMIDITY BIN DATA OF 50-100% FOR PORT HARCOURT (HOURS)

Month	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Jan	26.29	37.29	46.50	44.50	52.72	55.58	74.79	93.44	128.16	80.01
Feb	29.26	33.74	41.69	41.49	46.23	55.78	59.32	82.84	139.35	66.94
Mar	18.55	36.70	46.17	52.11	53.51	63.52	79.54	103.56	182.96	82.61
Apr	5.07	25.87	46.47	52.80	52.80	60.73	71.73	104.93	200.80	98.27
May	1.07	10.87	37.75	52.09	58.30	59.97	72.64	96.19	203.11	151.95
Jun	0.14	3.21	14.93	36.86	47.57	55.64	72.71	93.07	197.14	198.71
Jul	0.21	1.64	8.22	22.79	45.29	52.22	69.01	90.51	209.52	244.59
Aug	0.07	1.27	6.35	18.45	40.98	49.20	71.73	90.11	207.76	258.09
Sep	0.00	0.40	7.83	21.60	39.86	48.56	64.81	83.60	197.51	255.83
Oct	0.43	3.71	15.71	36.00	51.79	55.86	71.07	95.21	217.50	196.71
Nov	8.64	19.07	32.00	41.50	52.50	53.64	70.29	95.64	189.50	151.14
Dec	21.21	31.36	39.29	43.50	49.86	55.00	71.93	101.00	162.14	118.07

The sum of the hours in each month that has lower than 60% and higher than 60% relative humidity for both Sokoto and Port Harcourt are given in Table 7. Equally, Table 8 shows each month of the year with the number of hours for relative humidity lower and higher than 70% for the two cities.

FIGURE 7: THE SUMMARY OF THE HOURS THAT EACH STATION EXPERIENCED AMBIENT RELATIVE HUMIDITY LOWER AND HIGHER THAN 60%

Month	**RH (%) of Sokoto**		**RH (%) of Port Harcourt**	
	Lower than 60	**Higher than 60**	**Lower than 60**	**Higher than 60**
Jan	743.94	0.07	168.31	575.70
Feb	678.47	0.13	144.96	533.64
Mar	738.17	5.83	80.01	663.98
Apr	684.95	35.05	31.47	688.53
May	598.56	145.46	12.01	732.00
Jun	424.09	295.91	3.35	716.63
Jul	213.99	530.01	1.85	742.15
Aug	71.10	672.90	1.34	742.67
Sep	138.68	581.34	0.40	719.60
Oct	460.01	283.99	4.14	739.85
Nov	713.39	6.60	33.78	686.21
Dec	743.44	0.56	103.20	640.79

FIGURE 8: THE SUMMARY OF THE HOURS THAT EACH STATION EXPERIENCED AMBIENT RELATIVE HUMIDITY LOWER AND HIGHER THAN 70%

Month	**RH (%) of Sokoto**		**RH (%) of Port Harcourt**	
	Lower than 70	**Higher than 70**	**Lower than 70**	**Higher than 70**
Jan	744.00	0.00	259.31	484.70
Feb	678.60	0.00	228.14	450.46
Mar	742.86	1.14	178.29	565.70
Apr	707.52	12.48	130.74	589.26
May	677.85	66.17	101.85	642.16
Jun	562.88	157.12	55.14	664.84
Jul	373.56	370.44	32.86	711.14
Aug	211.48	532.52	26.14	717.87
Sep	281.46	438.56	29.83	690.17
Oct	561.82	182.18	55.85	688.14
Nov	718.55	1.44	107.28	612.71
Dec	744.00	0.00	185.99	558.00

Implication on practice of Agriculture

The relative humidity in Sokoto shows that storage of grains for preservation is possible in Sokoto as the number of hours that relative humidity falls below 60% is higher in the months of January to June and October to December, see Tables 2, 3, 4 and 7. For nine months of the year more hours have relative humidity lower than 60% in Sokoto. Therefore storage of grains is advantageous in Sokoto than Port Harcourt. Port Harcourt will not be good for storage of grains in ambient air situation as a humidifier is required most of the time to achieve non growth of fungi on the products. Therefore storage of grains in Port Harcourt will not be as economical like that of Sokoto.

Table 8 shows that for ten months out of the twelve months in the year, the number of hours that relative humidity is below 70% are higher than when it is above 70%. This humidity level allows drying in ambient air without supplementary heating (Thorpe, 1986). Therefore drying in sokoto only require using fan to blow ambient air over the grains to be dried most of the time.

For storage of agricultural produce such as potatoes, tomatoes and yam which require higher relative humidity of 80-95% (Table 1), a place like Port Harcourt will be more suitable to site storage facilities for such crops than Sokoto.

Atteh (2004) reported that for optimum results, a relative humidity of about 70% is required for hatching while a relative humidity of 50% is required for brooding. For hatching and brooding in poultry keeping, where about 70% relative humidity is expected to be maintained, the city of Sokoto which has most of the hours lower than 70% relative humidity will require the use of humidifier whereas Port Harcourt would require dehumidifier most of the hours to achieve the desired relative humidity of 70% during the period of hatching and 50% during brooding.

Conclusion and Recommendations

A statistical analysis of the relative humidity data of Sokoto and Port Harcourt in Nigeria is used in this work to determine the probability density function of the relative humidity distribution. The average maximum relative humidity of 78.7% and 89.93% occur in the month of August for Sokoto and Port Harcourt respectively. The highest bin data for Sokoto occurs in 15-20% bin with 173.98 hours in the month of March while that of Port Harcourt occurs in August with 258.09 hours in 95-100% bin.

It is then recommended that the area of strength with respect to relative humidity of these locations should be advantageously utilized for harvest and post harvest process of agricultural products. Therefore, there should be provision of storage facility for crops like fruits and tubers such as tomatoes, potatoes and yam in Port Harcourt area. There should be provision for storage silos for grain crops in Sokoto area.

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