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Analysis of Weather Data for Humidity Control for Paper Storage and Printing Press in Abuja, Nigeria

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Abstract-
One of the challenges of printing and paper industries is the issue of inappropriate humidity in the environment where the paper mills and printing shops or stores are located. Humidity of the environment is a factor of great concern for storage of papers and when printing. This work considers the needed optimum relative humidity that is required for high quality printing and analysis of a fifteen-year weather data of hourly dry bulb temperature (TDB) and relative humidity (RH) for Abuja in the Federal Capital Territory of Nigeria, obtained from the Nigerian Meteorological Agency (NiMet). A bin width of 1°C and 5% were used for TDB and RH respectively. The two-dimensional dry bulb temperature and relative humidity bin data were obtained for each month of the year. High relative humidity which is inimical to high quality printing production, occurs in many months of the year, especially June through October, hence dehumidification process would be desirable during such periods. The optimum relative humidity for quality printing of between 45%-55% occurred for about 1027.9 hours out of the 8766 hours in the year. Therefore, it can be concluded that dehumidification to the right humidity level is necessary most of the time in Abuja for good quality printing work.

Keywords: Printing, relative humidity, dry bulb temperature, Meteorological data.

1. Introduction

One of the oldest industries in Nigeria is publishing using the printing press. It was reported by Oyedokun [1] that the first printing press was established in Calabar in 1846 by a Presbyterian missionary named Reverend Hope Waddell.

Even with the advocacy of paperless meetings coupled with the promotion of the use of Information and Communication Technology (ICT) facilities, paper production still remains a prominent industrial sector having direct bearing on educational development all over the world. There are environmental challenges to printing and paper productions world over. One of the technological developments to solve the environmental related problems is by using appropriate air conditioning processes.

One of the areas of industrial applications of air conditioning [2] is printing which involves control of the humidity during the printing processes. Printing processes entail running paper through several different presses in which the atmospheric conditions should be maintained to give appropriate printing results. Improper humidity of the environment in printing or paper industry causes static electricity, curling or buckling of paper. The printing ink may fail to dry as required in the process of printing.

Paper is hygroscopic [3], a property which makes it absorb moisture from the environment. It does this so as to attain moisture content equilibrium with the environment. At equilibrium it does not take or give moisture to the surrounding air. This process of attaining moisture equilibrium can be controlled for optimum printing result.

There are different types of printing with advancement in technology. These include off-set printing, digital printing and ink jet printing.

In printing work, paper dimensional change is affected by either absorption of moisture from or release of moisture to the atmosphere [4].

The most appropriate humidification systems for printing outfit are adiabatic systems which are preferable to traditional isothermal systems with benefits which include reduced energy consumption largely lower than 10% of the energy consumption of a traditional steam system and evaporative cooling with the possibility of using these systems during hot weather to cool the air which helps to absorb the heat generated by the printing machinery [3]. The temperature of paper significantly affects the relative humidity of the paper. Hence, the environment in which paper is kept and utilized should be a prime consideration in printing press. Exposing paper to wrong environment may render the paper not usable.

Fert on [5] asserted that different printing processes work best with certain amount of moisture, proper humidity control is important to printing and there are certain benefits that can be obtained for example having an improved printing quality because paper distortion is rid of and static electricity is prevented.

For optimal printing work with digital printing, the RH level should be around 50-55%. With humidity below 40%RH, the paper loses water and tends to change the shape, stick together with other papers and attract dust from the environment [6].

In offset printing, moisture content has effect on the interaction between inks and the press, the paper and the press and ink and the paper. A higher moisture level of above 55% RH in the press shop is required. A lower RH will affect printing paper whereby the paper could be curling, creasing and dot doubling [6].

In the ink jet, paper is prone to ink related challenges such as spreading, show through and drying issues at low RH. Then printing will be achieved between 45-50% RH, a bit lower than what is obtainable in the digital printing will react well to the fuser heat at this RH level.

Abuja is located at Latitude 9°03′26″ N and Longitude 7°29′23″ E and is the Federal Capital Territory of Nigeria [7].

This work is aimed at analyzing a 15-year hourly weather data of dry bulb temperature and relative humidity obtained from meteorological agency NiMet and compiling of 2-dimensional bin of the weather parameters and compare these with the required condition for optimum printing work.

2. Methodology

2.1 Data collection

Hourly dry-bulb temperature and relative humidity data of 15 years of 1995-2009 for Abuja in the Federal Capital Territory (FCT) of Nigeria were obtained from Nigerian Meteorological Services (NiMet), Oshodi, Lagos. These data were obtained from NIMET form 131/3 for both dry-bulb temperature and for relative humidity which were gathered using appropriate instruments.

2.2 Data analysis

These data were keyed in and stored in the computer system using Microsoft excel office software 2007 version. Visual Basic codes were written for statistical analysis and compilation of the two-dimensional bin data of dry-bulb temperature/relative humidity. Bin sizes of 1°C and 5% were used for dry-bulb temperature and relative humidity, respectively. The two-dimensional bin data of dry-bulb temperature/relative humidity shows the coincidence of both weather parameters. Figure 1 shows the interface of the output of the two-dimensional bin data of dry-bulb temperature/relative humidity.
Results were obtained for each month and the results for the 12 months data were summed up to obtain a year report. The number in each cell of the interface gives the average number of hours that the dry-bulb temperature and relative humidity coincides for each month. The total for the 12 month gives the coincidence and spread of dry-bulb temperature and relative humidity per year.

3. Result and discussions

The two-dimensional bin data of dry-bulb temperature/relative humidity for Abuja obtained from total summation of results from each month of the twelve months are presented in Table 1. The value in each bin size is the number of hours that both dry-bulb temperature and relative humidity coincide in that bin. The sum of the hours in all gives the sum of total hours in all the 12 months which is 8766 hours.
The lowest, highest and mode of dry bulb temperature bins were determined along with the number of hours these bins occur which are given in the bracket below the bin name and equally their counterpart in relative humidity is given in Table 2.The monthly number of hours in which the relative humidity fall within 40-55% is shown in Figure 2.
Table 1 which shows the sum total of the average number of hours of 8766 hours from the 2-dimensional bin data from the 12 months analysis, the desirable relative humidity of 40-45% RH bin and 50-55% RH bin for any printing work vis-à-vis digital, offset and inkjet printing occurs in the average total number of hours which is 1027.9 hours, this is indicated by the coloured figures in the Table. The monthly occurrence of these number of hours is shown in Table 2 which indicates that March has the highest number of hours of 204.8 hours, however the ambient temperature of the press room must be lowered to meet desired temperature since March is characterized with high temperature which is evident in Table 2 in which the modal dry bulb temperature bin for the month is 26-27°C with about 65.6 hours.
The months of June through October with high relative humidity in the atmosphere which is evident from Table 2, there is a great need for dehumidification of air conditioning process to a level of achieving good printing, see Figure 2.
The modal relative humidity bin in January is 20-25% RH bin with an average of 67.57 hours out the 744 hours in the month hence there may be need for humidification during this period to attain the needed humidity for desirable printing work.

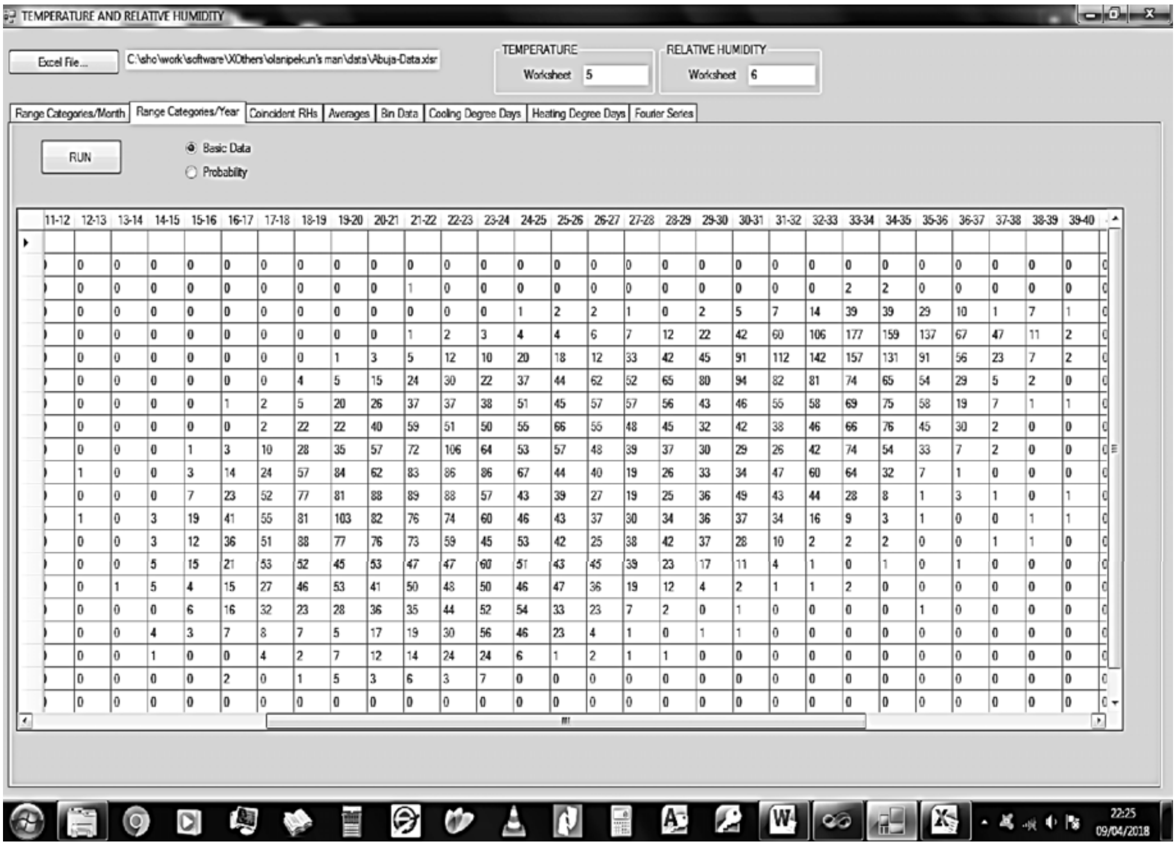

Figure 1: Programme interface for computing Two-Dimensional bin data of Dry bulb temperature and Relative humidity

Table 1: The Two -Dimensional Bin Data of Dry Bulb Temperature and Relative Humidity for Abuja

RH	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105
Temp																					
12-13	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0
14-15	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.4	1.0	0.8	0.1	0.3	0.1	0.0	0.0	0.0
15-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	1.7	1.5	2.6	1.6	1.7	0.4	0.4	0.1	0.0	0.0
16-17	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.5	1.2	2.3	3.4	4.5	3.9	4.1	4.2	2.0	1.4	0.8	0.0	0.0
17-18	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.4	1.5	2.4	5.6	6.3	7.3	8.4	7.5	7.3	5.3	3.8	1.1	0.1	0.
18-19	0.0	0.0	0.0	0.0	0.1	0.4	0.8	2.1	3.6	7.3	8.1	9.9	11.8	10.5	12.9	12.1	8.0	6.5	3.9	0.2	0.0
19-20	0.0	0.0	0.0	0.0	0.3	0.5	1.8	3.0	4.8	9.9	10.4	13.5	12.1	10.2	15.1	13.7	8.8	12.3	7.0	2.1	1.3
20-21	0.0	0.0	0.0	0.1	0.4	1.7	3.2	5.6	9.7	9.6	11.0	11.5	13.2	16.2	13.8	16.9	15.5	15.8	19.1	46.0	14.9
21-22	0.0	0.1	0.0	0.3	0.6	2.7	5.0	10.0	10.3	11.8	11.5	11.1	17.0	15.9	18.3	18.7	18.1	21.2	67.6	182.5	22.1
22-23	0.0	0.0	0.0	0.6	1.7	3.9	8.4	11.4	14.2	12.1	13.0	14.8	16.0	13.6	19.6	22.8	26.6	49.4	196.9	343.9	16.4
23-24	0.0	0.0	0.0	0.7	2.1	4.4	8.6	9.8	13.0	14.6	11.6	16.2	13.5	17.2	18.3	26.7	40.2	97.1	333.4	253.8	4.3
24-25	0.0	0.0	0.1	0.9	4.4	7.2	10.9	12.8	12.8	11.2	13.3	12.8	17.1	16.9	22.4	40.0	80.8	186.9	289.2	76.7	1.5
25-26	0.0	0.0	0.2	1.4	5.8	9.6	12.5	14.6	13.4	12.9	13.5	16.2	19.3	25.0	37.2	73.0	158.4	192.3	113.1	19.0	0.5
26-27	0.0	0.0	0.3	2.0	5.5	11.0	11.7	12.1	13.2	13.6	13.3	16.0	22.0	33.7	63.9	135.3	178.5	87.2	27.0	7.3	0.5
27-28	0.0	0.0	0.1	2.4	6.4	10.4	11.1	12.3	12.6	11.2	12.7	17.0	33.7	53.4	131.6	160.3	81.9	18.6	8.5	4.2	0.1
28-29	0.0	0.0	0.0	2.8	8.9	10.2	12.1	12.0	12.6	13.9	17.4	24.0	43.9	100.9	174.1	84.3	19.9	8.0	3.9	2.8	0.0
29-30	0.0	0.0	0.6	5.2	11.3	11.8	11.4	13.3	12.9	13.2	20.7	38.5	78.4	155.9	102.9	24.3	7.5	3.0	2.7	1.9	0.
30-31	0.0	0.0	0.7	7.4	14.3	15.2	13.9	15.6	14.2	19.6	32.3	46.9	115.2	116.8	27.1	6.3	3.8	1.4	1.7	1.4	0.2
31-32	0.0	0.1	1.8	11.8	18.3	18.0	16.2	15.1	17.8	26.3	39.0	62.7	95.3	36.1	7.9	2.1	1.5	1.1	0.6	0.7	0.1
32-33	0.0	0.0	2.6	17.5	26.0	22.8	23.6	21.6	23.6	35.5	52.3	62.5	35.5	6.2	2.4	1.1	0.7	0.4	0.1	0.4	0.1
33-34	0.0	0.2	7.5	28.0	33.1	28.6	27.1	26.9	36.4	42.3	44.3	29.2	5.7	2.2	0.8	0.3	0.3	0.2	0.4	0.3	0.0
34-35	0.0	0.2	8.0	29.4	32.7	28.7	27.0	26.2	37.5	39.6	24.7	6.2	1.3	0.8	0.5	0.2	0.3	0.2	0.3	0.0	0.0
35-36	0.0	0.2	11.7	29.2	30.2	25.4	21.5	26.9	35.5	21.1	5.3	0.8	0.5	0.3	0.5	0.5	0.1	0.1	0.1	0.0	0.0
36-37	0.0	0.3	10.7	25.7	19.3	15.4	19.1	29.0	19.3	5.1	1.2	0.5	0.0	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0
37-38	0.0	0.2	8.0	15.1	12.9	11.5	14.1	14.9	6.3	0.9	0.5	0.3	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
38-39	0.0	0.4	7.4	7.0	6.9	6.8	5.5	3.6	1.0	0.3	0.3	0.3	0.2	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
39-40	0.0	0.1	1.8	3.4	2.0	1.2	1.9	0.4	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
40-41	0.0	0.1	0.3	0.8	0.8	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41-42	0.0	0.0	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42-43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3-44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44-45	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2: The dry bulb temperature (T_{DB}) and relative humidity (RH) bins which have the lowest and highest magnitudes and modal bins for each month with the average number of hours in which the T_{DB} and RH are in those bins in bracket.

Month	**Dry bulb Temperature bin**			**Relative Humidity bin**		
	Lowest value bin (No of hours)	Highest value bin (No of hours)	Modal bin (No of hours)	Lowest value bin (No of hours)	Highest value bin (No of hours)	Modal bin (No of hours)
Jan.	12-13 (0.13)	39-40 (0.53)	33-34 (50.87)	5-10 (0.33)	90-95 (1.8)	20-25 (67.53)
Feb.	12-13 (0.08)	41-42 (0.62)	25-26 (49.65)	5-10 (0.85)	95-100 (0.15)	40-45 (70.82)
Mar.	18-19 (0.07)	44-45 (0.07)	26-27 (65.60)	5-10 (0.06)	100-105 (0.07)	40-45 (74.67)
Apr.	20-21 (0.20)	40-41 (0.47)	27-28 (68.73)	10-15 (0.53)	100-105 (0.40)	65-70 (73.80)
May	20-21 (1.8)	38-39 (0.33)	25-26 (87.53)	25-30 (0.13)	100–105 (1.53)	90-95 (107.93)
Jun.	19-20 (0.13)	39-40 (0.07)	24-25 (95.60)	45-50 (0.40)	100–105 (6.93)	90-95 (155.93)
Jul.	18-19 (0.20)	32-33 (0.6)	23-24 (139.73)	45-50 (0.07)	100–105 (15.93)	90-95 (195.53)
Aug.	19-20 (1.07)	31-32 (1.8)	23-24 (152.73)	50-55 (0.4)	100–105 (18.93)	95-100 (226.67)
Sep.	19-20 (0.93)	35-36 (0.07)	22-23 (116.47)	45-50 (0.07)	100–105 (14.53)	95-100 (194.07)
Oct.	17-18 (0.08)	39-40 (0.08)	22-23 (124.46)	25-30 (0.46)	100–105 (3.85)	90-95 (176.15)
Nov.	15-16 (0.71)	37-38 (0.93)	22-23 (66.50)	10-15 (0.07)	95-100 (19.43)	90-95 (84.50)
Dec.	12-13 (0.14)	37-38 (3.71)	21-22 (55.29)	10-15 (2.21)	95-100 (0.86)	60-85 (66.71)

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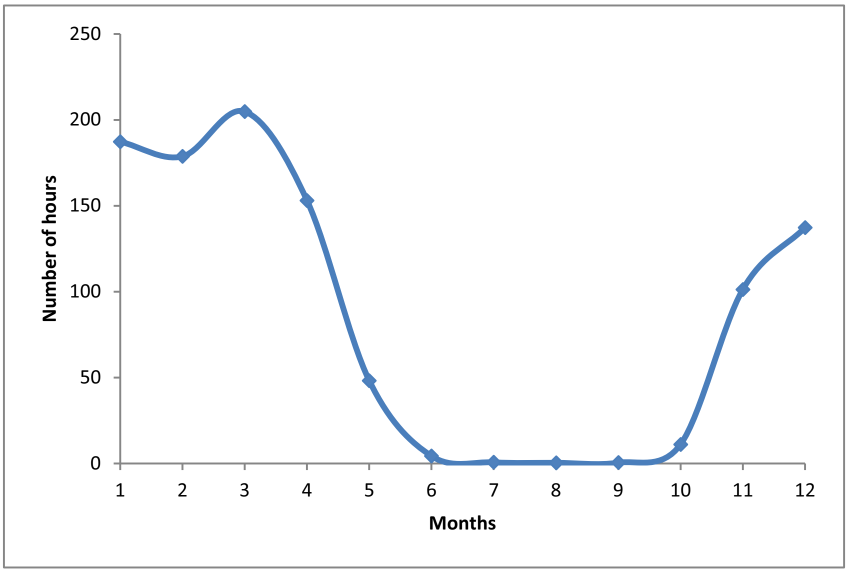

Figure 2: Number of hours in which the relative humidity fall within 40-55% RH in each month (Numbers 1 – 12 used to represent January - December).

4. Conclusion

The analysis of weather data of both hourly dry bulb temperature and relative humidity for Abuja was carried out to obtain 2-Dimensional bin data for each month and then cumulated for the whole year. The months of June through October would need dehumidification for optimum printing and some humidification process would be needed in January for better printing.

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