
THE ROLE OF CLIMATE IN THE SPREAD OF SAR-COV-2 VIRUS IN AEROSOL

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Abstract

The Covid-19 pandemic stimulated thoughts that it may be influenced by variation in air temperature and humidity. In this study we developed a model of psychrometric properties to assess the impact of climate on the survival of SAR-Cov-2 virus in the aerosol of Sokoto State, North-west region of Nigeria. The results of the statistical analysis show that specific volume, vapor pressure, enthalpy and decay constant are positively correlated with SAR – CoV-2 virus in the aerosol with values ranging from (0.078 – 1.000). It was also shown that the average half – life of the virus in the aerosols is in the months of March and April, which is the period of the pandemic, where the numbers of recorded cases were on increase, than it was in the Months of August and September, 2020. On this note, we conclude that the chance of the virus survivability is due to variations in the psychrometric quantities of air temperature which aid on influencing the spread of Covid-19. Likewise, as the number of recorded cases increases in the Months of July, August, September and October, there was also an increase in the psychrometric properties deduced. Therefore climate has a role in the spread of covid-19 virus and its survivability in the aerosol.

Keywords: Half-life, Enthalpy, Psychrometric Properties, Decay Constant K and Covid -19.

1.0 Introduction

The covid-19 pandemic arose thoughts that it may have a seasonal component influenced by climate, human activities and its immediate environment Donnelly *et al.* (2003). For instance Drosten *et al.*, (2003) noted that in Hubei and China, there is an increase in air temperature rising from 0 – 1°C with decrease in the number of recorded Covid – 19 cases ranging from (36 – 57) %, while relative humidity increase within the range of (67.0 – 85.5) %. Similarly, it was noted by the Hong Kong Department of Health (2003), that the daily decrease in the confirmed cases is in a range of (11 – 22) %, while relative humidity rises from (0 – 1) %, at a temperature range of (5.0 – 8.2) °C. It was recorded in Bangladesh that there is significant association with the reduction of transmission of Covid – 19 at a high temperature and high relative humidity. Undoubtedly, at the region that is cooler worldwide has a high spread of the virus within the temperature range of (5 – 11) °C at a relative humidity (RH) of (5 – 7) g/m³. This air temperature is said to be desiccated which aid the spread of the SARs– COV – 2 virus (Drosten *et al.*, 2003).

According to Pirtle and Beram, (2005) in their findings they show that SARs – COV – 2 might also exhibit seasonal pattern which is enveloped by the RNA virus. It is well known to survive in an air much longer when absolute humidity (AH), vapor pressure (VP) levels are relatively low in a given climatic region. This is possible due to presence of lecithin, which is contributing to the viral stability of the virus at low temperature, resulting to an increase in its transmissibility (Rabenan *et al.*, 2004).

Primarily, the reason for the change in the seasonal behavior of Covid – 19 is nuclear force, pertaining to the nucleus of a cell. However, it can also be related to variation in air temperature, humidity, and ultraviolet (UV) radiation from the sunlight, as well as immunological variation in behavior. Thus, many factors can affect Covid – 19 transmissions, but they are difficult to be identified in the extent to which the environmental factor influences the pandemic Hong Kong, Department of Health, (2003). For example, it was revealed by WHO report, (2003), that reduction in the number of transmission of Covid - 19 occurs in climatic region with high temperature due to an increase in UV – B radiation. In most of the countries that experienced some increase in the amount of UV- B radiation are closely associated with high temperature (Drosten *et al.*, 2003). This makes it difficult for researchers to be able to distinguish between the two modes of transmission of SARs-Cov-2 Virus. Most of the plotted graphical results by many researchers, determining the numbers of cases plotted against either temperature or relative humidity. Led to ambiguous predictions by misunderstanding the concept of relative humidity (RH), this is not an absolute value but a ratio of vapor pressure (Tan J. *et al.*, 2005). Relative humidity is the ratio of vapor pressure to its saturated vapor pressure, which is expressed in percentage which is strongly affected by air temperature. Consequently, at high-temperature, air is capable of holding more moisture than at low temperature. Unfortunately, many researchers fail to appreciate this fact. With the resume that was obtained during the winter, the air is more humid than in the summer due to high values of relative humidity. Another fact is that the air is much desiccated in the winter due to lower saturated vapor pressure (Peiris *et al.*, 1980).

On a general note, a lot of statistical analyses were done by many researchers on relative humidity but failed to appreciate it as a function of air temperature, because it involves the ratio of saturated vapor pressure (SP). See equation (1) which is not an independent variable (Pirtle *et al.*, (1991).

$$N_t = N_0 \times e^{(-k.t)} \quad (1)$$

As such, the mode which is best fit for the spread of SARs-Cov-2 virus is strongly at low temperate region. Consequently, there are clear associations that exist between air temperature and relative humidity with Covid-19 prevalences within a given location during the pandemic period. The accurate nature of the association between air temperature and relative humidity was said to be not too clearly explained by researchers (Sizum and Talbot, 2000).

As a result of great confusion by researchers on the mode of which is best fit for the spread of SARs-Cov-2 Virus in any given region of a place over a period of time couple with the nuclear force that exist within the nucleus of a cells arouse this research. In this case of study we built it by a well-defined models based on meteorological data with the aim to predict the extent that, this changes in the Psychrometric properties of the air is well understood and determined (that is the change which is associated with air temperature and relative humidity). See figure 1 (Tan J. *et al.*, 2005)

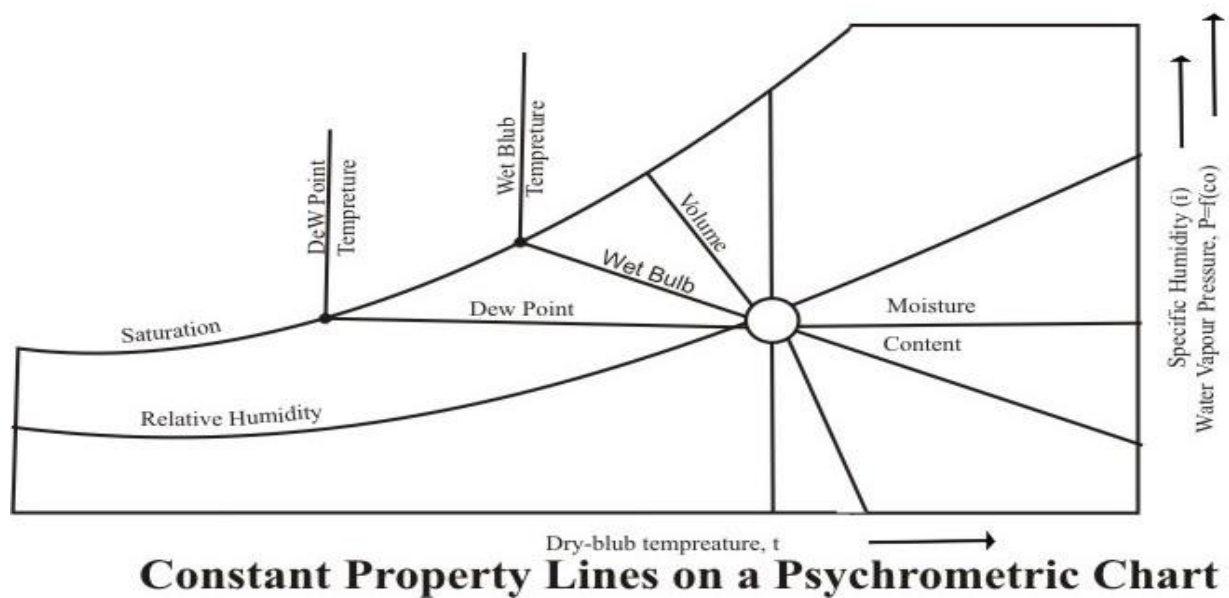


Fig1: psychrometric-chart-properties.jpg (701×499) (learnmech.com)

The psychrometric properties well explain biological survival of SARs – COV – 2 Virus in aerosols. In far-field, the transmission of Covid – 19 can occur due to inhalation of less amount of airborne respiratory droplet that sometimes remains in the air (Lin *et al.*, 2006).

Especially in the overcrowded room or a room with poor ventilation, there is a need for optimal understanding on how long the SARs – COV – 2 Virus can remain viable in aerosol, and to which extent air temperature and relative humidity influence the spread of Covid – 19 (Yuan *et al.*, 2006).

2.0 Methodology

This study was built on relevant scientific literature to be able to assess and identify data relating the survival of SARs – COV – 2 Virus in aerosols at different (various) climatic conditions. Sokoto State of North-Western Nigeria is chosen in order to assess the rate of the spread of Covid-19. Monthly mean air temperature and relative humidity were obtained at www.timesandday.com/weather. The Psychrometric properties such as saturated vapor pressure (SP), vapor pressure (VP), absolute humidity (AH), Specific volume (SV) and Specific enthalpy (h) are computed using empirical relations. As well as for Sokoto State, the

biological decay constant K was computed with great concern on the survival of the virus using the first-order decay equation (1) (Kenneth, 1988).

Where N_0 and N_1 are the number of viable viral air particles at a given period.

The saturated vapor pressure is given by Casanova *et al.* (2005).

$$P_s = 0.61078 \times e^{\left(\frac{17.2694 \times T}{T + 237.29}\right)}; \quad (2)$$

Where P_s Saturated vapor pressure (kPa) and T is air temperature ($^{\circ}\text{C}$);

Vapor pressure can be estimated by the empirical relation (Casanova *et al.*, 2005).

$$P_v = \frac{\phi_r + P_s}{100}; \quad (3)$$

Where P_v is saturated pressure (kPa) and (ϕ_a) is the relative humidity (%).

$$\phi_a = \frac{2.16679 \times \phi_r \times P_s}{100 \times (273.15 + T)}; \quad (4)$$

Where (ϕ_a) is absolute humidity (kg of moisture per m^3 of dry air);

Moisture content can be calculated by the given empirical relation (Casanova *et al.*, 2005).

$$g = \frac{0.622 \times P_v}{P_b - P_v}; \quad (5)$$

Where g moisture is content (kg of moisture per kg of dry air) and P_b is the barometer pressure (i.e 101.325 kPa)

Specific Volume can be calculated using the given empirical relation (Darnell *et al.*, 2001).

$$S = (0.287 + (0.461 \times g)) \times \frac{273.15 + T}{P_b}; \quad (6)$$

Where S is the specific volume per kilogram of dry air (m^3kg^{-1});

Specific enthalpy can be calculated by this equation;

$$\text{Specific enthalpy}(h) = ((1.007 \times T) - 0.026) + (g \times (2501 + (1.84 \times T))); \quad (7)$$

Where (h) is specific enthalpy (KJ/Kg);

4.0 Results and Discussions

After computing the above Psychrometric variables, correlation analysis was also conducted in predicting the trend between the climate and air borne disease (aerosol) (Darnell *et al.* (2001).

The significance of using saliva on decay constant K assessed using a one-way ANOVA, all the statistical analyses were performed using Microsoft excel. There is a significant $P < 0.05$ value (Casanova *et al.*, 2010). Linear regression analysis was performed with decay constant K as the dependent variable while SP, SV and enthalpy (AH) are independent variables as shown in table 2. In order to avoid multi-linear issues, it is required for two models to be developed based on SV and AH simultaneously with VP and SP, RH as dependent Variables.

Refinement of the models was performed using backward exclusion with only variables exhibiting $P < 0.1$ retained (Ijaz, Brunner and Sattew, 1985).

According to Reed and Muench (2005), the effect of Psychrometric variables on the survival of the SARS – COV – 2 Virus in the aerosol, they conducted their prediction using a regression models, to evaluate the monthly biological decay (K) and biological half-life ($I_{0.5}$) values using Meteorological data for the period of one year (1 January – 2020 – Dec 2020). This is also the period of the epidemic in Nigeria. As it is viable to acquire Covid-19 data worldwide through NCDC, the results obtained were compared with the numbers of Covid-19 cases with their relation to biological decay(K) values, in predicting the survival of the virus in the aerosol and also assessed the performance of psychrometric properties on the models developed based on empirical relation using climatic parameters (Evans *et al.*, 1990).

The **half-life** value is computed using the equation;

$$I_{0.5} = \frac{0.6931}{K} \quad (8)$$

Table 1: Predicted monthly mean biological decay constant, k, and half-life values for Sokoto.

City	parameter	Jan	Feb	Ma	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Sokoto	k-pred (min^{-1})	.4244	.247	.51	.125	.534	.525	.900	.950	.468	.780	.780	.440
	K (min^{-1})	.0106	.006	.01	.0025	.008	.017	.0180	.0190	.0078	.0180	.0130	.0190
	Half life	5.33	11.9	8.6	77.24	7.87	9.61	8.51	6.478	8.86	8.51	3.32	6.478

Table 2: Reported biological decay constant (k), results for various air conditions with computed Psychrometric values for Sokoto North-west, Nigerian 2020.

Month	Artificial Saliva	Decay Constant, k. (min^{-1})	Mean Temp ($^{\circ}\text{C}$)	Mean Relative Humidity (%)	Absolute Humidity (kg/m^3) 10^{-3}	Vapor Pressure (kp_a)	Saturated Vapor Pressure (kp_a)	Specific Enthalpy (kJ/kg)	Specific Volume (m^3/kg)
1	No	0.01061	25.0	96.0	5.07	0.697	3.168	36.10	0.849
2	No	0.00619	27.0	74.0	4.63	0.642	3.565	37.28	0.856
3	Yes	0.0101	33.0	55.0	6.76	0.956	5.030	48.45	0.880
4	Yes	0.0025	36.0	65.0	11.24	1.604	5.941	62.14	0.896
5	Yes	0.0089	35.0	84.0	16.21	2.305	5.623	72.65	0.898
6	No	0.1750	33.0	87.0	18.2	2.565	5.030	74.68	0.894
7	No	0.0180	29.0	96.0	20.11	2.804	4.006	74.62	0.883
8	No	0.0190	28.0	100.0	20.7	2.873	3.780	74.61	0.881
9	Yes	0.0078	29.0	100.0	16.10	2.964	4.006	77.18	0.884
10	Yes	0.0180	30.0	94.0	16.00	2.249	4.243	66.47	0.881
11	No	0.0130	28.0	60.0	8.16	1.134	3.780	46.16	0.864
12	No	0.0190	27.0	53.0	6.95	0.963	3.565	42.41	0.860

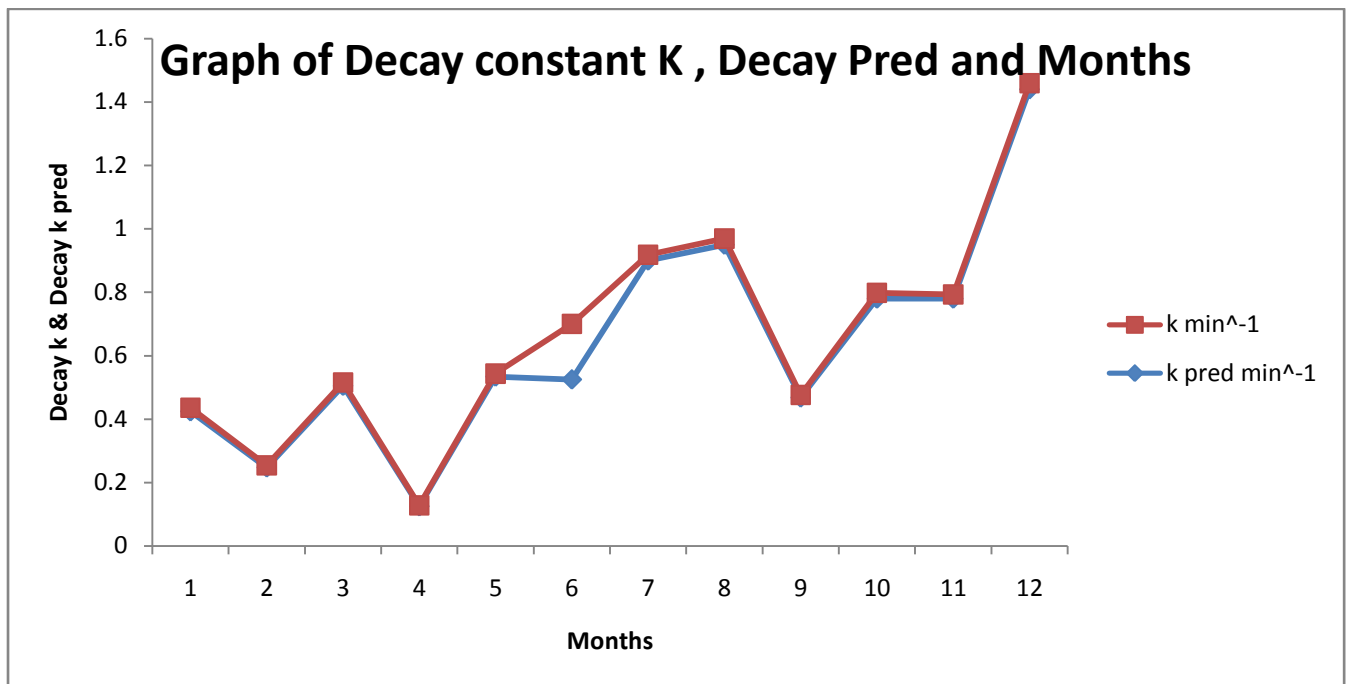


Fig 2: Measured and Predicted Decay Constant for Sokoto State 2020.

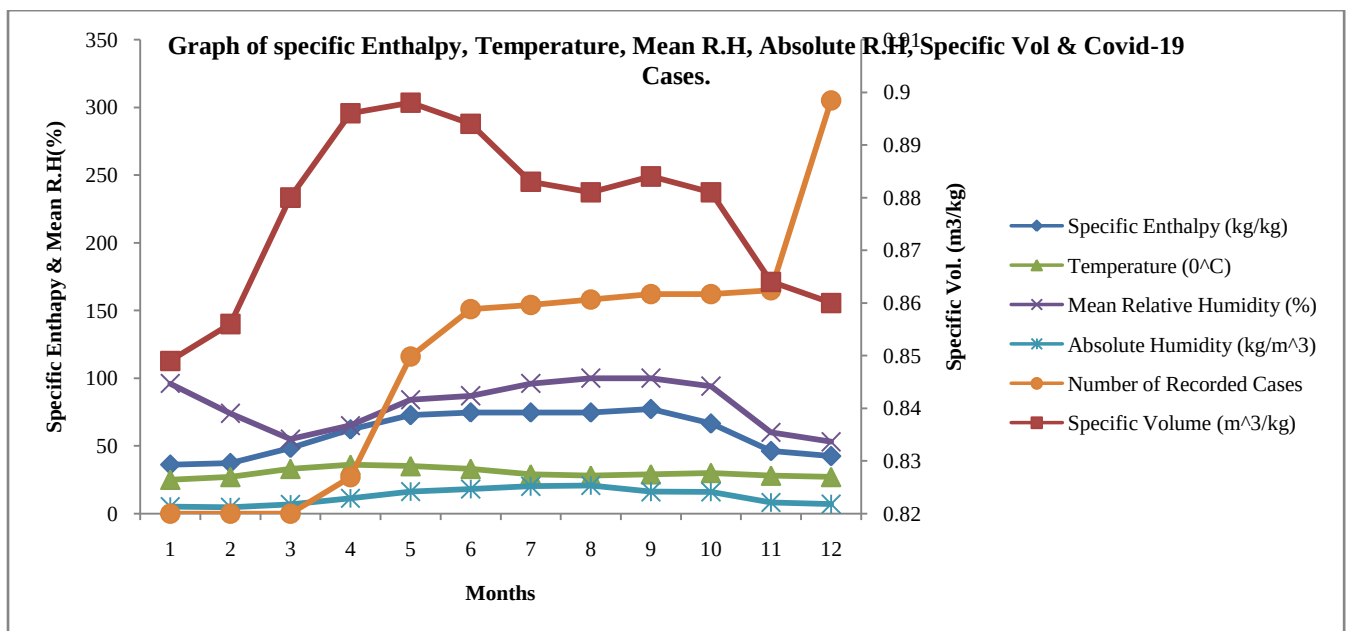


Fig 3: Psychrometric Parameters and Number of recorded Covid – 19 cases in Sokoto State

Conclusions

In this study we were able to analyze the role of climate in the spread of Covid-19 virus in the aerosols of Sokoto State, which is inversely related to both air temperature and Vapor Pressure. We also assessed the survival of the Covid -19 by developing an empirical model which exists between climatic parameters and the actual amount of water vapor in the atmosphere called psychrometric properties. The risk of contracting the virus was high during the winter period. It was also discovered that it is possible to predict relationship between

climatic parameters for 2020 during the period of the pandemic and SAR-CoV-2 Virus with high degree of accuracy using regression models with the following psychrometric parameters such as enthalpy, Vapor Pressure and Specific Volume as shown in **Table 2**. Figures **2-3** reveal that the average half – life of the virus in aerosols in the Months of March and April whereas this is the period when the outbreak was recorded to be high than it was in September and October, 2020. On this note, we conclude that the virus survivability is due to the variations in the psychrometric quantities of the air temperature which plays significant role on influencing the transmission of Covid -19.

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