Seasonal Variability of Air Quality Index (AQI), Particulate Matter ($PM_{2.5}$) and Weather Parameters of Minna Town, Niger State, Nigeria

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Abstract

This study investigated seasonal variability of Air Quality Index (AQI), Particulate Matter ($PM_{2.5}$) and weather parameters of Minna Town, Niger State, Nigeria. The study used secondary climatic data from IQ Air Earth (https://www.iqair.com/earth?nav) used for air quality monitoring and compared them with multiple sources such as real-time data from governments. The findings indicated that dry season had maximum of 137 AQI value and minimum of 64 AQI. Dry season had maximum Particulate Matter [PM2.5] value of 20.1µg/m3 and minimum value of 7.1µg/m3 with a range value of 13µg/m3 and the wet season had maximum Particulate Matter [$PM_{2.5}$] value of 19.1 µg/m^3 and minimum of 10.1µg/m^3 with a range of 9µg/m^3. Temperature had maximum value of 29^{0}C and minimum value of 23^{0}C with a range of 6^{0}C during the dry season and wet season temperature had maximum value of 28^{0}C and minimum value of 21^{0}C with a range of 7^{0}C. During the wet season, humidity had maximum value of 97% and minimum value of 72% with a range of

25% and in the dry season, humidity had maximum value of 89% and minimum value of 67% with a range of 22%. Thus, during the dry season, wind speed had maximum value of 11.2Km/h and minimum value of 5.7Km/h with a range of 5.5Km/h and in the wet season, wind speed had maximum value of 8.1Km/h and minimum value of 2.6Km/h with a range of 5.5Km/h. During the wet season air pressure had maximum value of 1015mb and minimum value of 1009mb with a range of 6mb. While during the dry season, air pressure had maximum value of 1014mb and minimum value of 1011mb with a range of 3mb. It is recommended that government and private partners should set-up functional weather stations and individuals should limit outdoor activities during harsh weather periods.

Keywords: *Air Quality Index (AQI), Humidity, Particulate Matter ($PM_{2.5}$), Pressure, Season, Temperature, Wind*

1.0 Introduction

Globally, air quality has become a modern day challenge across the cities due to rapid industrialization, urbanization and overpopulation. Air quality is influenced by emission sources and meteorological conditions of the area under investigation. The meteorological elements include temperature, humidity, pressure, wind, season etc [1]. Air pollution has the tendency to affect both flora and fauna species including human inhabitants. Air pollution such as Particulate Matter (PM2.5), Nitrogen Oxide, Sulphur Oxide and others can be generated from through manmade and natural sources [2]. Many studies across the world have been conducted on air quality and meteorological variables [3, 4, 5]. Other studies have focused on different air pollutions and their meteorological characteristic at regional scale [6, 7, 8, 9, 10]. Poor air quality can have detrimental effects such as asthma and other respiratory diseases to people, animal and plant species [11, 12, 13].

Climate variability such as temperature, humidity, wind and pressure can impact on the distribution pattern of air pollutants. Most studies have concentrated on air quality index without considering the influence of meteorological variables to the generation and dispersal of atmospheric pollutants which can be disastrous to human health [14, 15]. Weather parameters can influence air pollutants coming from anthropogenic and biogenic sources by changing the distribution pattern. According to [16] local temperature, precipitation, clouds, atmospheric water vapor, wind speed, and wind direction can influence air pollutants as a result of the interaction between local, regional and global scale atmospheric characteristics. Thus, warm and turbulent weather conditions will heavily impact on air quality such that calm and stable atmosphere will increase the concentration of air pollutants but turbulent atmospheric condition will disperse air pollutants [17].

Consequently, the relationship between ambient air temperature and daily mortality rate has been extensively studied with temperature affecting mortality, influenced by air pollution levels, geographic location and weather patterns, among other variables [18, 19]. For instance, the study in Wuhan, Shanghai and Tianjin showed that extreme temperature and relative humidity increased the effects of air pollution on the health of the people [20, 21, 22]. The challenge of managing air pollution and the influence of atmospheric variables has become more tedious than before due to the problem of increased anthropogenic activities for economic survival. In this vein, this study has objectively examined seasonal variability of

Air Quality Index (AQI), Particulate Matter ($PM_{2.5}$) and weather parameters of Minna town, Niger State, Nigeria.

2.0 Methodology

Minna town is located within geographical coordinates of latitude 9^0 33`N and $9^0$ 45`N and longitude 6^0 34`E and $6^0$ 42`E with road network and residential areas as shown in Figure 1. Minna town has the basement complex and sedimentary rocks as its geological formation. The city has both wet and dry seasons with rainfall capacity of 1100mm to 1600mm per annum. The wet season begins from April and ends in September, while the dry season begins October to March. The monthly mean temperature is at the peak in the month of March with a record of 30.5^0C and lowest in September at the record of 25.1^0C [23]. This study used secondary source of data for its information. Data for this study were generated from IQ Air Earth (https://www.iqair.com/earth?nav) used for air quality monitoring. It is a database for weather and air quality monitoring across several cities of the world. The quality of data was ensured by comparing them with multiple sources such as real-time data from governments' sources as well as weather sensors operated by people and institutions. Also, data were generated and compared with ground-based air quality monitoring stations with high level data availability and accuracy. Also, data were generated from weather live forecasts of climatic parameters and air quality at various locations in the study area for data validity and reliability. Thus, temperature, humidity, pressure, wind flow and $PM_{2.5}$ measurements were sourced from the IQ Air Earth database. Data were recorded on hourly basis (7:00Am, 10:00Am, 1:00Pm, 4:00Pm, 1:00AM) from Sunday through Monday Table 1. The data covered the period of both wet season (April to September) and dry season (October to March) in 2021/2022. The data were generated daily, weekly and monthly and divided into averages within the period of the study. The air quality index was derived using the Air Quality Index (AQI) Equation:

$$Ip = \frac{IHi - ILO}{BPHi - BPLo}(Cp - BPLo) + ILo$$

Where:

IP = Index for Pollutant P

CP = Rounded Concentration of Pollutant P

BPHi = Breakpoint Greater Than/Equal to CP

BPLo = Breakpoint Less Than/Equal to CP

IHi = AQI Value Corresponding to BPHi

ILo = AQI Value Corresponding to BPLo

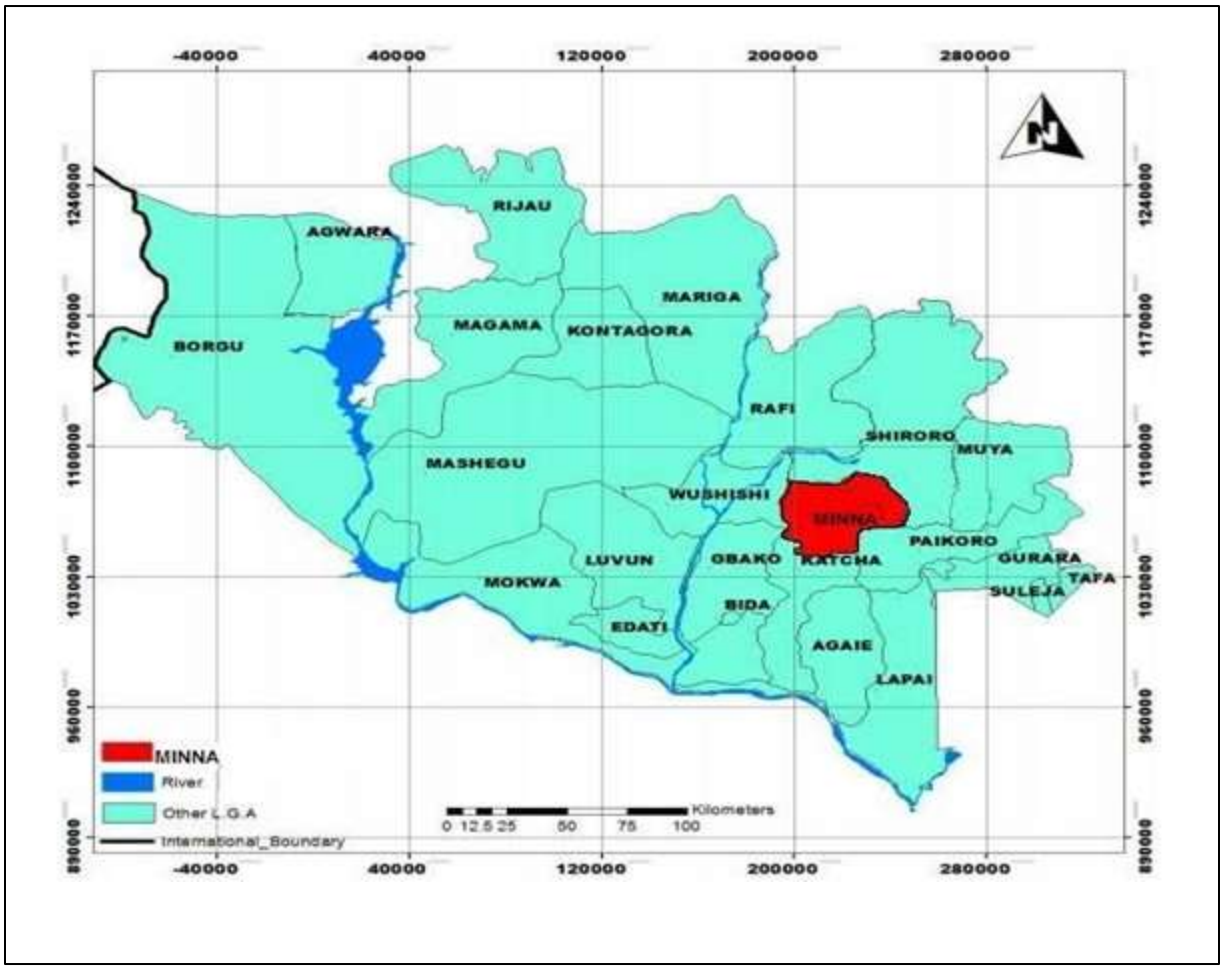


Table 1: Wet and Dry Seasons Air Quality Index (AQI), Particulate Matter [$PM_{2.5}$], Temperature, Humidity, Wind and Pressure of Minna Town

Variable	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
Air Quality Index (AQI)							
Wet Season	66	57	57	51	53	42	64
Dry Season	87	80	93	78	85	137	64
Particulate Matter [$PM_{2.5}$] ($\mu g/m^3$)							
Wet Season	19.1	15.1	16.1	12.1	13.1	10.1	18.1
Dry Season	20.1	7.1	7.1	7.2	12.1	13.1	13.1
Temperature (^0C)							
Wet Season	22	28	21	24	27	28	26
Dry Season	29	23	27	29	28	25	23

				Humidity (%)			
Wet Season	97	78	97	86	79	72	80
Dry Season	74	89	83	67	76	86	100
				Wind (km/h)			
Wet Season	4.1	2.6	6.6	4.7	3	5.9	8.1
Dry Season	14.8	8.5	9.4	8.6	11.5	5.7	11.2
				Pressure (mb)			
Wet Season	1015	1009	1011	1011	1009	1009	1015
Dry Season	1012	1012	1014	1012	1011	1012	1011

3.0 Results and Discussions

Air Quality Index (AQI) of wet and dry seasons in Minna indicated that dry season had the highest concentration of polluted air (Figure 2). The dry season had a maximum of 137 AQI value and minimum of 64 AQI in the series. While the wet season had the maximum of 66 AQI and minimum of 42 AQI respectively. The high concentration of AQI in the dry season is due to the presence of air particulate dusts released from the earth surface during the dry season. Also, in the dry season there is usually limited wet surface for particulate matter to be held by moist surfaces, thereby results to rapid release of withheld particulate matter into the atmospheric air. This fast release of particulate matter such as $PM_{2.5}$ and others quickly concentrate in the air resulting to high AQI during the dry season in Minna town.

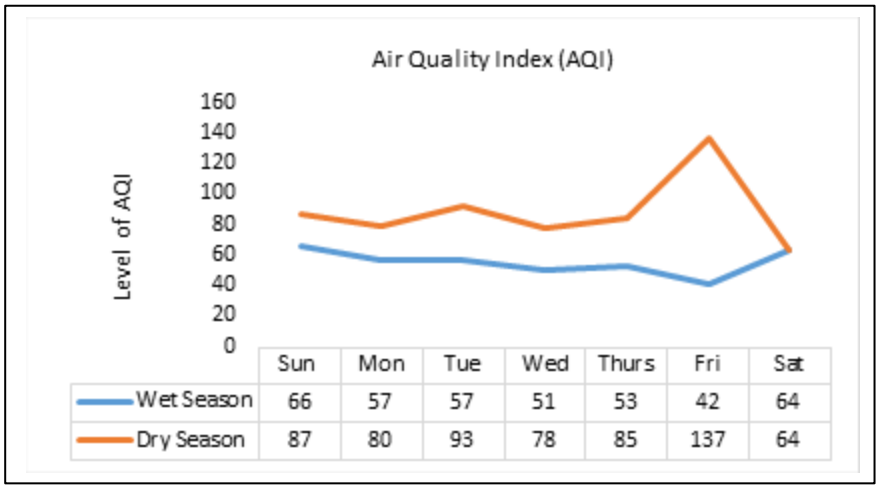


Figure 2: Air Quality Index of Wet and Dry Seasons in Minna

The dry season had the highest concentration of Particulate Matter [$PM_{2.5}$] during the period under study (Figure 3). The dry season had maximum Particulate Matter [$PM_{2.5}$] value

of 20.1µg/m^3 and minimum value of 7.1µg/m^3 with a range value of 13µg/m^3. While the wet season had maximum Particulate Matter [$PM_{2.5}$] value of 19.1 µg/m^3 and minimum of 10.1µg/m^3 with a range of 9µg/m^3 within the wet season. The higher concentration of Particulate Matter [PM2.5] during the dry season is due to the seasonal variability of dry surfaces to quickly detach and release Particulate Matter [$PM_{2.5}$] into the atmospheric air. Also, during the dry season, the earth surface is usually dry which results to Particulate Matter [$PM_{2.5}$] being blown away by wind into the atmosphere thereby giving way to more concentration of Particulate Matter [$PM_{2.5}$] in the air during the dry season.

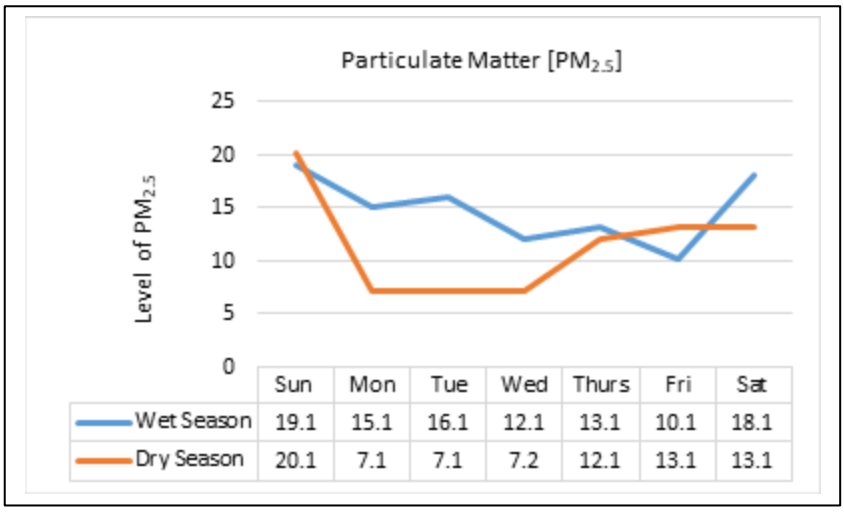


Figure 3: Particulate Matter [$PM_{2.5}$] of Wet and Dry Seasons in Minna

Temperature was higher during the dry season in Minna town (Figure 4). Temperature had maximum value of 29^{0}C and minimum value of 23^{0}C with a range of 6^{0}C during the dry season. In the wet season temperature had maximum value of 28^{0}C and minimum value of 21^{0}C with a range of 7^{0}C. The hottest period was the dry season due to the presence of less rain that fell within the period. The hamattern was a period of coldness with minimum temperature variation that occurred during the dry season in Minna town.

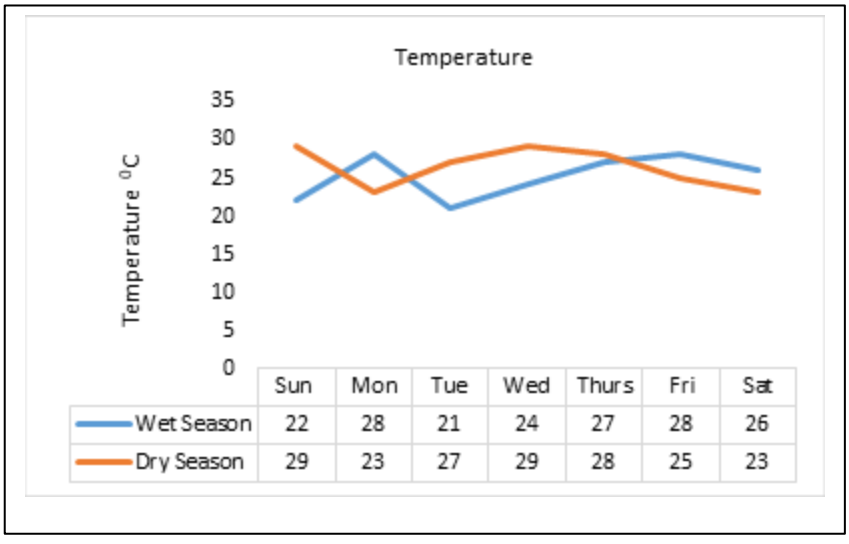
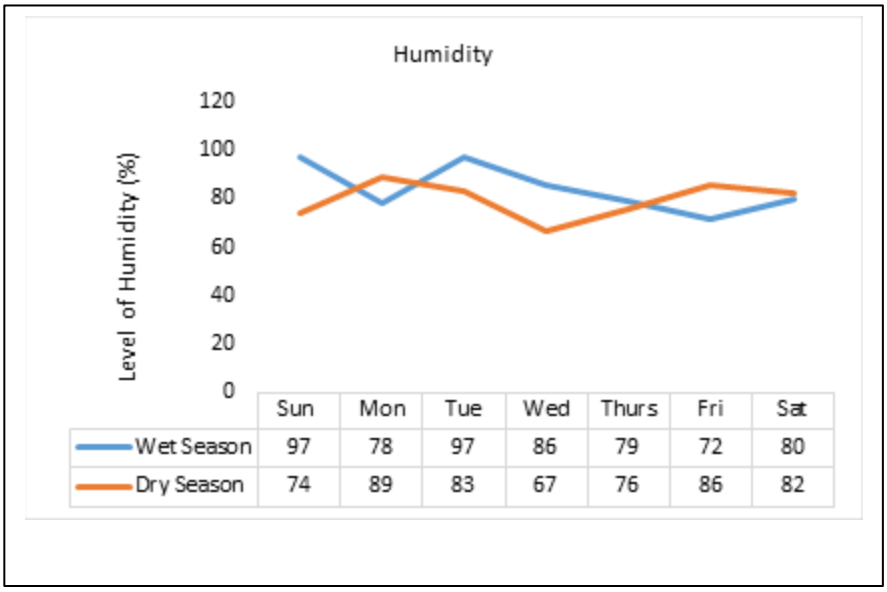


Figure 4: Temperature of Wet and Dry Seasons in Minna

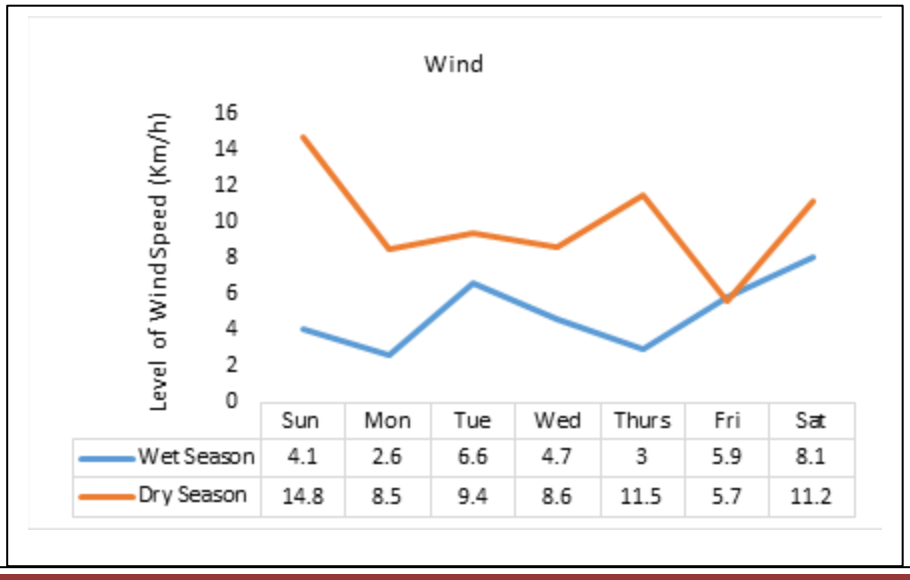
Humidity occurred mostly during the wet season (Figure 5). During the wet season, humidity had maximum value of 97% and minimum value of 72% with a range of 25% respectively. In the dry season, humidity had maximum value of 89% and minimum value of 67% with a range of 22%. Though the hamattern period do contribute to the high humidity during the dry season resulting from low temperature and high humidity within the period. However, the longest occurrence of humidity was during the wet season.



	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
Wet Season	97	78	97	86	79	72	80
Dry Season	74	89	83	67	76	86	82

Figure 5: Humidity of Wet and Dry Seasons in Minna

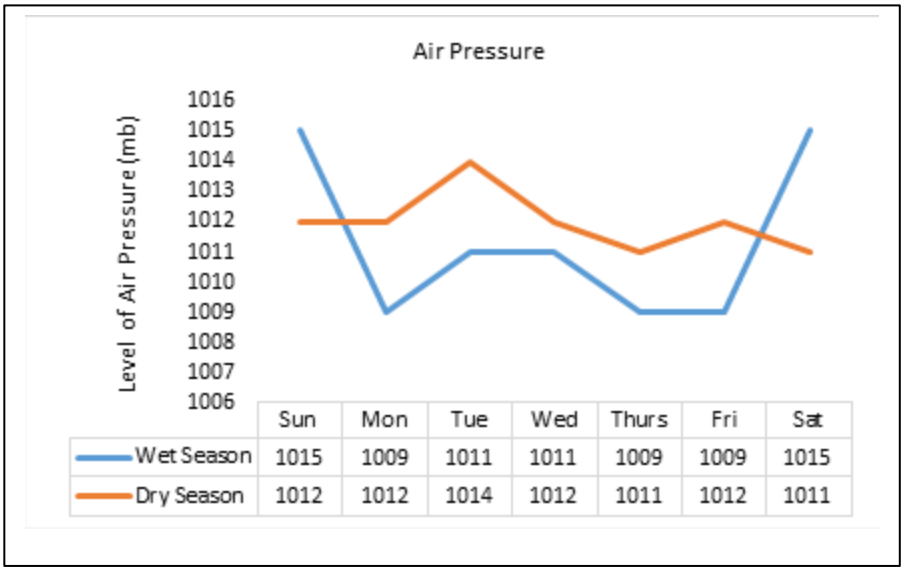
Wind speed was highest during the dry season (Figure 6). During the dry season, wind speed had maximum value of 11.2Km/h and minimum value of 5.7Km/h with a range of 5.5Km/h. While in the wet season, wind speed had maximum value of 8.1Km/h and minimum value of 2.6Km/h with a range of 5.5Km/h respectively. During the dry season, there was higher atmospheric turbulence because the air during this season had less moisture and light for both horizontal and vertical movement.



	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
Wet Season	4.1	2.6	6.6	4.7	3	5.9	8.1
Dry Season	14.8	8.5	9.4	8.6	11.5	5.7	11.2

Figure 6: Wind Speed of Wet and Dry Seasons in Minna

Air pressure was highest during the wet season (Figure 7). During the wet season air pressure had maximum value of 1015mb and minimum value of 1009mb with a range of 6mb. While during the dry season, air pressure had maximum value of 1014mb and minimum value of 1011mb with a range of 3mb respectively. The high occurrence of air pressure during the wet season was due to the presence of large amount of moisture in the atmospheric air which exerts pressure to the earth surface.



	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
Wet Season	1015	1009	1011	1011	1009	1009	1015
Dry Season	1012	1012	1014	1012	1011	1012	1011

Figure 7: Air Pressure of Wet and Dry Seasons in Minna

The seasonal variability of Air Quality Index (AQI), Particulate Matter ($PM_{2.5}$) and weather parameters of Minna Town, Niger State, Nigeria indicated that Particulate Matter [$PM_{2.5}$] was highest during the dry season, Air Quality Index (AQI) was at maximum during the dry season, temperature was highest in the dry season, humidity was at maximum in the wet season and wind speed was greatest during the dry season. Seasonal variability of climatic parameters can affect the health and comfort threshold of the people of Minna town. According to [24], seasonal variability of temperature and other climatic parameters were able to affect wide range of ecosystem deterioration indicators including effects on land, health and vegetative cover in Kenya. The seasonal variation can influence the physiological and psychological performance of the affected community. Therefore, harsh seasonal climatic elements such as AQI, Particulate Matter [$PM_{2.5}$], temperature, humidity and wind speed can influence the atmospheric performance of a place thereby affecting the overall health condition of both plant and animal species. Also, [25] concluded in their study that seasonal weather variations occur in an academic session which affected the academic performance of majority of the students such that (180) 58.3% were affected negatively and (129)41.7% were not affected by season weather variability. This showed the importance of seasonal weather variability in the everyday activity of man. It implies that people should adapt to seasonal weather conditions in order to cope with their daily living. [26] studied the impact of climate change on season rainfall and temperature and crop yields in Abia State, south-eastern Nigeria. If was found that persistent temperature variability affected the growth of crops in

2012 to 2016 and rainfall seasonal variation affected crop yield within the period of 2007 to 2016 respectively. It showed that seasonal variability of climatic parameters can influence the optimal yield of crops of a given area. Therefore, this study has added value to the understanding of seasonal climatic performance of Mina town as it affects the living condition of people, crops, animal and plant species.

4.0 Conclusion

The seasonal variability of Air Quality Index (AQI), Particulate Matter ($PM_{2.5}$), temperature, humidity and wind speed has used secondary data to assess the climatic parameters of Minna Town, Niger State, Nigeria. It is obvious that there is variation in the seasonal weather parameters between the wet and dry season in the study area. It is noteworthy that Minna Town has tremendous variability of weather elements across the months of the year. This study is very important in the middle-belt of Nigeria where majority of the people are farmers and there is usually a very hot period from January to March of every year. They need to be informed on the impeding presence of sharp climate variability for alternative coping strategies. Therefore, it is imperative for the government to give serious attention to farmers and Minna inhabitants on the effects of climate variability to their daily condition and performance. It is recommended that people should begin to adapt to seasonal weather variability by having weather warning systems that will alert the people on weather events on daily and seasonal basis.

References

[1] Kumar, S.D. & Dash, A. (2018). Seasonal variation of air quality index and assessment. *Global. J. Environ. Sci. Manage.*, 4(4): 483-492. doi:10.22034/gjesm.2018.04.008.

[2] Al-Salem, S.M. & Bouhamrah, W.S. (2006). Ambient concentrations of benzene and other VOCs at typical industrial sites in Kuwait and their cancer risk assessment. *Res. J. Chem. Environ.* 10: 42- 46.

[3] Yang, C. Y., Chang, C.C., Chuang, H.Y., Tsai, S.S., Wu, T.N. & Ho, C.K., (2004). Relationship between air pollution and daily mortality in a subtropical city: Taipei Taiwan. *Environ. Int*. 4(30), 519–523.

[4] Analitis, A., Katsouyanni, K., Dimakopoulou, K., Samoli, E., Nikoloulopoulos, A. K., Petasakis, Y., Touloumi, G., Schwartz, J., Anderson, H. R., Cambra, K., Forastiere, F., Zmirou, D., Vonk, J. M., Clancy, L., Kriz, B., Bobvos, J. & Pekkanen, J. (2006). Short term effects of ambient particles on cardiovascular and respiratory mortality. *Epidemiol*, 17(2), 230–233.

[5] Dash, A.K. & Dash, S.K. (2017). Atmospheric pollution load assessment through air quality index: A case study. Indian J. Environ. Prot., 37(9), 736-741.

[6] Samoli, E., Analitis, A., Touloumi, G., Schwartz, J., Anderson, H. R., Sunyer, J., Bisanti, L., Zmirou, D., Vonk, J.M., Pekkanen, J., Goodman, P., Paldy, A., Schindler, C. & Katsouyanni, K., (2005). Estimating the exposure response relationships between particulate matter and mortality within the APHEA multicity project. *Environ. Health Perspect*, 113(1), 88–95.

[7] Samoli, E., Schwartz, J., Wojtyniak, B., Touloumi, G., Spix, C., Balducci, F., Medina, S., Rossi, G., Sunyer, J., Bacharova, L., Anderson, H.R. & Katsouyanni, K.

(2001). Investigating regional differences in short term effects of air pollution on daily mortality in APHEA project: a sensitivity analysis for controlling long-term trends and seasonality. *Environ Health Perspect*, 109(4), 349–353.

[8] Zeka, A., Zanobetti, A. & Schwartz, J. (2005). Short term effects of particulate matter on cause specific mortality: effects of lags and modification by city characteristics. *Occup. Environ. Med*., 62(10), 718–725.

[9] Mamta, P. & Bassin, J.K. (2010). Analysis of ambient air quality using air quality index-A case study. Int. J. Adv. Res. Technol, 1(2), 106-114.

[10] Balashanmugam, P., Ramanathan, A. R. & Kumar, V.N. (2012). Ambient air quality monitoring in puducherry. *Int. J. Eng. Res. Appl*. 2(2), 300–30.

[11] Zaib, S., Lu, J. & Bilal, M. (2022). Spatio-Temporal Characteristics of Air Quality Index (AQI) over Northwest China. Atmosphere, 13, 1 - 22. https://doi.org/10.3390/atmos13030375.

[12] Qiu, Y., Yang, T., Seyler, B.C., Wang, X., Wang, Y., Jiang, M. & Li, F. (2020) Ambient air pollution and male fecundity: A retrospective analysis of longitudinal data from a Chinese human sperm bank (2013–2018). *Environ. Res.* 186, 109528.

[13] Feng, J., Yu, H., Mi, K., Su, X., Li, Y., Li, Q. & Sun, J. (2018). One-year study of PM2.5 in Xinxiang city, North China: Seasonal characteristics, climate impact and source. *Ecotoxicol. Environ. Saf*. 154, 75–83.

[14] Zhu, G., Hu, W., Liu, Y., Cao, J. Ma, Z., Deng, Y. & Wang, H. (2019). Health burdens of ambient $PM_{2.5}$ pollution across Chinese cities during 2006–2015. *J. Environ. Manage*, 24, 250–256.

[15] Wang, Q., Wang, J., Zhou, J., Ban, J. & Li, T. (2019). Estimation of $PM_{2.5}$ associated disease burden in China in 2020 and 2030 using population and air quality scenarios: A modelling study. Lancet Planet. Health, 3, 71–80.

[16] Bernard, S. M., Jonathan M. S., Grambsch, A. Kristie L. E., Isabelle, R. Cohen, A.J., Brauer, M., Burnett, R., Anderson, H. R., Frostad, J., Estep, K. & Feigin, V. (2017). Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: An analysis of data from the Global Burden of Diseases Study. Lancet, 389, 1907–1918.

[17] Edokpa, D & Nwaerema, P. (2019). Boundary Layer Turbulence and Urban Heat Variability in the Coastal City of Port Harcourt, Nigeria. American Journal of Environment and Sustainable Development, 4(2), 77-83. http://www.aiscience.org/journal/ajesd.

[18] Basu R & Samet, J. M. (2022). Relation between elevated ambient temperature and mortality: A review of the epidemiologic evidence. *Epidemiol. Rev*, 24, 190–202. doi:10.1093/epirev/mxf007.

[19] Mokoena, K. K, Ethan, C. J, Yu. Y. & Quachie, A. T. (2020). Interaction Effects of Air Pollution and Climatic Factors on Circulatory and Respiratory Mortality in Xi'an, China between 2014 and 2016. Int J Environ Res Public Health, 17(23, 9027. doi: 10.3390/ijerph17239027.

[20] Li G., Zhou M., Cai, Y., Zhang, Y. & Pan, X. (2011). Does temperature enhance acute mortality effects of ambient particle pollution in Tianjin city, China. *Sci. Total Environ*, 409, 1811–1817. doi: 10.1016/j.

[21] Qian, Z., He, Q., Lin, H. M., Kong, L., Bentle, C. M., Liu, W. & Zhou, D. (2008). High temperatures enhanced acute mortality effects of ambient particle pollution in the "Oven" city of Wuhan, China. *Environ. Health Perspect*, 116, 1172–1178. doi:10.1289/ehp.10847.

[22] Cheng, Y. & Kan, H. (2012). Effect of the interaction between outdoor air pollution and extreme temperature on daily mortality in Shanghai, China. *J. Epidemiol*, 22, 28–36. doi:10.2188/jea.JE20110049.

[23] Fred-Nwagwu, W. F, Nwaerema, P. & Dangana, K. (2022). Spatio-temporal variability of vehicular traffic, noise and temperature of Minna City, Niger State, Nigeria. *MOJ Ecology & Environmental Sciences*, 7(1), 7 - 9. doi: 10.15406/mojes.2022.07.00240.

[24] Mwenda, B., Dionysius, K., Kungu, J., Jeske, V., Carlo, F. & Yasuyuki, M. (2020). Seasonal climate dynamics, perceptions and multiple risk adaptations: Lessons from Smallholder mixed agro ecosystems in Semi-arid Kenya. *Journal of Agricultural Extension and Rural Development*, 12(3), 76-90.

[25] Dariya, H. K., Abdussalam, A. F. & Saleh, Y. (2012). Relationship between Seasonal Weather Variation and Students' Academic Performance in Kaduna State University, Nigeria. *Science World Journal*, 16(2), 152

[26] Ajiere, S., Nwagbara, M. O. & Nwaerema, P. (2019). Impact of Climate Change on Growing Season Rainfall and Temperature and Crop Yields in Abia State, South-Eastern Nigeria. *Annals of Geographic Studies*, 2(3), 1-7. https://www.sryahwapublications.com/annals-of-geographical-studies/volume-2-issue-3/.-156.