FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 4, August, 2023, pp 272 - 277
DOI: https://doi.org/10.33003/fjs-2023-0704-1924

ATMOSPHERE HEMISPHERIC ANALYSIS OF PARTICLES POLLUTION OVER AFRICA

[*1,2]Hammed A. Lawal, [1,3]Mukhtar I. Muhammed, [4]Ibrahim Bulus

[1]Department of Physics, Air Force Institute of Technology, NAF Base, Kaduna,
[2]School of Physics and Astronomy, University of Leicester, England, United Kingdom
[3]Department of Physics, Kaduna State University, Kaduna
[4]Department of Physics, School of Sciences, Kaduna State College of Education, Kafanchan

*Corresponding authors' email: hadelawal@yahoo.co.uk

ABSTRACT
Particulate Matters (PM) or particle pollution are mixture of microscopic solid and liquid particles present in air. The presence of PM in air can be monitored through modern devices known as Air Quality Sensors. In this study, we seek to investigate the concentration of PM at different latitude in some regions in Africa using purple air data available at map.purpleair.com downloaded for a period of 365 days in some African countries namely; Nigeria, Ghana, Ethiopia, Tanzania, Morocco and Zambia. Using Pearson correlational analysis, findings have revealed that the correlation coefficient **r** between the average PM concentration in some countries within the Northern hemisphere shows -0.91 and 1 for countries lying in the Southern hemisphere. Taken together, these results suggest that there is an association between the PM and latitude. It can therefore be inferred that the higher the country from the northern hemisphere, the lower the concentration of PM and vice versa.

Keywords: Africa, Air quality, Latitude, Particulate Matters, Pollution, Purpleair

INTRODUCTION
The air we breathe is known to compose of some percentage of impurity either physical or chemical. These impurities vary from particulate matters (PM), Chloro-Flouro Carbons (CFC), Sulphur dioxide, Nitrogen dioxide, ground level ozone etc. (Loannis et al. 2020). In addition to these, some chemicals such as benzene, xylems and formaldehyde etc. are another group of air pollutants referred to as Air toxics. They are present in the atmosphere although in low concentration. But however, their presence has been traced to cause serious health ailments such as cancer, birth defects etc. Particulate Matters (PM) or particle pollution are mixtures of microscopic solid and liquid particles present in air. PM are classified according to the size of their diameter in to $PM_{2.5}$ and $PM_{10.}$ i.e., 2.5 micrometers and 10.0 micrometers respectively. Their small size enable them to penetrate deep in to the human lung through breathing. Several attempts have been made to study the effect these pollutants can pose on human health, plants and even the environment. Long term exposure to PM can lead to serious heart problems, reduced lung function, diabetes and cardiovascular diseases etc. (Eze et al. 2014; Auchincloss et al. 2008). In the same vein, short term exposure have been linked to irritation of the nose and eyes, coughing, asthma, obesity and sometimes heart attack or Chronic Obstructive Pulmonary Diseases (COPD) (Kan et al. 2012; Cao et al. 2021). Previous studies e.g. (Nam et al. 2010; Hernandez et al. 2017) have shown that PM concentration increases as temperature decreases. However, Kim (2019), in his work demonstrated an inverse relationship between PM and Temperature. Similarly, Lawal & Mukhtar (2022) in an attempt to monitor the air pollution in some parts of Nigeria found both positive correlation and negative correlation between the PM and Temperature across the study location. This PM-Temperature variation was attributed to the variation of the climatic condition in these locations. On average, particulate matters are made of components emitted directly or indirectly in the atmosphere e.g. organic matters, dusts, black sooth, nitrates and compounds of Sulphur. The presence of PM in air can be monitored through modern devices known as Air Quality Sensors. These sensors measure real time particulate matters using laser counters. A sample of air is drawn through the fan of this laser counters and thereafter, the beam from these lasers reflects the air particle on to a detection plate which will then be measured as pulses. The concentration of PM are calculated using the number of pulses. Some of these sensors does not only measure PM but other meteorological parameters that tend to affect PM e.g. Temperature, Atmospheric (ATM) pressure and Relative Humidity (RH). Report by Liu et al. (2017) have shown that increase in RH aggravate the concentration of the PM. The most common air quality sensors are the stationary sensors which are designed to measure the air quality at a particular location unlike the mobile sensors which are designed very portable to measure air quality at different locations. Others include satellite based sensors that measures pollutants emitted from the earth and the atmosphere. A good number of literatures have in the past focused majorly on the effect of meteorological factors on PM concentration. However, these studies have shown controversial results and there is no unanimous agreement about the effect of temperature and RH on PM. In this paper, we seek to investigate the concentration of PM at different latitude in some regions in Africa using purple air data.

MATERIALS AND METHODS
Data and Method
The data used in this study was obtained from map.purpleair.com. The data contains outdoor or Atmospheric (ATM) PM concentration and Relative Humidity downloaded for some African countries for the period of one year (i.e. 365 days). To study the effect of latitude with PM, we arbitrarily chose two countries from the North, South, West and Eastern African countries. Namely; Nigeria, Ghana, Ethiopia, Tanzania, Morocco and Zambia. Readers should bear in mind that due to limited number of purpleair sensors and purpleair data in some part of the selected countries, only regions with purpleair coverage were selected as highlighted in the map: Figure 1 – 2. First, using Pearson correlation, we investigated the relationship between the RH variation and PM concentration for the whole of the

study period. The study areas were classified in two groups according to their latitudes as shown in Table 1. In order to find the effect of latitude on PM, we again used Pearson correlation coefficient **r** to find the relationship between the yearly average PM concentration for countries within the northern hemisphere and countries lying in the Southern hemisphere.

Study Location

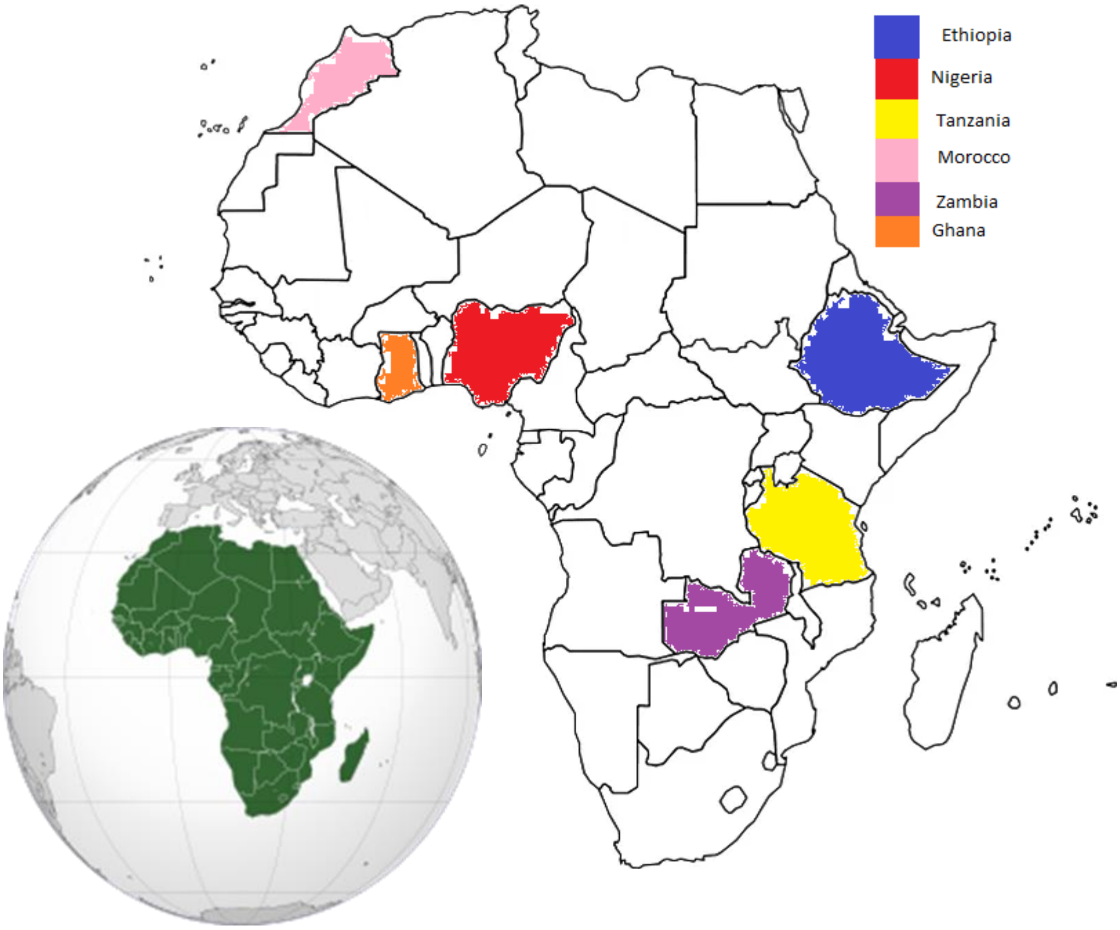

Figure 1: Map of Africa showing the study locations.

Africa is one of the most populous continents of the world. It has an area of about 30,370,000 km^2 and over 1,393,676,444 population as at 2021. It is surrounded by the Atlantic Ocean to the west, the Mediterranean Sea to the north, the Indian Ocean to the southeast and the Red Sea to the northeast. Africa is reported as the only continent that stretches from the northern temperate to the southern temperate zones.
The major physical regions in Africa are the Sahara which is the world's largest hot desert, Sahel, Savanna, Ethiopian Highlands, Swahili coast, Southern Africa, rainforest and African great lakes.

RESULTS AND DISCUSSION

Table 1: Locations and Coordinates of study locations with the yearly average Relative Humidity (RH) and PM$_{2.5}$ concentration

COUNTRY	SENSOR LOCATION	LATITUDE	LONGITUDE	YEARLY AVERAGE PM $_{2.5}$ (µg/m^3)	YEARLY AVERAGE RH (%)
Nigeria	CARSNADA- Abuja	9.07565°N	7.3986°E	38.7576	42.32113
Ghana	The Banda School	7.9465°N	1.0232°W	28.80005	47.89867
Ethiopia	Black Lion Hospital	9.1450°N	40.4897°E	40.63363	46.76333
Morocco	La Roseraie	31.7917°N	7.0926°W	8.524526	44.1773
Zambia	Kagem Mining	13.1339°S	27.8493°E	29.94161	40.34903
Tanzania	DIT	6.3690°S	34.8888°E	18.79049	57.98621

Result obtained from the analysis of the air quality variation in some selected countries within Africa are shown in Figure 3 – Figure 5. Figure 3 contains two panels (a) & (b) showing the RH and PM concentration in Abuja and Ghana respectively. As Table 1 shows, there is a proximity between the yearly $PM_{2.5}$ average concentration and yearly RH average concentration of Nigeria and Ghana from West Africa with latitude 9.07565°N and 7.9465°N respectively. It is apparent in figure 3, panel (a) and (b) that as $PM_{2.5}$ increases, the RH decreases and vice versa. Pearson correlation between the daily PM concentration and RH in the study location in Ghana and Nigeria was found to be -0.53 and -0.71 respectively. In the same vein, the PM concentration in Zambia shows negative correlation with RH. This strong negative correlation could be an evidence that RH variation contributed significantly to the PM concentration in Ghana and Nigeria respectively. This is in tandem with the result of Zhang et al. (2017). If we now turn to Ethiopia and Tanzania in the eastern Africa, it can be observed that the PM concentration correlated positively with the RH with r = 0.42 and 0.12 respectively. It was observed that the Pearson correlation coefficient **r** between the average PM concentration within the Northern hemisphere (Table1) shows -0.91 and 1 for countries lying in the Southern hemisphere. Taken together, these results suggest that there is an association between the PM and latitude. It can therefore be inferred that the higher the country from the northern hemisphere, the lower the concentration of PM and vice versa.

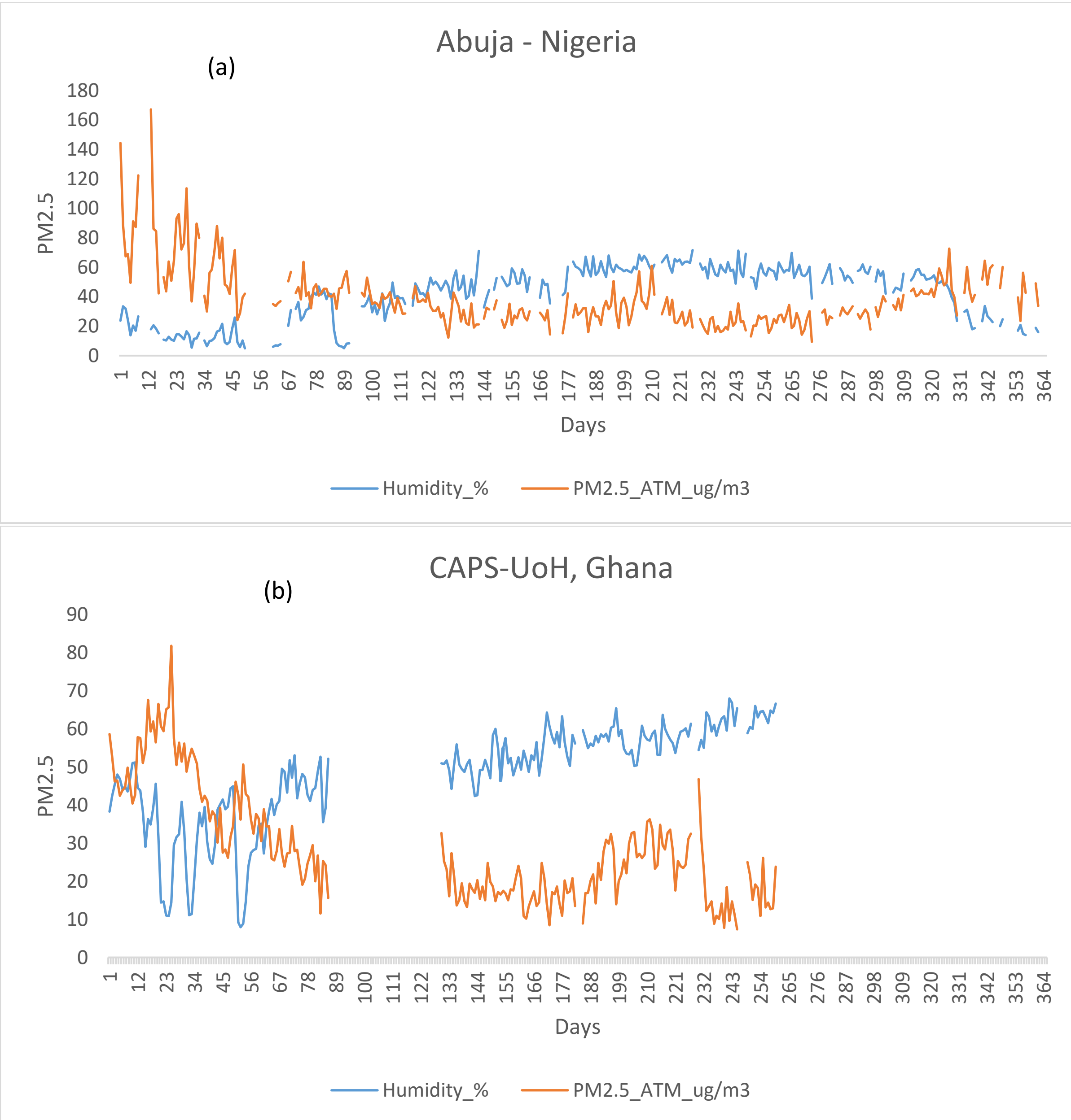

Figure 3: Variation of PM concentration and RH in (a) Nigeria and (b) Ghana; West Africa.

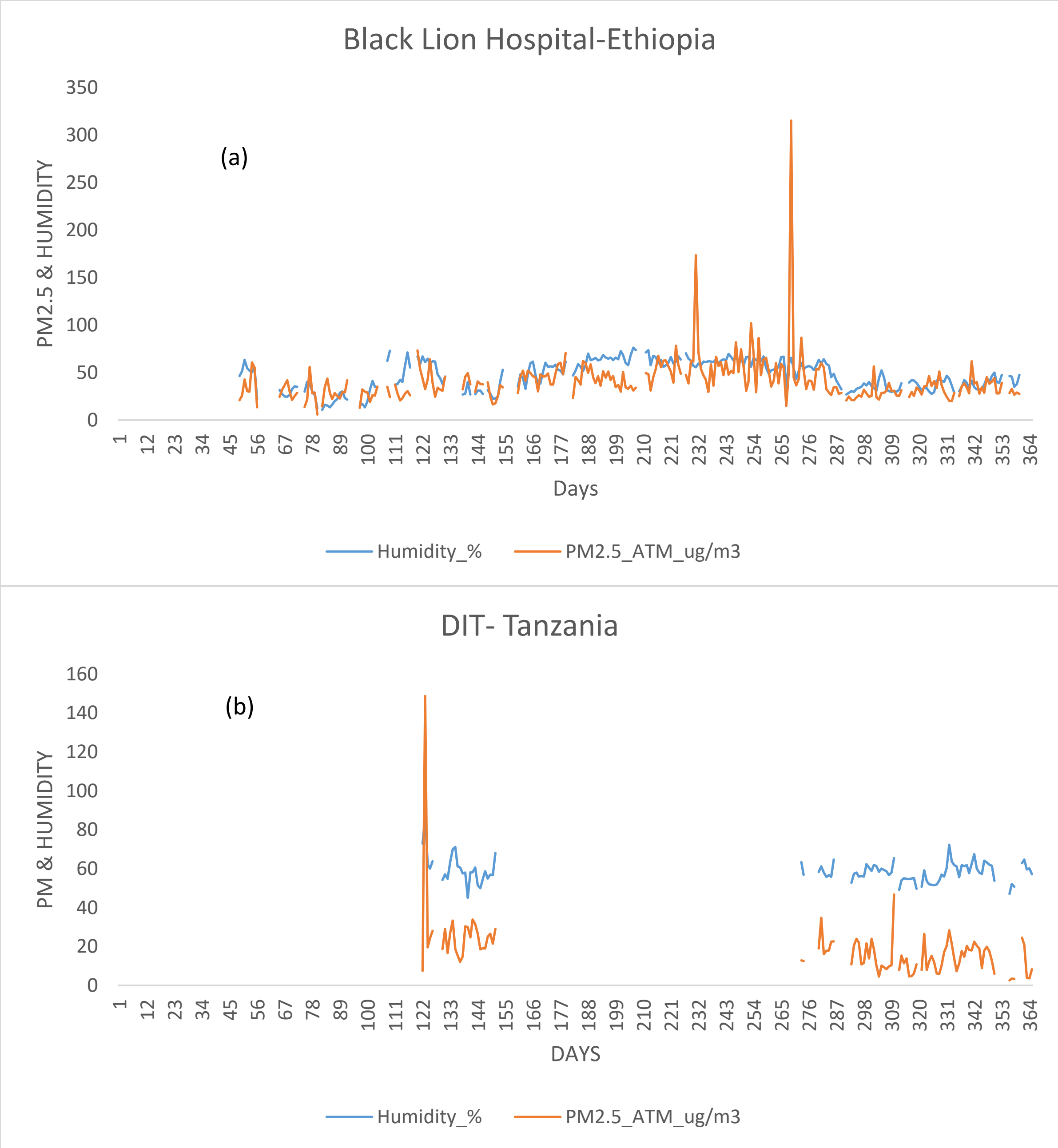

Figure 4: Variation of PM Concentration and Relative Humidity in (a) Ethiopia and (b) Tanzania; East Africa

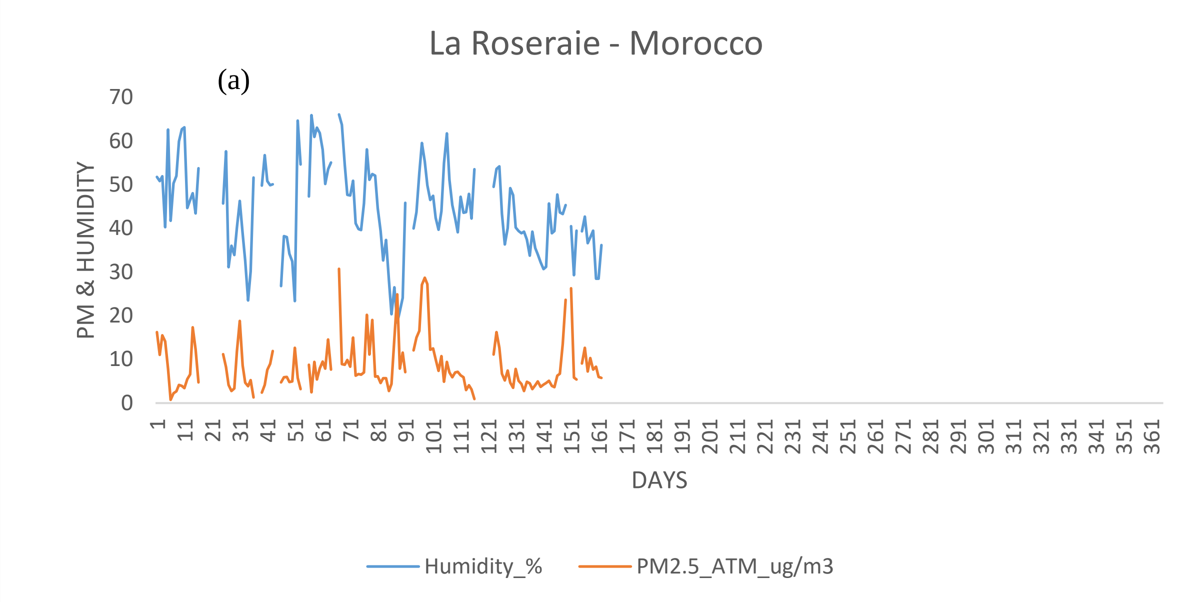

Figure 5: Variation of PM Concentration and Relative Humidity in Morocco; North Africa

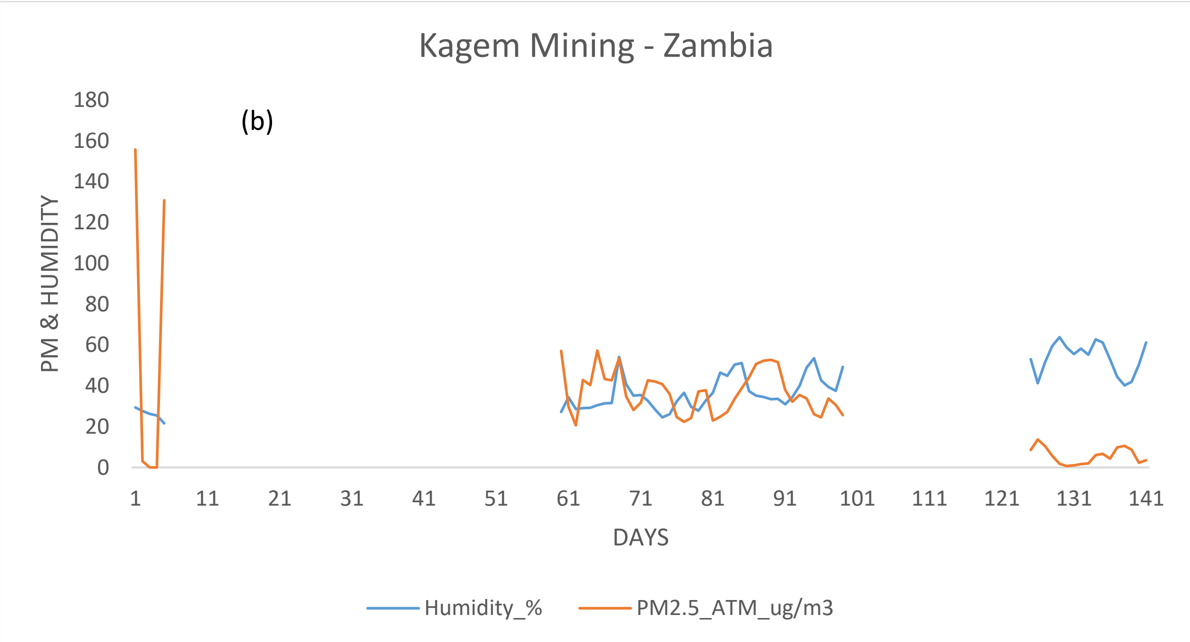

Figure 6: Variation of PM Concentration and Relative Humidity in Zambia; Southern Africa.

CONCLUSION

Particulate Matters (PM) or particle pollution are mixtures of microscopic solid and liquid particles present in air. PM are classified according to the size of their diameter in to $PM_{2.5}$ and PM_{10}. In this research, the major aim is to investigate the effect of latitude on Particulate Matter concentration using purpleair data. The study locations are some parts of Nigeria and Ghana, Tanzania and Ethiopia, Zambia and Morocco from North, East, West and Southern Africa. The Pearson correlation coefficient r = -0.91 for the study regions around the northern hemisphere and 1 for countries lying within the southern hemisphere respectively.

ACKNOWLEDGMENT

The primary data used in this study was provided by purpleair. We are very grateful.

REFERENCES

Auchincloss, A. H., Diez Roux, A. V., Dvonch, T., Brown, P. L., Bar, G. R., Daviglus, M. L., . . . O'Neill, M. S. (2008). Associations between Recent Exposure to Ambient Fine Particulate Matter and Blood Pressure in the Multi-Ethnic Study of Atherosclerosis. *Environmental Health Perspectives , 116*(4).

Cao, S., Qian, G., Xue, T., Wang, B., Wang, L., Duan, X., & Zhang, J. (2021). Long-term exposure to ambient PM2.5 increase obesity risk in Chinese adults: A cross-sectional study based on nationwide survey in China. *Science of The Environment, 778*, 145812. doi:doi.org/10.1016/j.scitotenv.2021.145812

Eze, I. C., Schaffner, E., Fischer, E., Schikowski, T., Adam, M., Imboden, M., . . . Nicole, P. (2014). Long-term air pollution exposure and diabeties in a population-based Swiss cohort. *Environment Internaional, 70*, 95-105. doi:doi.org/10.1016/j.envint.2014.05.014

Hammed, L. A., & Muhammed, M. I. (2022). Atmospheric Physics; Air Pollution and Analysis Using Purple Air Data. *African Scientific Report*. doi:10.46481/asr/2022.1.2.42

Hernandez, G., Berry, T.-A., Wallis, S. L., & Poyner, D. (2017). Temperature and Humidity Effects on Particulate Matter Concentrations in a Sub-Tropical Climate During Winter. *International Proceedings of Chemical, Biological and Environmental Engineering, 102.* doi:10.7763/ipcbee.2017.v102.8

Kan, H., Chen, R., & Tong, S. (2012). Ambient air pollution, climate change and population health in China. *nvironment Int, 42,* 10-19. doi:10.1016/j.envint.2011.03.003

Kim, M. J. (2019). Changes in the Relationship between Particulate Matter and Surface Temperature in Seoul from 2002-2017. *Atmosphere, 10*, 238. doi:doi.org/10.3390/atmos10050238

Liu, F., Tan, Q.-W., Jiang, X. x., Jiang, W.-J., & Song, D.-L. (2017). Effect of Relative Humidity on Particulate Matter Concentration and Visibility During Winter in Chengdu. *Environmental Science, 39*(4), 1466-1472. doi:10.13227/j.hjkx.201707112

Loannis, m., Elisavet, S., Agathangelos, S., & Eugenia, e. (2020). Environmental and Health Impacts of Air Pollution: A Review. *Front. Public Health*. doi:doi.org/10.3389/fpubh.2020.00014

Nam, E., Kishan, S., Baldauf, R. W., Fulper, C. R., Michael, S., & Warila, J. (2010). Temperature Effects on Particulate Matter Emissions from Light-Duty, Gasoline-Powered Motor Vehicles. *Environmental Science & Technology, 44*(12), 4672-4677. doi:https://doi.org/10.1021/es100219q

Zhang, L., Cheng, Y., Zhang, Y., He, Y., Gu, Z., & Yu, C. (2017). Impact of Air Humidity Fluctuation on the Rise of PM Mass Concentration on the High-resolution Monitoring Data. *Aerosol and Air Quality Research, 17*, 543-552. doi:10.4209/aaqr.2016.07.0296