INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

Measures of Day and Night Times Ozone (O_3) Concentration in Parts of Port Harcourt, Rivers State, Nigeria.

Onengiyeofori A. Davies, Sudum Esaenwi, Nicholas N. Tasie

Physics Department, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, Rivers State Nigeria

DOI: https://doi.org/10.51244/IJRSI.2023.10417

Received: 10 April 2023; Revised: 19 April 2023; Accepted: 26 April 2023; Published: 25 May 2023

Abstract: This work was aimed at taking measures of ozone concentration during day and night times in Port Harcourt. To this end, we employed a smart unmanned aerial vehicle (UAV) that we had previously designed and constructed to take measures of atmospheric zone concentration in mg/m^3. We collected data, in 5-minutes intervals, at noon for 245 minutes within 1pm-3:45pm and at night for 180minutes within 8pm-10pm on the 18/11/2022 on our pilot launch. The data collected was determined by how long our device battery could last on the pilot launch. Our results from the day time measures of ozone concentration showed that the concentration of ozone was quite stable, remaining between 0.1 and 0.2 mg/m^3 the whole period while the night time observation shows a natural rise in ozone levels throughout this time period, with concentrations ranging from 0.03 to 0.06 mg/m^3. This shows that the ozone concentration was higher during the night time, which could be attributed to Port Harcourt being an urban area and the weather condition in Port Harcourt during the period of this study.

Keywords: Ozone, Concentration, UAV, Day time, Night time

I. Introduction

The ozone (O_3) is a naturally occurring gas that can be found in the stratosphere, which is 10 to 50 kilometers above the surface of the planet [1, 2]. By absorbing and blocking damaging ultraviolet (UV) light from the sun, the ozone layer is a key factor in controlling the climate and weather on Earth [3-5].

Relative to Temperature Regulation, the ozone layer acts as a protective shield that absorbs the incoming UV radiation from the sun, which causes a temperature rise in the stratosphere [6]. This absorbed energy is then re-emitted as heat, warming the stratosphere and resulting in a temperature inversion. This inversion layer inhibits the mixing of colder air below with warmer air above, thereby regulating the temperature of the troposphere, the lower stratum of the atmosphere where meteorological phenomena occur [7, 8]. Without the ozone layer, the troposphere would substantially cool, resulting in a variety of climatic changes, such as alterations in temperature, wind patterns, and precipitation [9].

The ozone layer also plays a significant influence in the patterns of atmospheric circulation on Earth [10, 11]. The ozone layer absorbs ultraviolet radiation from the sun, which warms the stratosphere and generates a temperature gradient between the equator and the poles. The Hadley, Ferrel, and Polar cells, which control the distribution of heat and precipitation across the Earth's surface, as described by Qian *et. al.* [12], are driven by this temperature gradient [13]. Monsoons, hurricanes, and cyclones are caused by these circulation patterns [14, 15].

The ozone layer has a substantial effect on weather extremes such as droughts, heatwaves, and extreme precipitation events [16, 17]. Changes in the ozone layer can alter atmospheric circulation patterns, resulting in alterations in temperature and precipitation patterns, which can cause these extreme weather events. For instance, a decrease in ozone levels over the polar regions can result in the formation of the ozone hole, which can contribute to changes in the location of the polar jet stream. According to Turner *et. al.* [18], this change can alter the distribution of warm and frigid air masses, which can result in extreme weather events.

The ozone layer regulates the atmospheric variables on Earth. Without the protective shield of the ozone layer, the climate and weather patterns on Earth would endure significant changes, resulting in extreme weather events and climate change. It is crucial to continue monitoring and protecting the ozone layer in order to maintain the climate and weather patterns of our planet.

Nigeria research institution have been distressed over the year with lack of scientific data for research. Worst still, research and even government institution rely on foreign data source to carry out researches in our institution. Result from such efforts do not bring commensurable development impact on our nation. There is need to urgently generate research data from our terrain and make such affordable and accessible to users to foster national development.

This work is therefore geared towards acquiring measures of the concentration of the ozone (O_3) in areas of Port Harcourt metropolis employing the smart unmanned aerial vehicle (UAV) designed by Esaenwi *et. al.* [19].

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

II. Material and Method

Having successfully set up the circuits for both the drone and the control pad as designed by Esaenwi *et. al.* [19], we inserted an eternal memory in the SD card module before launch. When we powered the circuit, the MQ131 sensor automatically turns on and starts collecting air sample from the surrounding and ready for analysis. These analyses are not dependent on the flight of the Drone. The computer program on the drone, as described by Esaenwi *et. al.* [19], dictated that the MQ131 sensor takes the average of the surrounding Ozone and logs them into the memory card through the SD card module and stores the numeric at 5 minutes interval in parts per million (ppm), parts per billion (ppb), milligram per meter cube (mg/m^3), and nanogram per meter cube (ug/m^3).

After flying the drone for about 3 hours for day and night time data collection on the 18th of November 2022, with the time for data collection dependent on how long the device battery could last on the pilot launch, we landed the drone and extracted the data from the SD card. The data was then used to obtain day and night time plots of ozone concentration against time.

III. Result and Discussion

A. Result

The ozone concentration data collected for day and night times are shown in Tables 1 and 2. These datasets have also been plotted against time as shown in Figures 1 and 2.

Table 1: Measure of day time ozone concentration from 12noon to 3:45pm.

Time from 12noon to 3:45pm at 5mins interval (minutes)	Ozone (O_3) concentration (mg/m^3)
5	0.02
10	0.02
15	0.02
20	0.02
25	0.01
30	0.01
35	0.01
40	0.01
45	0.01
50	0.01
55	0.01
60	0.01
65	0.01
70	0.02
75	0.02
80	0.02
85	0.02
90	0.02
95	0.02
100	0.02
105	0.02
110	0.02
115	0.02
120	0.02
125	0.02
130	0.02
135	0.02
140	0.02
145	0.02
150	0.02
155	0.02
160	0.02
165	0.02

170	0.02
175	0.02
180	0.02
185	0.02
190	0.02
195	0.02
200	0.02
205	0.02
210	0.02
215	0.02
220	0.02
225	0.02

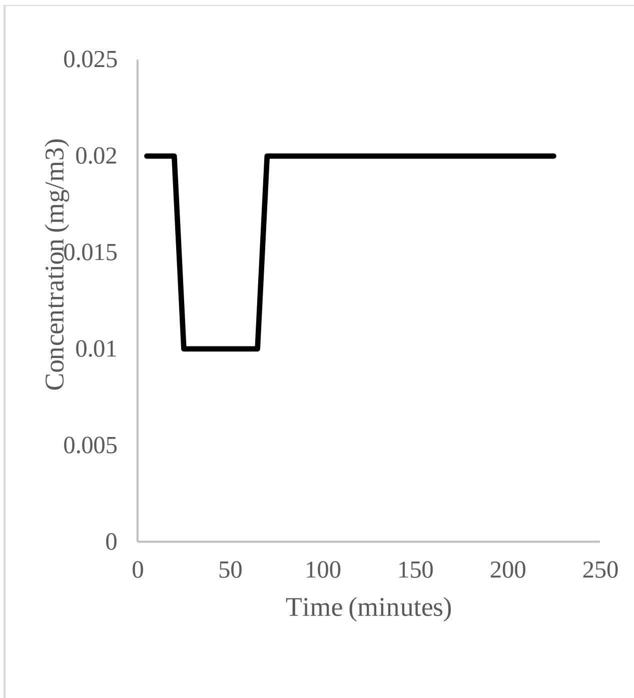

Figure 1: Plot of day time (12noon – 3:45pm) ozone concentration against time.

Table 2: Measure of night time ozone concentration from 7pm to 10pm.

Time from 7pm to 10pm at 5mins interval (minutes)	Ozone (O_3) concentration (mg/m^3)
5	0.03
10	0.03
15	0.03
20	0.04
25	0.04
30	0.04
35	0.04
40	0.04
45	0.05
50	0.05
55	0.05
60	0.05

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

65	0.05
70	0.05
75	0.05
80	0.05
85	0.06
90	0.06
95	0.06
100	0.06
105	0.06
110	0.06
115	0.06
120	0.05
125	0.05
130	0.05
135	0.05
140	0.05
145	0.05
150	0.05
155	0.05
160	0.05
165	0.05
170	0.05
175	0.05
180	0.05

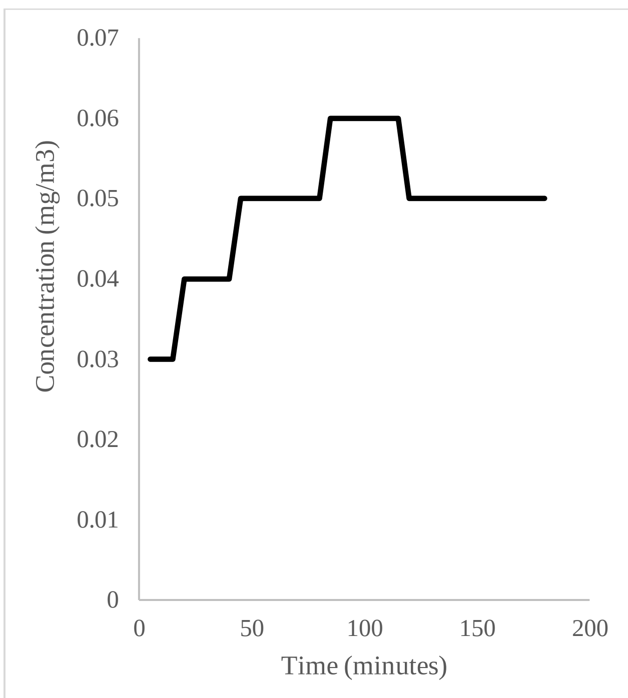

Figure 2: Plot of night time (7pm – 10pm) ozone concentration against time

B. Discussion

We plotted a graph of ozone concentration (in milligram per meter cube, mg/m^3) measured during day time (from 12 noon to 3:45pm) against a 5-minute interval time. The ozone concentration was fairly steady ranging between 0.1 – 0.2 mg/m^3 in this 245-minute period.

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

Similarly, a graph of ozone concentration (in milligram per meter cube, mg/m^3) measured during 3 hours of night time (from 7pm to 10pm) against a 5-minute interval time was also plotted. Our results from the night observation shows a spontaneous increase in ozone during this period ranging between $0.03 mg/m^3$ - $0.06 mg/m^3$.

The concentration of ozone in the Earth's atmosphere is maintained by a delicate equilibrium between ozone production and degradation [20, 21]. The formation of ozone in the atmosphere involves a series of complex chemical reactions, and the mathematics underlying this process is founded on chemical kinetics principles. Photodissociation of molecular oxygen (O_2) by solar radiation ($h\vartheta$) is the primary source of ozone in the atmosphere.

$$O_2 + h\vartheta \rightarrow 2O \qquad (1)$$

The resulting atomic oxygen (O) can then combine with molecular oxygen to create ozone.

$$O + O_2 + \mathcal{M} \rightarrow O_3 + \mathcal{M} \qquad (2)$$

Where $\mathcal{M}$ represents a third entity, typically a nitrogen or oxygen molecule, that collides with the reacting species to facilitate the reaction.

Therefore, the rate of ozone formation is dependent on the concentrations of atomic and molecular oxygen in the atmosphere as well as the intensity of solar radiation. This process is also affected by the concentration of other reactive species in the atmosphere, including nitrogen oxides (NOx) and volatile organic compounds (VOCs), which can contribute to the formation of secondary pollutants.

However, ozone is also continuously annihilated by a number of natural and anthropogenic processes, including reactions with other atmospheric molecules such as nitrogen oxides and chlorine compounds [22].

Due to the natural feedback mechanisms that regulate ozone production and destruction, the overall concentration of ozone in the atmosphere has remained relatively stable despite these ongoing processes of production and destruction. For instance, when there is an increase in ozone production due to an increase in UV radiation, the increased availability of reactive atmospheric molecules leads to an increase in ozone degradation. In contrast, ozone degradation decreases when ozone production declines.

In addition, human actions, have resulted in the reduction of ozone-depleting substances, such as chlorofluorocarbons (CFCs), which were largely responsible for past ozone depletion [23, 24]. This has contributed to the stabilization and even increase of ozone concentrations in certain regions of the atmosphere.

Overall, the stability of ozone concentrations in the atmosphere is the result of a delicate equilibrium between natural and human factors that regulate both the production and annihilation of ozone.

However, the average concentration of ozone is found to be greater during the day and lower throughout the night [25, 26]. This is due to the fact that the primary factor that contributes to the creation of ozone is the absorption of ultraviolet (UV) radiation from the sun, which is only present during the daytime. The absence of ultraviolet radiation causes a significant drop in the formation of ozone, which in turn results in a lower concentration of ozone in the atmosphere.

On the other hand, depending on the circumstances, the ozone concentration may be higher at night in certain places [27, 28]. For instance, during the course of the day in urban areas, the concentration of nitrogen oxides (NOx) might rise due to the combination of increased traffic and increased industrial activity. The concentration of nitrogen oxides (NOx) drops during the night since there is less traffic and fewer industrial operations. Due to the fact that NOx is one of the key contributors to the depletion of ozone in the atmosphere, this can result in an increase in the concentration of ozone.

In addition, particular patterns of weather can contribute to an increase in the concentration of ozone at night [29, 30]. For instance, if there is a temperature inversion, which occurs when a layer of warm air rests on top of a layer of cool air, pollutants such as ozone can become trapped close to the ground. This can result in a higher concentration of ozone at night, when there is less mixing of the atmosphere and contaminants are more prone to concentrate as a result of this phenomenon.

Therefore, the condition in which the ozone concentration in our study area is higher during night time relative to its day time measures could be due to the meteorological condition in the study area at the time and the fact that Port Harcourt is an urban area with probably high levels of atmospheric pollutants.

IV. Conclusion

The study was aimed at taking measures of day and night time ozone concentration in parts of Port Harcourt, Rivers State, Nigeria. The following conclusions were arrived at;

i. During the day time measurement of ozone concentration, the concentration of ozone remained rather consistent, hovering

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

between 0.1 and 0.2 mg/m^3.

ii. The night time observation reveals a natural rise in ozone concentration levels throughout the observation period, with concentrations ranging from 0.03 to 0.06 mg/m^3.

iii. There was an abnormally higher ozone concentration level during the night time relative to measures of ozone concentration during day time.

References

1. Andersen, S.O. and K.M. Sarma, Protecting the ozone layer: the United Nations history. 2012: Earthscan.
2. Graedel, T.E. and P.J. Crutzen, The changing atmosphere. Scientific American, 1989. 261(3): p. 58-69.
3. Soh, Y.C., F. Roddick, and J. Van Leeuwen, The future of water in Australia: The potential effects of climate change and ozone depletion on Australian water quality, quantity and treatability. The Environmentalist, 2008. 28: p. 158-165.
4. Diffey, B., Climate change, ozone depletion and the impact on ultraviolet exposure of human skin. Physics in Medicine Biology, 2003. 49(1): p. R1.
5. Barnes, P., T. Robson, P. Neale, C. Williamson, R. Zepp, S. Madronich, S. Wilson, A. Andrady, A. Heikkilä, and G. Bernhard, Environmental effects of stratospheric ozone depletion, UV radiation, and interactions with climate change: UNEP Environmental Effects Assessment Panel, Update 2021. Photochemical and Photobiological Sciences, 2022. 21(3): p. 275-301.
6. McKenzie, R.L., P.J. Aucamp, A.F. Bais, L.O. Björn, M. Ilyas, and S. Madronich, Ozone depletion and climate change: impacts on UV radiation. Photochemical & Photobiological Sciences, 2011. 10(2): p. 182-198.
7. Mohanakumar, K., Stratosphere troposphere interactions: an introduction. 2008: Springer Science & Business Media.
8. Rasilla, D.F., A. Martilli, F. Allende, and F. Fernández, Long-term evolution of cold air pools over the Madrid basin. International Journal of Climatology, 2023. 43(1): p. 38-56.
9. Martens, P., Health and climate change: modelling the impacts of global warming and ozone depletion. 2014: Routledge.
10. Zubov, V., E. Rozanov, T. Egorova, I. Karol, and W. Schmutz, Role of external factors in the evolution of the ozone layer and stratospheric circulation in 21st century. Atmospheric Chemistry and Physics, 2013. 13(9): p. 4697-4706.
11. Ramaswamy, V., M. Schwarzkopf, and W. Randel, Fingerprint of ozone depletion in the spatial and temporal pattern of recent lower-stratospheric cooling. Nature, 1996. 382: p. 616-618.
12. Qian, W., K. Wu, and D. Chen, The Arctic and Polar cells act on the Arctic sea ice variation. Tellus A: Dynamic Meteorology and Oceanography, 2015. 67(1): p. 27692.
13. Reis, A.H. and A. Bejan, Constructal theory of global circulation and climate. International Journal of Heat and Mass Transfer, 2006. 49(11-12): p. 1857-1875.
14. Zhang, Y., H. Mao, A. Ding, D. Zhou, and C. Fu, Impact of synoptic weather patterns on spatio-temporal variation in surface O3 levels in Hong Kong during 1999–2011. Atmospheric Environment, 2013. 73: p. 41-50.
15. Gao, D., M. Xie, X. Chen, T. Wang, J. Liu, Q. Xu, X. Mu, F. Chen, S. Li, and B. Zhuang, Systematic classification of circulation patterns and integrated analysis of their effects on different ozone pollution levels in the Yangtze River Delta Region, China. Atmospheric Environment, 2020. 242: p. 117760.
16. Randel, W.J. and F. Wu, Cooling of the Arctic and Antarctic polar stratospheres due to ozone depletion. Journal of Climate, 1999. 12(5): p. 1467-1479.
17. Ivy, D.J., S. Solomon, N. Calvo, and D.W. Thompson, Observed connections of Arctic stratospheric ozone extremes to Northern Hemisphere surface climate. Environmental Research Letters, 2017. 12(2): p. 024004.
18. Turner, J., H. Lu, J. King, G.J. Marshall, T. Phillips, D. Bannister, and S. Colwell, Extreme temperatures in the Antarctic. Journal of Climate, 2021. 34(7): p. 2653-2668.
19. Esaenwi, S., N.N. Tasie, and O.A. Davies, Development of Smart UAV (Drone) ozone (O3) monitoring system in Port Harcourt, Rivers State, Nigeria. World Journal of Advanced Research and Reviews, 2023. 17(03): p. 558-568.
20. Brassard, D.J., Ozone: The Earth's Sunscreen. 1992: Citeseer.
21. Holloway, A.M. and R.P. Wayne, Atmospheric Chemistry. 2015: Royal Society of Chemistry.
22. Akhobadze, G. Ozone layer destruction and ways of its recovery. in IOP Conference Series: Materials Science and Engineering. 2020. IOP Publishing.
23. Ravishankara, A., J.S. Daniel, and R.W. Portmann, Nitrous oxide (N2O): the dominant ozone-depleting substance emitted in the 21st century. Science, 2009. 326(5949): p. 123-125.
24. Singh, A. and A. Bhargawa, Atmospheric burden of ozone depleting substances (ODSs) and forecasting ozone layer recovery. Atmospheric Pollution Research, 2019. 10(3): p. 802-807.
25. Wang, T., Y. Wu, T. Cheung, and K.S. Lam, A study of surface ozone and the relation to complex wind flow in Hong Kong. Atmospheric Environment, 2001. 35(18): p. 3203-3215.
26. Ran, L., C. Zhao, W. Xu, X. Lu, M. Han, W. Lin, P. Yan, X. Xu, Z. Deng, and N. Ma, VOC reactivity and its effect on

ISSN No. 231-2705 | DOI: 10.51244/IJRSI | Volume X Issue IV April 2023

ozone production during the HaChi summer campaign. Atmospheric Chemistry and Physics, 2011. 11(10): p. 4657-4667.
27. Marr, L.C. and R.A. Harley, Modeling the effect of weekday– weekend differences in motor vehicle emissions on photochemical air pollution in Central California. Environmental Science & Technology, 2002. 36(19): p. 4099-4106.
28. Han, S., H. Bian, Y. Feng, A. Liu, X. Li, F. Zeng, and X. Zhang, Analysis of the relationship between O3, NO and NO2 in Tianjin, China. Aerosol and Air Quality Research, 2011. 11(2): p. 128-139.
29. David, L.M. and P.R. Nair, Diurnal and seasonal variability of surface ozone and NOx at a tropical coastal site: Association with mesoscale and synoptic meteorological conditions. Journal of Geophysical Research: Atmospheres, 2011. 116(D10).
30. Chan, C. and L. Chan, Effect of meteorology and air pollutant transport on ozone episodes at a subtropical coastal Asian city, Hong Kong. Journal of Geophysical Research: Atmospheres, 2000. 105(D16): p. 20707-20724.