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Monthly Variability of Selected Weather Elements in the Portharcourt Urban Enclaves, Rivers State, Nigeria from 2010 to 2020

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Abstract

The study examined Monthly Variability of selected weather elements in the Portharcourt urban enclaves, Rivers State, Nigeria from 2010 to 2020. Monthly weather data for 2010 to 2020 on temperature, rainfall, relative humidity and wind speed were obtained from Nigerian Meteorological Agency (NIMET) and used for the study. Both descriptive and inferential statistics were used for data analyses. Findings showed that mean monthly rainfall, relative humidity, temperature and wind speed were 2085.06 mm, 77.01%, 27.93˚C and 2.30 m/s respectively. The trend analysis shows that rainfall increased at the rate of 57.73 mm from January to December while relative humidity increased at the rate of 1.4846%. Monthly temperature was decreasing at the rate of 0.1075˚C and wind speed was also decreasing at the rate of 0.0562 m/s. The study concluded that the monthly rainfall, relative humidity and temperature varied significantly from January to December, due to natural and anthropogenic factors, while the wind speed was not varied, due to terrain and pressure gradient characteristics which are similar across the area. The month of highest rainfall was June, temperature was February, relative humidity was September and wind speed was August. The study recommended that more periodic monitoring studies are required to give in-depth knowledge about the variability in the weather parameters in Portharcourt Metropolis. Additionally, more studies on the influence of the seasons and land-use types on climate parameters should be initiated in the area.

Keywords

Variability, Temperature, Relative Humidity, Wind Speed, Monitoring, Port

Harcourt

1. Introduction

It is possible and has since been established in literature that weather variability happens within any climate system (Ozabor & Nwagbara, 2018; Cinto-Mejía & Wetzel, 2023). The reasons for occurrence ranges from natural factors (revolution, rotation, volcanic eruptions etc.) to manmade factors (urbanization, deforestation, atmospheric pollution, etc.) (Singh et al., 2023). Recent studies (Weli & Famous, 2018; Shehadeh et al., 2024) have emphasized the need for continuous examination of the weather and climatic systems, due to the impacts of climate variability on the environment, agriculture, food security and health. Also, studies have revealed that weather variability has been linked to urban flooding (Ojeh & Ozabor, 2013; Ozabor & Wodu, 2016; Dharmarathne et al., 2024) insecurity, indoor thermal discomfort (Ozabor & Ajukwu, 2023a, 2023b), and food fermentation (Nwagbara et al., 2017).

Zhou et al. (2023) identified that fluctuating relative humidity (RH) affects temperature characteristics. The same is also reported for relationships between the fluctuations in RH and rainfall (RF) (Oloketuyi & Omole, 2024). This indicates that changes in the characteristics of temperature affects rainfall and RH (Ozabor, 2014; Ogoro et al., 2020). Additionally, the rates of solar radiation (SR) and urbanization characteristic (UC) is linked to temperature changes (Nayak et al., 2023). Godspower et al. (2023) averred that the urban expansion, population rise, deforestation, and air pollution affects temperature variability. Also, Liu et al. (2023) identified that variations in SR causes variation in temperature. Zhang et al. (2023) asserted that SR variability correlated with increased rainfall variability. The issue of climate change is certainly not one that surfaced recently (Ozabor et al., 2024); climate change has been an issue since early civilization and scientists have been sounding the alarms about climate change (Amiri et al., 2024). In Southern Nigeria however, attenuation in rain patterns observed, results in unpredictable flooding, which has been detrimental to both mining and deep-water aquaculture in that area (Queirós et al., 2024; Nwaogu et al., 2024a). Department for International Development (DFID) history also included in 2009 documents large loss in the manufacturing sector due to possibilities of flooding that affected the fulfilment of production objectives (Trujillo, 2015). This is especially true because the sector's agricultural input is quite sensitive to climate change (Okumagba & Ozabor, 2016; Nwaogu et al., 2024b)

The adverse consequences of climate change such as, increased temperature have also resulted in more frequent and severe heat waves (Luber & McGeehin, 2008), with the worst summers registered to date being in the year of 2003 (Russo et al., 2014); where heat waves in that year saw nearly 40,000 people die from excess heat primarily in Europe (García-Herrera et al., 2010). This event and its magnitude has since been eclipsed by the Russian heat-wave of the year 2010 (Konovalov et al., 2011), but that too resulted in excess deaths of 55,000 with estimated economic losses of an estimated 15 billion dollars. All these climate change milieu are traceable to manmade contributions through urbanisation, pollution and deforestation (Iacovino & Randazzo, 2023).

Greenhouse gas (GHG) emissions in Nigeria and other parts of the world however, have largely been attributed to human activities including agriculture (Ushurhe et al., 2024a). In the climate change discussion, projections are that hundreds of millions of people (especially in developing parts of the world) will be at risk of water and food shortages (Ahmed et al., 2024) that will harm health over the coming decades (Ozabor & Obaro, 2016). Thus, governments and all concerned, must act jointly on a global scale to minimize the permanent effects of climatic variability and change (Abbass et al., 2022). However, a modest increase in global temperature is expected to exacerbate the nature, frequency and intensity of extreme climatic events (Zwiers et al., 2013).

Human activities have drastically changed many aspects of the atmosphere (Li., et al., 2020), including temperature (Nwagbara et al., 2018), rainfall (Ojeh et al., 2018), levels of carbon dioxide (Kwakwa et al., 2023) and levels of ozone close to the ground (Ozabor & Obisesan, 2015). The Intergovernmental Panel on Climate Change (IPCC) averred that, despite its lack of scepticism about specific climate change, the warming of the climate system is undeniable (Bucknam, 2023). As GHG levels rise, models predict that the frequency and intensity of heat waves will increase globally throughout the 21st century (Domeisen et al., 2023; Iyama et al., 2024). Dramatic declines in soil moisture in the United States are expected to further increase summer temperatures in parts of the Midwest (Sun et al., 2023). Historically, rare heat waves, which occurred once every 20 years, are expected to occur every 2 - 3 years in the second half of this century (Yule et al., 2023). By the end of the century, under the IPCC High Emissions Scenario (AR5), extreme events like the 2010 Russian heat wave are projected to occur every two years in places like Southern Europe, North and South America, Africa and Indonesia (Moustafa et al., 2023). Although extreme heat waves and heat waves are common, unusually cold weather has decreased dramatically since the 1950s (Bardin et al., 2024). For example, in 2015, 16% of the Earth experienced an extremely warm year, while only 0.2% experienced an extremely cold year (Ke et al., 2024). Similarly, in 2014, no significant cold rainfall was observed anywhere on Earth, while 12% experienced significantly warmer rainfall (Trancoso et al., 2024). Climate models have shown that these effects are primarily driven by high levels of GHGs (Wang et al., 2023).

The 2000s in the US, has experienced fewer cold waves since 1895, more than double the lows of the late 1990s (LaDochy & Witiw, 2023). Projections suggest a sharp decline in the coldest temperatures by the end of the 21st century, and the coldest nights of the year were warmer than the warmest days, especially in the northern elevations (Asadi-RahimBeygi et al., 2024). At the same time, winter storm tracks moved northward, which is increasing and becoming more frequent since the 1950s (Collins et al., 2024).

The rain-fed and dependent agriculture in the southern region of Nigeria makes it particularly vulnerable to climate change (Fadairo et al., 2023). This is because weather affects agriculture directly or indirectly. Previous studies (Nwagbara et al., 2017; Ozabor & Nwagbara, 2018) have shown variations in climate over time and space, however these studies did not specifically focus on Portharcourt. The current study examined climate variability and plausible natural and anthropogenic factors affecting temperature, rainfall, and humidity in Rivers State. The variability in climate, have severe impacts on agriculture, food security, health, and urban flooding. Therefore, this study examined the monthly changes in temperature, precipitation, humidity and wind speed from 2010 to 2020 in Portharcourt Metropolis, Rivers State, Nigeria.

2. Materials and Methods

The study area for this study is Portharcourt Metropolis, which is a coastal area in the southern part of Nigeria (Okumagba & Ozabor, 2014). Geographically, Portharcourt is located on latitudes 4˚73'06 N and 4˚90'17 N of the equator and longitudes 6˚92'05 E and 7˚07'56 E of the Greenwich meridian (**Figure 1**). Over the years, the city has experienced rapid urbanization driven by factors such as natural population growth, employment opportunities created by the oil boom of the 1970s, migration (Famous & Adekunle, 2020; Famous et al., 2023), improvements in transportation and communication. It is estimated that the presence of multinational oil companies has influenced the growth in population in this region of Nigeria (Uduji & Okolo-Obasi, 2017).

The development of Portharcourt is incredibly linked to the socio-economic history of Nigeria (Obafemi & Odubo, 2013). **Figure 1** shows the study areas in Portharcourt Municipality. The rapid population growth coupled with the lack of housing has created many urban challenges such as unplanned sprawl, environmental pollution, waste challenges, lack of basic infrastructure, poverty, urban decay, overcrowding, irregular rural and settlement (Ozabor et al., 2024). However, it has been reported that private companies have been slow to meet the demands of the growing urban population. Historically, about 80% of the housing developments in the Port have been developed by the Harcourt private sector. However, these private companies prefer to develop buildings for Medium- and high income groups, neglecting the housing demands of lower income groups (Ozabor et al., 2024). However, there is a link between these population growth, urbanization and climate variability in the area.

In terms of climate, the area falls under the koppens classification with high rainfall (2015 - 2250 mm), high relative humidity (85% to 95%) high annual mean temperature (27˚C - 30˚C). However, the changing urbanization characteristics and other anthropogenic activities have been affecting the climate over the year, causing effects on the local climate in the area (Obafemi & Odubo, 2013; Ushurhe, et al., 2024b).

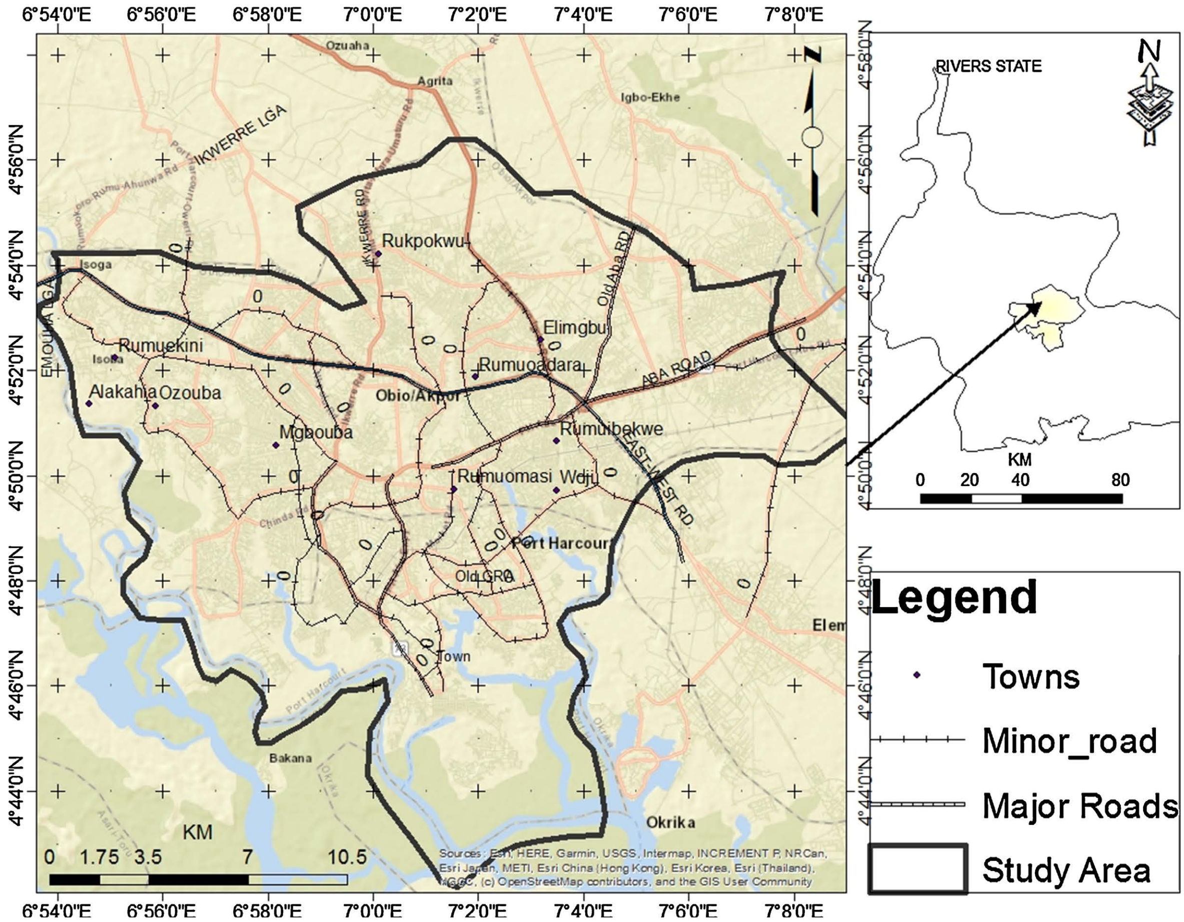

Figure 1. Port Harcourt Metropolis.

Longitudinal research design was deployed in this study. The annual and monthly record of temperature, rainfall, relative humidity and wind speed from 2010 to 2020 were collected from the Nigerian Meteorological Agency (NiMet). The meteorological data were grouped into both wet season (April-October) and dry season (November-March) and used for further analysis. The descriptive statistics involved the means, standard deviation, frequency and percentages while analysis of variance was used to determine the significant variability in climate data. The null hypothesis which states 'there is no significant variation in the rainfall, temperature and relative humidity in the study area' was tested using Analysis of Variance (ANOVA). These analyses were done using the IBM/statistical package for the social sciences (SPSS) version 25.

3. Results and Discussions

The monthly analysis of meteorological data is presented in **Table 1**. It is shown that the minimum monthly total rainfall was 162.50 mm and the maximum was 3697.20 mm while the mean monthly rainfall was 2085.06 mm. The monthly relative humidity had a minimum value of 44.25% and the maximum was 83.93% while the mean relative humidity was 77.01%. The monthly temperature analysis shows that the minimum was 26.41˚C and the maximum was 29.35˚C with the mean temperature of 27.93˚C. The wind speed monthly analysis reveals that the minimum was 1.81 m/s, maximum of 2.59 m/s with mean wind speed of 2.30 m/s.

Furthermore, it is observed that the rainfall monthly analysis shown in Figure 1 reveals that temperature was higher in both June and September with above 3500 mm of rainfall. The lower rainfall was experienced in January and December. It is thus observed that the trend surface line increases with increasing in the month from January to December. The trend line also showed that rainfall increased at a rate of 57.728 mm from January to December. The R Square analysis reveals that 2.72% of the variation in the rainfall could be explained by the variation in the months.

The relative humidity monthly analysis in Figure 2 shows that the least was experienced in January while the higher relative humidity was experienced between June and November. The trend surface analysis reveals that relative humidity increases at the rate of 1.4846% and the R Square analysis reveals that 22.04% of the variation of relative humidity could be explained by the variation in the months between January and December.

Table 1. Descriptive statistics of monthly analysis of meteorological parameters.

Meteorological Parameters	Minimum	Maximum	Mean	Std. Deviation
Monthly Total Rainfall	162.50	3697.20	2085.06	1261.9
Monthly Mean Relative Humidity	44.25	83.93	77.01	11.0
Monthly Mean Temperature	26.41	29.35	27.93	1.0
Monthly Mean Wind Speed	1.81	2.59	2.30	0.25

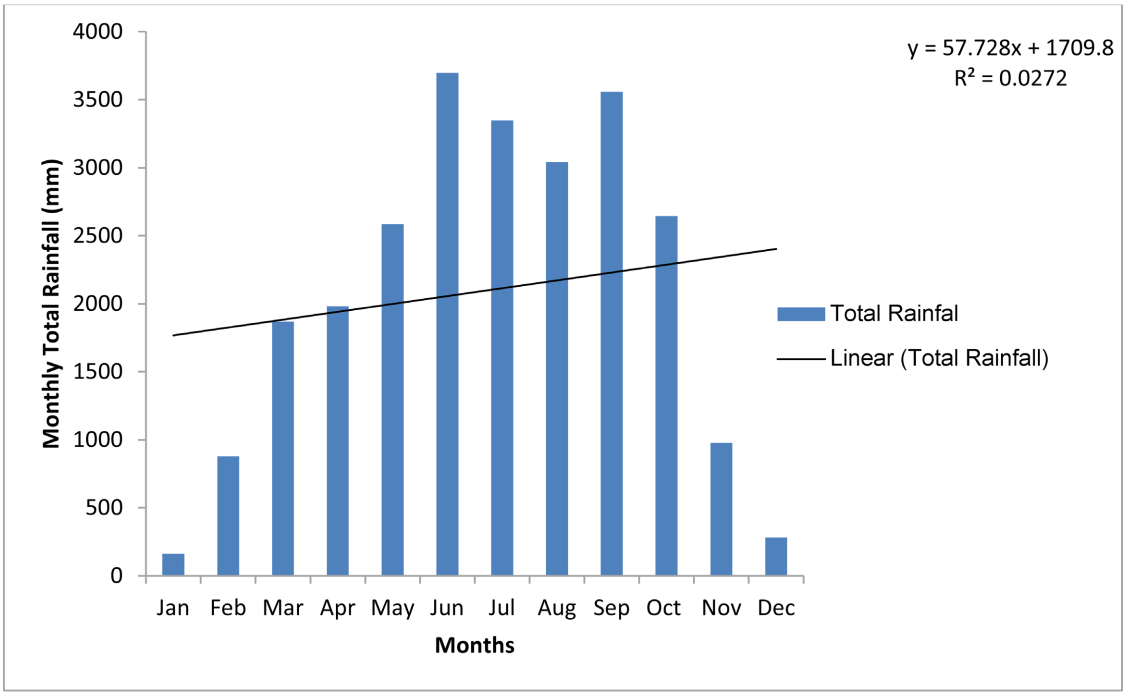

Figure 2. Total monthly rainfall of Port Harcourt from 2010 to 2020.

The monthly analysis of temperature of Port Harcourt between 2010 and 2020 shows that temperature was lower between June and July while the highest temperature was noticed in February and December (**Figure 3**). However, the trend surface analysis reveals that monthly temperature was decreasing at the rate of 0.1075˚C and the R Square analysis shows that 14.97% of the variation in the monthly temperature could be explained by the variation in the months between January and December.

Similarly, the analysis of monthly wind speed of Port Harcourt displayed in **Figure 4** reveals that the wind speed across the months was lower than 3.00 m/s

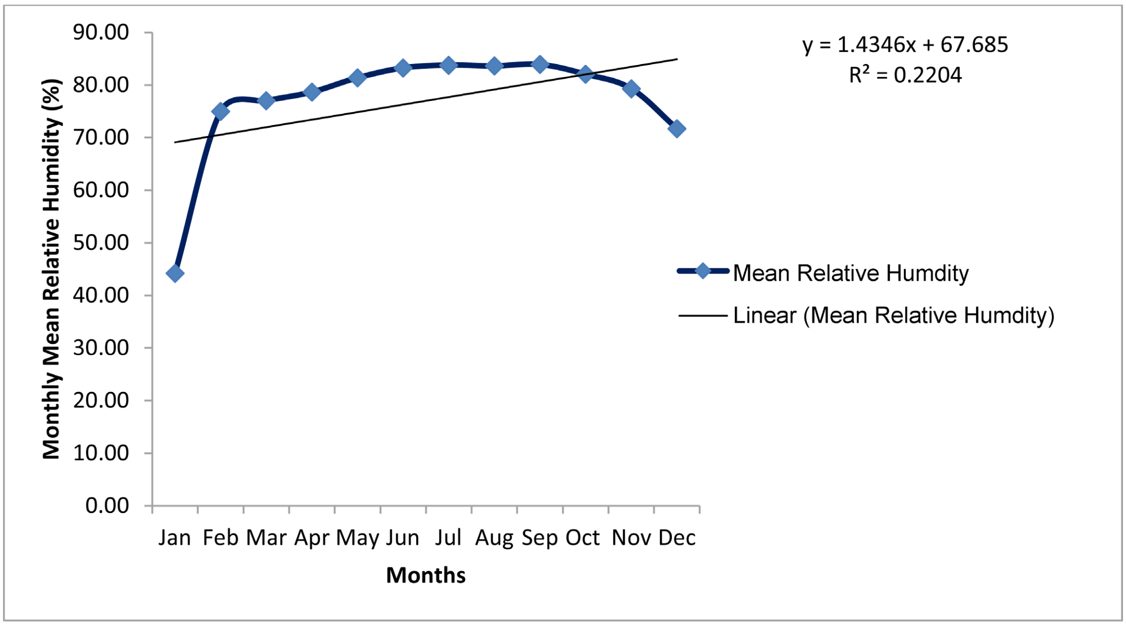

Figure 3. Monthly relative humidity of Port Harcourt from 2010 to 2020.

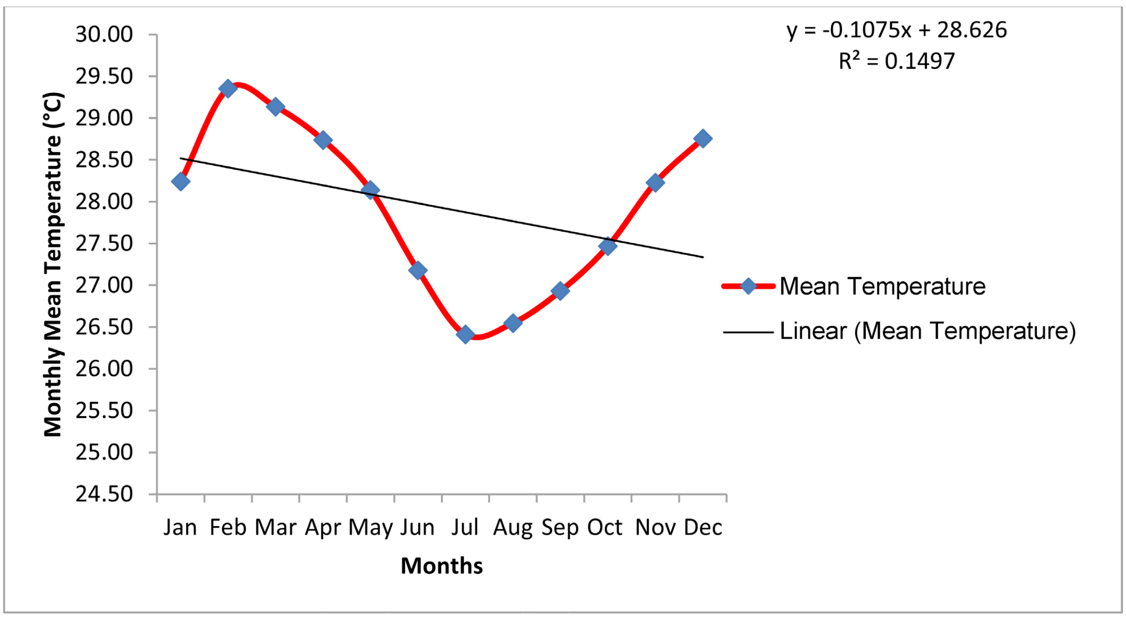

Figure 4. Monthly temperature of Port Harcourt from 2010 to 2020.

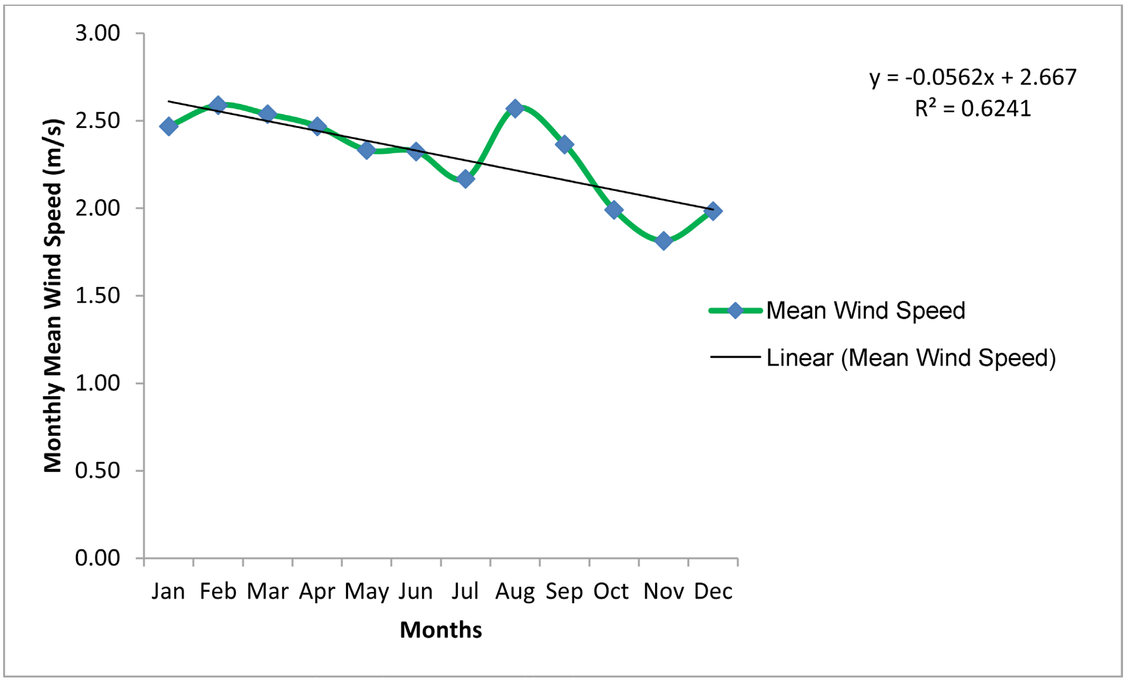

Figure 5. Monthly wind speed of Port Harcourt from 2010 to 2020.

Table 2. ANOVA of monthly meteorological parameters.

		Sum of Squares	df	Mean Square	F	Sig.
Rainfall	Between Groups	15,92,608.822	11	144,782.620	30.358	0.000
	Within Groups	572,296.986	120	4769.142		
	Total	2,164,905.807	131			
Relative Humidity	Between Groups	14,689.533	11	1335.412	28.188	0.000
	Within Groups	5684.953	120	47.375		
	Total	20,374.486	131			
Temperature	Between Groups	121.309	11	11.028	5.054	0.000
	Within Groups	261.839	120	2.182		
	Total	383.148	131			
Wind Speed	Between Groups	7.956	11	0.723	1.710	0.079
	Within Groups	50.744	120	0.423		
	Total	58.700	131			

and it continued to decrease from January to December. The trend surface line continues to decrease from January to December and the decrease was at the rate of 0.0562 m/s. The R Square analysis suggests that 62.41% of variation in the wind speed could be explained by the variation in the months.

The analysis in Table 2 presents the analysis of variance of the monthly meteorological parameters and it is revealed that total rainfall ($F = 30.358$; $p < 0.05$), relative humidity ($F = 28.188$; $p < 0.05$) and temperature ($F = 5.054$; $p < 0.05$) were significantly varied among the months while the wind speed was not significantly varied by months. Therefore, the null hypothesis is accepted for only the wind speed while the alternative hypothesis is accepted for total rainfall, relative humidity and temperature.

4. Discussion of Findings

The monthly relative humidity was higher from June to October affirming its significant influence on the total rainfall. The wind speed was highest in August and the least was observed in December. The least in December may be attributed to the presence of harmattan whereby several suspended dust particles could slow down the wind movement. The monthly analysis for the rainfall was increasing at the rate of 57.728 mm and the months of June and September served as the higher peaks of rainfall. This is corroborated the findings of Ushurhe et al. (2024b) that observed highest rainfall amount average prevailed in the area from July to September. Oguntunde et al. (2011) studied monthly rainfall distribution in Nigeria between 1985-1994 and 1995-2004 and noticed some fluctuations in most months within the decades. Areola & Fasona (2018) also investigated the seasonal rainfall variability in Guinea savannah part of Nigeria and concluded that rainfall variability continues to be on the increase as an element of climate change. Portharcourt experienced more rainfall months than dry months. This is in agreement to the study of Ayanlade et al. (2019) which revealed that in the tropical coastal belts, it was observed that there are more wet months than dry ones. Similar to rainfall is relative humidity which was higher between June and October. The hottest months were February and December while the coldest months were June and July. The wind speed in the entire study area was relatively low and it shows a calm condition. However, the highest windy month was August and the least windy month was November. Rainfall, relative humidity and temperature varied significantly among the months.

5. Conclusion and Recommendations

The study concluded that the monthly rainfall, relative humidity and temperature varied significantly from January to December while the wind speed was less erratic. The month with the highest rainfall was June. Temperature was hottest in February, while relative humidity was highest in the month of September. The study recommended that more periodic monitoring studies are required to have more in-depth knowledge about the variability in the weather parameters in Port Harcourt Metropolis and more studies on the influence of the seasons and land use types on climate parameters can be proposed and executed. This kind of study should be extended to other urban centres and rural areas for comparison purposes.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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