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ORIGINAL RESEARCH

Relationship Between Some Atmospheric and Long Time Evolution Variables on Signal Network Performance

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ABSTRACT

Wireless communications have significantly changed how people communicate with one another. As a result, despite the increased demand for mobile services, mobile network operators are now more concerned than ever with maintaining steady network performance. However, network operation is significantly influenced by atmospheric factors such as temperature and relative humidity, which can lead to call drop and Radio Resource Control failure. Investigating the connection between this two atmospheric parameters and Long Time Evolution network performance is the goal of this study. The study was conducted in Lokoja, the capital city of Kogi State, Nigeria. The city has a tropical savanna climate, characterized by high temperatures and humidity levels throughout the year. This study focused only on two atmospheric parameters (Temperature and Relative Humidity) and two LTE network performance (RRC and Call drop). This study used secondary data collection techniques and a quantitative research approach. The Nigerian Meteorological Agency (NIMET) office in Lokoja, Kogi State, provided the atmospheric data; the Globacom (GLO) office in Lokoja provided the cell report data for LTE in Lokoja. Assuming all other meteorological factors remain constant, it was observed that, Radio Resource Control has an inverse proportionality with temperature and relative humidity, whereas call drop is directly proportional to both. In terms of statistics, call drop and temperature had a positive correlation of 0.35493 and 0.63769, respectively, whereas Radio Resource Control and Temperature had a positive correlation of 0.37289 and 0.5756, respectively. When combined, these results showed that higher humidity and temperature promoted call drops and decreased Radio Resource Control success rates. In tropical areas like Lokoja, this research has given telecom operators and regulatory agencies valuable information to guarantee network dependability, improved resource allocation, environmental consideration, and service quality.

Keywords: Call Drop, Radio Resource Control, Temperature, Relative Humidity, Long Time Evolution.

Introduction

The way people connect with one other has changed dramatically because of the growing use of cell phones. As a result of the constantly increasing demand for mobile services, mobile operators are now more concerned than ever with maintaining network performance (Teodorescu et al., 2023). However, network performance is significantly impacted by climate parameters such as temperature and relative humidity, which can result in call dropouts and Radio Resource Control (RRC) problems (Segun et al., 2013). Temperature varies inversely to signal strength provided the transmission parameters remain constant, higher temperature causes signal strength degradation (Chigozie, 2018). Humidity has a significant effect on signal strength performance; higher humidity leads to a poor signal strength (Mat et al., 2020). Rainfall also affects signal propagation, as higher rainfall leads to signal attenuation. Noise is one of the factors limiting the performance of the communication system. And noisy signal is a signal that has been corrupted by unwanted modifications of the original signal before and after transmission (Olukanni et al., 2023). The term "call drop" describes the abrupt termination of any signal due to network problems or malfunctions. This may occur during a data session, video call, or phone call. Poor network signal strength, leaving the network coverage area, problems with cell tower handovers, network congestion or high traffic, issues with phone hardware or software, and environmental factors like physical barriers or interference and atmospheric issues are the common scenarios where call drops can happen (Ekah et al., 2022). Radio Resource Control is a protocol for managing radio resources in mobile networks (TSGR, 2020) (Radio Resource Control, 2024). RRC_IDLE and RRC_CONNECTED are the two RRC (Radio Resource Control) states. The UE controls control channels to decide whether data is scheduled for transmission when in the RRC_IDLE state, when no RRC connection is formed. In addition, the UE gathers measurement reports, selects or re-selects cells, measures nearby cells, and receives system data. Data transfer occurs, an RRC connection is formed, and the status is RRC_CONNECTED. The UE performs paging, receives system information, sends channel quality information, and receives the control channel. In the RRC Connection setup state, the UE alternates between the RRC_IDLE and RRC_CONNECTED states (Agrawal et al., 2016). Equipment breakdown brought on by high temperatures can result in call dropouts and RRC problems.

According to (Ukhurebor and Umukoro, 2018.), relative humidity can also have an impact on Radio Resource Control's (RRC) performance, resulting in poor network coverage and call dropouts. The number of mobile users has less of an impact on the likelihood of RRC failure than coverage area and signal strength (Ivan et al., 2019). Globacom netwrok has a moderate signal strength in Emmanuel Alayande College of Education (EACOED), Oyo, Oyo State, Nigeria compared to Airtel network with poor signal strength. The study suggest that more base station should be position close to the environment (Sheu et al., 2022).

The city of Lokoja, which has an unusual climate, is the center of the study. The year's high temperatures and humidity make it an ideal place to research how these factors affect LTE signal performance (Federal University Lokoja, 2025).

Materials and Methods

This study used secondary data collection techniques and a quantitative research approach. The Nigerian Meteorological Agency (NIMET) office in Lokoja, Kogi State, provided the atmospheric data, which included temperature and humidity readings (Table 1). In particular, the information was gathered from the NIMET weather station in Lokoja, which offered precise and trustworthy observations of the atmospheric conditions.

Furthermore, the Globacom (GLO) office in Lokoja provided the cell report data for LTE in Lokoja. Metrics including dropped call rates and Radio Resource Control (RRC) were included in the data to evaluate the local LTE network's performance. During the course of the data-collecting process, which lasted from January to December 2019, atmospheric data and cell report data were gathered twice a month and twice a month, respectively. To investigate the correlations between the variables and accomplish the research goals, the data was subsequently preprocessed and analyzed using Matlab tools.

Study Location

The study was carried out in Nigeria's Kogi State capital, Lokoja. Lokoja is situated on the banks of the Niger River in central Niger (Federal University Lokoja, 2025). Lokoja was chosen as the study location due to its strategic position as a major urban center in the region, with a growing population and increasing demand for mobile telecommunications services. The city's location in the Niger River valley also makes it prone to extreme weather conditions, such as heavy rainfall and high temperatures, which can influence the performance of mobile networks.

The coverage of the city's LTE network was the specific focus of the study area. The study used cell report data from the Globacom (GLO) office in Lokoja and atmospheric data from the Nigerian Meteorological Agency (NIMET) office in Lokoja. For mobile network operators and regulators operating in comparable climes, the study site offered a rare chance to investigate the connection between atmospheric conditions and LTE network performance in a tropical area.

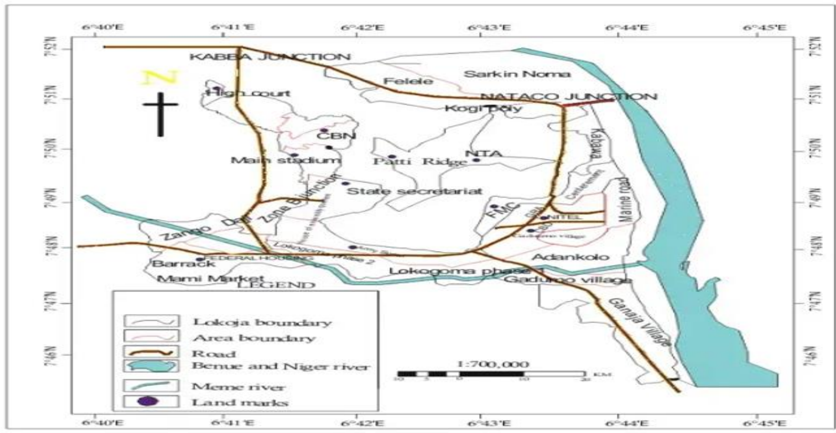

Fig 1: A map of Lokoja metropolis.

Figure 1: Map of Lokoja metropolis

The amount of water vapour in the air, represented as a percentage of the greatest amount the air can store at a specific temperature, is known as relative humidity. Water vapour is one of the many gases that make up the air, and each has a unique vapour pressure. According to its definition, relative humidity (RH) is the ratio of the saturation vapour pressure (Ps) at a specific temperature to the actual vapour pressure of water (Pa), as shown in equation (1).

$$RH = \frac{P_a}{P_s} \times 100 \qquad (1)$$

Results

Table 1: Categorized Monthly Temperature, Relative Humidity, Call drop and Radio Resource Control from January to December 2019.

Table 1: Monthly Temperature, Humidity, Call Drop and Radio Resource Control Data.

MONTH	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)	RRC (%)	CALL DROP (%)
JANUARY	28.4	52	99.8022	0.1263
FEBRUARY	29.55	50	99.85	0.17
MARCH	32.1	63	99.8764	0.2055
APRIL	31.6	65	99.8301	0.2234
MAY	29.55	72	99.7	0.48
JUNE	27.95	77	99.45	0.6
JULY	27.5	79	98.64	1.89
AUGUST	27.1	79	98.486	1.9451
SEPTEMBER	27.15	79	97.9862	2.2442
OCTOBER	27.2	78	98.9979	1.5199
NOVEMBER	28.3	71	99.3037	0.7819
DECEMBER	26.8	63	99.83	0.17

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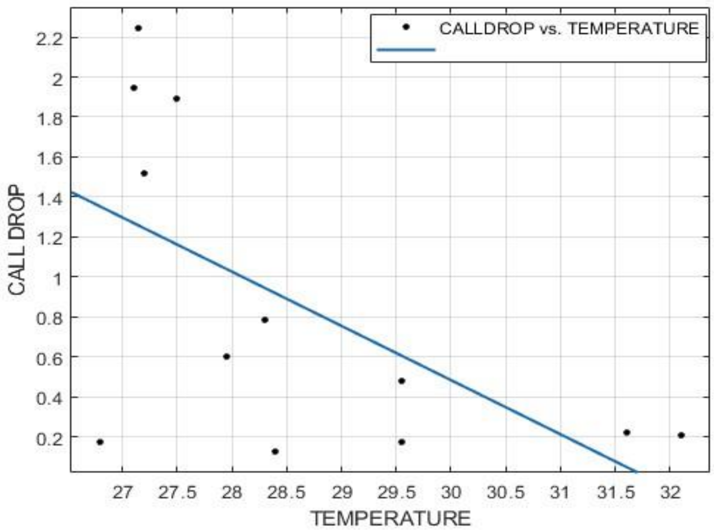

Figure 2: Graphical Representation of the Call Drop against Temperature

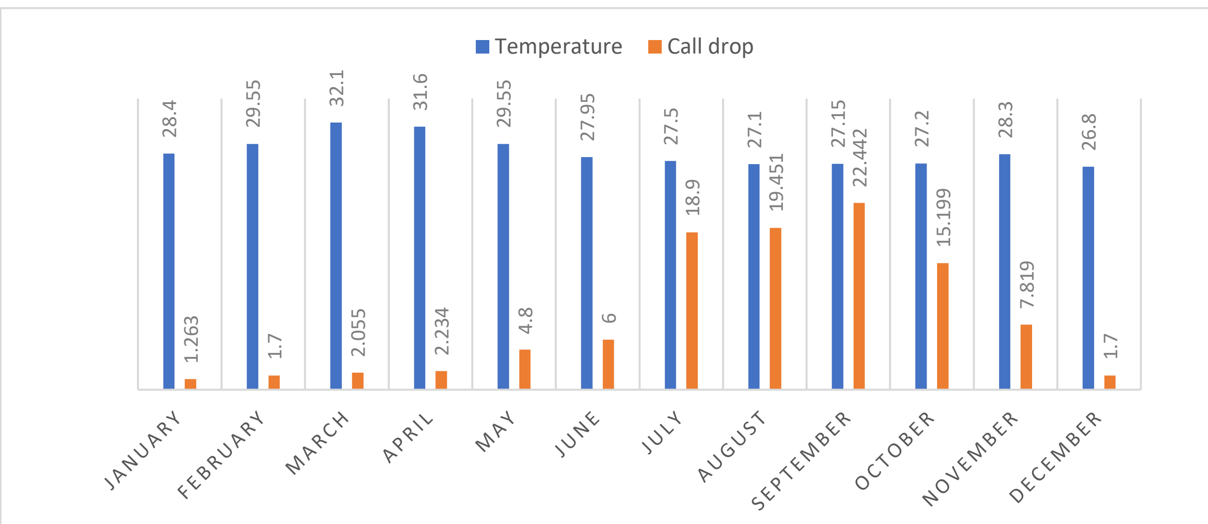

Figure 3: Graphical Representation of the Call Drop against Temperature

Figure 2 and 3 shows the correlation between Call Drop and Temperature: 0.35493 (weak positive correlation).

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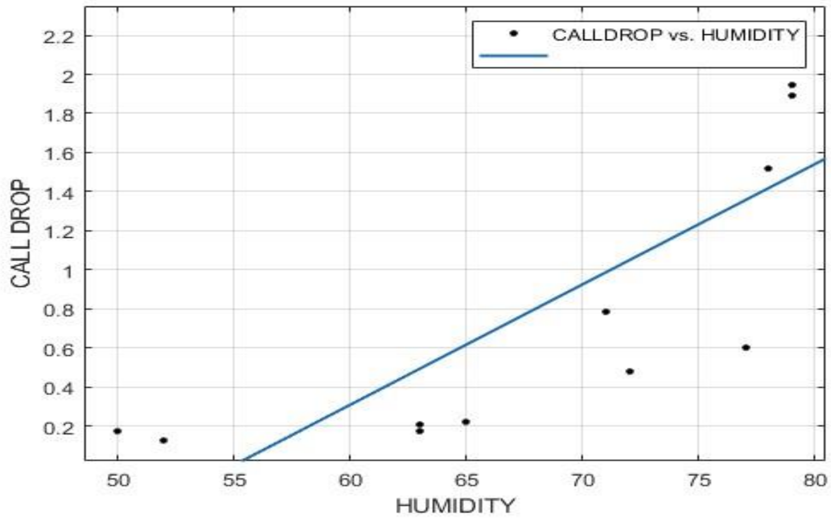

Figure 4: Graphical Representation of Call Drop against Relative Humidity.

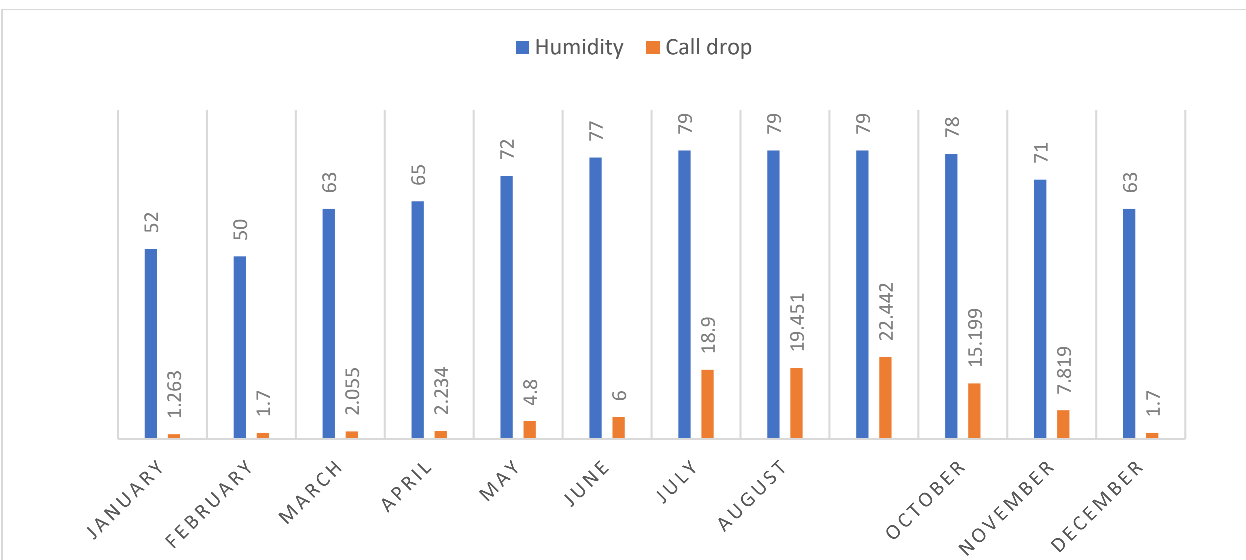

Figure 5: Graphical Representation of Call Drop against Relative Humidity.

Figure 4 and 5 shows the correlation between Call Drop and Relative Humidity: 0.63769 (moderate-to-strong positive correlation).

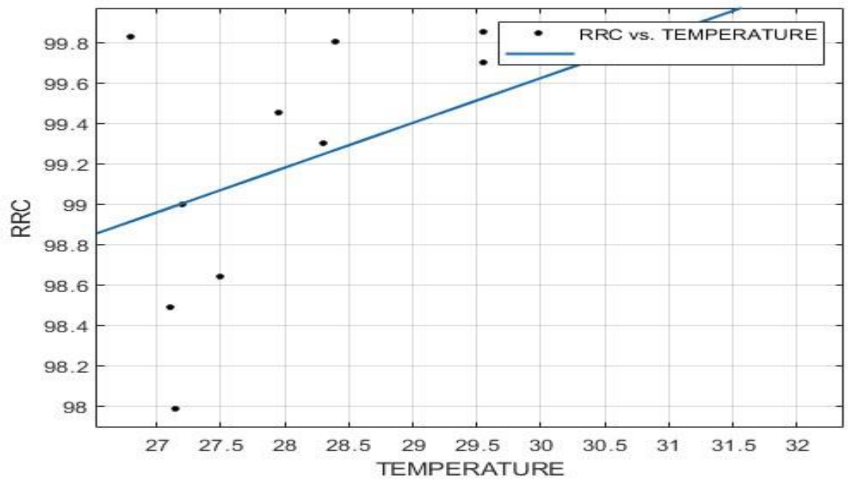

Figure 6: Graphical Representation of Radio Resource Control (RRC) against Temperature.

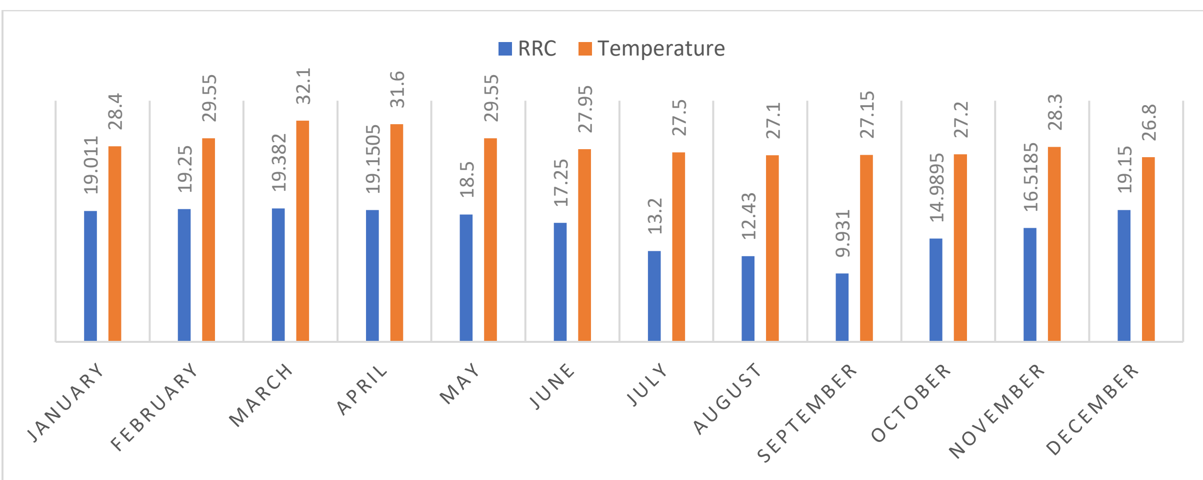

Figure 7: Graphical Representation of Radio Resource Control (RRC) against Temperature.

Figure 6 and 7 shows the Correlation between RRC and Temperature: 0.37289 (weak positive correlation).

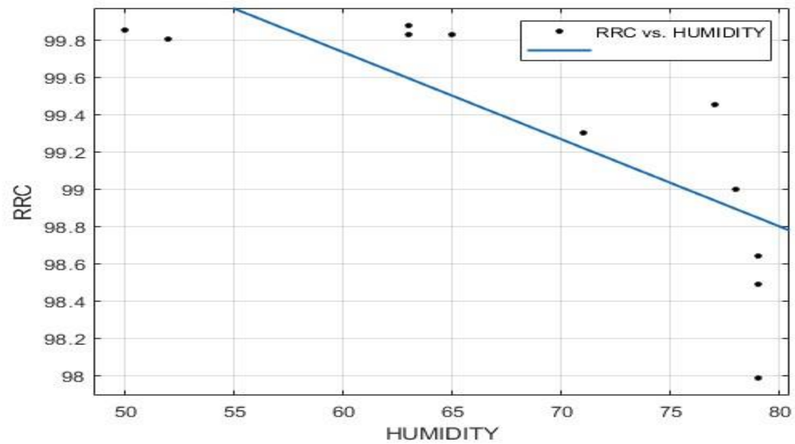

Figure 8: Graphical Representation of RRC against Relative Humidity.

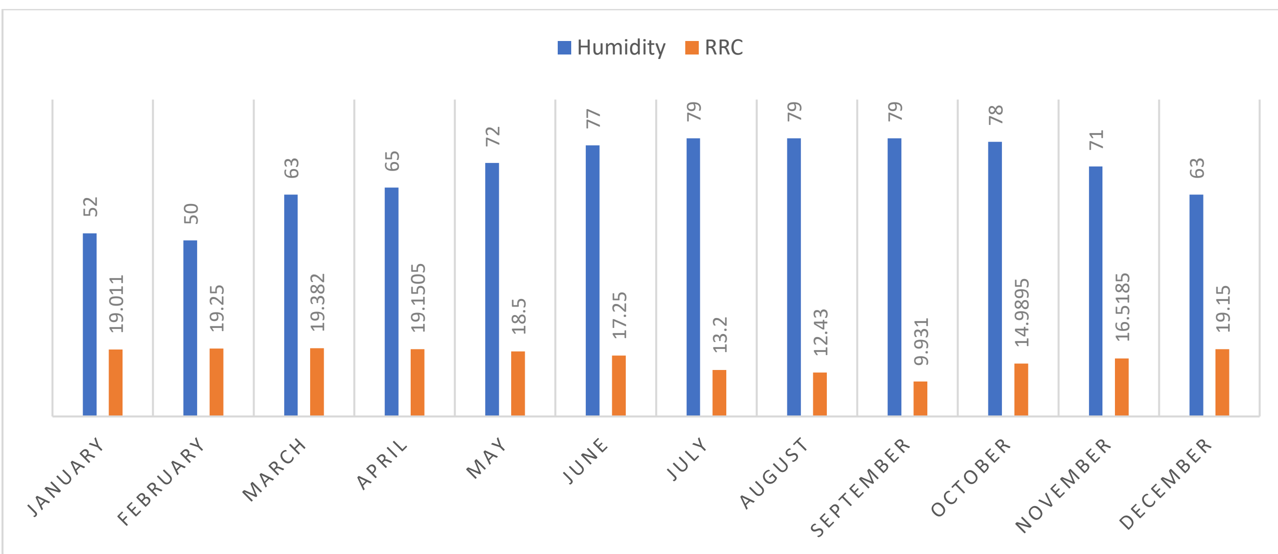

Figure 9: Graphical Representation of RRC against Relative Humidity.

Figure 8 and 9 shows the Correlation between RRC and Humidity: 0.5756 (moderate positive correlation).

Discussion

From Figures 2 and 3, it was found that as the temperature rises, the call drop somewhat lowers. With a statistical correlation of 0.35493 between call drop and absolute temperature, the two variables have a weakly positive relationship, suggesting that call drop is proportional to temperature. The dispersed data points demonstrate that temperature is not a reliable indicator of call drop rate. Based on these findings, it can be said that temperature has little bearing on call drop rates. Temperature alters several important characteristics of RF signal attenuation. The atomic mobility in the atmosphere increases with temperature, leading to a rise in molecular collisions. RF signals are absorbed and scattered because of these collisions, which eventually results in their attenuation (Odesanya et al., 2025).

Figures 4 and 5 demonstrate that as humidity rises, call drop rises as well. There is a strong positive linear link between call drop and humidity, as indicated by the statistical correlation of 0.63769. This implies that the decrease in calls increases with humidity. Based on this relationship, it appears that humidity has a significant role in call drop, accounting for around 40% of the variation in call loss. Because of its upward trend, this graph indicates a direct correlation: the higher the humidity, the higher the call drop rate. This might be because dampness deteriorates wireless communication systems, where interference and attenuation are key causes of signal losses. To determine the fundamental causes of this association and to take potential confounding variables into account, more research is necessary. This finding, however, prioritizes environmental elements such as humidity when it comes to maintaining and enhancing wireless communication networks to lower the incidence of call drops. Higher humidity rate affects call drop rates (Ekah et al., 2022).

Radio Resource Control (RRC) is plotted against temperature in Figures 6 and 7. From the month of January, February, March, and April we find out that as the temperature rises, RRC somewhat decreases. RRC and temperature have a statistically significant association of 0.37289. As a result, there is a poor association between the two variables, indicating that RRC is unaffected by even small variations in temperature. Though this relationship is less important, we assumed that RRC diminishes as temperature rises.

This could be the consequence of electromagnetic waves, such as radio signals, interacting with solar light particles, which weaken and attenuate signals. When it comes to RRC failure, temperature is not a crucial meteorological parameter. The number of mobile users has less of an impact on the likelihood of RRC failure than coverage area and signal strength (Ivan et al., 2019). The relative humidity and radio resource control graph. It can be seen from Figures 8 and 9 that RRC significantly drops when humidity rises. RRC and humidity had a statistically significant positive linear connection, as indicated by the correlation coefficient of 0.5756. This indicates that the success rate of RRC setup is impacted by an increase in humidity. Humidity has a considerable impact on RRC, which is in charge of managing radio resources in LTE networks, as seen by the correlation value of 0.5756. There is a clear association between humidity's impact on radio signal quality and propagation and the need for more RRC activity to sustain network performance.

This result emphasizes how crucial it is to take humidity into account while developing and optimizing networks in order to guarantee effective radio resource management.

Based on these findings, we deduced a mathematical connection between the measured meteorological variables (temperature and humidity) and RRC (radio resource control).

We used a mathematical equation, like this one, to express this relationship:

$$R \propto 1/T \quad (2)$$

$$R \propto 1/H \quad (3)$$

Combining and resolving Eqn. (2 and (3) mathematically, we have;

$$R = K/T \times H \quad (4)$$

$$K = R \times T \times H \quad (5)$$

Where, R= RRC (Radio Resource Control), T = Temperature, H = Humidity and K is a constant that describes the relationship between the variables

Also from the results, we established a mathematical relationship between Call drop and the measured meteorological variables (Temperature and Humidity).

We expressed this relationship using a mathematical equation, such that:

$$C \propto T \quad (6)$$

$$C \propto H \quad (7)$$

Combining and resolving Eqn. (6) and (7) mathematically, we have;

$$C = K \times T \times H \quad (8)$$

$$K = C/(TH) \quad (9)$$

Where, C= Call drop, T = Temperature, H = Relative Humidity and K is a constant that describes the relationship between the variables

With the application of this formula, RRC and call drop values may be predicted from temperature and humidity readings, allowing for more precise wireless communication system planning and optimization.

Conclusion

The study examined how temperature and relative humidity affected call drops and radio resource control (RRC) in the Lokoja Metropolis of North-Central Nigeria. Communication network providers will benefit from the research's findings as they attempt to raise the caliber of their offerings both inside and outside the study area. Significant insight was gained during the 2019 study year from the examination of the relationships between climatic factors and Radio Resource Control performance and call drop rates. Notably, the study demonstrates an inverse relationship between RRC performance and temperature and relative humidity, meaning that as these metrological factors rise, RRC performance falls. However, there is a clear relationship between these factors (temperature and relative humidity) and call drop rates, indicating that higher temperatures and relative humidity lead to higher call drop rates.

With a stronger correlation coefficient, the results show that temperature and relative humidity had a greater impact on call drop rates than they did on RRC performance. As a result, call drop rates are more susceptible to variations in these two climatic factors. According to the data, temperature has the least impact on RRC performance and call drop rates, whereas relative humidity has the greatest. Based on the results, it can be concluded that the number of call drops and RRC performance are directly related. Thus, one practical way to reduce the call drop rate is to have high RRC performance.

Therefore, it is clear from these results that regulating temperature and relative humidity is essential to achieving this RRC performance enhancement. Therefore, telecommunications operators and network providers will greatly benefit from the deployment of environmental management to regulate temperature and humidity levels in order to increase the dependability and efficiency of their networks.

Declarations of Authors Contribution

Usman A.O and Odesanya I. conceptualized the study. Usman A.O designed the study. Usman A.O participated in fieldwork and data collection. Usman A.O and Odesanya I. performed the data analysis and interpreted the data. Usman A.O prepared the first draft of the manuscript, reviewed by Odesanya I. All authors contributed to the development of the final manuscript and approved its submission.

Conflict of Interest

None

Ethics Approval and Informed Consent

Data used for this study were obtained secondarily for public databases, without participants' identifier information. Therefore, informed consent was not applicable.

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