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Base-Station Transmission Microwave Radiation Effect on Agriculture: Case Study of Moor Plantation Teaching & Research Farm, Nigeria

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***Abstract*—** Microwave radio frequency radiation has been proved by many researchers and the World Health Organization (WHO) that it is dangerous to human being as it leads to various health related diseases. There is need for Agricultural and Bio-Environmental Engineers to investigate the effect of electromagnetic force (EMF) radiation on plants around the telecommunication masts, which usually consists of outdoor microwave radio equipments. This examination focuses majorly on two telecommunication sites radiation on plants located inside the premises of Federal College of Agriculture, Moor Plantation, Ibadan, Nigeria Teaching and Research Farm. Electromagnetic Force Analyser (Digital 3-axis EMF ELF RF Electromagnetic Wave Field Strenght Radiation Microwave Taiwan Meter) were used on the two telecom mast, where the measurement was taken for each of the mast between 0 and 550 meters in every 5 minutes for an hour. Measuring tape, EMF meter, computer system, GDHS Data-Science Software and stop watch were also used as materials for this study with two telecommunication base station. The base station antenna was mounted around the College Demonstration Farm (Site 1) and Cocoa Research Farm (Site 2). The cell tower transmits in the frequency range of 869 – 894 MHz (CDMA), 935 - 960 MHz (GSM900) and 1805 - 1880 MHz (GSM1800). The study was conducted within the period of 7am to 8am (morning), 1pm-2pm (afternoon), and 7pm to 8pm (night). Regression predictions through GMDH Data-Science was employed to determine the variation around the mean of the dependent variable while the regression line was centered on the data point. These data will be quantified to know how close the predictions are to the observed values. Measured power densities were reported with a median distance of 325 meters, which is the range of teaching and demonstration farm of the college. The lowest value for power density was at a distance of 550 meters in the morning, afternoon and evening from both sites with 90, 245, 101, 98, 261 and 93 ($\mu W/m^2$) respectively. The effect of the radiation to the plant is negligible or minimal based on the International Standard recommendation. Farmers are advised to leave at least 500 meters away from the telecommunication masts before they will embark on the crop or animal production to avoid significant effects of microwave radiation on the plant and animal.

Keywords— Base Station Transmission, Radiation, Agriculture, Teaching and Research farm

I. INTRODUCTION

[9] have pronounced that different researchers have revealed that these days urban communities are confronting enormous scale electromagnetic contamination due to GSM innovation for remote correspondence. In Nigeria, there have been reports on the cities of Ibadan [3], Lagos [6], among probably many others. In this regard, urban areas face the most extraordinary electromagnetic contamination as far as non-ionizing radiation because of the nearness of transmitters for portable correspondence in jam-packed regions. This kind of sources enlisted continually developing in a year ago in view of the enormous number of versatile administrations suppliers and receiving wires locales. Wellbeing impacts of phone radiation were logically drawn nearer by James C. Lin, concerning electromagnetic field in living frameworks which gives a principal comprehension of (RF) electromagnetic association with organic frameworks (See Figure 1).

Different wellsprings of portable correspondence bring about ceaseless presentation of a noteworthy piece of the agriculture and wildlife to microwaves at non-warm levels. As of late, agriculture and wildlife has been constantly presented to microwaves and RFR (Radiofrequency radiation) signals from different sources, including GSM and UMTS/3G remote telephones and base stations, WLAN (Wireless Local Area Networks), WPAN (Wireless Personal Area Networks, for example, Bluetooth), and DECT (Digital Enhanced (previous European) Cordless

Telecommunications) that are raised unpredictably without investigations of ecological effect estimating long-term effects. These exposures are characterized by low intensities, varieties of signals, and long-term durations. The greater portion of this exposure is from mobile telecommunications [2].

[4] as cited by [6] has observed that the World Health Organization (WHO) cautions that a media transmission (telecom) pole ought to be situated at any rate 10-meter span away from a private quarter. In any case, numerous Nigerian landowners let out their lands for the erection of telecom poles close residential and instructive offices without thinking about the wellbeing perils that may emerge therefrom. On their part, telecom firms insensitively exploit the individuals' naivety to send them to their initial graves [4]. As per restorative reports, a few infirmities are brought about by radiation or discharge of electromagnetic motivations from a telecom pole raised near private premises. These executioner poles transmit noxious gases that debilitate the safe framework and human neurological capacities. Close and regular contacts with the radioactive substances could hamper memory and rest designs, cause mind tumors, malignancies and Alzheimer's malady (loss of memory and capacity to talk plainly with more established individuals). The radiation impacts on fruitfulness and digestion and can cause despondency and weariness.

The main aim of this research work is to examine the effect of radiation on agriculture and recommend mast erection distance which will have little or no effect on plant and animal to the network operators.

The distance from the wellspring of radiation is another basic factor. The power density changes by (1/R2), where R is the distance. As one moves away from the reception apparatus (antenna), the less is the radiation. In the figure 1.5 underneath, at the point when a structure of stature 8 m is situated at a level separation of 11 m from a 40m Ground based pinnacle (with an antenna at a height of 37 m), the locale is the sheltered zone. The determined EMF control density is 0.164 Watts/sq.m and the structure (accepting that the impact of radiation is as it were from the principle flaps) is inside the points of confinement of the standards prescribed.(For 900MHz GSM, the points of confinement recommended is 0.45 Watts/sq.m) [10]. [11] as cited by [8] publicized that the decision of appropriate locales for the erection of broadcast communications poles and base stations relies upon the earth surface comparative with the encompassing zone; bearing on the development of media transmission administration of the advocate; the need to save and moderate places and destinations of great, structural and notable significance, among different variables.

II. RELATED WORK

[7] has discovered that for the most part, a mobile phone tower is shared by more than one administrator to give portable administrations. The more the quantity of reception apparatuses, the more noteworthy is the power force in the close by territory. Power levels close to the towers are higher and decrease with separation. It is decreased to ¼ when the separation from recieving wire duplicates, and 1/9 when separation is significantly increased, etc. The electromagnetic force (EMF) control thickness differs with separation as appeared in Figure 2 and 3.

Based on [5] study, radiation levels may include an expanding design inside 30-150m, and as one moves from 200m span of the base station, the presentation may start to have a decreasing example. Additionally, the South African National Department of Health has likewise perceived the need to make a preparatory zone or an avoidance zone around base stations dependent on the way that Radio recurrence discharges are most noteworthy at source, near the reception apparatuses, and reduce with expanded good ways from the source.

[1] examination has revealed that the wellbeing risks of non-ionizing radiation from media transmission pole on the uncovered network were evaluated utilizing a clear cross-sectional study. The socio-statistic example and risk profile of the respondent were archived. The consequences of the information indicated that larger part of respondents (60.8%) were youth inside age scope of 20 – 30 years. Peril profile indicated greater part (62%) having various manifestations with cerebral pain being the most successive (51.6%), like other built up discoveries. There is a critical synergistic connection between high voltage link and telecom pole on the wellbeing impact, with $p< 0.05$. It was additionally indicated that closeness and span of introduction to pole radiation is legitimately relative to danger impact, with $p< 0.05$. This examination in this manner sets up that there are wellbeing ramifications of introduction to pole radiation and limiting them will go far to improve sound living.

Telecommunication antennas have general electrical properties; Gain (unity 3dBi), connector (multi – type option), VSWR (2:1), Bandwidth (broad band), Impedence (50 ohms), H-plane Beam width (omni directional), E-plane Beam width (100 degree), polarization (vertical), mounting (double side tape) and mechanical properties such as antenna cover (polyurethane), Operational temperature (-20 to +60°C), Storage temperature (-30 to +75°C) [12].

All the GSM Operators radio wire were made to emanate 1800 MHz; they have the accompanying details GLO,MTN and ZAIN have down connection recurrence of 1820 – 1835 MHz, 1835 – 1850 MHz, 1850 – 1865 MHz, uplink

recurrence of 1725 – 1740 MHz, 1740 – 1755 MHz and 1756 – 1770 MHz, individually [14].

III. METHODOLOGY

The study was carried out at Federal College of Agriculture, Moor Plantation Ibadan, Nigeria in the Cocoa Research Farm (Site 1) and Students Research Farm (Site 2). Electromagnetic Force Analyser (Digital 3-axis EMF ELF RF Electromagnetic Wave Field Strenght Radiation Microwave Taiwan Meter) were used on the two telecom mast, where the measurement was taken for each of the mast between 0 and 550 meters in every 5 minutes for an hour. Measuring tape and stop watch were also used as materials for this study with two telecommunication base station. The base station antenna was mounted around the College Demonstration Farm (Site 1) and Cocoa Research Farm (Site 2). The cell tower transmits in the frequency range of 869 – 894 MHz (CDMA), 935 - 960 MHz (GSM900) and 1805 - 1880 MHz (GSM1800).

The study was conducted within the period of 7am to 8am (morning), 1pm-2pm (afternoon), and 7pm to 8pm (night). Regression predictions through GMDH Data-Science was employed to determine the variation around the mean of the dependent variable while the regression line was centered of the data point. These data will be quantified to know how close the predictions are to the observed values.

In figure 5 above the blue line denote the actual model, the ash line represents the raw data while the red line represents the predicted model. The base station distance to plant is the dependent variable while the duration of radiation and measurement taken are independent variables. The graph reveals that the raw data moves on straight line, the predicted value revealed that the microwave transmission is significant at distance of 250 and 550 m respectively.

IV. RESULTS AND DISCUSSION

Table 1 above shows the mean value of the microwave radiation data collected in the field for three months, in the morning, afternoon and evening. EMF meter results were recorded and collated between month of August to October, 2019. Two different telecommunication mast site results were revealed in table 1. The highest power density was noticed in the afternoon at 0 meter in the afternoon at site 1 and 2 with 19,563 and 18,935 ($\mu W/m^2$) respectively. While the lowest power density was recorded in the morning at both sites at 90 and 98 ($\mu W/m^2$) respectively.

Table 2 result above revealed statistical analysis of the power density. The number of intervals within the distance of the microwave base station radiation to the plant with numerical value of 12 at interval of 50 meters each. The minimum, maximum, median, mean and standard deviation value were shown respectively. Measured power densities are reported in Table 1 with a median distance of 325 meters, which is the range of teaching and demonstration farm of the college. The lowest value for power density was at a distance of 550 meters in the morning, afternoon and evening from both sites with 90, 245, 101, 98, 261 and 93 milliwatt hour per square meter ($\mu W/m^2$) respectively.

Goodness of Fit Measures

The statistical result revealed in Figure 5, that predicted R-squared (R^2) (90.2%) value is lower than that of the model fit (regular value) (97.7%). This is the proportion of variance in the dependent variable (Base station distance to plant) which was predicted by the independent variables (Time, morning, afternoon and evening radiation on both site 1 and 2). This indicates that 90.2% of the variance in the base station distance to the plant can be predicted from the independent variables.

The residual sum in the prediction model (-92.2) is lower than that of the actual model (3.69E-13). This simply implies that the errors in the prediction is more lower and makes the model to be more reliable in predicting the effect of radio microwave radiation on the plant around the mast. The Mean Absolute Error (MAE) predicted is higher than that of the actual model. This means that the average magnitude of the errors in the forecast was accurate for continuous variables. This means that the model weighs all the individual differences equally averagely. The Root Mean Squared Error (RMSE) is equal to Mean Absolute Error (MAE). This simply means that all the errors are of the same magnitude.
The result of the residual regression chat revealed that there is a spread of data points around the line. This shows a random pattern and indicates the linear model provides a good fit. The predictions are close to the observed values. The spread is not too large. This simply means that the information from the model is useful in determining the effect of microwave radiation to plant in relation to distance of the farm and time.

Table 3 illustrates the International worthy standard for power density and the mean power densities estimated on the two destinations. The official global models on presentation points of confinement to non-ionizing High Frequency radiation are for the most part dependent on International Commission on Non-Ionizing Radiation Protection (ICNIRP) suggestions with reference limits for potential exposure. The research work has revealed that low level to radiation exposure to the plant occurred majorly in the morning in both study area and ranges between 90 to 261 ($\mu W/m^2$) while afternoon readings on both sites recorded the medium range level of exposure to the plant between 14,811 to 19,563 ($\mu W/m^2$).

V. CONCLUSION AND FUTURE SCOPE

The investigation of microwave radio radiation on telecommunication masts with its effect on plant has been carried out at the Teaching and Research Farm of Federal College of Agriculture, Ibadan, Nigeria. The outcome of the examination revealed that telecommunication base station radiation is lower in the morning and higher in the afternoon. This can be as a result of increase in the numbers of their subscribers that are using the link for communication. The radiation effect in the study area shows that plant and trees have to be planted at a minimum of 325 meters to the mast to reduce the effect on the plant or trees around the farm. The effect of the radiation to the plant is negligible or minimal based on the International Standard recommendation.

A. Figures and Tables

Table 1: Power Densities Measured

S/N	Base station Distance to plant	Time (mins)	Morning Radiation (Site 1) ($\mu W/m^2$)	Afternoon Radiation (Site 1) ($\mu W/m^2$)	Evening Radiation(Site 1) ($\mu W/m^2$)	Morning Radiation(Site 2) ($\mu W/m^2$)	Afternoon Radiation(Site 2) ($\mu W/m^2$)	Evening Radiation(Site 2) ($\mu W/m^2$)
1	0	5	15385	19563	14934	16465	18935	14811
2	50	10	14287	17483	13567	15389	16374	12982
3	100	15	12357	15983	11345	12034	15666	10345
4	150	20	9576	13677	9425	10364	13657	9201
5	200	25	5230	10756	7562	6027	11045	8560
6	250	30	4890	8628	5002	5032	8543	4867
7	300	35	1106	7235	1890	1504	6935	1620
8	350	40	915	5912	1005	1002	5673	990
9	400	45	621	1390	721	736	1209	727
10	450	50	211	880	251	255	853	249
11	500	55	155	450	144	165	455	139
12	550	60	90	245	101	98	261	93

Table 2: Statistical Analysis for Power Densities

Variable	Distance from the base station	Time (mins)	Morning Radiation (Site 1) ($\mu W/m^2$)	Afternoon Radiation (Site 1) ($\mu W/m^2$)	Evening Radiation (Site 1) ($\mu W/m^2$)	Morning Radiation (Site 2) ($\mu W/m^2$)	Afternoon Radiation (Site 2) ($\mu W/m^2$)	Evening Radiation(Site 2) ($\mu W/m^2$)
Numeric values	12	12	12	12	12	12	12	12
Unique values	12	12	12	12	12	12	12	12
Zero values	1	0	0	0	0	0	0	0
Min. value	0	5	90	245	101	98	261	93
Max. value	550	60	15385	19563	14934	16465	18935	14811
Median	325	37.5	5060	9692	6282	5529.5	9794	6713.5
Mean value	275	32.5	5401.916667	8516.833333	5495.583333	5755.916667	8300.5	5382
Std. deviation	172.6026	17.260263	5692.327606	6713.452848	5397.607594	5973.103611	6516.109313	5269.160844

Table 3: Comparison of ICNIRP Standard with the Measured Power Density (μW/m2)

Type of exposure	Power Density ($\mu W/m^2$)	Frequency Downlink (f)MHz	Frequency Uplink (f)MHz
General Public (ICNIRP Standard)		f/200	
	10,000,000	**400-2000**	**2000-30000**
Morning (Site 1)	**90 - 15385**	1835 – 1850	1740 – 1755
Morning (Site 2)	**98 - 16465**	1820 – 1835	1725 – 1740
Afternoon (Site 1)	**245 - 19563**	1835 – 1850	1740 – 1755
Afternoon (Site 2)	**261 - 18935**	1820 – 1835	1725 – 1740
Evening (Site 1)	**101 - 14934**	1835 – 1850	1740 – 1755
Evening (Site 2)	**93 - 14811**	1820 – 1835	1725 – 1740

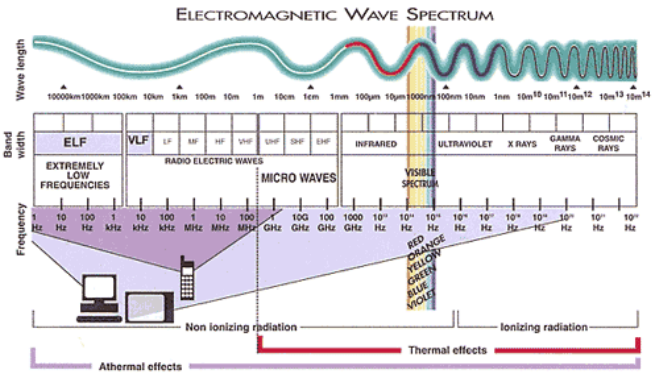

Figure 1: Electro-Magnetic Force Radiation

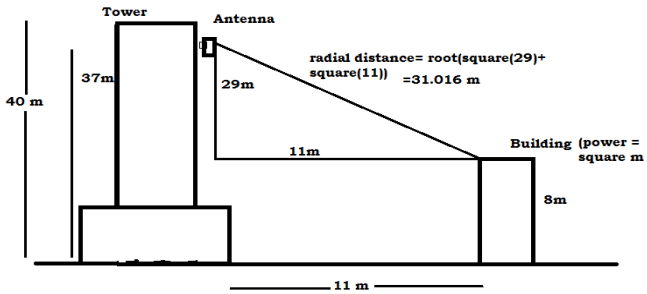

Figure 2: Power Density Level for BTS (Base Station Transmission System)

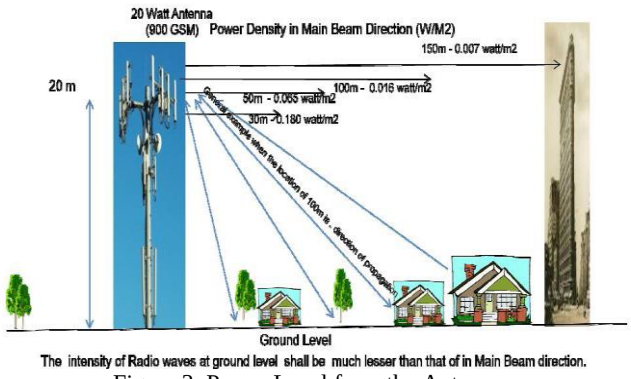

Figure 3: Power Level from the Antenna

Figure 4 : Digital 3-axis EMF ELF RF Electromagnetic Wave Field Strenght Radiation Microwave Taiwan Meter

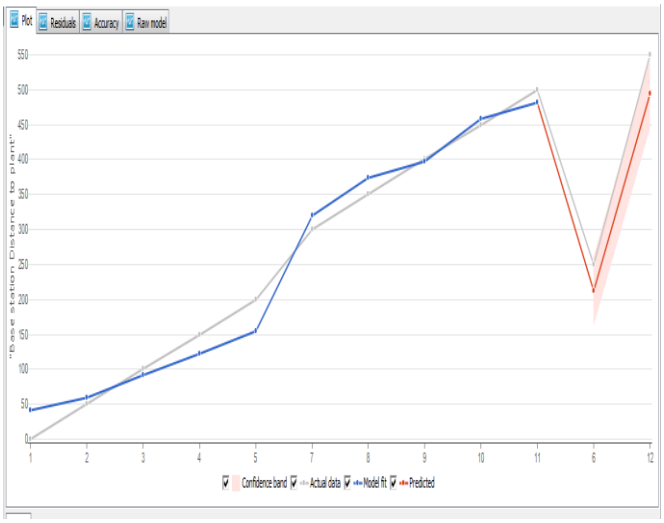

Figure 5: Regression Curve

Plot | Residuals | Accuracy | Raw model

Error measure: Absolute — Target: "Base station Distance to plant"

Postprocessed results	Model fit	Predictions
Number of observations	10	2
Max. negative error	-44.5655	-54.9496
Max. positive error	42.0615	0
Mean absolute error (MAE)	20.6011	46.1057
Root mean square error (RMSE)	24.6934	46.9463
Residual sum	3.69482E-13	-92.2114
Standard deviation of residuals	24.6934	8.84389
Coefficient of determination (R^2)	0.977827	0.902047
Correlation	0.988851	1

Figure 5: Model Accuracy

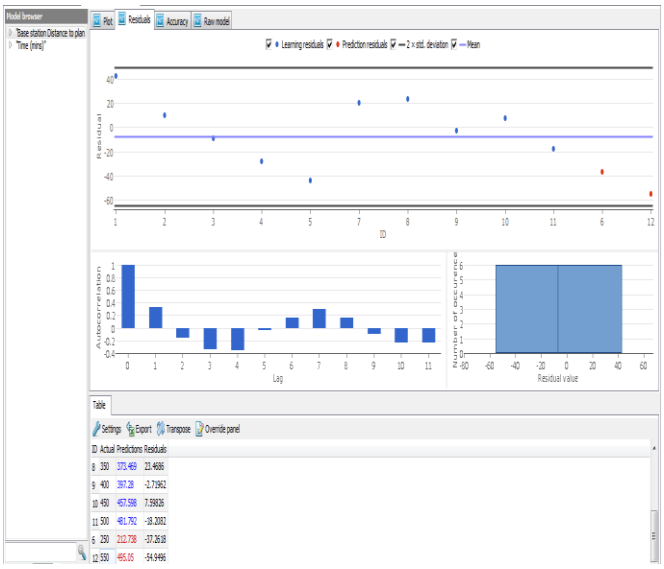

Figure 6: Regression Residual Chart

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AUTHORS PROFILE

Idowu Olugbenga Adewumi proceeded to the prestigious University of Ibadan where he graduated with a B.Sc. Degree in Industrial & Production Engineering at Second Class honor level in 2009. From the same University, he completed a Master of Science (M.Sc) degree in Agricultural & Environmental Engineering (Farm Power & Machinery Option) in 2014. Idowu was bagged with Doctor of Science (DSc) in ICT from Commonwealth University, through London Graduate School, UK in 2019. Aside from the normal degree, he had professional certificates in the areas of ICT, which include; NSQAP Software Expert, PhP Expert, Html5 Programming Language, Certified Cisco Network Design (CCND), Certified Computer Technician Associate (CCTA), (CCNA), Software Development, among others. Engr Adewumi is currently on his PhD program at the Prestigious Premier University in the country, University of Ibadan, with special focus on alternative energy. Adewumi started his career with Federal College of Agriculture, Ibadan, Nigeria where he assumed duty as Mechanical Engineer II in 2011. He rose through the ranks to the position of Lecturer II on 1st October, 2017 respectively. He is currently, Director of ICT, FCA Ibadan Nigeria. Idowu have consistently been a highly devoted, dedicated and efficient worker. An excellent teacher who consistently demonstrates rich depth of the knowledge of his subject matter, clearly presenting same and always endeavoring to come down to the level of his students, being very observant and patient with them. He is a member of various professional bodies and married to Funmi with a child.

