Effect of Pollution due to Vehicular Emission around T-Junctions in Port Harcourt Metropolis, Rivers State, Nigeria.

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Abstract:

This research is investigating pollution due to vehicular emission within congested T-junctions in Port Harcourt, Nigeria. The five major T-junctions, statistically selected for this study includes: Rumuola, Waterlines, Garrison, LNG and Rumuokoro junction. The parameter measures each sampling location with six different distances of 5m away from mid-point of the T-junction on the stated following variables of interest: Volatile Organic Compounds (VOC), Carbon Dioxide (CO_2), Nitrogen Oxides (NO_2), Sulphur Dioxide (SO_2), Particulate Matter (PM), Carbon Monoxide (CO) and the Sound level (SL). The gas analyzers was determined with a digital gas instrument called Aeroqual Series 500. The gas instrument was set to stabilize, analyse the environment and read after 3 minutes at a particular distance. For each location, the reading was taken in the morning (7.00am-10am), afternoon (1.00pm-4pm) and night (6.00pm-9.00pm) respectively for MJ, 5m, 10m, 15m, 20m, 25m and 30m away from the T-junction. This enable the determination of the value of pollutant gas concentration for each day base on average. Analyses of gases concentration over time was established via quantitative, time plots, least square regression model and analysis of variance with the aid of statistical software (E-View, Minitab, SPSS and Excel). Trend analysis of the variable of interest is determined over time with the respective equations and forecast values. The study shows that, the emission concentration for CO, NO_2, SO_2, CO_2 VOC, $PM_{2.5}$, PM_{10} and Sound level was found to be above the WHO limit, highest at Romuokoro, followed by Garrism, Rumuola and water lines junctions in Port Harcourt, where the intersections and traffic count is higher. It was also observed that LNG junction recorded the least emission among all the junctions. Analysis of the forecast values was obtained for the average monthly period of two years (2020 and 2021). The study concludes that, gases pollutant concentration diffusivity observed is related to vehicular movement, which indeed is significant with possible severe health consequences within the study area. It is therefore recommended that all business men and women should operates some meters away from all junctions. The road network within the research axis should be improved by constructing more routes to ease the traffic within the study area.

Keywords: Effect of Pollutant, Vehicular Emission, T-Junctions, Port Harcourt Metropolis.

General Introduction

Introduction of contaminants into the natural environment that cause adverse change is called pollution. "It can take the form of chemical substances or energy, such as noise, heat or light. Pollutants is the components of pollution, which can be either foreign substances, energies or naturally occurring contaminants. There are five major types of pollution, which includes; air, water, soil, light, and noise pollution, Adoki, (2012); Akukwe *et al.,* (2015); Allen, (2017); Ana & Sridhar, (2009); Armistead, (2020)".

The four main "types of air pollution sources includes: mobile or transportation sources (such as cars, buses, planes, trucks, and trains), stationary source **(s**uch as power plants, oil refineries, industrial facilities, and factories), area sources (such as agricultural areas, cities, and wood burning fire places) and natural sources (such as wind-blown dust, wild fires, and volcanoes). Mobile or transportation sources account for more than half of all the air pollution in the world and the primary mobile source of air pollution is the automobile", or vehicular emission, Armistead (2020); Briggs-Kamara *et al.,* (2013); Brown *et al.,* (2002),

The development of technology has led to the exploitation of man's environment in a bid to increasing his standard of living. "It is now very obvious, even to those who had initial doubts about the veracity of the claim

by scientists and researchers of the resultant effects of pollutant induced by automobile at T-junctions in most region of the world". Therefore, the short and long term effect of people that are living, working or relaxing around T-junction in the world populated cities requires urgent attention. The "motor vehicles are the major contributors to urban air Pollution, controlling strategies need to be developed that minimize the environmental impacts but maximize the efficiency of motorized transport". "However, the phenomenon of road traffic air pollution shows considerable variation within a street as a function of distance to the source of pollution, therefore, the levels and consequently the effected number of inhabitants varies, Bennett *et al.,* (1997); Bateson & Schwartz; (2014); Obi *et al.,* (2014)".

Many studies are "known to have been carried out on the health impacts of" Pollution diffusivity of Vehicular emission on several cities in the Niger Delta area of Nigeria, without details experimental and theoretical evidence. However, the city dwellers know and firmly believe that this vehicular emission "is damaging their health, reducing crop production, destroying and damaging their homes. While other factors may be at play, the lack of attention paid to this crucial issue, means that people questions and fears are unanswered", Osang *et al*., (2013); Park *et al*., (2005); Peel *et al*. (2007); Pekene *et al*., (2015); Pope *et al*., (2006). Even in the absence of such a study, however, it is clear that traffic generated air pollution "must be of great concern to the general public" because emission harms people, destroy buildings and causes negative effects to the environment see fig. 1.1.

Fig. 1: Gas pollutants emitted from vehicles

Source: https://www.google.com/search?q=pollutants+from+ vehicular+emission&tbm

The motor "vehicle engine and exhaust emits many types of pollutants including nitrogen oxides (NO_2), volatile organic compounds (VOCs), and carbon monoxide (CO), carbon dioxide (CO_2), particulates matter (PM), sulphur dioxide (SO_2) and lead into the air see" Fig. 1.1. "Pollutants from vehicle exhaust can affect more than just your lungs. Indeed, tailpipe pollutants pose health risks at every stage of life, and can even cause premature death, Rim-Rukeh, (2015); Sun *et al*., (2018); Tawari & Abowei, (2012); Trenga *et al*., (2006); Ubong *et al*., (2014); Uquetan *et al*., (2017); Yakubu, (2017).

Pollutant Diffusivity due to vehicular emission remains a noticeable threat to environmental health problems which is expected to increase conspicuously as vehicle ownership increases in the world. Over 600 million people globally are exposed to hazardous level of traffic generated pollutants. Human exposure to these air pollutants due to traffic is believed to have constituted severe health problems especially in urban areas where pollution levels are on the increase, Chanson *et al.,* (2009); Dinesh *et al.,* (2012); Ede *et al.,* (2015); Ede *et al.,* (2011)". Fig. 2, shows clearly that, vehicular "emissions are a major source of ambient air pollution and must be controlled if acceptable air quality is needed. In addition, there are numerous health problems associated with high concentration of these pollutants. For example NO_2 is responsible for immune system impairment, exacerbation of asthma and chronic respiratory diseases: reduced lung function and cardiovascular disease. Particulates are dangerous and are linked as facilitators in the development of lung cancer and increase rate of mortality," Emetere, (2013); Evanoff *et al.,* (1993); Ewona *et al.,* (2013); Ewona *et al.,* (2014).

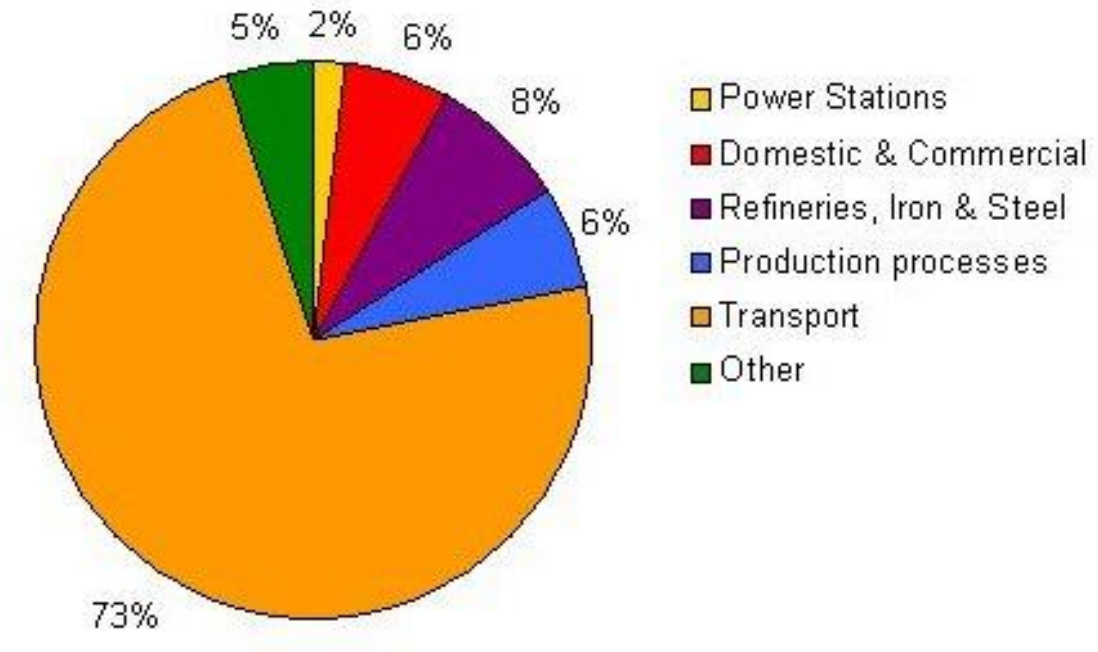

Fig. 2: showing vehicular emissions accounting for over 80% of total air pollutants in the atmosphere
Source: https://www.google.com/search?q=pollutants+ from+vehicular+ emission

An "epidemiological research study in the world has clearly shown that acute exposure to vehicle emissions over years reduces lung function among tunnel officers. A similar study confirms that there is a prevalence of chronic bronchitis and asthma for street cleaners exposed to vehicle pollutants in concentrations higher than WHO recommended limit, and as such leading to significant increase in respiratory problems in the world", Uquetan *et al*., (2016); USEPA, (2017); Weli, (2014); Wellenius *et al*., (2018); WHO, (2018); Yakubu, (2017).

Having "viewed these consequences, the need to embark on research of this kind, becomes very obvious. This research work is intended to investigate the level of vehicular emission and air quality standard in a growing city Port Harcourt, Nigeria. The knowledge from this investigation will assist authority in planning adequate pollution control measures. It is equally hoped that the study will generate interest on further research on the impact of vehicle emission on air quality and health implications in Port Harcourt in particular and Nigeria in general for effective air quality control and management", Sun *et al*., (2018); Tawari & Abowei, (2012); Trenga *et al*., (2006); Ubong *et al*., (2014); WHO, (2018); Yakubu, (2017).

1.2.1 World Acceptable Limit of Gas Pollutant:

The world acceptable limit of gas is clearly summarized table 1.1

Table 1: Showing W.H.O/AQI Acceptable Limit of Gas Pollutant Source: https://ec.europa.eu/environment/air/quality/standards.htm

Gas Pollutant	Concentration Value
CO(mg/m^3)	10
VOC(mg/m^3)	0.5
CO_2(mg/m^3)	1000
SO_2(mg/m^3)	350
NO_2(mg/m^3)	40
$PM_{2.5}$(µm /m^3)	25
PM_{10}(µm /m^3)	50
Sound Level(dB)	90

Materials and Method

Study Area

Port "Harcourt is the capital and largest city of Rivers State, Nigeria. It lies along the Bonny River and is located in the Niger Delta. In 2016, Port Harcourt urban area has an estimated population of 1,865,000 inhabitants compared to 1,382,592 in 2006". And a geography coordinates of 4.8156° N, 7.0498° E. "The dry season occurs between November and March while the rainy season occurs between April and October with peak rain fall in August and September. The selected areas for this investigation are areas with high traffic and business activities. These areas are busy within the hours of 7:30 – 11:30 a.m. when offices and commercial activities commence and 12:30 – 10:00 p.m. in the evening at the close of work and market activities". Port Harcourt is a fast growing city in terms of industrialization, Kio-Lawson & Dekor (2014) & (2006); Nwachukwu *et al*., (2012); Obi *et al*., (2017); Obi *et al*. (2013); Onubo-Pepple *et al*., (2013); Osang *et al*., (2014). The five different locations in Port Harcourt we consider for these research due to the traffic congested nature are:

(1.) Rumuola Junctions

(2.) Waterlines Junctions

(3.) Garrison junctions

(4.) LNG junctions and

(5.) Rumuokoro junctions

Data Source

This research is investing pollutant diffusivity of vehicular emission within some congested junctions in Port Harcourt, Nigeria. Five locations selected for this study includes: Rumuola Junctions, Waterlines Junctions, Garrison junctions, LNG junctions and Rumuokoro junction. The parameters measured at each sampling location with seven different distances are: Volatile Organic Compounds (VOC), including methane, Carbon Dioxide (CO2), Sulphur Dioxide (SO2), Particulate matter (PM), Carbon monoxide (CO) and the Sound Level (dB).

Gas Analyzers

The five gas analyzers was determined with a digital gas instrument called Aeroqual Series 500 (see fig. 3.1). The gas instrument was set to stabilize, analyzed the environment and read after 3 minutes at a particular distance. For each location, the readings was taken in the morning, afternoon and night respectively for MJ, 5m, 10m, 15m, 20m, 25m and 30m away from the T- junction. This enable the determination of the value of gas pollutant concentration for the day.

Particulate Mass (PM)

The PM values of each location was determined using a portable digital particle mass/count instrument call Met One instruments AEROCET 531S (see fig. 3.2). The PM instrument was set to stabilize, analyzes environment and read after 1 to 2 minutes at a particular distance before withdrawal. For each location, the readings was taken during the morning (7.00am-10am), afternoon (1.00pm-4pm) and night (5.00pm-8.00pm) respectively for MJ, 5m, 10m, 15m, 20m, 25m and 30m away from the T-junction. This was to enable the determination of the PM concentration value for the day in each location. "The AEROCET 531S is a full-featured, battery operated, handheld mass monitor or particle counter. This amazing unit simultaneously measures 6 mass concentration ranges (PM_1, $PM_{2.5}$, PM_4, PM_7, PM_{10} and TSP) or five particle count sizes (0.3µm, 0.5µm, 1.0µm, 5.0µm and 10µm). This instrument can view sample history data in either mode".

Fig. 3: A Portable Digital Particle Mass/Count Instrument Call Met One Instruments AEROCET 531S

Fig 4: Aeroqual Series 500 Digital Gas Analyzers

Sound Level (dB)

Sound level (dB) was detected using a digital sound level meter with RS232 Extech 407750 (see fig 3.3). The Sound level (dB) instrument was set to stabilize, analyzed the environment and read after 3 minutes at a particular distance before withdrawal. For each location, the readings was taken during the morning (7.00am-10am), afternoon (1.00pm-4pm) and night (5.00pm-8.00pm) respectively for MJ, 5m, 10m, 15m, 20m, 25m and 30m away from the roundabout junction. This was to enable the determination of the sound value concentration for the day in each location.

Fig. 5: A Portable Digital Sound Level Meter with RS232 Extech 407750

Data Analysis Technique

In this study, the descriptive and quantitatively method of analysis through data collected from primary source was used. "Charts such as time plots and tables were employed to aid in the proper actualization of the set objectives. The study adopted the analysis of variance (ANOVA) and the univariate modeling of time series variables which was described by the statistical packages e.g E-view, SPSS, Minitab and Excel etc. More so, diagnostic test of the chosen model was conducted and where appropriate for use in its forecast values".

The Least Square Regression Method

The least square regression method eliminates the human judgment inherent in the free hand method of estimating the regression line, and gives one line only, which is the line of best fit. Two variables x and y are linearly related if the relationship can be expressed by the equation 3.1 below:

$$y_i = \alpha + \beta x_i + e_i \quad (1)$$

Where α and β are parameters called the regression constant and regression coefficient. e_i is the random variable with mean zero.

Using equation 3.1, we see the residuals e_i can be given as:

$$e_i = Y_i - (\alpha + \beta x_i) \quad (2)$$

With

$$\sum_{i-1}^{n} e_i^2 = \sum_{i-1}^{n} [Y_I - (\alpha + \beta x_i)]^2 \quad (3)$$

Equation 3.3 shows the sum of squares of the residuals or deviation.

The least squares estimators of α and β are those values of which α and β which minimize $\sum_{i-1}^{n} e_i^2$. These values are the constants α and β in equation 3.4 below:

$$Y = a + bx \quad (4)$$

And it can be obtained by solving the following two normal simultaneous equations which were derived using differential calculus

$$\sum Y = na + b \sum X \quad (5)$$

$$\sum XY = a \sum X + b \sum X^2 \quad (6)$$

Solving equation 3.6 simultaneously, we have

$$a = \frac{\sum Y \sum X^2 - \sum X \sum XY}{n \sum X^2 - (\sum X)^2} \quad (7)$$

$$b = \frac{n \sum XY - \sum X \sum Y}{n \sum X^2 - (\sum X)^2} \quad (8)$$

The Principle of ANOVA

Analysis of variance (ANOVA) is a statistical method for determining the existence of differences among several population/sample means. ANOVA is used to measure the different between variation between sample and variation within samples. It allow us to analyze and interpret observations from several populations/samples. This particular statistical tool partitions the total variation in a data set according to the source of variation that are present.

The Sum of Square and Mean Square

To test the quality of population or sample means, we use the sum of squares of the three types of variation, namely the

i. Total sum of squares (TSS)

ii. Treatment sum of squares (TRSS)

iii. Error sum of square (ESS)

Where

$$TSS = TRSS + ESS \quad (9)$$

3.5.1 Total sum square (TSS)

The formula for the variation sum of squares is as follows:

$$TSS = \sum_{i-1}^{n_j} \sum_{j-1}^{r} \left(X_{ij} - \bar{\bar{X}}\right)^2 \quad (10)$$

The will becomes

$$TSS = \sum_{i-1}^{n_j} \sum_{j-1}^{1} X_{ij}^2 - \frac{\left[\sum_{i-1}^{n_j} \sum_{j-1}^{1} X_{ij}^2\right]^2}{n} \quad (11)$$

$$\bar{\bar{X}} = \sum_{i-1}^{n_j} \sum_{j-1}^{1} X_{ij} \quad (12)$$

Equation 3.12 is the grand mean of all the observations or samples.

The total sum squares has $(n-1)$ degrees of freedom.

3.5.2 Treatment sum square (TSS)

$$TRSS = \sum_{i-1}^{1} n_j \left(\bar{X}_J - \bar{\bar{X}}\right)^2 \quad (13)$$

$$\bar{X}_J = \frac{\sum_{i=1}^{n_j} X_{ij}}{n} \quad (14)$$

Equation 3.14 becomes the mean for the jth treatment.

$$TRSS = \sum_{j=1} n_j \bar{X}_J - n \bar{\bar{X}}^2 \quad (15)$$

If $n_1 = n_2 = \cdots n_r = m$ (16)

Then the formula for TRSS reduces to reduces to

$$TRSS = m \sum_{j-1}^{r} X_j^2 - n\bar{\bar{X}}^2 \quad (17)$$

The treatment sum of squares has $(r-1)$ as degree of freedom.

3.5.3 Error sum square (TSS)

$$ESS = \sum_{i=1}^{n_j} \sum_{j=1}^{r} \left(X_{ij} - \bar{\bar{X}}_j\right) \quad (18)$$

In practice, the ESS is obtained by subtracting the $TRSS$ from the TSS

Then

$$ESS = TSS - TRSS \quad (19)$$

$$(n-1) - (r-1) = r - 1 \quad (20)$$

The error sum square as equation 3.20 as the degree of freedom. We calculate the treatment mean square $TRMA$ and the error mean square EMS by dividing their sum

$$TRMS = \frac{TRSS}{r-1} \quad (21)$$

$$EMS = \frac{ESS}{n-r} \quad (22)$$

These mean squares.....

$$F = \frac{TRMS}{EMS} \quad (23)$$

We then look at the F-table for the critical value of the test, with $r-1$ and $n-r$ degree of freedom. In the table, r-1 is for the numerator and $n-r$ for the denominator degrees of freedom.

RESULTS

The research seeks to present and analyzes the pollution from vehicular emission within some congested T-junctions in Port Harcourt. The study established models for Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen oxides (NO_2), Volatile Organic Compounds (VOCs), and Particulates Matter ($PM_{2.5}$ *and* PM_{10} and P_{10}), Sulphur Dioxide (SO_2) and Sound Level (SL) or Noise Pollution. This chapter mathematically and graphically present analysis of the aims of the study in several sections. Analysis of Weekly Carbon Monoxide (CO) Gas Pollutant Concentration in Port Harcourt is sown below:

Table 2: **The CO (mg/M^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.**

Distance(M)	**Time (T)**	$\bar{X}_{CORJ}$	$\bar{X}_{COLNGJ}$	$\bar{X}_{COWLJ}$	$\bar{X}_{COGJ}$	$\bar{X}_{CORUJ}$
MJ	7:30am	13.4	9.4	10.6	12.2	11.8
	1:30pm	18.6	10.5	15.6	17.4	16.4
	4:30pm	15.4	9.9	12.5	15.4	15.4
5M	7:35am	12.2	7.7	9.9	10.4	9.7
	1:35pm	17.4	8.2	14.6	16.4	14.5
	4:35pm	15.4	7.9	10.5	14.5	10.4
10M	7:40am	10.4	6.6	9.4	9.7	10.2
	1:45pm	16.4	7.6	10.5	13.2	13.2
	4:40pm	14.5	6.7	9.7	11.6	10.9
15M	7:45am	9.7	6.5	7.7	9.3	9.2
	1:50pm	13.2	6.5	8.2	10.2	10.5
	4:45pm	11.6	6.5	7.9	9.8	9.6
20M	7:50am	9.3	4.8	6.6	8.3	7.6
	1:45pm	10.2	5.6	7.6	9.4	8.2
	4:50pm	9.8	5.0	6.7	8.8	7.9
25M	7:55am	8.3	4.4	6.5	7.6	6.5
	1:155pm	9.4	4.9	6.5	8.2	7.6
	4:55pm	8.8	4.5	6.5	7.9	6.7
30M	8:00am	7.6	4.3	4.8	6.5	6.4
	2:00pm	7.7	4.7	5.6	7.6	6.5
	5:00pm	7.9	4.4	5.0	6.7	6.5
	TOTAL	**247.1**	**136.3**	**182.7**	**221.2**	**205.7**

Fig 6: Bar Chart showing the CO (mg/M^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Volatile Organic Compounds (VOC) Gas Pollutant Concentration in Port Harcourt

Table 3: Shows the VOC (mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Distance(M)	Time (T)	$\bar{X}_{VOCRJ}$	$\bar{X}_{VOCLNGJ}$	$\bar{X}_{VOCWLJ}$	$\bar{X}_{VOVGJ}$	$\bar{X}_{VOCRUJ}$
MJ	7:30am	6.8	1.7	2.5	4.1	4.2
	1:30pm	9.4	2.2	4.3	5.6	4.6
	4:30pm	8.3	1.9	4.2	4.6	4.3
5M	7:35am	4.1	0.8	1.7	4.3	1.7
	1:35pm	5.6	0.9	2.2	4.4	2.5
	4:35pm	4.6	0.9	1.9	4.5	1.9
10M	7:40am	4.3	0.4	0.8	3.3	0.8
	1:45pm	4.4	0.5	0.9	3.6	0.9
	4:40pm	4.5	0.4	0.9	3.5	0.9
15M	7:45am	3.3	0.3	0.4	0.8	0.4
	1:50pm	3.6	0.4	0.5	0.9	0.5
	4:45pm	3.5	0.3	0.4	0.9	0.4
20M	7:50am	0.8	0.2	0.3	0.4	0.3
	1:45pm	0.9	0.4	0.4	0.5	0.4
	4:50pm	0.9	0.3	0.3	0.4	0.3
25M	7:55am	0.4	0.2	0.2	0.3	0.2
	1:155pm	0.5	0.2	0.4	0.4	0.4
	4:55pm	0.4	0.2	0.3	0.3	0.3
30M	8:00am	0.3	0.2	0.2	0.2	0.2
	2:00pm	0.5	0.2	0.2	0.4	0.2

5:00pm	0.3	0.2	0.2	0.3	0.2
TOTAL	**67.6**	**13.1**	**23.5**	**43.9**	**25.8**

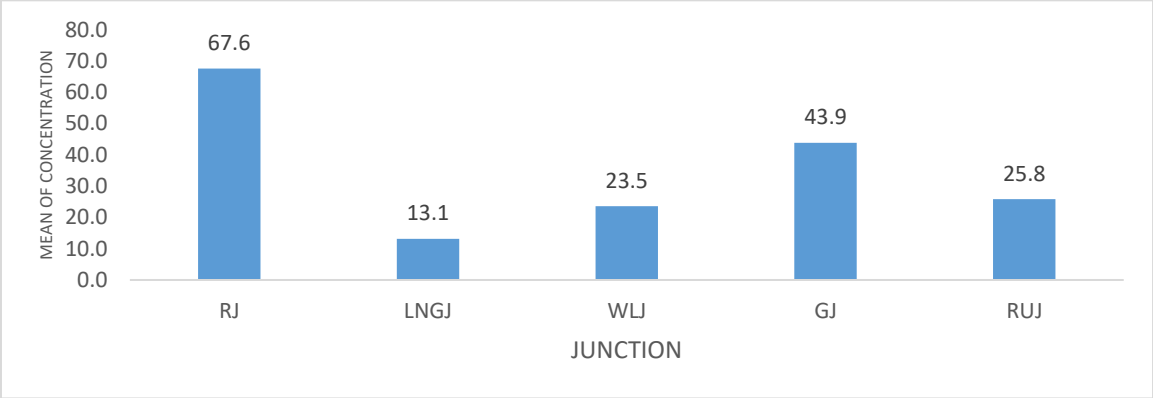

Fig 7: Bar Chart showing the VOC (mg/M^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Carbon Dioxide **(CO_2)** Gas Pollutant Concentration in Port Harcourt

Table 4: Shows the CO_2 (mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Distance(M)	**Time (T)**	$\bar{X}_{CO_2RJ}$	$\bar{X}_{CO_2LNGJ}$	$\bar{X}_{CO_2WLJ}$	$\bar{X}_{CO_2GJ}$	$\bar{X}_{CO_2RUJ}$
MJ	7:30am	1264	669	992	1229	1121
	1:30pm	1354	683	1123	1245	1131
	4:30pm	1230	673	1121	1225	1123
5M	7:35am	1229	474	1000	1121	1014
	1:35pm	1245	587	1018	1131	1018
	4:35pm	1225	482	1016	1123	1016
10M	7:40am	1121	415	579	1014	942
	1:45pm	1131	436	947	1018	947
	4:40pm	1123	422	944	1016	944
15M	7:45am	1014	415	474	942	579
	1:50pm	1018	426	587	947	587
	4:45pm	1016	417	482	944	580
20M	7:50am	942	410	414	579	474
	1:45pm	947	428	434	587	482
	4:50pm	944	413	420	580	476
25M	7:55am	579	378	414	474	414
	1:155pm	587	405	423	482	434
	4:55pm	580	383	416	476	420

30M	8:00am	474	363	411	414	414
	2:00pm	482	365	431	434	423
	5:00pm	476	362	414	420	416
	TOTAL	19982	9607	14063	17403	14958

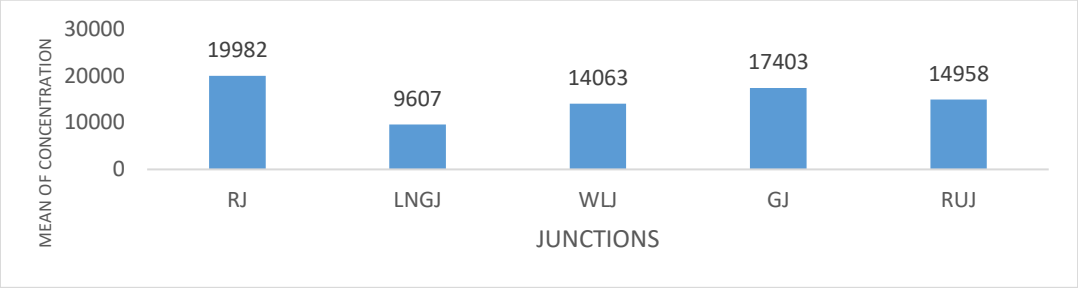

Fig 8: Bar Chart showing the CO_2 (mg/M^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Sulphur Dioxide **(SO_2)** Gas Pollutant Concentration in Port Harcourt

Table 5: The SO_2 (mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

Distance(M)	**Time(T)**	$\bar{X}_{SO_2RJ}$	$\bar{X}_{SO_2LNGJ}$	$\bar{X}_{SO_2WLJ}$	$\bar{X}_{SO_2GJ}$	$\bar{X}_{SO_2RUJ}$
MJ	7:30am	669	354	484	552	465
	1:30pm	683	414	485	573	506
	4:30pm	673	356	465	561	485
5M	7:35am	552	345	354	465	376
	1:35pm	573	347	414	506	420
	4:35pm	561	346	356	485	388
10M	7:40am	465	333	345	376	354
	1:45pm	506	343	347	420	356
	4:40pm	485	336	346	388	355
15M	7:45am	376	268	333	354	345
	1:50pm	420	291	343	356	347
	4:45pm	388	276	336	355	346
20M	7:50am	354	223	268	345	333
	1:45pm	356	256	291	347	343
	4:50pm	355	239	276	346	336
25M	7:55am	345	227	223	333	268
	1:155pm	347	244	256	343	291
	4:55pm	346	232	239	336	276

30M	8:00am	333	222	227	268	223
	2:00pm	343	232	244	291	256
	5:00pm	336	227	232	276	239
	TOTAL	9468	6112	6865	8278	7310

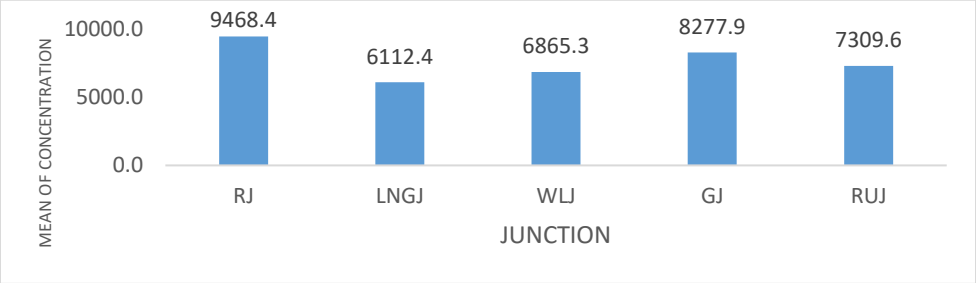

Fig 9: Bar Chart showing the SO_2 (mg/M^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Nitrogen Oxide **(NO_2)** Gas Pollutant Concentration in Port Harcourt

Table 6: Shows the NO_2 (mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig**.**

Distance(M)	**Time (T)**	$\bar{X}_{NO_2RJ}$	$\bar{X}_{NO_2LNGJ}$	$\bar{X}_{NO_2WLJ}$	$\bar{X}_{N_2GJ}$	$\bar{X}_{NO_2RUJ}$
MJ	7:30am	355	63	167	313	251
	1:30pm	393	174	252	333	254
	4:30pm	373	147	251	310	245
5M	7:35am	313	58	63	251	147
	1:35pm	333	62	174	254	167
	4:35pm	310	60	147	245	155
10M	7:40am	251	36	58	147	60
	1:45pm	254	38	62	167	63
	4:40pm	245	37	60	155	62
15M	7:45am	147	30	36	60	38
	1:50pm	167	34	38	63	40
	4:45pm	155	31	37	62	39
20M	7:50am	60	26	30	38	36
	1:45pm	63	29	34	40	38
	4:50pm	62	27	31	39	37
25M	7:55am	38	23	26	36	29
	1:155pm	40	33	29	38	33
	4:55pm	39	31	27	37	31

30M	8:00am	36	31	23	34	26
	2:00pm	38	32	33	35	29
	5:00pm	37	31	31	35	27
	TOTAL	**3709**	**1034**	**1609**	**2693**	**1807**

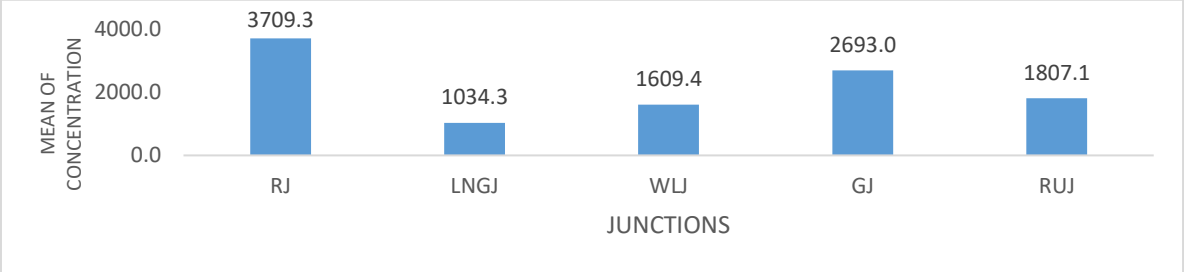

Fig 10: Bar Chart showing the NO_2 (mg/M³) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Nitrogen Oxide **($PM_{2.5}$)** Gas Pollutant Concentration in Port Harcourt

Table 7: Shows the $PM_{2.5}$ (µm/m³) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Distance(M)	**Time (T)**	$\bar{X}_{PM_{2.5}RJ}$	$\bar{X}_{PM_{2.5}LNGJ}$	$\bar{X}_{PM_{2.5}WLJ}$	$\bar{X}_{PM_{2.5}GJ}$	$\bar{X}_{PM_{2.5}RUJ}$
MJ	7:30am	52.3	27.6	36.9	45.9	42.3
	1:30pm	55.7	29.1	43.0	50.3	45.3
	4:30pm	53.4	28.6	39.6	47.4	42.7
5M	7:35am	45.9	23.4	27.6	42.3	35.1
	1:35pm	50.3	24.1	29.1	45.3	41.1
	4:35pm	47.4	22.9	28.6	42.7	37.9
10M	7:40am	42.3	21.0	23.4	35.1	27.4
	1:45pm	45.3	22.9	24.1	41.1	29.0
	4:40pm	42.7	22.0	22.9	37.9	28.3
15M	7:45am	35.1	19.1	21.0	27.4	23.0
	1:50pm	41.1	22.3	22.9	29.0	24.0
	4:45pm	37.9	20.3	22.0	28.3	22.6
20M	7:50am	27.4	17.7	19.1	23.0	20.9
	1:45pm	29.0	21.3	22.3	24.0	22.9
	4:50pm	28.3	18.9	20.3	22.6	21.9
25M	7:55am	23.0	16.4	17.7	20.9	18.9
	1:155pm	24.0	21.1	21.3	22.9	22.0
	4:55pm	22.6	17.7	18.9	21.9	20.0

30M	8:00am	20.9	16.3	16.4	21.9	17.3
	2:00pm	22.9	17.7	21.1	22.6	20.9
	5:00pm	21.9	17.0	17.7	22.6	18.3
	TOTAL	769.3	447.4	515.9	674.9	581.6

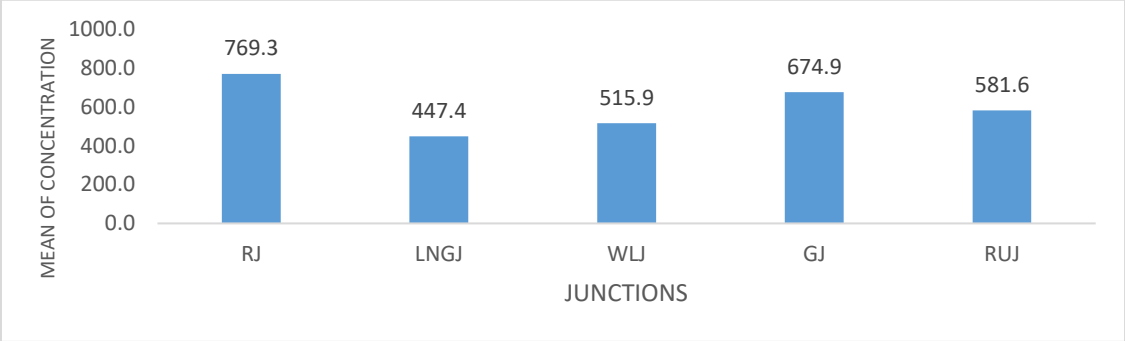

Fig 11: Bar Chart showing the $PM_{2.5}$ (μm/M³) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Nitrogen Oxide **(PM_{10})** Gas Pollutant Concentration in Port Harcourt

Table 8: The PM_{10} (μm/m³) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

Distance(M)	**Time (T)**	$\bar{X}_{PM_{10}RJ}$	$\bar{X}_{PM_{10}LNGJ}$	$\bar{X}_{PM_{10}WLJ}$	$\bar{X}_{PM_{10}GJ}$	$\bar{X}_{PM_{10}RUJ}$
MJ	7:30am	132.4	53.7	106.9	129.3	119.7
	1:30pm	136.1	101.4	120.1	130.6	122.3
	4:30pm	133.3	99.4	119.7	129.6	120.1
5M	7:35am	129.3	47.3	53.7	119.7	99.4
	1:35pm	130.6	52.0	101.4	122.3	106.9
	4:35pm	129.6	51.0	99.4	120.1	101.4
10M	7:40am	119.7	45.7	47.3	99.4	51.0
	1:45pm	122.3	47.6	52.0	106.9	53.7
	4:40pm	120.1	46.3	51.0	101.4	52.0
15M	7:45am	99.4	43.3	45.7	51.0	45.6
	1:50pm	106.9	45.7	47.6	53.7	48.7
	4:45pm	101.4	44.3	46.3	52.0	47.6
20M	7:50am	51.0	40.3	43.3	45.6	43.3
	1:45pm	53.7	44.6	45.7	48.7	46.1
	4:50pm	52.0	43.0	44.3	47.6	44.6
25M	7:55am	45.6	33.4	40.3	43.3	41.3
	1:155pm	48.7	42.3	44.6	46.1	44.6

	4:55pm	47.6	37.1	43.0	44.4	43.0
30M	8:00am	43.3	32.4	33.4	42.6	37.1
	2:00pm	46.1	35.0	42.3	44.4	42.3
	5:00pm	44.4	34.1	37.1	43.1	40.3
	TOTAL	1893.6	1020.0	1265.1	1621.9	1351.0

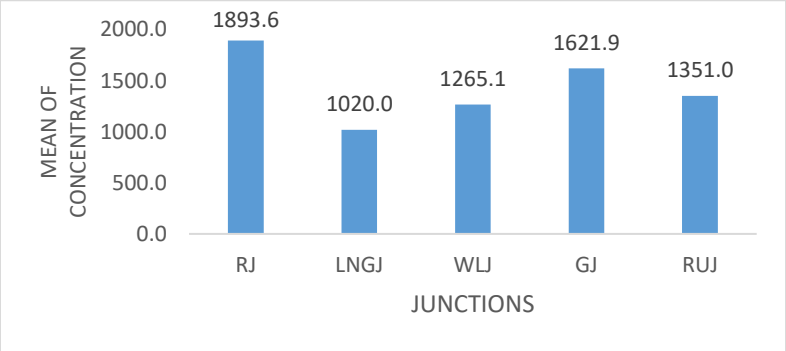

Fig 12: Bar Chart showing the PM_{10} (μm/M^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Analysis of Weekly Nitrogen Oxide (SL) Gas Pollutant Concentration in Port Harcourt

Table 9: Shows the SL (dB) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Distance(M)	Time (T)	$\bar{X}_{SLRJ}$	$\bar{X}_{SLLNGJ}$	$\bar{X}_{SLWLJ}$	$\bar{X}_{SLGJ}$	$\bar{X}_{SLRUJ}$
RAJ	7:30am	123.3	83.0	89.3	125.3	113.6
	1:30pm	134.7	91.7	113.6	126.3	115.0
	4:30pm	131.1	86.7	92.9	123.0	113.4
5M	7:35am	125.3	82.4	83.0	113.6	85.1
	1:35pm	126.3	93.1	91.7	115.0	92.9
	4:35pm	123.0	85.0	86.7	113.4	89.3
10M	7:40am	113.6	77.9	82.4	85.1	84.4
	1:45pm	115.0	83.0	93.1	92.9	87.0
	4:40pm	113.4	80.4	85.0	89.3	86.0
15M	7:45am	85.1	62.9	77.9	84.4	82.7
	1:50pm	92.9	71.9	83.0	87.0	84.6
	4:45pm	89.3	69.3	80.4	86.0	83.4
20M	7:50am	84.4	57.6	62.9	82.7	77.9
	1:45pm	87.0	71.9	71.9	84.6	83.0
	4:50pm	86.0	60.4	69.3	83.4	80.4
25M	7:55am	82.7	51.4	57.6	77.9	62.9

	1:155pm	84.6	57.6	71.9	83.0	71.9
	4:55pm	83.4	50.6	60.4	80.4	69.3
30M	8:00am	77.9	48.3	51.4	74.3	57.6
	2:00pm	83.0	49.9	57.6	78.3	66.6
	5:00pm	80.4	48.7	50.6	75.6	60.4
	TOTAL	**2122.4**	**1463.6**	**1612.4**	**1961.4**	**1747.3**

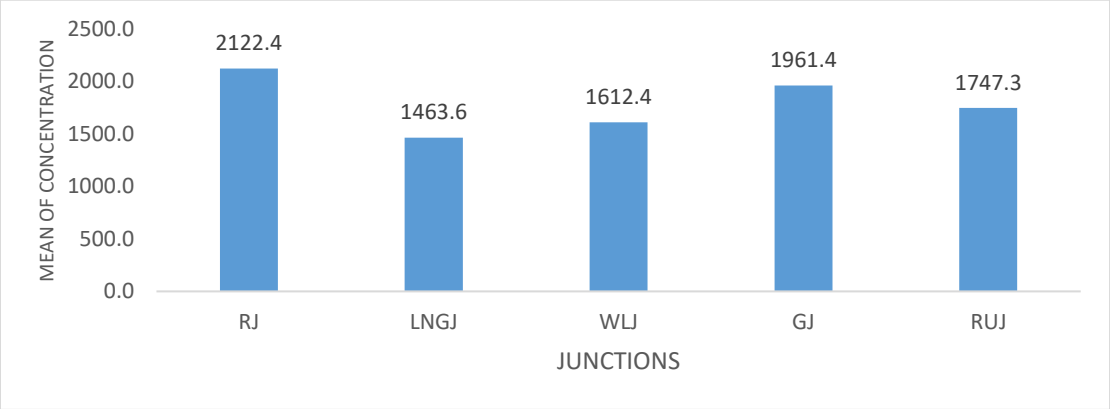

Fig 13: Bar Chart showing the SL (dB) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

Estimation Pollutant Diffusivity of Vehicular Emission in Port Harcourt

This section present the analysis of monthly average of Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen oxides (NO_2), Volatile Organic Compounds (VOCs), and Particulates Matter ($PM_{2.5}$ *and* PM_{10} and P_{10}), Sulphur Dioxide (SO_2) and Sound Level (SL) or Noise Pollution representing the least square estimation procedure. The result also indicates the plots of the variables of interest showing the actual and forecast of the selected junctions.

Table 10: Shows the average CO (mg/M^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANCORJ	MEANCOLNGJ	MEANCOWLJ	MEANCOGJ	MEANCORUJ
JANUARY	13.4	9.4	10.6	12.2	11.8
FEBUARY	15.6	10.1	10.3	14.3	10.3
MARCH	16.4	9.9	11.2	15.4	12.1
APRIL	12.2	7.7	9.5	10.4	9.7
MAY	16.5	8.2	14.3	16.4	14.5
JUNE	15.4	7.9	10.5	14.5	10.4
JULY	13.9	8.4	11.2	13.5	10.2
AUGUST	16.4	7.6	10.5	13.2	13.2
SEPTEMBER	16.8	10.5	9.7	16.5	14.9
OCTOBER	17.5	11.2	15.6	17.4	16.4
NOVERMBER	21.0	11.4	14.6	15.4	15.4

DECEMBER	21.3	12.1	16.2	16.9	16.8

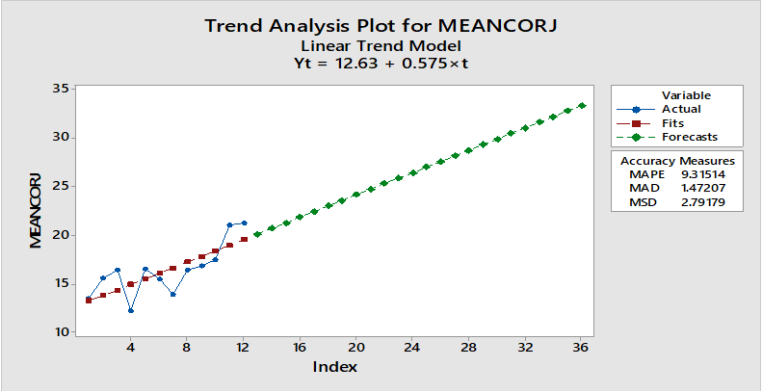

Fig 14: Displays the actual, trend analysis and forecast plot of the monthly average CO (mg/M^3) of Gases Pollutant Concentration in RJ.

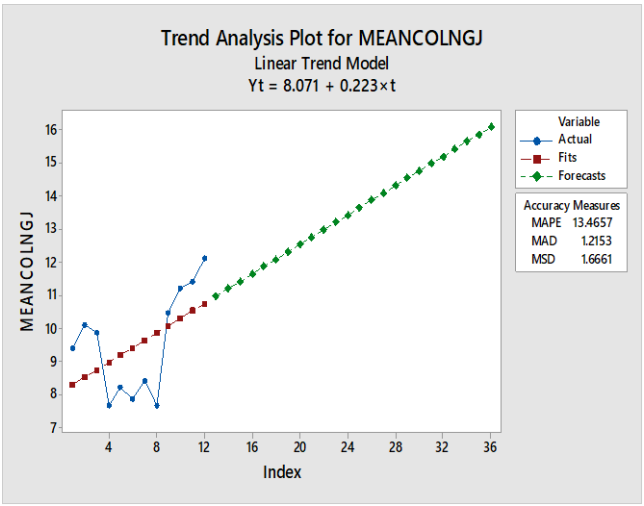

Fig 15: Displays the actual, trend analysis and forecast plot of the monthly average CO (mg/M^3) of Gases Pollutant Concentration in LNGJ.

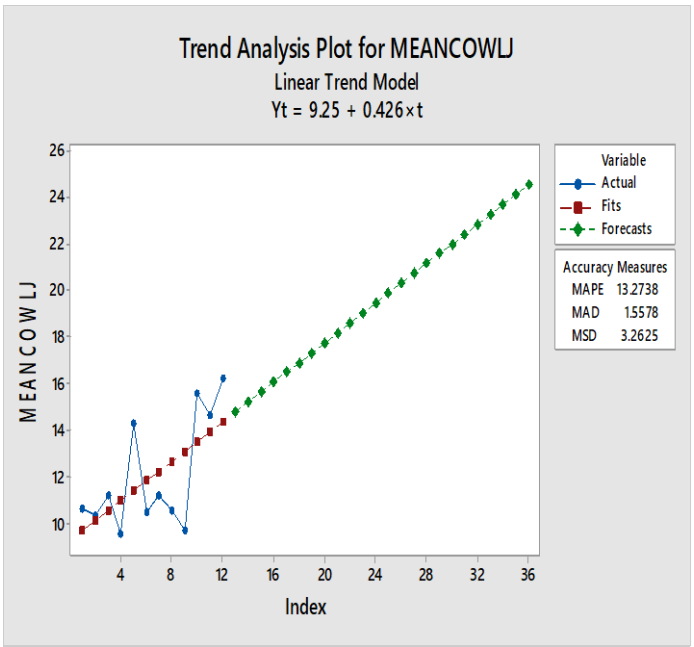

Fig 16: Displays the actual, trend analysis and forecast plot of the monthly average CO (mg/M^3) of Gases Pollutant Concentration in WLJ.

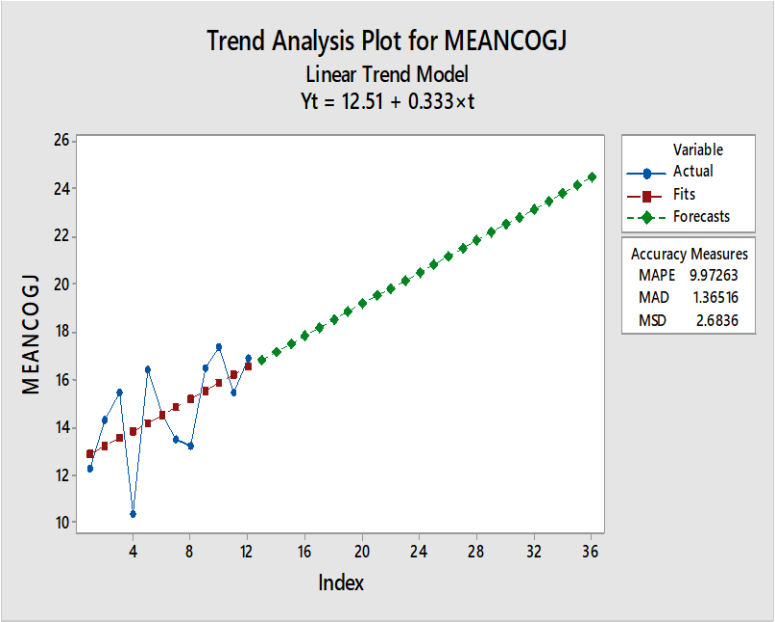

Fig 17: Displays the actual, trend analysis and forecast plot of the monthly average CO (mg/M^3) of Gases Pollutant Concentration in GJ.

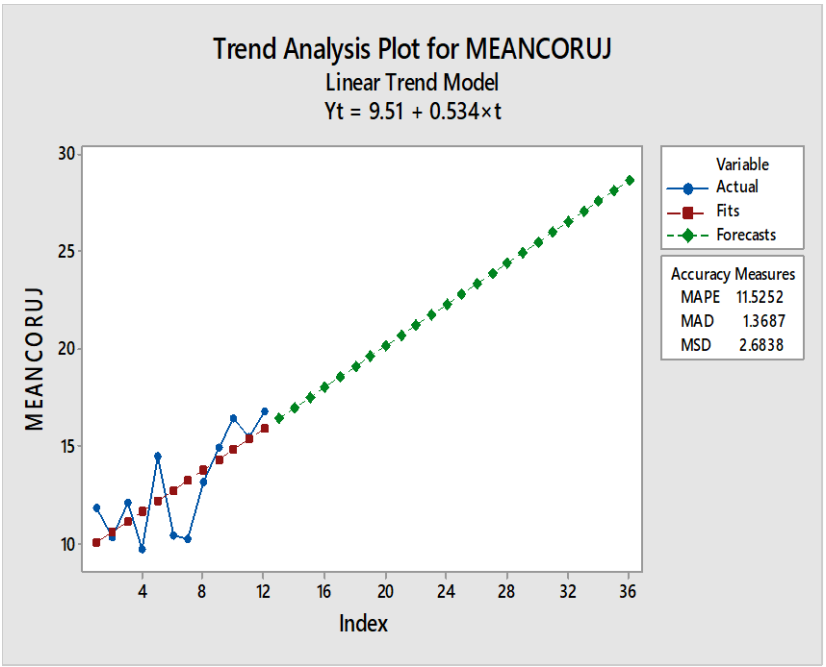

Fig 18: Displays the actual, trend analysis and forecast plot of the monthly average CO (mg/M^3) of Gases Pollutant Concentration in RUJ.

Table 11: The average VOC (mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANVOCRJ	MEANVOCLNGJ	MEANVOCWLJ	MEANVOCGJ	MEANVOCRUJ
JANUARY	6.8	0.8	2.5	4.3	4.2

FEBRUARY	7.5	1.6	3.2	4.6	3.7
MARCH	8.3	1.9	2.6	4.3	3.3
APRIL	4.1	0.9	1.7	3.3	1.7
MAY	5.6	2.1	2.2	4.4	2.5
JUNE	4.6	0.9	1.9	4.5	1.9
JULY	4.3	2.1	0.8	3.3	1.2
AUGUST	4.4	1.6	0.9	3.6	3.3
SEPTEMBER	8.6	1.4	1.8	3.5	3.9
OCTOBER	9.4	2.2	4.2	5.6	4.3
NOVEMBER	9.7	2.8	4.1	4.6	4.5
DECEMBER	9.80	2.70	4.60	5.9	5.2

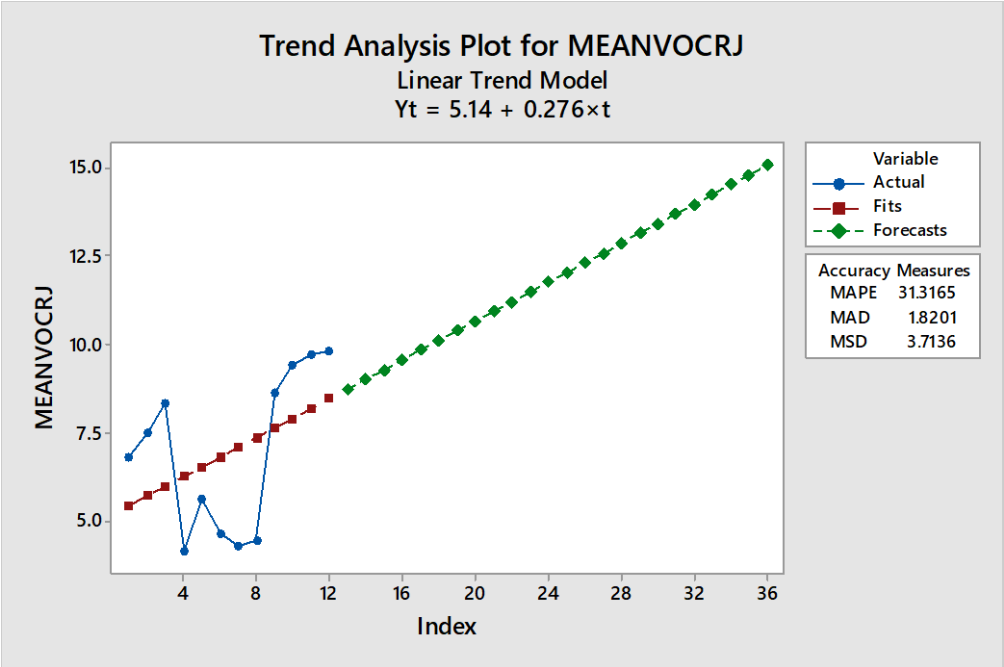

Fig 19: Displays the actual, trend analysis and forecast plot of the monthly average VOC (mg/M^3) of Gases Pollutant Concentration in RJ.

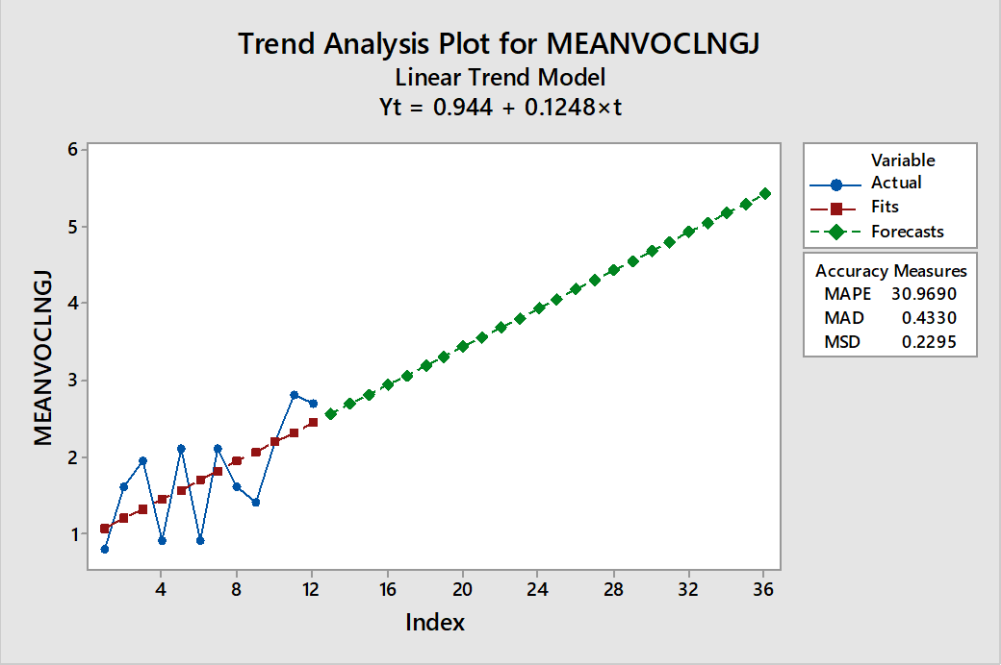

Fig 20: Displays the actual, trend analysis and forecast plot of the monthly average VOC (mg/M^3) of Gases Pollutant Concentration in LNGJ.

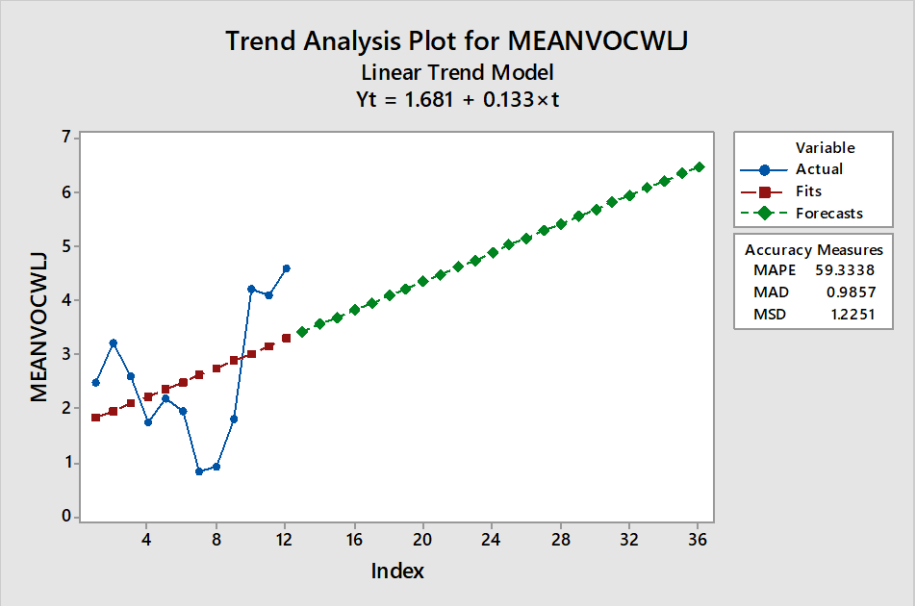

Fig 21: Displays the actual, trend analysis and forecast plot of the monthly average VOC (mg/M^3) of Gases Pollutant Concentration in WLJ.

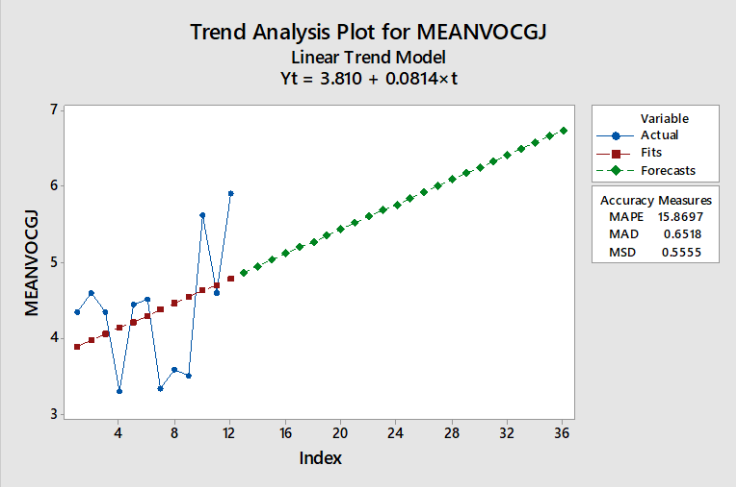

Fig 22: Displays the actual, trend analysis and forecast plot of the monthly average VOC (mg/M^3) of Gases Pollutant Concentration in GJ.

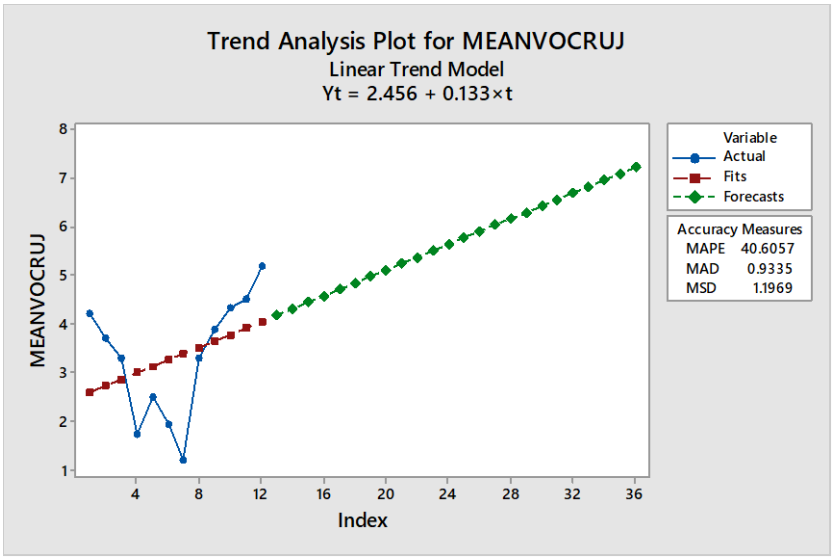

Fig 23: Displays the actual, trend analysis and forecast plot of the monthly average VOC (mg/M^3) of Gases Pollutant Concentration in RUJ.

Table 12: The average CO_2(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANCO2RJ	MEANCO2LNGJ	MEANCO2WLJ	MEANCO2GJ	MEANCO2RUJ
JANUARY	1264	436	587	1121	863
FEBRUARY	1354	423	579	1131	942
MARCH	1230	673	947	1014	947
APRIL	1229	474	940	1121	944
MAY	1245	470	474	1131	579
JUNE	1225	482	634	1123	983
JULY	1221	415	992	1229	1123
AUGUST	1231	436	1000	1225	1014
SEPTEMBER	1264	422	1018	1225	1018

OCTOBER	1354	415	1014	1230	1016
NOVEMBER	1230	579	1123	1229	1121
DECEMBER	1354	673	1121	1225	1131

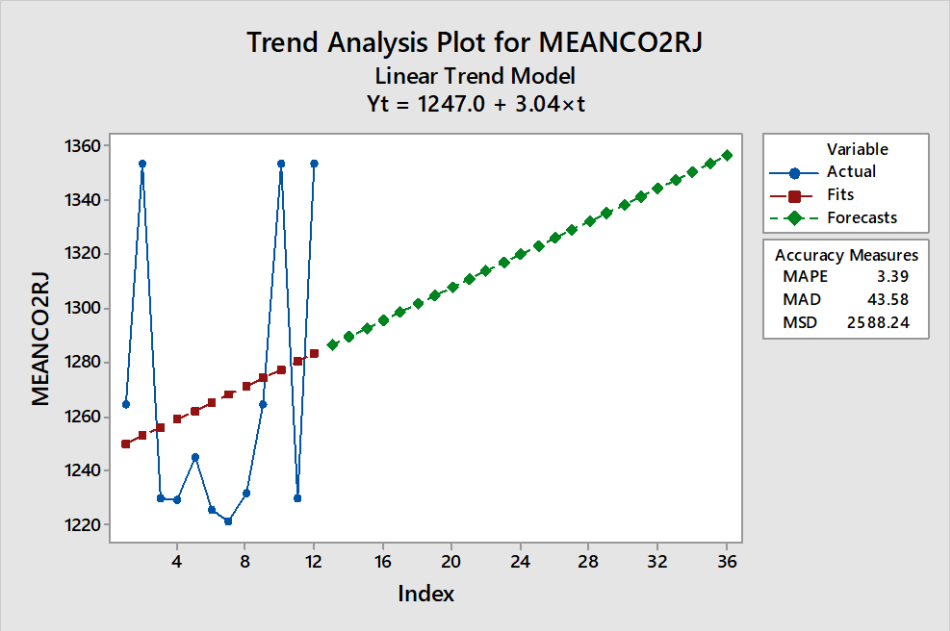

Fig 24: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in RJ.

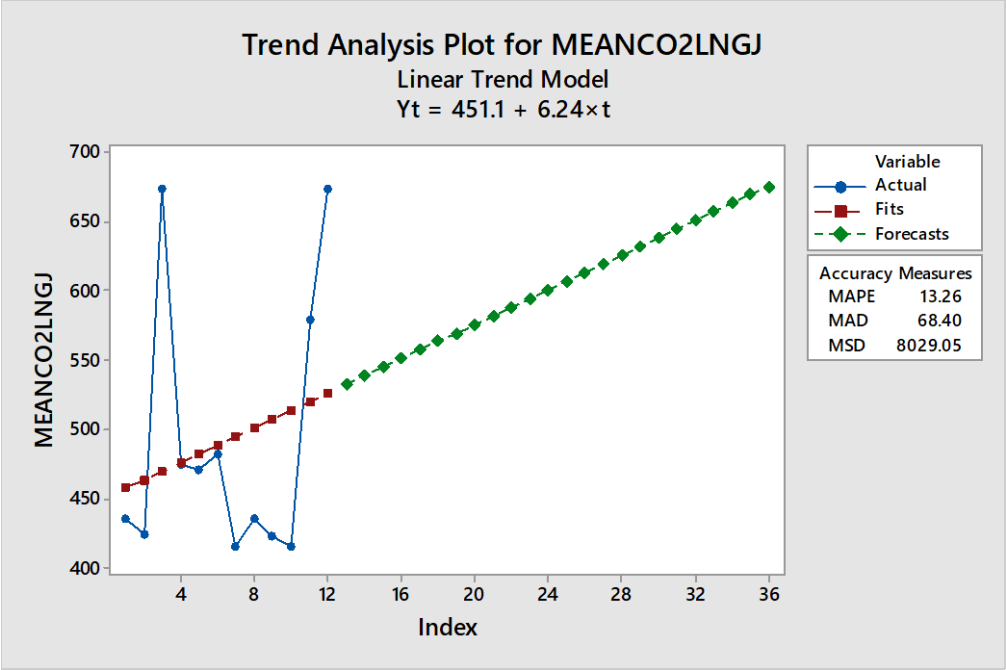

Fig 25: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in LNGJ.

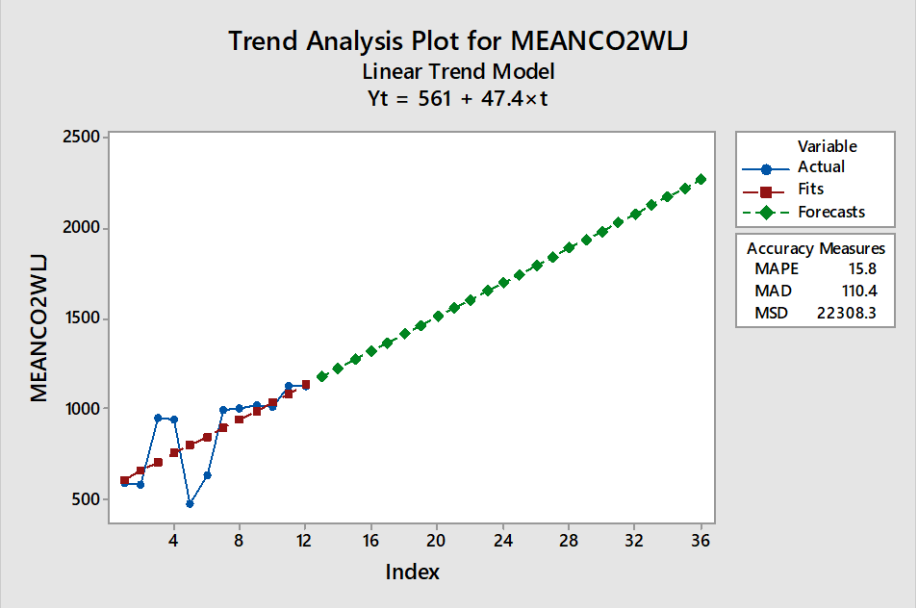

Fig 26: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in WLJ

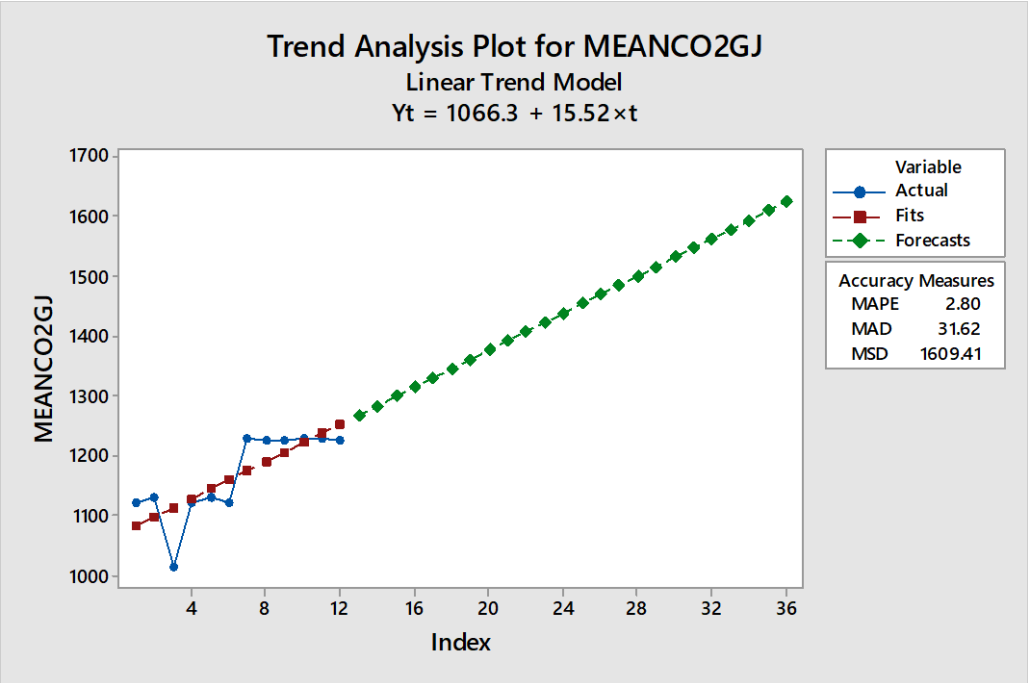

Fig 27: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in GJ

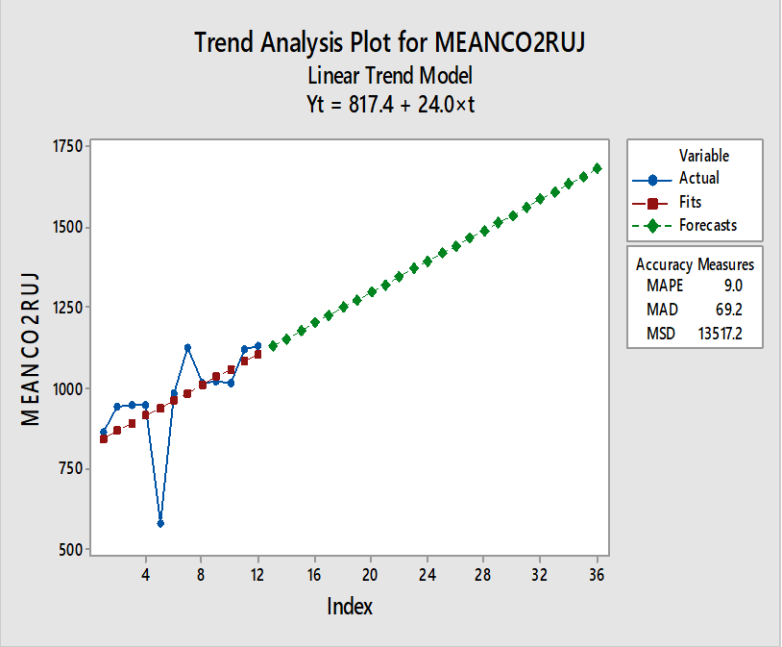

Fig 28: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in RUJ

Table 13: Shows the average NO_2(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANSO2RJ	MEANSO2LNGJ	MEANSO2WLJ	MEANSO2GJ	MEANS02RUJ
JANUARY	498	346	336	465	461
FEBRUARY	523	351	354	506	456
MARCH	485	356	354	465	450
APRIL	498	345	414	492	489
MAY	502	347	465	481	476
JUNE	552	346	356	485	388
JULY	573	333	345	376	354
AUGUST	561	343	347	420	356
SEPTEMBER	584	336	346	388	355
OCTOBER	669	354	484	552	465
NOVERMBER	683	414	485	573	506
DECEMBER	673	420	493	586	518

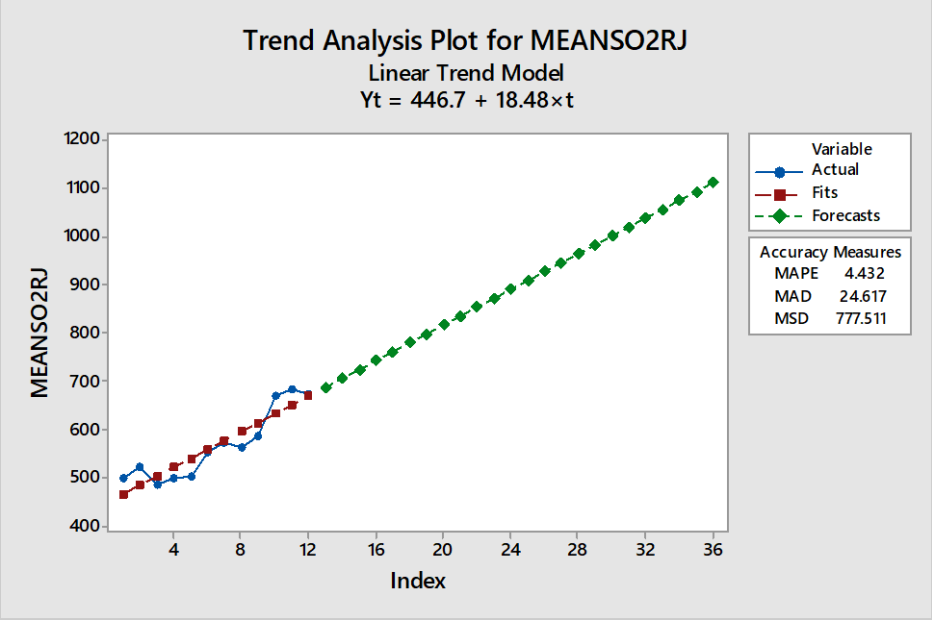

Fig 29: Displays the actual, trend analysis and forecast plot of the monthly average SO_2 (mg/M^3) of Gases Pollutant Concentration in RJ

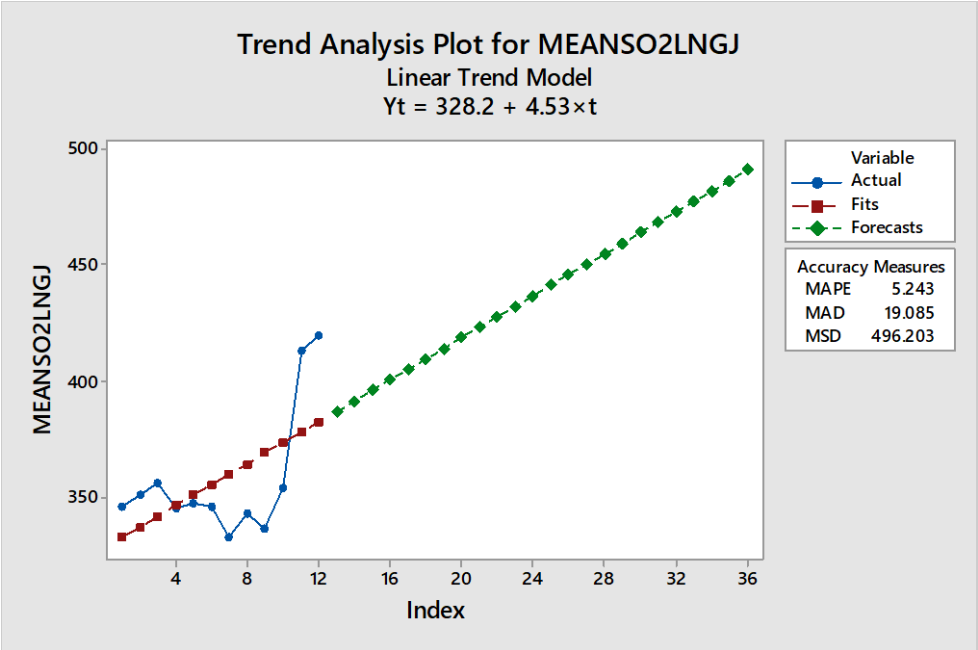

Fig 30: Displays the actual, trend analysis and forecast plot of the monthly average SO_2 (mg/M^3) of Gases Pollutant Concentration in LNGJ

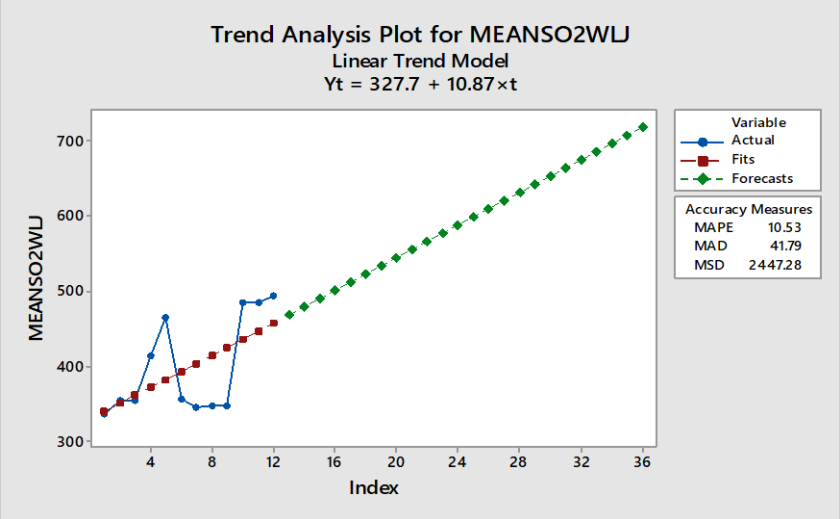

Fig 31: Displays the actual, trend analysis and forecast plot of the monthly average SO_2 (mg/M^3) of Gases Pollutant Concentration in WLJ

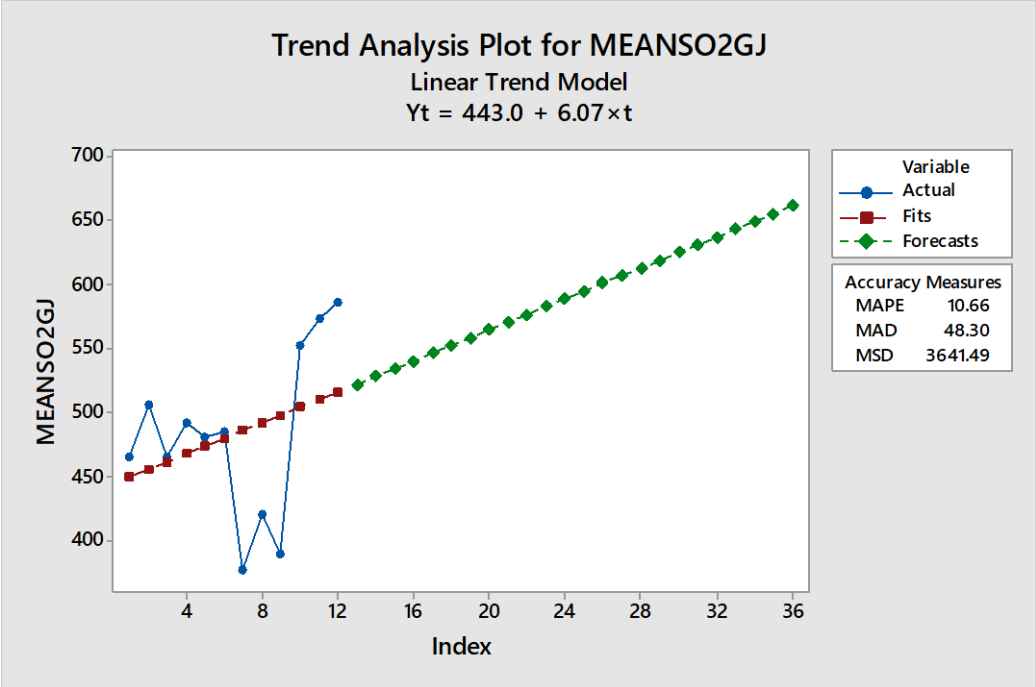

Fig 32: Displays the actual, trend analysis and forecast plot of the monthly average SO_2 (mg/M^3) of Gases Pollutant Concentration in GJ

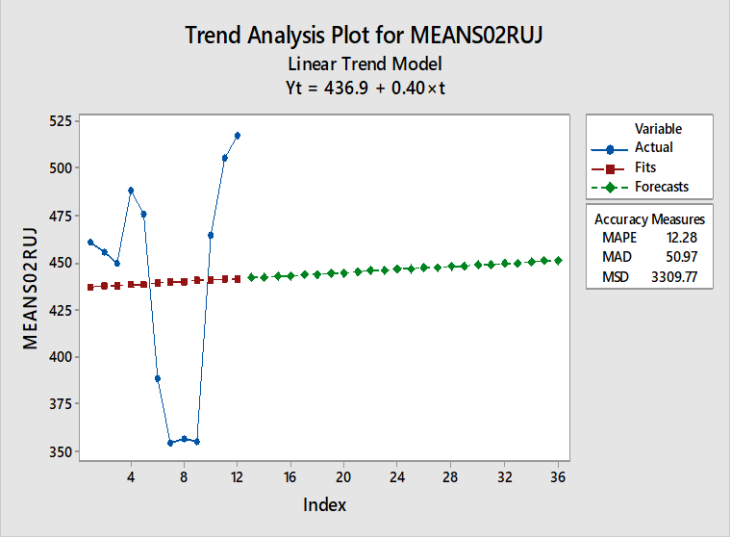

Fig 33: Displays the actual, trend analysis and forecast plot of the monthly average SO_2 (mg/M^3) of Gases Pollutant Concentration in RUJ

Table 14: Shows the average SO_2(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANNO2RJ	MEANNO2LNGJ	MEANNO2WLJ	MEANNO2GJ	MEANNO2RUJ
JANUARY	251	60	180	246	242
FEBRUARY	310	36	153	245	167
MARCH	251	38	132	242	237
APRIL	254	174	173	216	212
MAY	250	62	171	313	267
JUNE	167	60	147	158	149
JULY	252	36	217	232	220
AUGUST	205	38	124	167	154
SEPTEMBER	313	135	167	287	251
OCTOBER	310	147	187	223	214
NOVEMBER	355	128	190	310	245
DECEMBER	393	187	231	332	251

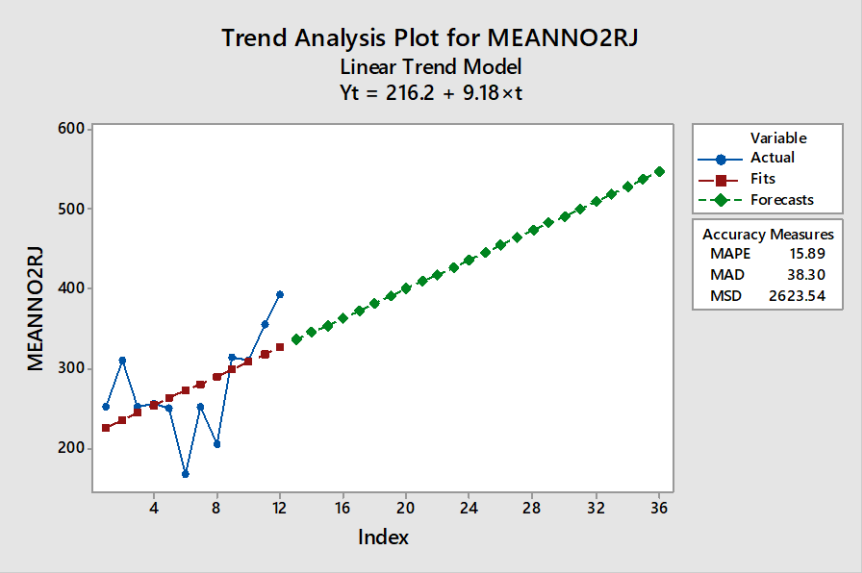

Fig 34: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in RJ

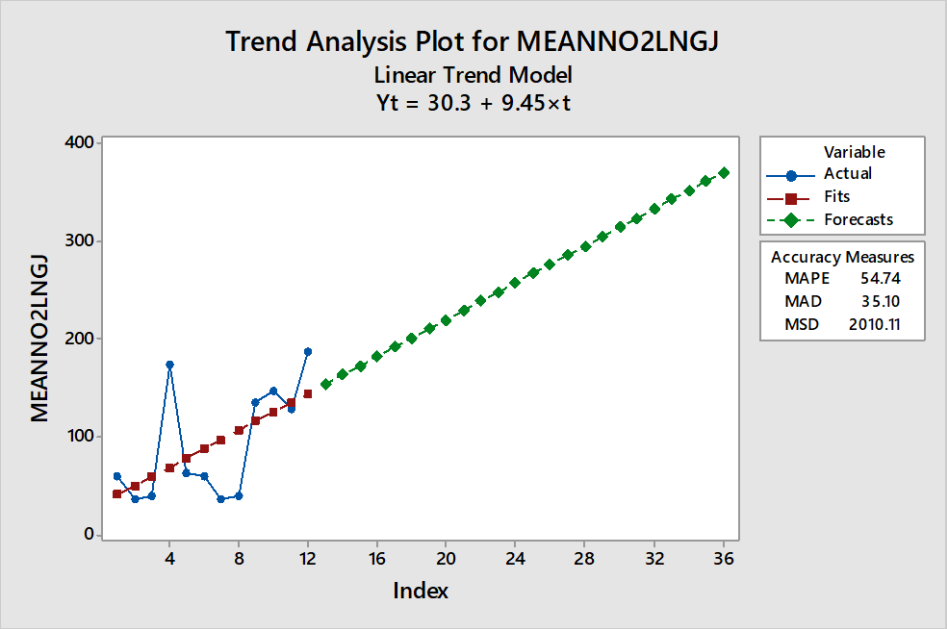

Fig 35: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in LNGJ

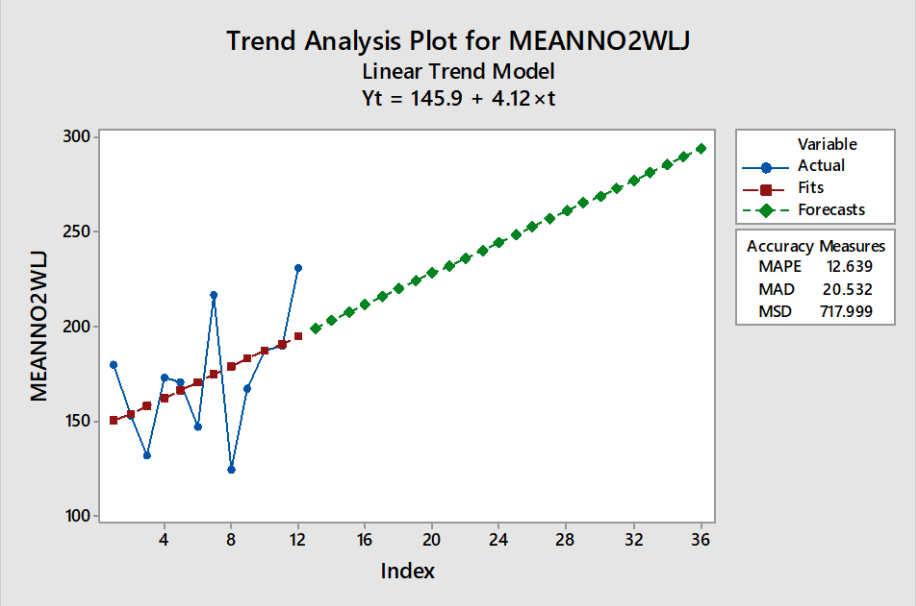

Fig 36: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in WLJ

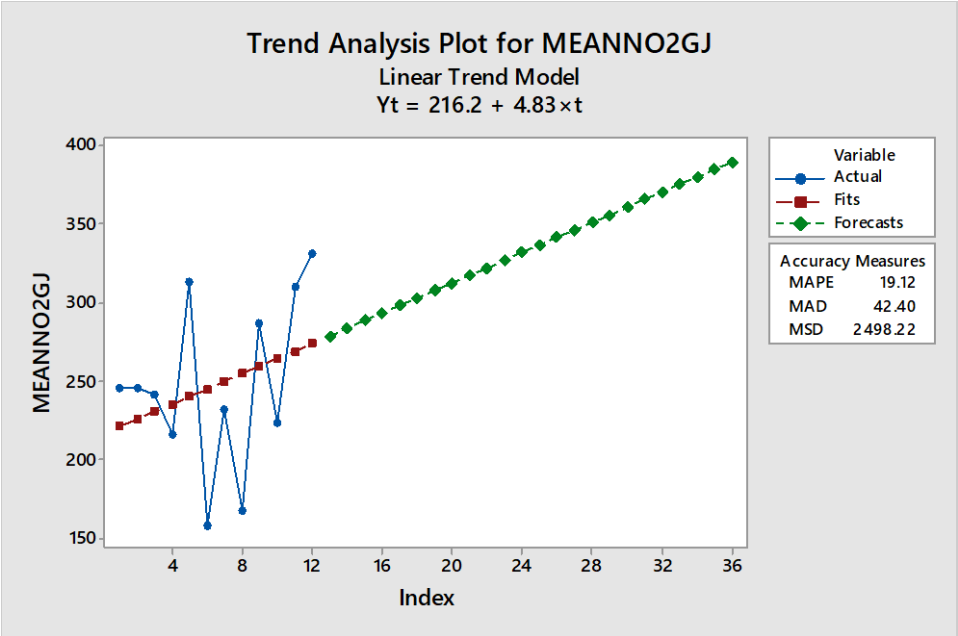

Fig 37: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in GJ

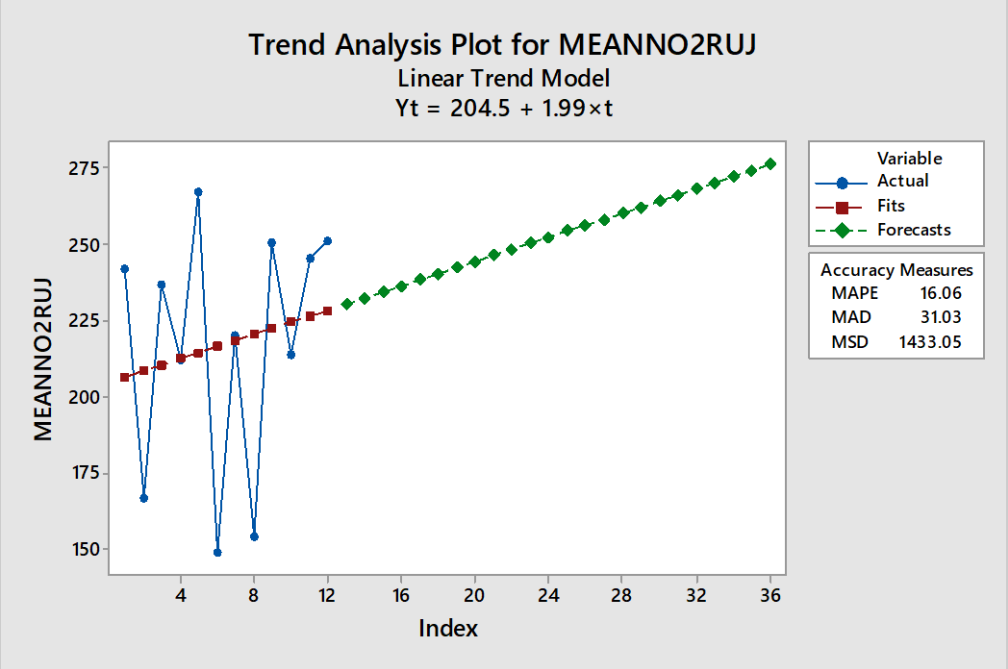

Fig 38: Displays the actual, trend analysis and forecast plot of the monthly average CO_2 (mg/M^3) of Gases Pollutant Concentration in RUJ

Table 15: Shows the average $PM_{2.5}$(µm/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANPM2.5RJ	MEANPM2.5LNGJ	MEANPM2.5WLJ	MEANPM2.5GJ	MEANPM2.5RUJ
JANUARY	47.4	22.9	28.6	42.7	37.9
FEBRUARY	41.6	21.0	23.4	35.1	28.4
MARCH	45.3	22.9	24.1	41.1	29.0
APRIL	45.9	23.4	27.6	42.3	35.1
MAY	50.3	24.1	29.1	45.3	41.1
JUNE	47.4	22.9	28.6	42.7	37.9
JULY	42.3	21.0	23.4	35.1	27.4
AUGUST	45.3	22.9	24.1	41.1	29.0
SEPTEMBER	52.3	27.6	36.9	45.9	42.3
OCTOBER	55.7	29.1	43.0	50.3	45.3
NOVEMBER	53.4	28.6	39.6	47.4	42.7
DECEMBER	55.8	34.2	42.8	54.2	44.2

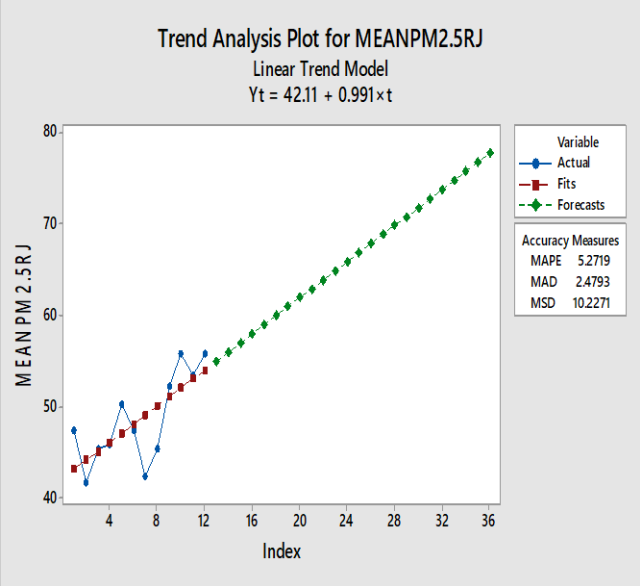

Fig 39: Displays the actual, trend analysis and forecast plot of the monthly average $PM_{2.5}$ (μm/M³) of Gases Pollutant Concentration in RJ

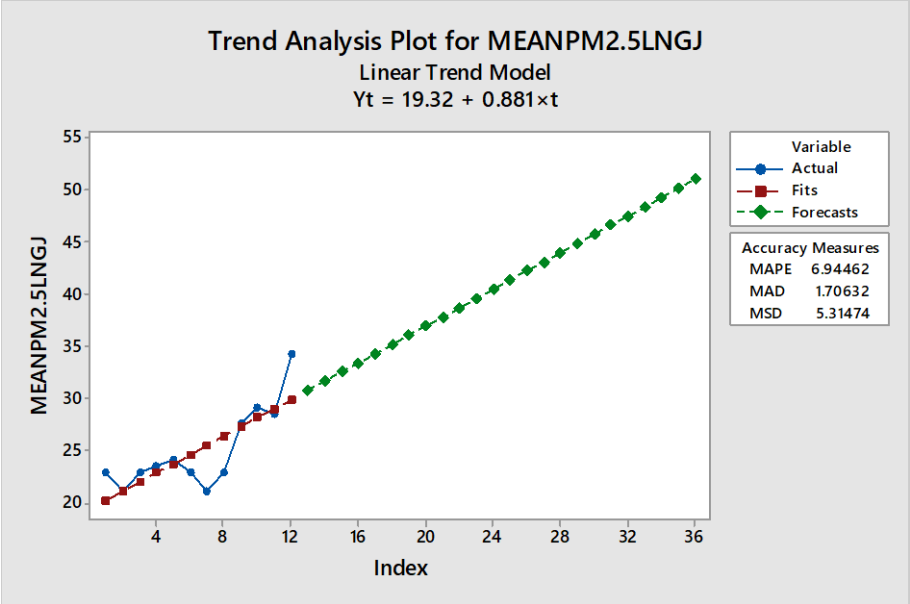

Fig 40: Displays the actual, trend analysis and forecast plot of the monthly average $PM_{2.5}$ (μm/M³) of Gases Pollutant Concentration in LNGJ

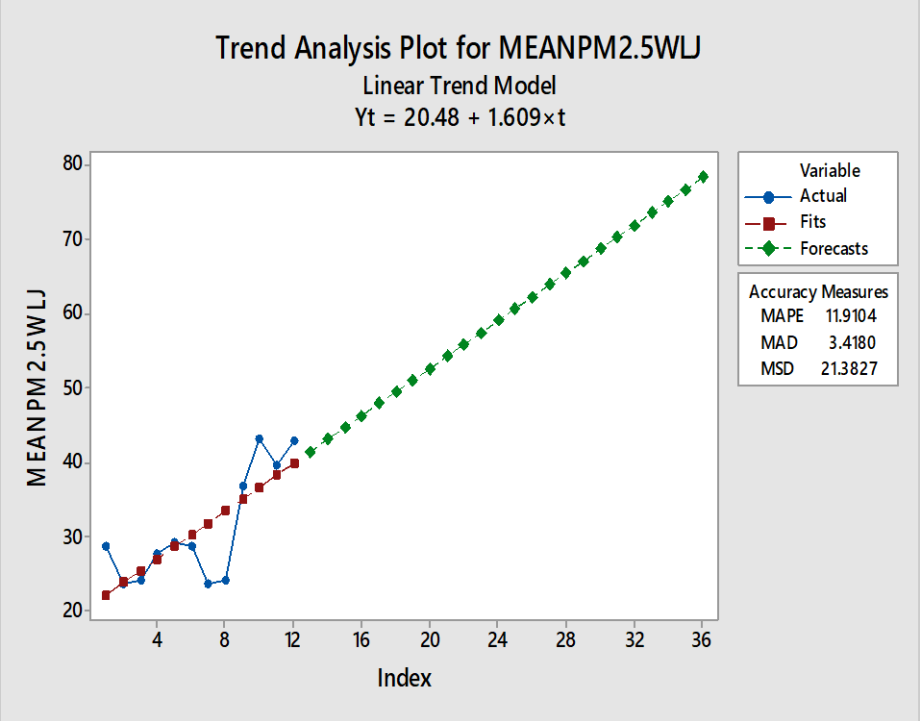

Fig 41: Displays the actual, trend analysis and forecast plot of the monthly average $PM_{2.5}$ (μm/M^3) of Gases Pollutant Concentration in WLJ

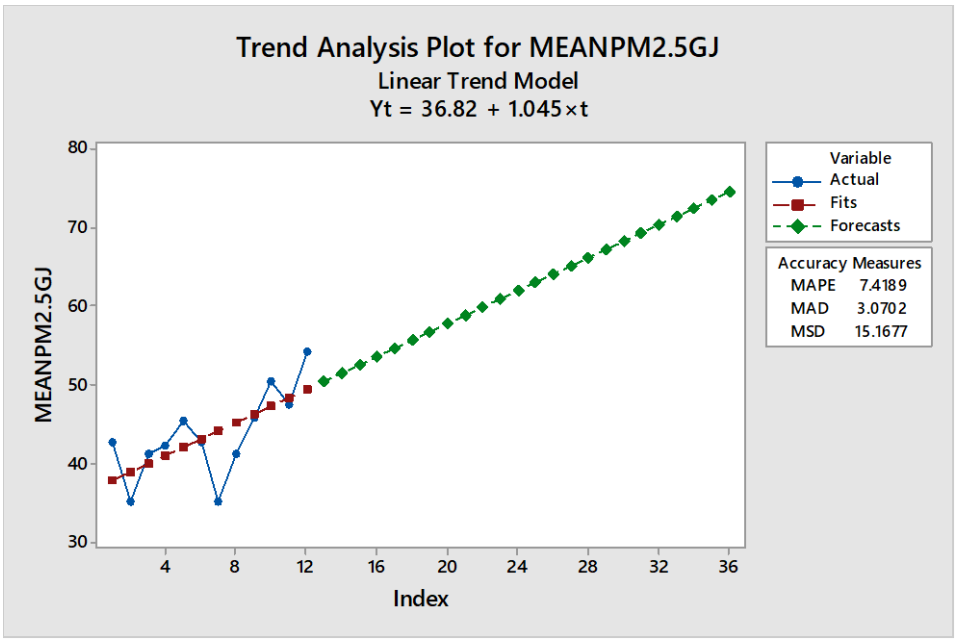

Fig 42: Displays the actual, trend analysis and forecast plot of the monthly average $PM_{2.5}$ (μm/M^3) of Gases Pollutant Concentration in GJ

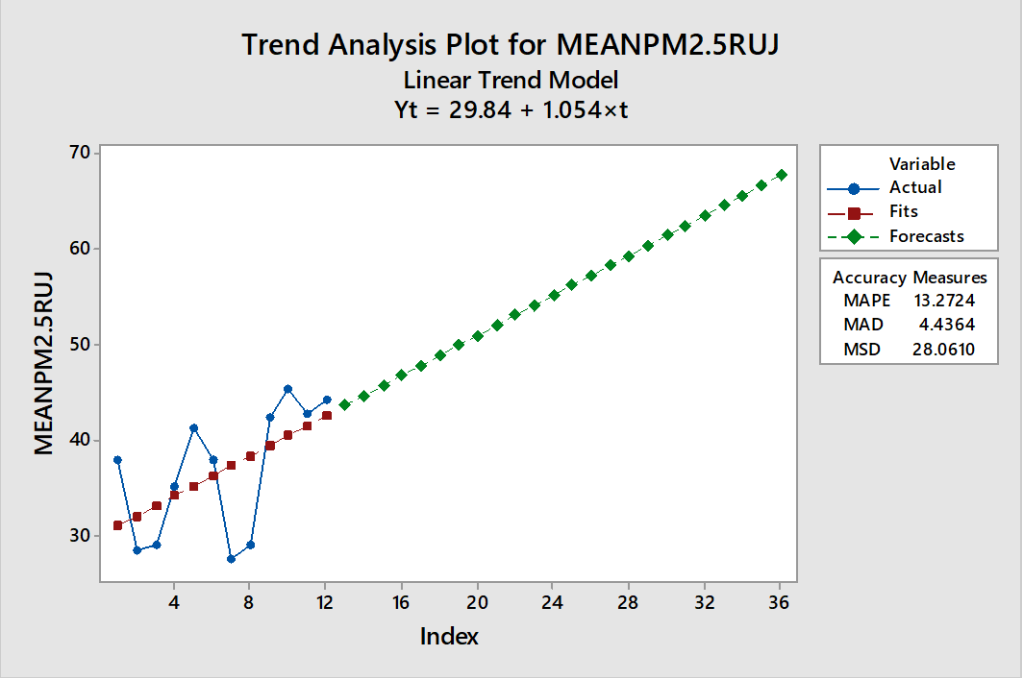

Fig 43: Displays the actual, trend analysis and forecast plot of the monthly average $PM_{2.5}$ (μm/M³) of Gases Pollutant Concentration in RUJ

Table 16: Shows the average PM_{10}(μm/m³) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

TIME	MEANPM10RJ	MEANPM10LNGJ	MEANPM10WLJ	MEANPM10GJ	MEANPM10RUJ
JANUARY	119.7	48.7	55.1	99.4	66.3
FEBRUARY	122.3	47.6	52.0	106.9	53.7
MARCH	130.3	98.5	101.2	124.6	103.1
APRIL	129.3	47.3	53.7	119.7	99.4
MAY	130.6	52.0	101.4	122.3	106.9
JUNE	129.6	51.0	99.4	120.1	101.4
JULY	119.7	45.7	47.3	99.4	51.0
AUGUST	122.3	47.6	52.0	106.9	53.7
SEPTEMBER	132.4	53.7	106.9	129.3	119.7
OCTOBER	136.1	101.4	120.1	130.6	122.3
NOVERMBER	133.3	99.4	119.7	129.6	120.1
DECEMBER	142.7	112.1	123.2	131.4	126.9

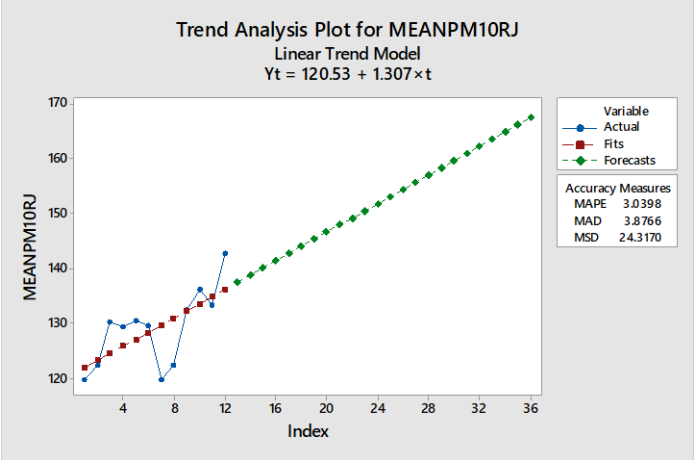

Fig 44: Displays the actual, trend analysis and forecast plot of the monthly average PM_{10} (μm/M^3) of Gases Pollutant Concentration in RJ

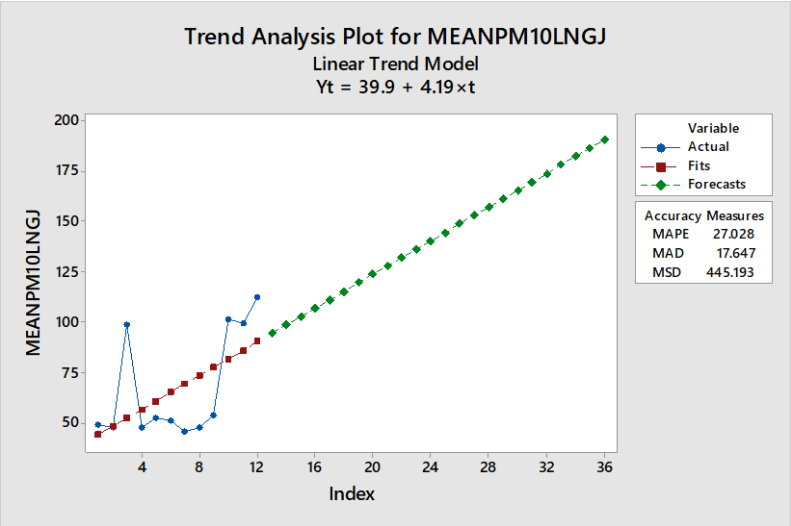

Fig 45: Displays the actual, trend analysis and forecast plot of the monthly average PM_{10} (μm/M^3) of Gases Pollutant Concentration in LNGJ

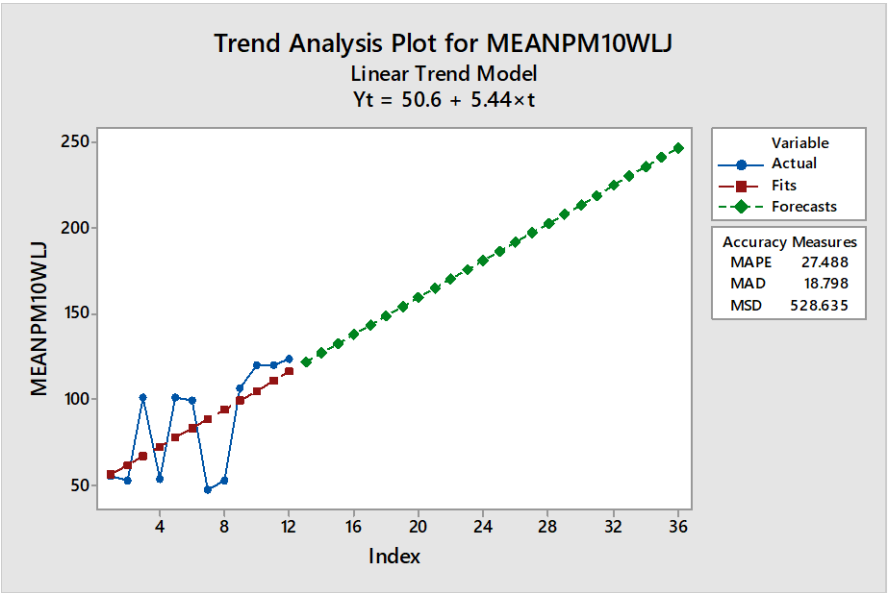

Fig 46: Displays the actual, trend analysis and forecast plot of the monthly average PM_{10} (μm/M^3) of Gases Pollutant Concentration in WLJ

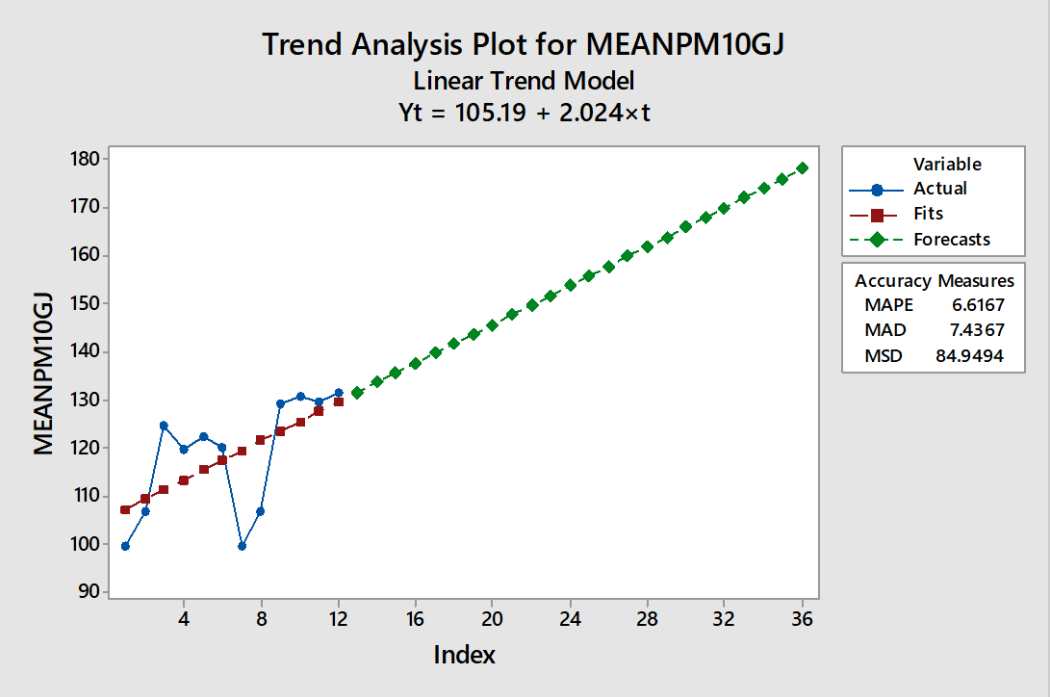

Fig 47: Displays the actual, trend analysis and forecast plot of the monthly average PM_{10} (μm/M^3) of Gases Pollutant Concentration in GJ

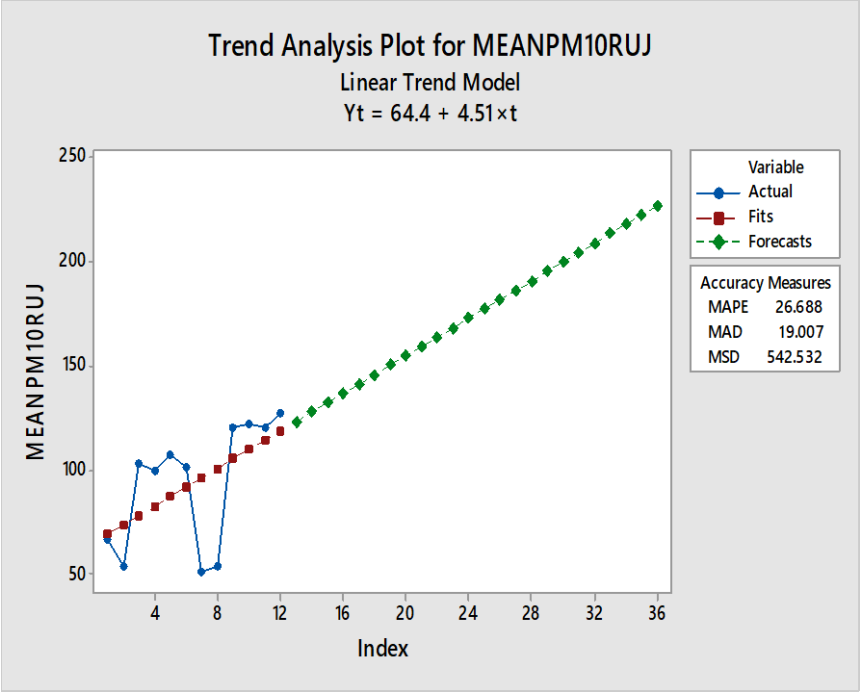

Fig 48: Displays the actual, trend analysis and forecast plot of the monthly average PM_{10} (μm/M^3) of Gases Pollutant Concentration in RUJ

Table 18: Shows the Average SL (dB) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

TIME	MEANSLRJ	MEANSLLNGJ	MEANSLWLJ	MEANSLGJ	MEANSLRUJ

JANUARY	112.8	84.0	104.3	111.6	107.2
FEBRUARY	113.6	77.9	82.4	85.1	84.4
MARCH	115.0	83.0	93.1	92.9	87.0
APRIL	125.3	82.4	83.0	113.6	85.1
MAY	126.3	93.1	91.7	115.0	92.9
JUNE	123.0	85.0	86.7	113.4	89.3
JULY	113.6	77.9	82.4	85.1	84.4
AUGUST	115.0	83.0	93.1	92.9	87.0
SEPTEMBER	123.3	83.0	89.3	125.3	113.6
OCTOBER	134.7	91.7	113.6	126.3	115.0
NOVEMBER	131.1	86.7	92.9	123.0	113.4
DECEMBER	134.6	98.9	114.3	128.1	115.2

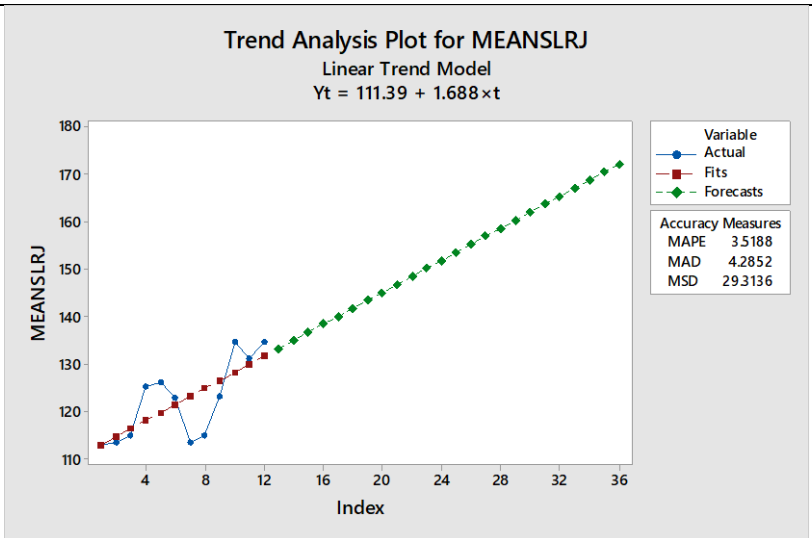

Fig 49: Displays the actual, trend analysis and forecast plot of the monthly average SL (dB) of Gases Pollutant Concentration in RJ

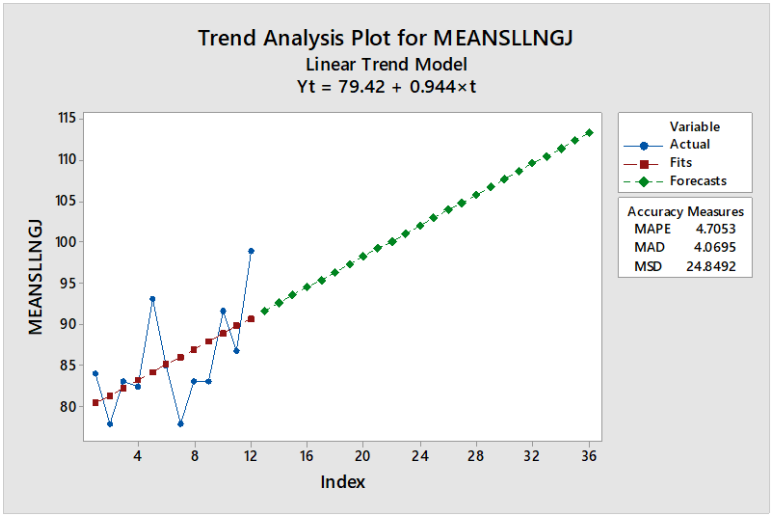

Fig 50: Displays the Actual, Trend Analysis and Forecast Plot of the Monthly Average SL (dB) of Gases Pollutant Concentration in LNGJ

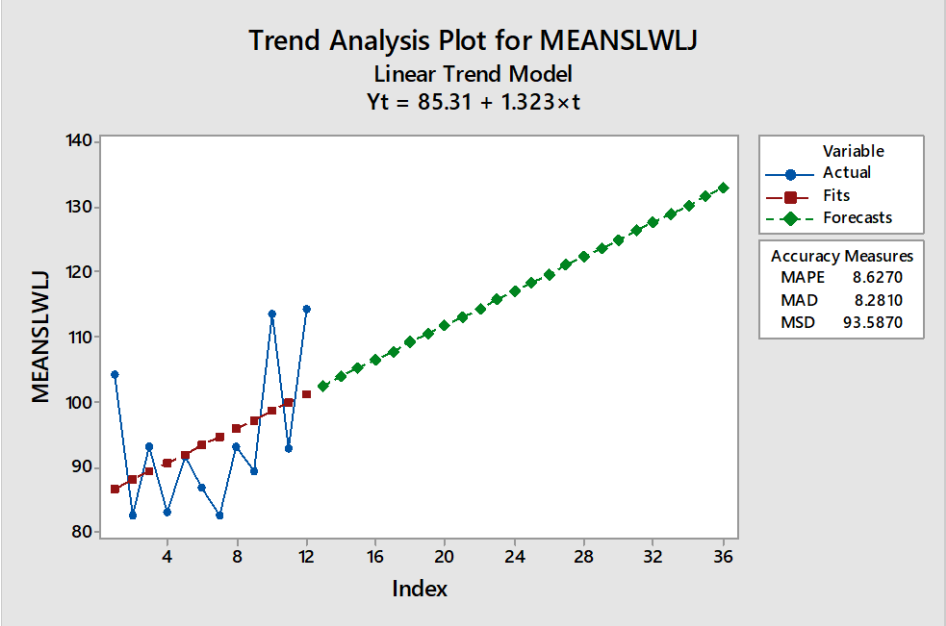

Fig 51: Displays the Actual, Trend Analysis and Forecast Plot of the Monthly Average SL (dB) of Gases Pollutant Concentration in WLJ

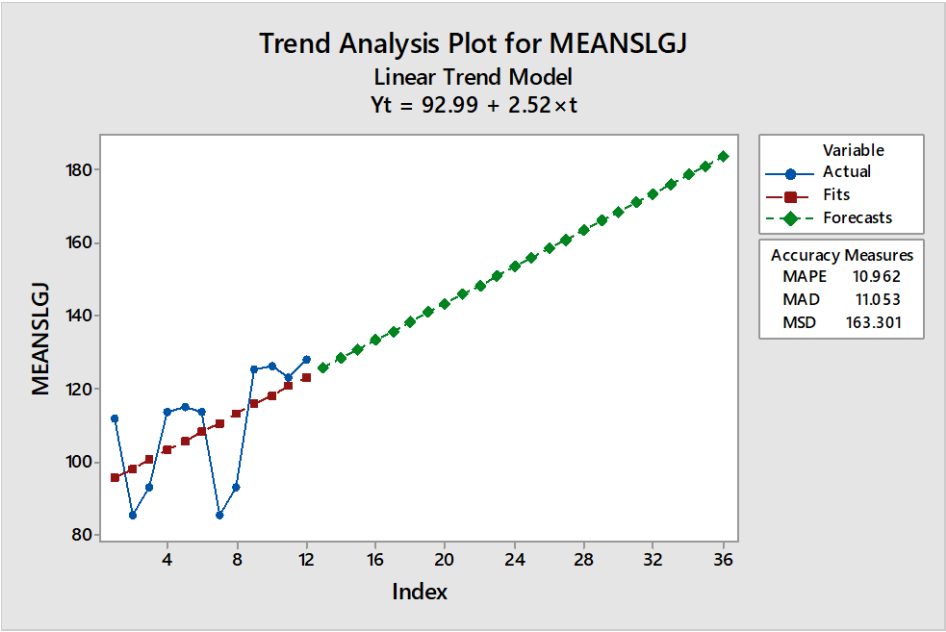

Fig 52: Displays the Actual, Trend Analysis and Forecast Plot of the Monthly Average SL (dB) of Gases Pollutant Concentration in GJ

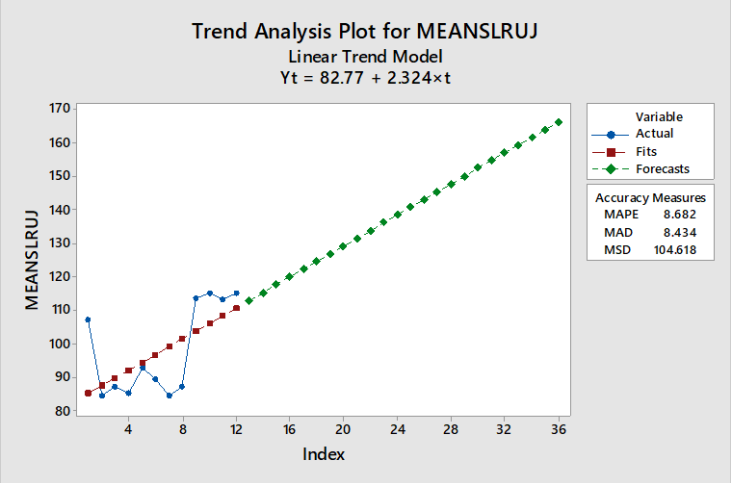

Fig 53: Displays the Actual, Trend Analysis and Forecast Plot of the Monthly Average SL (dB) of Gases Pollutant Concentration in RUJ

Estimation of Effect of Gases Pollutant Concentration in Port Harcourt

The study employed the analysis of variance to estimation and obtain the significant effect of the gases pollutant concentration in selected junctions of Port Harcourt.

Table 19: Shows the ANOVA of CO(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	325.9598	4	81.48995	15.24264	1.9E-08	2.539689
Within Groups	294.0401	55	5.346183			
Total	619.9999	59				

Table 20: Shows the ANOVA of VOC(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	193.0828	4	48.27069	25.99401	4E-12	2.539689
Within Groups	102.1346	55	1.856993			
Total	295.2173	59				

Table 21: Shows the ANOVA of CO_2(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	4375594	4	1093899	58.87255	3.1E-19	2.539689
Within Groups	1021944	55	18580.79			
Total	5397538	59				

Table 22: Shows the ANOVA of NO_2(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	311884.2	4	77971.05	21.22718	1.25E-10	2.539689
Within Groups	202024.4	55	3673.171			
Total	513908.6	59				

Table 23: Shows the ANOVA of SO_2(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	249703.4	4	62425.84	24.08646	1.51E-11	2.539689
Within Groups	142545.7	55	2591.74			
Total	392249.1	59				

Table 24: Shows the ANOVA of $PM_{2.5}$(μm/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	4286.156	4	1071.539	31.0454	1.57E-13	2.539689
Within Groups	1898.337	55	34.51523			
Total	6184.494	59				

Table 25: Shows the ANOVA of PM_{10}(μm/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	29890.8	4	7472.701	13.70316	8.13E-08	2.539689
Within Groups	29992.97	55	545.3267			
Total	59883.77	59				

Table 26: Shows the ANOVA of SL(μm/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

ANOVA

Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F crit***
Between Groups	9855.466	4	2463.866	18.18532	1.44E-09	2.539689
Within Groups	7451.761	55	135.4866			
Total	17307.23	59				

Estimation of Least Square Model

This section present the model for the study on the variables of interest.

Table 27: **Shows 2years forecast of CO(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.**

FORECAST	MEANCORJ	MEANCOLNGJ	MEANCOWLJ	MEANCOGJ	MEANCORUJ
1	20.1073	10.9721	14.7797	16.8413	16.8413
2	20.6826	11.1953	15.2053	17.1743	17.1743
3	21.258	11.4184	15.6309	17.5073	17.5073
4	21.8334	11.6416	16.0565	17.8403	17.8403
5	22.4087	11.8648	16.4822	18.1733	18.1733
6	22.9841	12.088	16.9078	18.5064	18.5064
7	23.5595	12.3111	17.3334	18.8394	18.8394
8	24.1348	12.5343	17.759	19.1724	19.1724
9	24.7102	12.7575	18.1846	19.5054	19.5054
10	25.2856	12.9807	18.6103	19.8384	19.8384
11	25.8609	13.2038	19.0359	20.1714	20.1714
12	26.4363	13.427	19.4615	20.5045	20.5045
13	27.0117	13.6502	19.8871	20.8375	20.8375
14	27.587	13.8734	20.3128	21.1705	21.1705
15	28.1624	14.0966	20.7384	21.5035	21.5035
16	28.7378	14.3197	21.164	21.8365	21.8365
17	29.3131	14.5429	21.5896	22.1695	22.1695
18	29.8885	14.7661	22.0153	22.5026	22.5026
19	30.4639	14.9893	22.4409	22.8356	22.8356
20	31.0392	15.2124	22.8665	23.1686	23.1686
21	31.6146	15.4356	23.2921	23.5016	23.5016
22	32.19	15.6588	23.7178	23.8346	23.8346
23	32.7653	15.882	24.1434	24.1677	24.1677
24	33.3407	16.1051	24.569	24.5007	24.5007

Table 28: Shows 2years forecast of VOC(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig

FORECAST	**MEANVOCRJ**	**MEANVOCLNGJ**	**MEANVOCWLJ**	**MEANVOCGJ**	**MEANVOCRUJ**
1	8.7249	2.5658	3.41385	4.86818	4.17922
2	9.0005	2.69058	3.54712	4.94955	4.31174
3	9.2761	2.81535	3.68039	5.03092	4.44426

4	9.5518	2.94013	3.81365	5.11229	4.57677
5	9.8274	3.0649	3.94692	5.19366	4.70929
6	10.103	3.18968	4.08019	5.27502	4.84181
7	10.3786	3.31445	4.21345	5.35639	4.97433
8	10.6543	3.43923	4.34672	5.43776	5.10684
9	10.9299	3.564	4.47999	5.51913	5.23936
10	11.2055	3.68878	4.61325	5.6005	5.37188
11	11.4811	3.81355	4.74652	5.68187	5.5044
12	11.7568	3.93833	4.87979	5.76324	5.63691
13	12.0324	4.0631	5.01305	5.84461	5.76943
14	12.308	4.18788	5.14632	5.92597	5.90195
15	12.5836	4.31265	5.27959	6.00734	6.03447
16	12.8593	4.43743	5.41285	6.08871	6.16698
17	13.1349	4.5622	5.54612	6.17008	6.2995
18	13.4105	4.68698	5.67939	6.25145	6.43202
19	13.6861	4.81175	5.81265	6.33282	6.56454
20	13.9618	4.93653	5.94592	6.41419	6.69705
21	14.2374	5.06131	6.07919	6.49555	6.82957
22	14.513	5.18608	6.21245	6.57692	6.96209
23	14.7886	5.31086	6.34572	6.65829	7.09461
24	15.0643	5.43563	6.47899	6.73966	7.22712

Table 29: Shows 2years forecast of CO_2(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig

FORECAST	MEANCO2RJ	MEANCO2LNGJ	MEANCO2WLJ	MEANCO2GJ	MEANCO2RUJ
1	1286.48	532.128	1177.42	1268	1129.57
2	1289.52	538.363	1224.84	1283.52	1153.58
3	1292.55	544.599	1272.27	1299.03	1177.59
4	1295.59	550.835	1319.69	1314.55	1201.6
5	1298.62	557.071	1367.11	1330.07	1225.62
6	1301.66	563.307	1414.53	1345.58	1249.63
7	1304.69	569.542	1461.95	1361.1	1273.64
8	1307.73	575.778	1509.37	1376.62	1297.65
9	1310.76	582.014	1556.79	1392.13	1321.66
10	1313.8	588.25	1604.21	1407.65	1345.67
11	1316.84	594.485	1651.63	1423.16	1369.68

12	1319.87	600.721	1699.05	1438.68	1393.69
13	1322.91	606.957	1746.47	1454.2	1417.7
14	1325.94	613.193	1793.89	1469.71	1441.71
15	1328.98	619.428	1841.31	1485.23	1465.73
16	1332.01	625.664	1888.73	1500.75	1489.74
17	1335.05	631.9	1936.15	1516.26	1513.75
18	1338.08	638.136	1983.57	1531.78	1537.76
19	1341.12	644.371	2030.99	1547.3	1561.77
20	1344.15	650.607	2078.42	1562.81	1585.78
21	1347.19	656.843	2125.84	1578.33	1609.79
22	1350.23	663.079	2173.26	1593.85	1633.8
23	1353.26	669.315	2220.68	1609.36	1657.81
24	1356.3	675.55	2268.1	1624.88	1681.82

Table 30: Shows 2years forecast of SO_2(mg/m^3) Gases Pollutant Concentration values in the selected Junctions of Port Harcourt, Nig.

FORECAST	MEANSO2RJ	MEANSO2LNGJ	MEANSO2WLJ	MEANSO2GJ	MEANS02RUJ
1	686.93	387.095	469.039	521.92	442.152
2	705.41	391.623	479.908	527.992	442.552
3	723.89	396.15	490.776	534.064	442.953
4	742.37	400.678	501.645	540.136	443.353
5	760.85	405.205	512.513	546.208	443.754
6	779.34	409.733	523.382	552.28	444.155
7	797.82	414.26	534.251	558.351	444.555
8	816.3	418.788	545.119	564.423	444.956
9	834.78	423.315	555.988	570.495	445.356
10	853.26	427.842	566.857	576.567	445.757
11	871.74	432.37	577.725	582.639	446.158
12	890.22	436.897	588.594	588.711	446.558
13	908.7	441.425	599.463	594.783	446.959
14	927.18	445.952	610.331	600.855	447.359
15	945.66	450.48	621.2	606.927	447.76
16	964.14	455.007	632.068	612.999	448.161
17	982.62	459.535	642.937	619.071	448.561
18	1001.1	464.062	653.806	625.143	448.962
19	1019.58	468.59	664.674	631.215	449.362

20	1038.06	473.117	675.543	637.287	449.763
21	1056.54	477.645	686.412	643.358	450.164
22	1075.02	482.172	697.28	649.43	450.564
23	1093.5	486.7	708.149	655.502	450.965
24	1111.98	491.227	719.017	661.574	451.365

Table 31: Shows 2years forecast of NO_2(mg/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig

FORECAST	MEANNO2RJ	MEANNO2LNGJ	MEANNO2WLJ	MEANNO2GJ	MEANNO2RUJ
1	335.563	153.076	199.403	279.043	230.359
2	344.745	162.523	203.519	283.876	232.352
3	353.926	171.971	207.636	288.709	234.345
4	363.108	181.418	211.753	293.541	236.338
5	372.29	190.866	215.87	298.374	238.331
6	381.472	200.314	219.987	303.207	240.324
7	390.654	209.761	224.104	308.039	242.317
8	399.835	219.209	228.221	312.872	244.31
9	409.017	228.656	232.338	317.705	246.303
10	418.199	238.104	236.455	322.537	248.296
11	427.381	247.551	240.571	327.37	250.289
12	436.563	256.999	244.688	332.203	252.282
13	445.745	266.446	248.805	337.035	254.275
14	454.926	275.894	252.922	341.868	256.268
15	464.108	285.341	257.039	346.701	258.261
16	473.29	294.789	261.156	351.533	260.254
17	482.472	304.237	265.273	356.366	262.247
18	491.654	313.684	269.39	361.199	264.24
19	500.835	323.132	273.506	366.031	266.233
20	510.017	332.579	277.623	370.864	268.226
21	519.199	342.027	281.74	375.697	270.219
22	528.381	351.474	285.857	380.529	272.212
23	537.563	360.922	289.974	385.362	274.205
24	546.745	370.369	294.091	390.195	276.198

Table 32: Shows 2years forecast of $PM_{2.5}$(μm/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

FORECAST	MEANPM2.5RJ	MEANPM2.5LNGJ	MEANPM2.5WLJ	MEANPM2.5GJ	MEANPM2.5RUJ
1	55.0013	30.7658	41.3922	50.4022	43.5442
2	55.9927	31.6466	43.0009	51.4468	44.5982
3	56.9841	32.5274	44.6096	52.4915	45.6522
4	57.9755	33.4083	46.2183	53.5361	46.7063
5	58.9669	34.2891	47.827	54.5808	47.7603
6	59.9583	35.1699	49.4357	55.6254	48.8144
7	60.9498	36.0507	51.0444	56.6701	49.8684
8	61.9412	36.9315	52.653	57.7148	50.9225
9	62.9326	37.8124	54.2617	58.7594	51.9765
10	63.924	38.6932	55.8704	59.8041	53.0306
11	64.9154	39.574	57.4791	60.8487	54.0846
12	65.9068	40.4548	59.0878	61.8934	55.1387
13	66.8982	41.3356	60.6965	62.938	56.1927
14	67.8896	42.2165	62.3052	63.9827	57.2468
15	68.881	43.0973	63.9139	65.0273	58.3008
16	69.8724	43.9781	65.5226	66.072	59.3548
17	70.8638	44.8589	67.1313	67.1167	60.4089
18	71.8552	45.7397	68.74	68.1613	61.4629
19	72.8467	46.6205	70.3487	69.206	62.517
20	73.8381	47.5014	71.9573	70.2506	63.571
21	74.8295	48.3822	73.566	71.2953	64.6251
22	75.8209	49.263	75.1747	72.3399	65.6791
23	76.8123	50.1438	76.7834	73.3846	66.7332
24	77.8037	51.0246	78.3921	74.4292	67.7872

Table 33: Shows the Forecast of PM_{10}(μm/m^3) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

FORECAST	MEANPM10RJ	MEANPM10LNGJ	MEANPM10WLJ	MEANPM10GJ	MEANPM10RUJ
1	137.518	94.316	121.379	131.499	123.041
2	138.825	98.505	126.821	133.523	127.553
3	140.132	102.695	132.263	135.546	132.064
4	141.438	106.884	137.705	137.57	136.576
5	142.745	111.074	143.147	139.594	141.088
6	144.052	115.263	148.589	141.618	145.599

7	145.359	119.453	154.031	143.641	150.111
8	146.666	123.642	159.473	145.665	154.623
9	147.972	127.832	164.915	147.689	159.134
10	149.279	132.021	170.357	149.712	163.646
11	150.586	136.211	175.799	151.736	168.158
12	151.893	140.4	181.241	153.76	172.669
13	153.199	144.59	186.683	155.783	177.181
14	154.506	148.779	192.125	157.807	181.692
15	155.813	152.968	197.567	159.831	186.204
16	157.12	157.158	203.009	161.854	190.716
17	158.427	161.347	208.451	163.878	195.227
18	159.733	165.537	213.893	165.902	199.739
19	161.04	169.726	219.335	167.925	204.251
20	162.347	173.916	224.777	169.949	208.762
21	163.654	178.105	230.219	171.973	213.274
22	164.961	182.295	235.661	173.996	217.786
23	166.267	186.484	241.103	176.02	222.297
24	167.574	190.674	246.545	178.044	226.809

Table 34: Shows the Forecast of SL(dB) Gases Pollutant Concentration Values in the Selected Junctions of Port Harcourt, Nig.

FORECAST	MEANSLRJ	MEANSLLNGJ	MEANSLWLJ	MEANSLGJ	MEANSLRUJ
1	133.324	91.685	102.505	125.721	112.986
2	135.012	92.629	103.827	128.239	115.31
3	136.699	93.573	105.15	130.757	117.634
4	138.387	94.516	106.473	133.274	119.958
5	140.075	95.46	107.795	135.792	122.282
6	141.762	96.404	109.118	138.31	124.607
7	143.45	97.348	110.441	140.828	126.931
8	145.138	98.291	111.763	143.345	129.255
9	146.825	99.235	113.086	145.863	131.579
10	148.513	100.179	114.409	148.381	133.903
11	150.2	101.122	115.731	150.899	136.227
12	151.888	102.066	117.054	153.416	138.552
13	153.576	103.01	118.377	155.934	140.876
14	155.263	103.953	119.699	158.452	143.2

15	156.951	104.897	121.022	160.969	145.524
16	158.638	105.841	122.345	163.487	147.848
17	160.326	106.785	123.667	166.005	150.173
18	162.014	107.728	124.99	168.523	152.497
19	163.701	108.672	126.313	171.04	154.821
20	165.389	109.616	127.635	173.558	157.145
21	167.076	110.559	128.958	176.076	159.469
22	168.764	111.503	130.281	178.594	161.793
23	170.452	112.447	131.603	181.111	164.118
24	172.139	113.391	132.926	183.629	166.442

Discussion

This research present the summary of the primarily empirical findings in the study environment. The discussion of pollutant diffusivity of vehicular emission in the five major junctions of Port Harcourt namely: Rumuokoro, LNG, Waterlines, Garrison and Rumuola junctions was to evaluate the effect of the following gases: Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen oxides (NO_2), Volatile Organic Compounds (VOCs), and Particulates Matter ($PM_{2.5}$ and PM_{10}), Sulphur Dioxide (SO_2) and Sound Level (SL) or Noise Pollution due to the level of congestion of vehicular movement in the area. The study is in no doubts about the veracity of the claims by scientists and researchers of the resultant effects of pollutant induced by automobiles at the selected junctions in Port Harcourt. The study however explained the phenomenon of road traffic air pollution which shows considerable variation within the selected junctions, this is shown in table 4.1, which also explain the mean weekly of CO gas pollutant concentration in the of study.

From the analysis in Fig. 4.1, indicates the bar chart showing the CO, by implication signifies that Rumuokoro junction has the highest emission of pollutant gases concentration in all the selected junctions of Port Harcourt, see Table 4.1, Fig. 4.1 and Fig. 4.2. The study also determines that VOC gas in the same Rumuokoro junction was seen to be the highest concentration see table 4.2, fig. 4.3 and fig. 4.4. From the study, it was observed that table 4.3, fig. 4.5, 4.7, 4.9, 4.13 and 4.15 on the same Rumuokoro junction is said to be the highest. The least pollutant gases concentration within the study area was found in LNG junctions, see Fig.4.2, 4.6, 4.8, 4.10, 4.12, 4.14 and 4.16 respectively.

The estimation of the result of the gases concentration on monthly average over the period of one year data collation is indicated in table 4.9 which shows the average CO gas pollutant concentration in all the selected junctions in Port Harcourt of the variables of study. The analysis in fig. 4.17 displays the actual values, trend and forecast plot of monthly average of carbon monoxides (CO) gas concentration in Rumuokoro junction. In line to determine the trend analysis of Carbon Dioxide (CO_2), Nitrogen oxides (NO_2), Volatile Organic Compounds (VOCs), and Particulates Matter ($PM_{2.5}$ and PM_{10}), Sulphur Dioxide (SO_2) and Sound Level (SL) in the five junctions of Port Harcourt, see fig. 4.17 to fig. 4.56. The study also indicates that fig. 4.17 to 4.56 provides the forecast plot of all the gases concentration over the period of two years at start origin of 13 to 36.

The least square estimate of the various gases with respect to the selected five major junctions were estimated in fig. 4.17 to 4.56. This estimates was based on average monthly concentration of the variable of interest, and eventually yields Equations in the figures above. The gas pollutant concentration of Carbon monoxide (CO) for the five selected major junctions namely: Rumuokoro, LNG, Waterlines, Garrison and Rumuola gave rise to the following equations: $Y_t = 12.63 + 0.575t$, $Y_t = 8.071 + 0.223t$,$Y_t = 9.25 + 0.426t$, $Y_t = 12.51 + 0.333t$, $Y_t = 9.51 + 0.53t$ in the figures above respectively. And the concentration of gas pollutant for the same selected junctions for Volatile Organic Compounds (VOC) yields equation 4.6 to 4.10 (ie $Y_t = 5.14 + 0.27t$, $Y_t = 0.944 + 0.1248t$, $Y_t = 1.681 + 0.133t$, $Y_t = 3.810 + 0.081t$, $Y_t = 2.456 + 0.133t$ respectively). In the same vain, the concentration

of gas pollutant for the same selected junctions for CO_2 yields equation 4.11 to 4.15 (ie $Y_t = 446.7 + 18.48t$, $Y_t = 328.2 + 453t$, $Y_t = 327.7 + 10.87t$, $Y_t = 443.0 + 6.07t$, $Y_t = 436.9 + 0.40t$). The study further revealed that, Sulphur Dioxide (SO_2), Nitrogen oxide (NO_2), Particulate matter ($PM_{2.5}$), Particulate matter (PM_{10}), and that of Sound Level (SL) gas concentration for the same five selected junctions gives rise to equations above.

The study through the estimated equations produce a valid forecast values for the period of 24 months, basically 2 years (2020 and 2021) see table 4.25 to 4,32 on the variables of interest for the selected five junctions in Port Harcourt. From the analysis at all the estimated/findings, it was established that Rumuokoro junction and Garrism junction will in future experience high / increasing level of gases concentration emission of vehicular diffusivity in the study area (also see fig. 4.17 to 4.56).

It is of great important that the overall effect of all the estimated gasses in five junctions of the study area is determined. This is shown in table 4.17 to 4.24, which indicates the analysis of variance table for the significant effect of the variables of interest. The condition of acceptance of the claim that there is no effect of the emission of gases on the human / living organism is clearly established. Hence the P-value of 1.9E-08, see table 4.17; 4E-12, see table 4.18; 3.1E-19, see table 4.19; 1.25E-10, see table 4.20; 1.51E-11; see table 4.21, 1.57E-13, see 4.22; 8.13E-08; see table 4.23; 1.44-09; see table 4.24 which shows the existence of significant effect of the vehicular emission of gasses in the selected junctions: Rumuokoro, LNG, Waterlines, Garrison and Rumuola, since the P-value < 0.05.

Conclusion

Finally, the investigation of Pollutant diffusivity of vehicular emission within some congested junctions in Port Harcourt revealed that gases pollutant concentration for CO, NO_2, SO_2, CO_2 VOC, $PM_{2.5}$, PM_{10} and noise level was found to be above the WHO limit, highest at Romuokoro, followed by Garrism, Rumuola and water lines junctions in Port Harcourt, where the intersections and traffic count is higher. It was also observed that LNG junction recorded the least emission concentration among all the other stations due to less traffic within the area. The study concludes that, gases pollutant concentration diffusivity observed is related to vehicular movement. Based on the analysis in table 4.1 to 4.31 and fig. 4.1 to 4.56, it is clear that, air quality standard will deteriorate as the city continues to grow which will eventually result in possible severe health consequences within the study area. This implies that, the health condition of roadside artisans, street hawkers, traffic workers, traders and, people living around these locations are at risk. The overall comparison of data for different sections shows that concentrations of the pollutants were fluctuating depending on the volume of traffic count within the area of interest.

6.2 Recommendations

1. The road network within the research axis of Port Harcourt should be improved by constructing more routes and bypass to ease the traffic.
2. All public facilities especially those located along major roads should have good parking plots before approval for construction.
3. The government should encourage the use of pollutant detecting equipment by training and retraining personnel in their various fields of application regarding road usage.
4. Business men and women should operates 15m away from all junctions in Port Harcourt.
5. Farmers cultivate their farms 20m away from all junctions in Port Harcourt.
6. The government should be engaged in projects that would ease traffic flow along the roads through the Ministry of Transport and Ministry of Works. Such projects should include the dualization of all major routes especially at T-junctions.
7. The government should work to improve fuel quality through sulfurs reduction.
8. The width of roads should be extended on approaching major cross junctions with more than twelve conflict points.

9. It is also recommended that at proximity of 500km from a developing area, where population is expected to increase, a boulevard should be constructed at the junction linking such area to the center of the town. Example is the Romuokoro, Romula and Garrism junctions.
10. In areas to be developed, the government should ensure a proper road plan is developed prior to construction of buildings.
11. Provisions for buses and taxi parks should be considered.

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