

Theoretical Prediction of Air Pollutants from Diesel Utilization at Base Transceiver Stations in Local Government Areas of Abia State, Nigeria

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ABSTRACT

Air pollutants are threats to air integrity. The aim of this work is to predict the amount of air pollutants from diesel utilization at Base Transceiver Stations (BTS) in local government areas of Abia State, Nigeria with a view of carrying out one way analysis of variance (ANOVA). The mass flow rate of particulate matter (PM), carbon monoxide (CO), oxides of nitrogen (NO_x) and oxides of sulphur (SO_x) were predicted using the model of Okedere et al.. ANOVA was carried out with the aid of in-built solver tool in MicroSoft Excel version 2007. The results obtained ranged between 10.05 and 34.16 tons/yr and between 30.75 and 104.20 tons/yr for PM and CO respectively. The values for oxides of nitrogen varied between 142.86 and 484.13 tons/yr while that of oxides of sulphur ranged between 9.39 and 31.82 tons/yr. The ANOVA result indicated that there were significant differences in the mean air pollutants emitted from BTS at 5% significant level which implied that the pollutants from BTS in local government areas in Abia State may lead to different health problems. It is pertinent that regulatory agencies and policies makers ensure BTS owners put control in place to minimize the emission of pollutants from BTS.

Keywords: Abia state, base transceiver stations, diesel utilization, pollutants, prediction

1. INTRODUCTION

Air is made up of a mixture of gases and particulates which have been released into the atmosphere by man – made processes [1]. Contamination occurs when concentration of chemicals, nutrients or elements in the environment becomes more than its normal or natural level as a result of human actions. Contamination is a problem the world is currently battling [2 – 8]. Air pollution is the contamination of air which makes it unfit for living. Over the past few decades, studies have shown that repeated exposures to ambient air pollutants over a prolonged period of time increases the risk of susceptibility to air borne diseases such as cardiovascular disease, respiratory disease and lung cancer [9 – 10]. Air pollution is a threat not only to living beings but also to plants and vegetations in developed and developing countries.

The telecommunication operators make use of Base Transceiver Stations (BTS) and masts which form part of the infrastructure required for effective telecommunication system [11 - 12]. BTS equipment have to be powered by electricity but because of the epileptic power supply in the country, the BTS are powered by diesel fuelled 27 kVA electric power generators, Every BTS normally have two sets of electric power generators, when one is functioning, the other will be on standby so that no time is lost since there is no guarantee of stable supply of electricity from the national grid [12]. The combustion of diesel emits pollutants which include oxides of nitrogen (NO_x), oxides of sulphur (SO_x), particulate matter (PM) and carbon monoxide (CO) [12 - 14].

Several researchers have worked on air pollution. The examination of concentrations of pollutants and their effects on environment have been carried out by some scholars [15 - 18]. Kanchan and Pramila (2015) [9] reviewed air quality indexing system. The review revealed various indices used by different countries for computing air quality. Okedere et al. (2016) [12] estimated air pollutants from utilization of diesel as energy source at BTS in Nigeria. The work revealed that there was significant increase in the annual amount of pollutants released from BTS into the Nigeria’s air shed as a result of increase in diesel consumption. However, the work did not estimate the amount of air pollutants from diesel utilization as energy source at BTS in each state of Nigeria. It is very essential that the amount of air pollutants from diesel utilization as energy source at BTS in each state of Nigeria are known for state environmental protection agencies to take necessary decisions and actions for the protection of environmental integrity. Therefore, the aim and object of this work is to predict the amount of air pollutants from diesel utilization at BTS in local government areas of Abia State, Nigeria with a view of carrying out one way analysis of variance (ANOVA). It is imperative that the prediction of the amount of air pollutants from diesel utilization at BTS in local government areas of Abia State is carried out in order to make available fundamental air pollutants data base which can be used by chemical engineers, environmental engineers, scientist, regulatory bodies and other users of such materials who might work on pollutants from diesel utilization at BTS which justifies this work. Moreover, if the amount of air pollutants from BTS in Abia State contributes to the Nigeria’s air shed is established, it will help the authorities and policy makers to put in place environmental policies and plans to mitigate the pollutants which further justifies this work.

1.1 The Study Area

Abia State was created on August 27, 1991 with its capital in Umuahia. It is an acronym formed from the initial letters of four groups of people: Aba, Bendel, Isuikwuato and Afikpo (Nigeria Galleria, 2017). Abia State is situated between latitudes 04^o45’ and 6^o07’ north and longitude 07^o00’ and 08^o10’ east. It is located in the south – eastern geo – political region of Nigeria and bounded at the west by Imo State, at the south by River State, at the north by Anambra and Ebonyi State and at the east by Cross – River State [11]. Abia State covers an area of about 5,243 square kilometers which is approximately 5.8 percent of the total land area of Nigeria [19] and has seventeen local government areas. The map of Nigeria and map of Abia State showing the seventeen local government areas are presented in Figure 1.

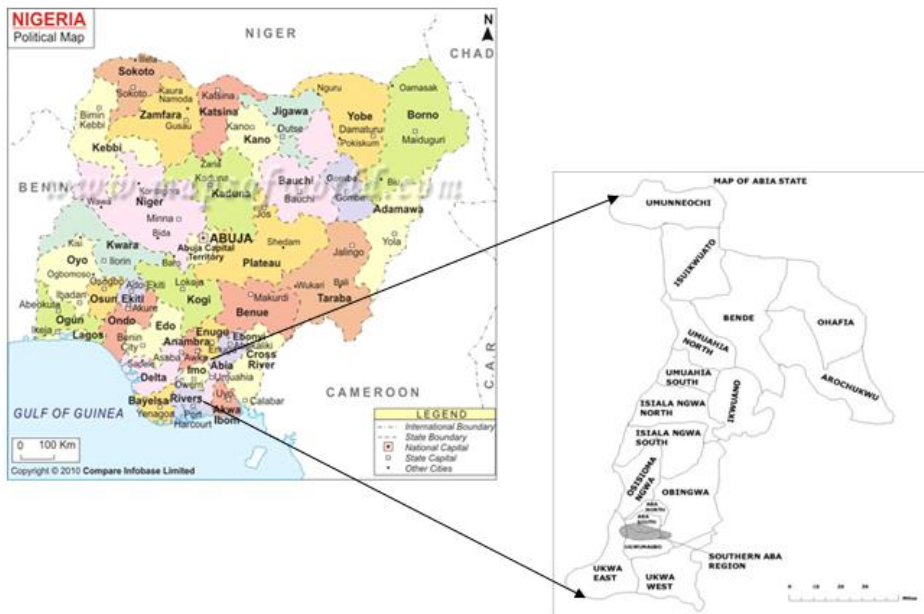


Fig. 1. Map of Nigeria and map of Abia State

Source: Ogonna et al., (2016) [11] and Ministry of Land and Urban Planning, Abia State, Nigeria (2017) [20].

2. METHODOLOGY

The reported industry figure of 1 gallon of diesel consumed per BTS generator per hour [12] was used. The flow rate of PM, SO_x, CO and NO_x for each of the local government in Abia State were predicted using the model of Okedere et al., 2016 [12] shown in Equations 1 – 4. The values of D were obtained by multiplying the number of base stations in each local government shown in Table 1 which was taken from the work of Ogbonna et al., 2016 [11] by 3. One way analysis of variance was carried out on the flow rate data obtained using the in-built solver tool in Microsoft Excel version 2007.

$$PM(\text{tons/yr}) = D \times (42.5 \text{ lbs PM} \setminus 1000 \text{ gallons of diesel}) \times (8760 \text{ hrs} \setminus \text{yr}) \times (1 \text{ ton} \setminus 2000\text{lbs}) \quad (1)$$

$$SO_x(\text{tons/yr}) = D \times (39.7 \text{ lbs } SO_x \setminus 1000 \text{ gallons of diesel}) \times (8760 \text{ hrs} \setminus \text{yr}) \times (1 \text{ ton} \setminus 2000\text{lbs}) \quad (2)$$

$$CO(\text{tons/yr}) = D \times (130 \text{ lbs } CO \setminus 1000 \text{ gallons of diesel}) \times (8760 \text{ hrs} \setminus \text{yr}) \times (1 \text{ ton} \setminus 2000\text{lbs}) \quad (3)$$

$$NO_x(\text{tons/yr}) = D \times (604 \text{ lbs } NO_x \setminus 1000 \text{ gallons of diesel}) \times (8760 \text{ hrs} \setminus \text{yr}) \times (1 \text{ ton} \setminus 2000\text{lbs}) \quad (4)$$

Table 1. Distribution of BTS by local governments in Abia State, Nigeria

S/N	Local government	Number of base stations	Percentage
1	Aba North	54	8.64
2	Aba South	61	9.76
3	Arochukwu	29	4.64
4	Bende	36	5.76
5	Ikwuano	48	7.68
6	Isiala Ngwa North	33	5.28
7	Isiala Ngwa South	39	6.24
8	Isuikwato	21	3.36
9	Obi Ngwa	36	5.76
10	Ohafia	27	4.32
11	Osioma	41	6.56
12	Ugwunagbo	28	4.48
13	Ukwa East	27	4.32
14	Ukwa West	25	4.0
15	Umuahia North	53	8.48
16	Umuahia South	49	7.84
17	Umunneochi	18	2.88

3. RESULTS AND DISCUSSION

Table 2 presents the numerical values of pollutants from BTS in local government areas of Abia State, Nigeria. The standard characteristics of diesel stipulated by the department of petroleum resources are assumed in this work. The values of particulate matter ranged between 10.05 and 34.16 tons/yr with Aba South and Umunneochi having the highest and least value of 34.16 and 10.05 tons/yr respectively. This is due to the fact that Aba South and Umunneochi have the highest and least number of base stations of 61 and 18 respectively. Most particulate matters are resulted from incomplete combustion of hydrocarbons in the fuel [21]. The formation process of particulate emissions is dependent on combustion and expansion process, fuel quality, combustion temperature and exhaust gas cooling [21-22].

Particulate matter emissions when inhaled may cause health problems such as premature death, asthma and lung cancer [21]. Particulate emissions contribute to pollution of air, water, soil, cause reductions in visibility and global climate change [23 - 25]. This indicates that the people in Aba South local government of Abia state have a higher chance of developing health problems associated with particulate matter emissions from BTS than those in Umunneochi local government of Abia State because of the amount of particulate matter emissions from Aba South which is thrice the amount from Umunneochi.

The numerical values of carbonmonoxide varied between 30.75 and 104.20 tons/yr with Aba South and Umunneochi local government having the highest and least value respectively. Carbonmonoxide occurs as a result of incomplete combustion that is the oxidation process of incomplete. it is a strong reducing agent and capable of reducing metallic oxides to their metals. It combines with haemoglobin to produce carbon – oxyhaemoglobin which causes seizure, coma and fatality [26]. People in Aba South are more prone to health problems resulting from carbonmonoxide because Aba South has the highest value of carbonmonoxide emissions.

The values of oxides of nitrogen ranged between 142.86 and 484.13 ton/yr. Ibrahim et al., 2014 revealed that oxides of nitrogen content in exhaust of diesel engine has the highest percentage among the pollutants emissions. This work also corroborated the findings of Ibrahim et al., 2014 as the values of oxides of nitrogen among the pollutants investigated are the highest in each of the local government. Oxides of nitrogen emissions

Table 2. Numerical values of pollutants from BTS in local government areas of Abia State, Nigeria

S/N	Local Government Area	Ton/yr			
		PM	CO	NO _x	SO _x
1	Aba North	30.16	92.24	428.51	28.16
2	Aba South	34.07	104.20	484.13	31.82
3	Arochukwu	16.20	49.54	230.16	15.12
4	Bende	20.10	61.50	285.72	18.78
5	Ikwuano	26.81	82.00	380.95	25.04
6	Isiala Ngwa North	18.43	56.37	261.91	17.21
7	Isiala Ngwa South	21.78	66.62	309.8	20.34
8	Isuikwato	11.73	35.87	166.67	10.95
9	Obi Ngwa	20.10	61.50	285.72	18.78
10	Ohafia	15.08	46.12	214.29	14.08
11	Osisoma	22.90	70.04	325.40	21.39
12	Ugwunagbo	15.64	47.83	222.23	14.61
13	Ukwa East	15.08	46.12	214.29	14.08
14	Ukwa West	13.96	42.71	198.41	13.04
15	Umuahia North	29.60	90.53	420.64	27.65
16	Umuahia South	27.36	83.70	388.89	25.56
17	Umunneochi	10.05	30.75	142.86	9.39

contribute to formation of ozone, acidification and smog formation which have become considerable problems in most major cities of world [21]. Oxides of nitrogen are referred as nitrogen (II) oxide (NO) and nitrogen (iv) oxide (NO₂). NO constitutes 85 – 95% of NO_x and is converted to NO₂ in the atmospheric air [21]. However there is a distinctive differences between NO and NO₂. No is a colourless and odorless gas while NO₂ is a reddish brown gas with pungent odour [27 - 29].

Oxides of sulphur or sulphur (iv) oxide are formed during combustion process in the generators because of presence of sulphur content in the fuel. The numerical values of oxides of sulphur varied between 9.39 and 31.82 tons/yr with Aba South and Umunneochi having the highest and least value of 31.82 and 9.39 tons/yr respectively. The highest value of 31.82 tons/yr of oxides of sulphur from Aba South local government is due to the highest number of base stations presence in Aba South among all the local government in Abia State. Sulpur (iv) oxide is a colourless and poisonous gas with a very irritating smell like that of burning matches. It is very soluble in water and about 2.5 times denser than air [30].

The pollutants from BTS have very serious environmental implications hence they should be controlled. The particulate matter can be controlled with the use of particulate filters which are used to remove particulate matter emissions from exhaust gas by physical filtration. The filters are attached to exhaust channel and the particulate matters pass through the porous substrate walls which act as mechanical filters as shown in Figure 2. The soot particles are transported into the pore walls by diffusion as they pass through the wall and they adhere [29].

Oxides of nitrogen emissions can be minimized by hydrocarbon selective catalytic reaction (HC - SCR). The most promising catalyst for HC – SCR is Ag – Al₂O₃ [29]. Hydrocarbons such as ethanol, acetone and propanol are used as reductants. They are injected into the exhaust stream to aid reduction of oxides of nitrogen. Oxides of Sulphur emission can be minimized using exhaust gas scrubber technology. The exhaust gas is passed through the scrubber tower where a liquid which is a blend of fresh water and caustic soda is showered over it. Carbonmonoxide can be controlled using diesel oxidation catalyst (DOC) method. DOC oxidizes carbonmonoxide emissions. Diesel exhaust gases contain oxygen ranging from 2 to 17 percent by volume which does react with fuel in the combustion chamber and it is consumed in DOC [28, 31]. Above all, the best way to avoid pollutants from BTS is to do away with fossil fuel. Nigeria should improve on its electricity generation so that users of BTS can rely on electricity from national grid.

Analysis of variance is a collection of statistical models used to analyse the differences among group means and their associated procedures that is it provides a statistical test of whether or not the means of several groups are equal. The values of F and F critical in this work were 5.7 and 2.75 respectively at 5% significant level ($\alpha = 5\%$). Hence null hypothesis (H_0) is rejected. This implied that there were significant differences in the mean pollutants emitted from BTS by combustion of diesel in local government areas of Abia State at 5% significant level. This further implies that the pollutants emitted from BTS in Abia State may result to different health problems

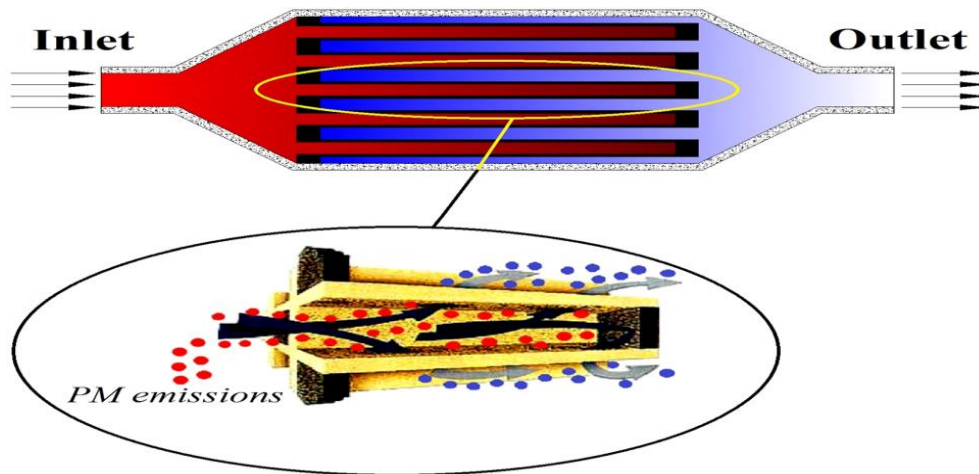


Fig. 2: Filtration of particulate filter (Source: Ibrahim et al., 2014) [28].

.Table 3. Analysis of variance of pollutants from diesel utilization in BTS in Abia AState

Sources of variation	Sum of square	Degree of freedom	Mean square	F	Fcritical
Between treatment	44,925	3	14,975	5.70	2.75
Residue	168,148.50	64	2,627.32		
Total	213,073.50	67			

4. CONCLUSION

The air pollutants from diesel utilization at BTS in local government areas of Abia State have been predicted. The numerical values of particulate matter ranged between 10.05 and 34.16 tons/yr while that of carbonmonoxide varied between 30.75 and 104.20 tons/yr. The numerical values of oxides of nitrogen ranged between 142.86 and 484.13 tons/yr which were higher than values of oxides of sulphur that varied between 9.39 and 31.82 tons/yr. ANOVA result revealed that there were significant differences in the mean pollutants emitted from BTS due to combustion of diesel in local government areas of Abia State at 5% significant level. The implication of this is that the pollutants

from BTS in Abia State may also lead to different health problems. It is pertinent that the regulatory agencies and policies makers ensure BTS owners put in place control measures which have elucidated in this work to minimize the emission of air pollutants from BTS.

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