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Inventory of Greenhouse Gases from Consumption of Key Refined Petroleum Products in Nigeria

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ABSTRACT

Nigeria being a signatory to the global convention on greenhouse gas emissions and climate change appears not to be doing much in cutting down carbon dioxide (CO_2) emissions. A practical step in the implementation of an emission reduction programme is a robust inventory of emitting sources. This study estimated the emission of CO_2 from the consumption of premium motor spirit (PMS) and automotive gas oil (AGO), two principal refined petroleum products used in Nigeria using an emission factor technique. Ten years consumption data of PMS and AGO were deployed for the study. The study revealed that anthropogenic CO_2 from the consumption of refined petroleum products is on the increase in the country with the largest proportion of the emissions happening in the South-West and South-South regions of the country. As of 2014, the percentage increases in annual national CO_2 emissions from consumption of PMS and AGO had risen by 246.77% and 375.70% of their year 2012 values. Given the global concerns on the implementation of an emission reduction programme for greenhouse gases, the study concluded that Nigeria needs to muster political will in formulating and implementing policies that will result in the reduction of CO_2 emissions.

1. INTRODUCTION

Nigeria depends primarily on conventional fossil-based energy sources for power generation, transportation, industrial utilities, domestic cooking among other things (Okedere *et al.*, 2021). In recent times, the demand for these products has increased tremendously owing to a rapid increase in population. Based on information from Nigeria's National Bureau of Statistics (NBS), the number of registered motor vehicles increased by 3.4% between 2017 and 2018. Roughly 700,000 additional drivers' licenses were issued in 2018, hence, the upsurge in the consumption of refined petroleum products (NBS, 2019). Other features of the transportation system in the country include the huge deployment of heavy-duty haulage trucks as well as proliferation of motorcycles and tricycles which have been reported to be up to 8 million (Fakinle *et al.*, 2013; Premium Times, 2014; Okedere *et al.*, 2021). This huge number logically translates to increase in demand for fuel. Other factors include industrial growth, an increase in the number of small and medium businesses as well as domestic energy needs with heavy reliance on power utilities such as diesel and small gasoline generators (Okedere *et al.*, 2021; Okedere and Oyelami, 2021). The near absolute dependence on the conventional fossil by industries, small business owners and households is predicated on the non-reliability of supply of electricity from the countries national grid (Sonibare, 2010; Okedere *et* *al.,* 2021). According to reports from Nigeria National Petroleum Corporation (NNPC) and the Department of Petroleum Resources, two major refined petroleum products that are heavily in use in Nigeria include premium motor spirit (PMS) and automotive gas oil (AGO). Based on these reports, the consumption of PMS and AGO has increased tremendously over the past decade. The consumption of these products is associated with the emission of air pollutants and greenhouse gases.

Greenhouse gases (GHG) (CO_2, CH_4, N_2O) among others are excellent heat trappers and have been noted to play vital roles in the atmospheric processes leading to climate change (Okedere and Oyelami, 2021). Notable manifestations of climate change include global warming, melting of glacial ice, rise in sea levels, floods and drought. These factors affect the social and environmental determinants of health such as availability of clean air, safe drinking water, food abundance and housing security. Consequently, they have the tendencies to slow down the drive towards attainment of the sustainable development goals through the aggravation of food insecurity.

Carbon dioxide (CO_2) is the leading GHG in terms of atmospheric chemistry leading to global warming (Okedere and Oyelami, 2021). Presently, there are several on-going efforts aimed at addressing the issue of global warming and climate change and these efforts are geared towards reducing the anthropogenic emissions of GHGs among which is CO_2. The concept of global warming is closely associated with the greenhouse effect. When visible light, ultraviolet and infra-red radiations from the sun reach the earth, a considerable fraction is returned to space by reflection. About 70% is taken by oceans, land and atmosphere which become heated up. Thermal radiation in the form of infra-red is therefore released back into the space by these hot bodies. This interchange of incoming and outgoing radiations that warm earth is termed the greenhouse effect (Lallanilla, 2015). However, GHGs being generated from all sorts of sources are dumped into the atmosphere. The layers of these gases are getting thicker by the unabated release of these pollutants. While radiations from the sun pass through this thick layer of gases, weaker infra-red thermal radiations are unable to escape to the atmosphere. The continuous build of thermal energy in this manner will cause excess heat on the earth which is regarded as global warming.

The atmospheric levels of GHGs have been reported to be on the increase globally and a major contributor has been the heavy reliance on the consumption of fossil-based fuels (Okedere *et al.,* 2021). Nigeria as a signatory to the global treaties and protocols on the emission of GHGs and climate change needs to evolve practical approaches for the management of these gases. One positive step in this direction is the development of a robust emission inventory for sources of these gases to quantify them and subsequently implement an emission reduction programme. The emission inventory technique offers a simplified and reliable approach for the quantification of emission rates of pollutants from sources based on source activity and emission factors. Presently, information on the emission inventory of GHGs is not sufficient in Nigeria. The present study therefore, seeks to quantify the emission rates of CO_2 from consumption of key refined petroleum products such as PMS and AGO.

2. METHODOLOGY

Brief description of the study area

The study area (Nigeria) has a population of about 200 million people occupying a land area of 923,768 square kilometer. It is located in West Africa and is delineated by the Niger Republic and the Atlantic Ocean in the North and South, respectively. The west and east boundaries are shared with the Republic of Benin and Cameroun, respectively. The country comprises States that are further categorized into six geopolitical zones which include the North-West (NW), North-Central (NC), North- East (NE), South-West (SW), South-East (SE) and the South-South (SS). Nigeria is rich in oil and gas reserves, having the largest petroleum industry on the African Continent. The oil is chiefly situated in the Niger Delta Region of the country which comprises mainly the SS States and partly SW. A huge proportion of the refined petroleum products consumed in the country are imported with only a little fraction refined locally. Figure 1 presents a map of Nigeria which shows the States and the six Regions.

Figure 1: Map of Nigeria showing the different zones

Determination of CO_2 emitted from consumption of PMS and AGO

Quantification of CO_2 emitted from the consumption of PMS and AGO in Nigeria was achieved by the emission factor approach. The emission factors of CO_2 from PMS and AGO were obtained from the Units and Conversion Fact Sheet of Massachusetts Institute of Technology Energy Club (MIT, 2007) as summarized in Table 1. These were combined with annual fuel consumptions (inventory of PMS and AGO) which were obtained from the Annual Statistical Bulletin of the NNPC (NNPC, 2016) as presented in Table 2 and Table 3. The emission rate of CO_2 was calculated as:

$$CO_2\left(\frac{\text{ton}}{\text{annum}}\right) = \text{Emission factor}\left(\frac{\text{ton}}{\text{litre}}\right) \times \text{Annual fuel consumption}\left(\frac{\text{litre}}{\text{annum}}\right) \quad (1)$$

Table 1: Emission Factors of CO_2 from PMS and AGO

	Emission Factor	
	Ib/gal	lb/mmBtu
PMS	19.56	156.4
AGO	22.38	161.4

MIT (2007)

Table 2: Annual Consumption of PMS in Nigeria

Location	PMS (klitres)									
	2001	2002	2003	2005	2009	2010	2011	2012	2013	2014
NW	335708	518116	313618	388136	819553	419229	465028	304149	2675673	2433049
NC	1330559	1614780	1586597	2050475	1884242	1226404	1118722	1123153	2949837	3061947
NE	212017	321528	141984	190642	494305	302454	331234	205185	1788128	1650901
SW	3137825	3300853	4048795	3639562	4231943	3147507	2717300	2264834	5316811	5985582
SE	475220	650169	582536	604812	366481	189225	174546	192021	1016188	1191951
SS	1651386	2282149	2052408	1770637	1709093	1068699	881620	928193	2147835	3076046
National	7142715	8687595	8725938	8644264	9505616	6353518	5688450	5017535	15894471	17399477

NNPC (2016)

Table 3: Annual Consumption of AGO in Nigeria

Location	AGO (klitres)									
	2001	2002	2003	2005	2009	2010	2011	2012	2013	2014
NW	136485	147706	84516	121327	91400	46050	51220	29679	341696	157671
NC	386602	523134	409571	650111	153853	238864	255361	275154	212072	170046
NE	130144	132561	74970	49483	39662	43155	32201	21014	60777	44148
SW	782818	530650	619015	413203	208415	144958	180919	43668	1414932	1749450
SE	308518	254764	502811	228677	119531	26974	26099	24312	146711	116335
SS	773871	1057160	684828	905313	517584	379366	432089	282902	654568	981514
National	2518438	2645975	2375711	2368114	1130445	879368	926672	647049	2830758	3219164

NNPC (2016)

3. RESULTS AND DISCUSSION

The yearly estimates of CO_2 from consumption of PMS and AGO in the six regions of Nigeria between 2001 and 2014 are presented in Tables 4 and 5, respectively. Across the regions, CO_2 emissions from consumption of PMS (Table 4) ranged between 493 – 7295 ktons/year, 13748 - 7674 kton/year, 443 – 8462 ktons/year, 852 – 9839 kton/year, 440 – 7318 ktons/year, 406 – 6318 ktons/year, 446 – 5266 kton/year, 2363 – 12361 kton/year and 2771 - 13916 ton/year for years 2001, 2002, 2003, 2005, 2009, 2010, 2011, 2012, 2013 and 2014, respectively. Between 2001 and 2005, the least annual CO_2 emissions from consumption of PMS were from North – East region of the country while the South- East region contributed the least annual emissions of CO_2 between 2009 and 2014. For all the selected years, the maximum CO_2 emissions from consumption of PMS were from South – West Nigeria.

The corresponding CO_2 emissions from consumption of AGO (Table 5) ranged between 346 – 2083 kton/year, 353 – 2813 kton/year, 199 – 1822 kton/year, 132 – 2409 kton/year, 106 – 1377 kton/year, 72 – 1009 kton/year, 69 – 1150 kton/year, 56 – 753 kton/year, 162 – 3765 kton/year, 117 - 4655 ton/year for years 2001, 2002, 2003, 2005, 2009, 2010, 2011, 2012, 2013 and 2014, respectively. Except for years 2010 and 2011 when the least emissions of CO_2 due to consumption of AGO in the country were from the South-East region, the least emissions of CO_2 were generally from the North-East region of the country. Over the selected years, maximum CO_2 emissions from AGO consumption were generally from the South-South region of Nigeria; although, this trend has now shifted to the South–West in the most recent years.

The pattern of CO_2 emission observed from the consumption of PMS and AGO across the six regions of Nigeria is associated with the demand for petroleum products occasioned by population and volume of commercial activities in each region. The South-West Region of the country is the second most populous region in Nigeria after the North–West and it is the most commercially active centre in the country largely because of the largest sea ports located in Lagos State which is part of the region. Most of the industries in Nigeria are also located in the Lagos – Ogun State axis of the country. Although, the availability of electricity at any instance in any part of the country is not easy to predict, an occasional experience of stability in electricity supply can influence the pattern of refined petroleum product consumption and emissions of CO_2.

A closer look at the available data shows that CO_2 emission from the consumption of refined petroleum products in the country has been on the increase since 2013. Figure 2 shows the National trends of CO_2 emissions from consumption of PMS and AGO for the ten years investigated. As of 2014, the percentage increases in annual CO_2 emissions from consumption of PMS and AGO had risen by 246.77% and 375.70% of their year 2012 figures, respectively. The seemingly decline in emissions figures of CO_2 during some of the years was never due to any intervention to mitigate its emission; rather, it could be due to a combination of factors such as low income, hike in the price of refined petroleum products and temporary stability in electricity generation and availability forcing down demand for refined petroleum products.

Table 4: Annual Regional Estimates of CO_2 Emissions from Consumption of PMS for Ten Selected Years

Location	Annual CO_2 estimates (ton/year)									
	2001	2002	2003	2005	2009	2010	2011	2012	2013	2014
NW	780,521.10	1,204,619.70	729,161.85	902,416.20	1,905,459.61	974,706.89	1,081,189.52	707,147.10	6,220,939.12	5,656,839.27
NC	3,093,549.68	3,754,363.50	3,688,838.03	4,767,354.38	4,380,862.09	2,851,389.79	2,601,029.44	2,611,330.54	6,858,371.07	7,119,027.80
NE	492,939.53	747,552.60	330,112.80	443,242.65	1,149,258.08	703,205.81	770,118.77	477,055.43	4,157,397.79	3,838,344.69
SW	7,295,443.13	7,674,483.23	9,413,448.38	8,461,981.65	9,839,266.52	7,317,953.73	6,317,722.69	5,265,738.28	12,361,584.76	13,916,478.27
SE	1,104,886.50	1,511,642.93	1,354,396.20	1,406,187.90	852,068.81	439,948.19	405,819.36	446,448.94	2,362,636.33	2,771,286.21
SS	3,839,472.45	5,305,996.43	4,771,848.60	4,116,731.03	3,973,641.04	2,484,724.92	2,049,765.38	2,158,048.84	4,993,716.79	7,151,806.93

Table 5: Annual Regional Estimates of CO_2 Emissions from Consumption of AGO for Ten Selected Years

Location	Annual CO_2 Estimates (ton/year)									
	2001	2002	2003	2005	2009	2010	2011	2012	2013	2014
NW	363186.59	393045.67	224897.08	322851.15	243215.96	122539.24	136296.61	78975.18	909254.07	419563.83
NC	1028747.92	1392059.57	1089868.43	1729945.37	409401.82	635617.77	679515.41	732185.41	564323.09	452491.66
NE	346313.18	352744.82	199495.17	131674.26	105539.62	114834.26	85692.08	55918.04	161728.37	117477.22
SW	2083078.70	1412059.65	1647198.92	1099533.18	554591.54	385733.53	481426.23	116199.24	3765135.17	4655285.44
SE	820966.40	677927.00	1337980.07	608509.50	318073.00	71778.03	69449.60	64692.93	390396.80	309567.01
SS	2059270.73	2813102.76	1822327.31	2409037.89	1377291.18	1009494.23	1149790.03	752801.50	1741806.33	2611809.53

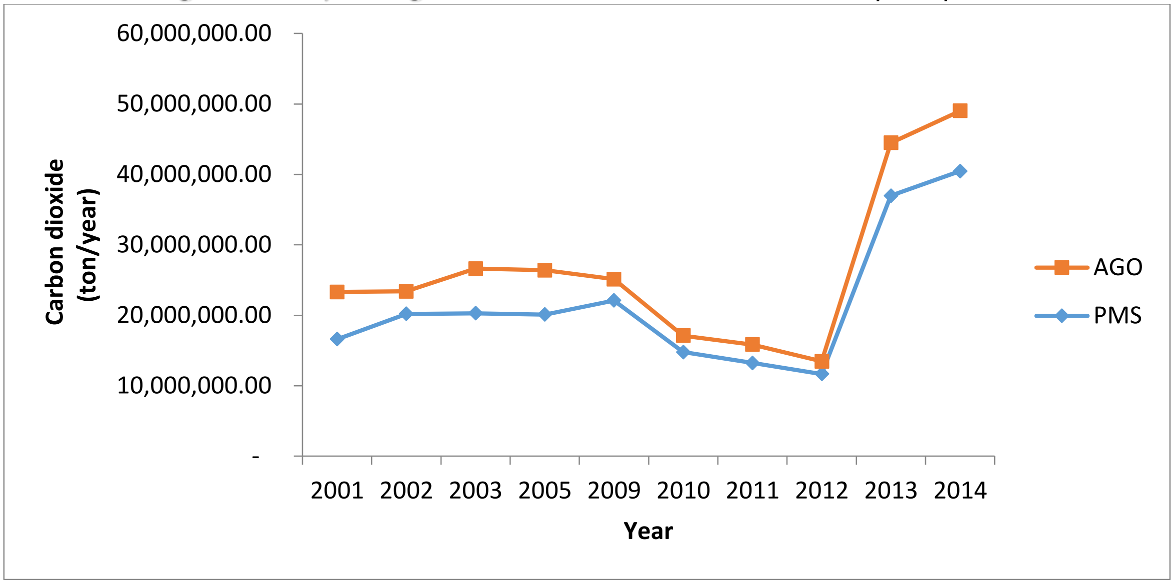

Figure 2: Annual Estimated Emissions of CO_2 from PMS and AGO

4. CONCLUSION

Annual emissions of CO_2 (the number one GHG) from consumption of PMS and AGO in Nigeria over ten decades were estimated using the emission factor approach. The study revealed that an increase in consumption of PMS and AGO in the country has a considerable incremental impact on the annual estimates of CO_2 emissions in the country. Among the regions of the country, the South-West and South-South regions which were the leading consumers of refined petroleum products were observed to contribute to national emissions of CO_2 more than any other region. Given the general awareness about CO_2 as the leading GHG and the efforts being put in place by various governments; the study concluded that Nigeria needs to justify her being a signatory to some of the protocols and treaties on GHG and climate change by the evolvement of CO_2 emission reduction programme.

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