Journal of Applied Sciences

ISSN 1812-5654

science alert

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Journal of Applied Sciences 11 (17): 3209-3214, 2011
ISSN 1812-5654 / DOI: 10.3923/jas.2011.3209.3214

Estimating the Greenhouse Gas Emission from Petroleum Product Combustion in Nigeria

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Abstract: The fact that the concentration of greenhouse gases in the atmosphere are increasing and contributing to the degradation of the environment has elicited global concern. One greenhouse gas which plays prominent role in this regard is carbon dioxide (CO_2). Hence, this study investigated the amount of CO_2 emissions obtained from petroleum products consumed in Nigeria from 1990 to 2009. Data were obtained from record of all petroleum products distributed and consumed in Nigeria within this period. These were subjected to the Tier 1 method of greenhouse gas determination using the Reference Approach. Result showed that 518.84 million metric tons (mmt) of CO_2 was released into the atmosphere between 1990 and 2009. This value represents 0.26% when compared with the global value of 202,640 mmt. Result also showed that there was a remarkable decrease in the total CO_2 emission in the first ten years from a peak value of 30.76 mmt in 1992 to a low value of 17.26 mmt in 1999. Between 2000 and 2009, greenhouse gas emission increased systematically reaching a peak of 32.56 mmt. Result also suggests that the consumption of Premium Motor Spirit, Automotive Gas Oil and House Hold Kerosene constituted 85% of the total emission in the past twenty years. Furthermore, the study showed that the average yearly increase in CO_2 emission in the past ten years was 4.7% as against global average rate of 1.9%. It is recommended that good and efficient energy utilization process be put in place in Nigeria.

Key words: Greenhouse gas, carbon dioxide (CO_2), emission, reference approach, pollution

INTRODUCTION

The challenges connected with the emission of greenhouse gases and the worsening quality of the environment have become of great concern to environmentalists and policy makers alike Lotfalipour and Falahi (2010) and Kamalan *et al.* (2011). Ghorbani *et al.* (2008) reason that this concern is based on the fact that the increase associated with greenhouse gas have negative impact both on the climate and the environment. This was what led many countries of the world to enter into many international agreements including the Kyoto protocol. The greenhouse gases which constitute important environmental issue are atmospheric gases that are transparent to radiation at one wavelength and absorb at another, usually at a longer wavelength. The Intergovernmental Panel on Climate Change (IPCC, 2007) stated that the important anthropogenic greenhouse gases which can be traced to human activities include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs).

Carbon dioxide emissions are produced in our daily lives through burning fossil fuels to meet essential needs such as electricity, heating and transportation and have been identified to be a major component of greenhouse gas emission (Nkongolo *et al.*, 2008). Various researchers have stated that CO_2 emission is known to contribute significantly to global warming which account for rising global temperatures and eventually cause sea level to rise (Guy and Levine, 2001; Joseph *et al.*, 2011; Shu *et al.*, 2010). As mentioned by Azam and Farooq (2005), the increase of CO_2 in the atmosphere also threaten to alter global as well as local climate condition, affect forests, crop yields and water supplies. This fact was also collaborated by Blasing *et al.* (2004) when they emphasized that anthropogenic emissions of carbon dioxide when compared with global warming potentials constitute by far, the largest part of the emission of greenhouse gases.

According to Wijnsma (2009), the Swedish scientist Svante Arrhenius was the first to speculate that the increase in CO_2 levels has the potential of changing the earth's surface temperature. He noted that cutting CO_2 levels by half would lower the earth's temperature by 4.5°C.

It is a common fact that CO_2 emissions produced from fuel combustion make up the great majority of the total greenhouse gas concentration and that almost all may be directly estimated from the combustion activities

(Boden *et al*., 2010). The main fossil fuels burned by humans are petroleum (oil), natural gas and coal. Good estimates of CO_2 emissions are essential for the construction of inventories, monitoring of emission control obligations and are utilized for potential control measures. The estimates are invaluable for the preparation and analysis of emission abatement policies.

Hingane and Murty (1984) have shown that CO_2 emission from the combustion of fossil fuels in India from 1950 to 1982 has increased ten-fold due to petroleum products. This is on the high side when compared with two fold due to firewood and four fold due to coal.

Boden *et al*. (2010) remarked that the extensive use of nuclear power has clearly curtailed fossil fuel related greenhouse gas emissions from France. They stated that the per capital emissions have declined steadily since the 1970s to present level which is 1600 kg per French person.

The Intergovernmental Panel on Climate Change (IPCC) noted in their publication that the estimation of CO_2 emission from fuels can be classified under two broad terms which are short term and long term (IPCC, 1996). Short-term emissions of CO_2 are those emissions occurring within twenty years of the fuel use. Long-term CO_2 emissions result from the final oxidation of long-life materials manufactured from fuel carbon and are usually emissions from waste destruction. However, Friedlingstein *et al*. (2010) stated that CO_2 emissions are computed from statistics on energy consumption and converted to CO_2 emission by fuel type.

Shu *et al*. (2010) identified two methods of estimating the quantity of CO_2 emission from fuel. They are the Tier 1 method and the 'bottom-up' method. The Tier 1 methods comprise the Reference Approach (RA) and the Sectoral Approach (SA) and both estimate the carbon emissions from the supply of fuels to the economy rather than from the actual emissions at combustion plant. On the other hand, a more detailed method known as 'bottom up' method uses records of fuel consumed at various combustion plants together with details of fuel supplied to other sources of emission.

According to the Environmental Protection Agency (EPA, 2006), where a country has detailed information on the consumption of fuels in the main consuming activities or sectors then detailed 'bottom-up' calculation can be made. Whichever method is used in CO_2 determination, the equation by the EPA is applicable and has been used in this study.

This study which is aimed at determining CO_2 emission derived from petroleum products consumed in Nigeria was carried out as a result of the growing concern that the concentration of greenhouse gases in the atmosphere are increasing and contributing to the rising average global surface temperature, sea level rise, flooding and other environmental crises. This study will therefore evaluate the quantity of CO_2 emission from this source to the atmosphere and provide information which will be the bases for the monitoring and control of CO_2 emission in Nigeria.

MATERIALS AND METHODS

The study area is Nigeria situated along West African Coast and covering a land area of 910,770 km^2. It is bordered on the north with Niger, to the east with Cameroon, to the west with Republic of Benin and to the south with the Atlantic Ocean (Fig. 1). It has a population of 140 million people (FGN, 2009) with the economy depending mainly on petroleum.

The method adopted for this study because of its suitability is the Reference Approach (RA) which provides estimates of CO_2 emission from all fuel supplied to the various consuming activities and also offers a breakdown of emissions by main fuel type. The quantity of petroleum products supplied to the various consuming activities across the country from 1990 to 2009 was calculated in this study by using the IPCC guideline for estimating the apparent fuel consumption by a country (IPCC, 1996). The guideline takes into account the quantity of petroleum products produced locally, the quantity imported, the quantity exported, the quantity used for international transport also known as bunkers and the net increases and decreases in stocks of the products.

The estimation of the carbon dioxide emitted from the petroleum products supplied across the country was carried out using the procedure as defined by the IPCC and the EPA (IPCC, 1996; EPA, 2006). The process involves six main steps which are as follows:

- Estimating the apparent fuel consumption in original units
- Converting to a common energy unit
- Multiplying the values obtained by emission factors to compute the carbon content for each product
- Computing the carbon stored
- Correction for carbon unoxidised
- Converting carbon oxidised to CO_2 emission

These steps were carried out for all the petroleum products on a year by year base for the twenty years and the results analysed. The average yearly increase in CO_2 emission in the past 10 years was calculated and compared with the global average rate. The study also determined the average CO_2 emission per person in Nigeria from this source.

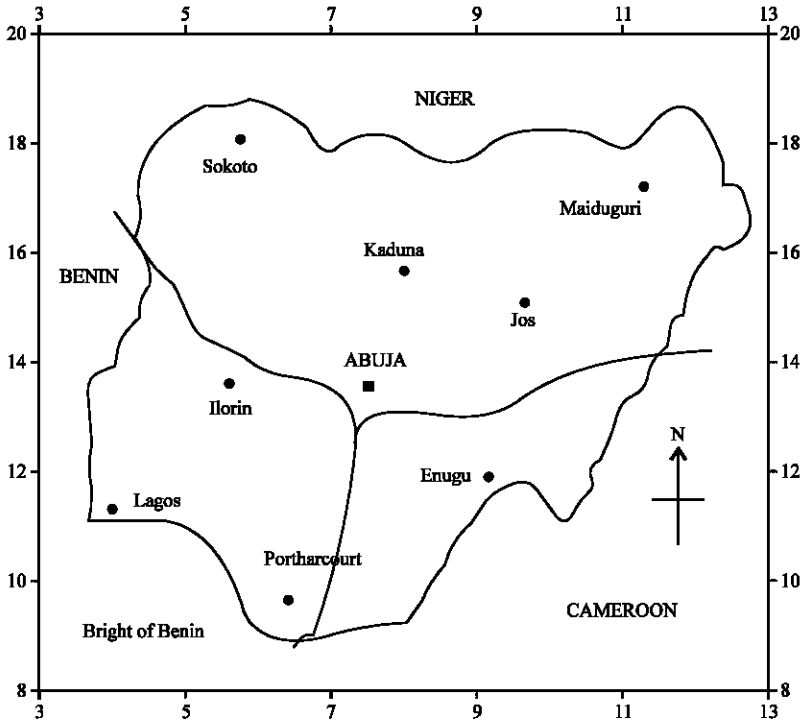

Fig. 1: Map of Nigeria

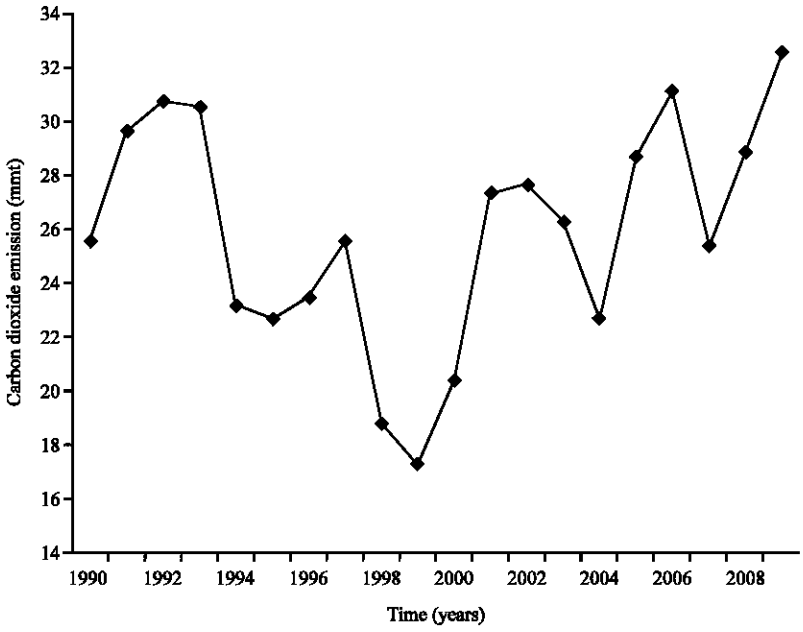

Fig. 2: A plot of CO_2 emission from 1990 to 2009

RESULTS AND DISCUSSION

The data collected for this study was subjected to the various calculations as specified by EPA and IPCC and the quantity of CO_2 emitted on a year by year bases from 1990 to 2009 determined.

The quantity of CO_2 emission on a yearly base was plotted as shown in Fig. 2. Figure 2 shows that 518.84 million metric tons (mmt) of CO_2 was realised to the atmosphere from the use of petroleum products from 1990 to 2009. This value represents 0.26% of the global CO_2 emission from petroleum products within the same

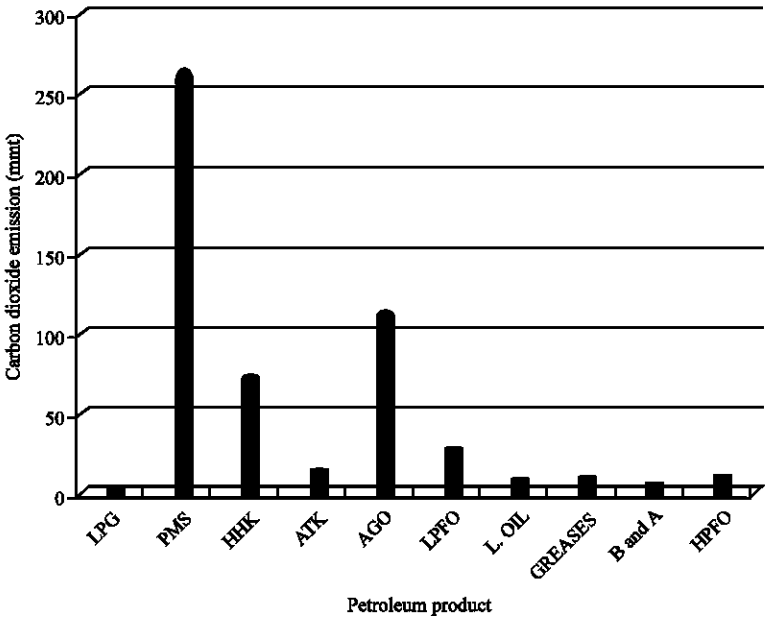

Fig. 3: Total CO_2 Emission from the Various Petroleum Products from 1990 to 2009 (20 Years)

period which stood at 202, 640 mmt of CO_2 (EIA, 2010). Figure 2 also shows that there was a modest increase in CO_2 emission from 25.59 (mmt) to 30.76 million metric tons between 1990 and 1992. From 1993 to 1999, there was a remarkable reduction of CO_2 emission. The value reduced from 30.61 mmt in 1993 and attaining its lowest value of 17.26 mmt of CO_2 emission in 1999. Meanwhile, from the year 2000, the total CO_2 emission started rising again until it attains a value of 32.56 mmt in 2009. This continuous increase between 2000 and 2009 tend to buttress the fear raised by Nwaichi and Uzazobona (2011), that CO_2 associated air pollution gave significant and worrisome concentration as a result of gas flaring. It again conform the point by Azam and Farooq (2005), that there is the likelihood that CO_2 concentration in the atmosphere will continue to rise as a result of growth in population. It is pertinent to observe that the reduction of CO_2 emission between 1992 and 1999 was not as a result of any government policy geared towards reducing CO_2 emission, rather, it was due to the various austerity measures introduced by the then Military Government of Nigeria. This was what gave rise to the low demand for petroleum products and it is in agreement with the work of Wijnsma (2009) which claimed that there was fall in the rising rate of CO_2 between 1998 and 1999 and that this period coincides with global economic recessions. However, with the successful transition to civilian regime in 1999, the economy bounced back to life hence the demand for petroleum products increased tremendously. Also, the use of electricity generating sets became rampant during the last 10 years of 2000 to 2009 thereby increasing the quantity of petroleum products consumed and by implication increase the quantity of CO_2 emitted. This is in agreement with the fact that economic growth is related to CO_2 emissions (Friedlingstein *et al*., 2010). This fact was also confirmed by Igwenagu (2011), when he observed that in Nigeria there was strong positive correlation between CO_2 emission and gross domestic product.

Analysis of the data as shown in Fig. 2 shows that the yearly average increases of CO_2 emission in the past 10 years which is from 2000 to 2009 is 4.7%. This is 2.8% higher than the global average rate of 1.9% (EIA, 2010).

Analysis of the data also shows that the average CO_2 emitted per person in Nigeria through the consumption of petroleum products in 2009 is 229 kg. This value is comforting when compared with the France value of 1600 kg of CO_2 per French person.

Figure 3 shows the total CO_2 emission of each of the petroleum products over the period of twenty years. The figure reveals that the use of Premium Motor Spirit (PMS) introduced 262.31 mmt of CO_2 into the atmosphere in the past twenty years. This is followed closely by Automotive Gas Oil (AGO) with a value of 111.80 mmt and House Hold Kerosene (HHK) with a value of 71.20 mmt. These three products were responsible for the release of 455.31 mmt of CO_2 to the environment between 1990 and 2009. This amounts to 86% of the total CO_2 emitted into the atmosphere from consumed petroleum products in

Nigeria within the period of study. This value corresponds to 0.23% of the total global release for the period. This is the more reason while measures which will reduce the consumption of these products and by implication reduced the quantity of CO_2 released into the atmosphere should be encouraged by all to ensure the future of our environment (Jegannathan *et al*., 2011; Sharma *et al*., 2011; Ab-Rahman *et al*., 2009; Azmi *et al*., 2011; Fakoya *et al*., 2011).

CONCLUSION

This study has shown that greenhouse gas emission resulting from the consumption of petroleum products in Nigeria has increased in the past ten years. It is recommended that good and efficient energy utilization process that will check waste and reduce the quantity of petroleum products consumed in Nigeria should be put in place. It is also recommended that the policy of one man to plant one tree be encouraged and pursued with vigour in Nigeria as these trees have the potential of utilizing a good size of the greenhouse gas emitted.

ACKNOWLEDGMENT

The author wishes to thank the authorities of the Nigerian National Petroleum Corporation for the availability of the data used in this study.

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