ESTIMATED INVENTORY OF CARBON DIOXIDE (CO_2) EMISSION IN NIGERIA FROM THREE MAJOR PETROLEUM PRODUCTS FROM 2000 TO 2014 USING A MODIFIED REFERENCE APPROACH

G.E. Akpojotor, M.O. Ofomola and Z. Ezoukumo
Department of Physics, Delta State University, Abraka, Delta State, Nigeria.
*Corresponding author. E-mail: Akpoji@yahoo.co.uk or akpogea@deltastate.edu.ng

ABSTRACT

The recent Paris Agreement on how to abate the climate change requires both developed and developing countries to assumed increasing responsibility to address climate change in line with their capabilities. The implication is that every country must obtain an inventory of the greenhouse gases (GHG) emission from all reliable sources to enable them strategize on how to reduce it. Nigeria like many developing countries, still do not have reliable data base for many of these sources for now. So here the study propose that a theoretical approach of estimating the amount of carbon dioxide (CO_2) in kg that is emitted by n-litres of fuel which is a modification of the reference approach, can be a starting point in planning for the inventory of CO_2 emission in Nigeria. The method is demonstrated to obtain an estimate of the CO_2 in Nigeria from 2000 to 2014 from only the three major petroleum products which are Premium Motor Spirit (PMS), Diesel (AGO) and House Hold Kerosene (HHK) that can be obtained from government official agency. The results depict fluctuation in the CO_2 emission in Nigeria in the 15 years period in agreement with the projection in the literature. The results also shown that for the total emission of CO_2 in this period, the highest emission was from PMS with 73.60%, followed by AGO with 15.60% and the least emitter is HHK with 10.80%. This trend is also in agreement with the distributive uses of these petroleum products.

Key words: Global warming, carbon dioxide, inventory, reference approach, petroleum products

INTRODUCTION

There has been an increasing global concern for the increasing global climate temperature often referred to as global warming in the last 5 decades. It is predicted that the global average temperature will rise by about 1.6°C to 6°C above pre-industrial level by the year 2100 if current trends of greenhouse gases (GHG) emission continue (IPCC, 1995; Akpojotor and Akporhonor, 2005).

There is already a gradual increment of the global temperature as the National Oceanic and Atmospheric Administration (NOAA) said that 2015 was 97% likely to be the hottest year so far (NOAA, 2015), eclipsing 2014, the current warmest year (Goldenberg, 2015). While the years 2011 to 2015 are the hottest five-year period on record (WMO, 2015). Further, apart from July 2015 wherein the average temperature across global land and ocean surfaces was 0.81°C above the 20th century average thereby making it the warmest month on record for the earth dating back to January 1880, the world experienced record-breaking warmth every month in 2015 (NOAA, 2015).

There is already a growing literature strongly linking a number of extreme events occurring in this century and climate change worldwide, and these include unprecedented increment in global average air and ocean temperatures, widespread melting of snow and ice, rising global average sea level leading to flooding, health related problems, uncertain effects on Agriculture, etc (IPCC, 2007; Perrings, 2010; Rahmstorf and Coumou, 2011; Kang and Banga. 2013; Coffel and Horton, 2015). These challenges are faced by both industrialized and developing countries in maintaining a sustained process of development.

The major greenhouse gas responsible for global warming is CO_2 derived from multiple natural sources including volcanic out gassing, the combination of organic matter and the respiration processes of living anaerobic organisms. Apart from these natural phenomena, man-made sources include the burning of various fossil fuels for power generation in the industry, agriculture, transportation, domestic uses as well as emission from industrial processes such as cement production, carbonate use of limestone and dolomite, non-energy use of fuels and other combustions (Albert, 1987; NRC, 2010). There is a growing scientific consensus that increase in man-made sources of emission of GHG which are responsible for global warming (Cook et al., 2013; Bolsen et al., 2015), hence it is also known as anthropogenic climate change (ACC).

In a study of 11 944 climate abstracts from 1991 to 2011, matching the topics 'global climate change' or 'global warming', 97.2% of them endorsed this scientific consensus on ACC (Cook et al., 2013). Thus the most challenging issue about the global warming is that there is global consensus that the solution to abate the ACC is to reduce the emission of GHG especially CO_2, yet implementing this solution has become very difficult. The reason is that the ACC is emanating from the economies of the various countries either as source of energy, through sales of fossil fuels or both. This was why the first international treaty on carbon cutting known as the Kyoto Protocol which was negotiated in December 1997 at the city of Kyoto, Japan, was unsuccessful. The Kyoto protocol which came into force on February 16th, 2005 as an extension of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) was intended to commit the indus-trialized countries to reduce GHG emissions by an average of 5.2% against 1990 levels by 2012. As it is now well known, the USA that is a major emitter of the CO_2, refused to rectify this treaty because they feared it will harm their economy as well as the absence of binding targets of CO_2 emission for developing nations in the treaty especially fast growing economies such as China and India (William, 2010; Rosen, 2015).

It was therefore a global relief when the Governments of 195 countries overcame decades of deep divisions and politics to strike a watershed deal aimed at preventing this catastrophic ACC in Paris on December 12, 2015 (Parish Agreement, 2015). The countries agreed that maintaining the increase in global temperature at the 2°C above the pre-industrial levels earlier adopted by more than 100 countries (Meinshausen et al., 2009) is the floor, not the ceiling, and they agreed to try to limit the temperature increase to 1.5°C. Article 13 of the Parish agreement reiterates the invitation to all countries that have not yet communicated to the UN secretariat their intended nationally determined contributions towards achieving the objective of the Convention to do so as soon as possible and well in advance of the twenty-second session of the Conference of the Parties scheduled for November, 2016. The Article also stipulates that the presentation should be prepared in a manner that facilitates the clarity, transparency and understanding of the intended nationally determined contributions.

Further, beginning before from 2020, for every five years, countries will submit updated climate plans, called nationally determined contributions to review what further emissions cuts are needed in line with science. Thus, the salient aspect of the agreement is that all countries – developed and developing – are required to subject their national emission reduction commitments to monitoring and verification, and to reconvene every five years to review progress towards target.

Nigeria, like other developing countries, shares the need for fast economic growth given the current low standard of living and increasing population. It also shares the global concern of protecting the environment. Therefore, even as a country that its mainstay is oil which is the major source of the GHG, the country needs to begin to strategize on how to cut its CO_2 emission to make this Paris Agreement succeeds. The first step is to devise a means to take inventory of GHG in Nigeria from all possible and very reliable database sources.

As pointed out in 2005 by Akpojotor and Akporhonor, though Nigeria is not considered by global indices of classification as an industrialized nation, the amount of CO_2 emitted into the atmosphere in the country can be alarming when compared to those released in some other developing countries. The reason being that the over 160 million persons (FGN, 2009) based on the 2006 census and projected to 178 million in 2014 by the World Bank (2014) which makes her the most populated African count and HHK ry and the 7th most populated country in the world, means a large transport potential and domestic demand of energy which may translate into a remarkable emission of CO_2. This has been aggravated by the epileptic power supply from the national grid and deforestation in the tropical parts of the country (Small and Kazimi, 1995). It is worthy of note that from the World Data Bank (2015), Nigeria is ranked 41st among 200 countries in CO_2 emission with 93.87 mmt, as against the United States with a CO_2 emission of 5334.53 mmt which makes her second behind China with an emission of 10540.75 mmt in 2014 (Olivier et.al., 2015).

The data only considered CO_2 emission from totals of fossil fuel use and industrial processes (cement production, carbonate use of limestone and dolomite, non-energy use of fuels and other combustion), excluding emissions from bunker fuels, international shipping, gas flaring, short-cycle biomass burning (such as agricultural waste burning) and large-scale biomass burning (such as forest fires). Further, other powerful and potent GHG such as methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and SF6 were not included in this data.

One major problem in obtaining the inventory of CO_2 emission in a country is that many of the methods are still cumbersome (Ravindranath and Ostwald, 2007). The study here is to demonstrate that the theoretical estimation approach (Akpojotor and Ofomola, 2009) of estimating the amount of CO_2 that is emitted by n litres of fuel which can be used as a modification of the Reference Approach can be a starting point in planning for the inventory of CO_2 emission in Nigeria.

The study is planned as follows. In the next two sections, the study will consider the default Reference Approach and how to simplify it into a method of converting n-litres of fuel into CO_2 emission in Kg. This will be followed by the presentation and discussion of results and then the conclusion.

It should be noted that only CO_2 emissions from the three major petroleum products, Premium Motor Spirit (PMS), Diesel (AGO) and House Hold Kerosene (HHK) are used in this current study. The implication is that there are other major CO_2 emitters in the country such as coal/peat, natural gas, deforestation, cement, and even the minor petroleum products as well as bunker fuel which are not included in this work.

The reference approach

There is a general consensus that good quality estimates of CO_2 emissions from fuel combustion are essential for the construction of inventories since they have direct link between fuel use and emission which is key to strategizing how to reduce these emissions.

The IPCC (2006) reversed guideline for national GHG emission inventories adduced that the calculation of CO_2 emissions from fuel combustion may be done at three different levels referred to as Tiers 1, 2 and 3 depending on the available statistics. The Tier 1 method is a top-down approach used to calculate the estimates of the emissions from the carbon content of mainly fossil fuels: if the calculation is done for the fuel supplied to the country as a whole, it is known as Reference Approach and if it is done at the main fuel combustion activities, it is called Sectorial Approach.

Therefore, for Nigeria which like most developing countries have less developed energy data system, the Reference Approach is preferable. The uniqueness of this approach is that it is a straightforward method that can be applied on the basis of relatively easily available energy supply statistics thereby making it possible for a country to produce estimate of CO_2 emissions from fuel combustion with limited additional effort and data requirements. The approach has five basic steps in its algorithm for the calculation of CO_2 emissions from fuel combustion which are used to formulate the equation:

$$CO_2 \;\; Emissions = \sum_{all \;\; fuels} AC * CF * CC * 10^{-3} - EC * COF * 44/22 \qquad (1)$$

where AC is Apparent Consumption: production + imports – exports – international bunkers ± stock change, CF is Conversion Factor: conversion factor for the fuel to energy units (TJ) on a net calorific value basis, CC is carbon content (tonne C/TJ) with tonne C/TJ identical to kg C/GJ, EC is Excluded Carbon: carbon in feedstocks and non-energy use excluded from fuel combustion emissions (Gg C), COF is carbon oxidation factor: fraction of carbon oxidized and 44/12 is molecular weight ratio of CO_2 to C.

It is easy to observe that as simple as the philosophy of the Reference Approach is, Eq. (1) which emerged from its mathematical formulation is complex, and may not be easily achieved especially in countries where activity data are not reliable and may not even be available (Guendehou and Ahlonsou, 2003; Andres et al., 2012).

For example, EC may not be readily available especially in developing countries. Similarly, it may be difficult to obtain the COF. This is why it is often assumed to be a unity (that is, COF = 1) reflecting complete oxidation. Lower values are used only to account for carbon retained indefinitely in ash or soot. Thus, one can assume that the EC is negligible (that is, EC → 0), and COF = 1, Eq (1) is reduced to,

$$CO_2 \;\; Emissions = \sum_{all \;\; fuels} AC * CF * CC * 10^{-3} \quad (2)$$

This is how to convert the AC into CO_2 emission in the appropriate unit taking into account the CF and CC.

In general, characterization of petroleum products which are usually based on predictive methods varies from one method to the other (Riazi, 2005; Speight, 2015). The implication is that, the CC will vary from one method to the other as well as from one source of crude oil to the other and this will in turn affects the CF. Since the CF and CC are responsible for the conversion of the AC in Eq. (2), the study propose here that they can be replaced by developing a direct method to convert n-litre of fuel to CO_2 emission in kg (Akpojotor and Ofomola, 2009).

Conversion of apparent consumption in litre to CO2 emission in kg.

The starting philosophy is that carbon varies from one source of crude oil to the other, and therefore even same petroleum product outputs from these various crude oils have slightly different carbon content hence will emit different amount of CO2 assuming they are burnt at the same conditions. The implication is that for now, one can only use an estimated value for each of the petroleum products irrespective of its source. This is the basic assumption for the modified Reference Approach of converting n-litres of fuel to CO_2 emission in kg adopted in Akpojotor and Ofomola (2009). In this approach, the study estimated the amount of CO_2 from burning n-litres of petrol, kerosene and diesel as:

$$CO_2 \;\; Emissions = n * SC * PC * ECT \quad (3)$$

where n is number of litres consumed, SC is specific gravity of the petroleum product, PC is proportionality of carbon in the petroleum product and ECT is 3.6667 which is an empirical constant. Then n = AC taking into account Eq. (3) in Eq. (2) which will yield:

$$CO_2 \;\; Emissions = \sum_{fuels} AC * SC * PC * ECT \quad (4)$$

It is pertinent to emphasize that Eq. (3) hence Eq. (4) is only an estimate which need to be improved upon. Further, owing to the aforementioned variation in the sources of petroleum products, the values of both the specific gravities of the petroleum products and the carbon proportionality contents in them also varies slightly in each same product, and therefore are in ranges.

For example, the SC ranges which in turn depends on the temperature is from 0.71 to 0.77 for PMS, 0.81 to 0.96 for HHK and 0.78 to 0.82 for AGO at 15.56°C. Thus, for the purpose of this study, the study made use of values of SC as 0.74 and PC as 0.84; for PMS, SC as 0.85 and PC as 0.86; for AGO, SC as 0.817 and PC as 0.84. Therefore, computing for one litre of these product, the study obtain for PMS:

CO_2 emission in 1litre of petrol = 1 × 0.74 × 0.84 × 3.6667 = 2.27 kg of CO_2

For AGO

CO_2 emission in 1litre of diesel = 1 × 0.85 × 0.86 × 3.667 = 2.68 kg of CO_2

For HHK

CO2 emission in 1litre of kerosene = 1 × 0.817 × 0.86 × 3.6667 = 2.58 kg of CO_2

The beauty of this simplified method of conversion of AC in litre to CO_2 emission is that once we know the amount of petroleum product consumed, then we can determine the amount of

CO_2 in Kg. Then depending on the amount, we can convert to tonnes (t) which is also known as metric tons (mt) which is one standard unit of CO_2 measurement by dividing 1000 as 1000 kg gives 1 t (= 1 mt) or kilotonnes (kt) also known as kilometric tons (kmt) by dividing 1000000 as 1000000 kg gives 1 kT (= 1 kmt) or into million metric tons (mmt) by dividing1000000000 as 1000000000 kg gives 1 mmt.

RESULTS AND DISCUSSION

To demonstrate how to use the modified Reference Approach of converting n-litre of fuel to CO_2 emission in kg to obtain an estimate of CO_2 inventory in the country, the study will used only the three major petroleum products (PMS, HHK and AGO) distributed by marketing companies in Nigeria from January to December for the years 2000 to 2014 as reported by Nigerian National Petroleum Corporation (NNPC). Therefore, the apparent consumption for each product is its total distribution for that year which are then converted into the CO_2 emissions in mmt by taking into account Eq. (4). These CO_2 emissions on a yearly base is plotted as shown in Figure 1.

An inspiring observation is that, the curve is not a smooth direct variation in that there is an

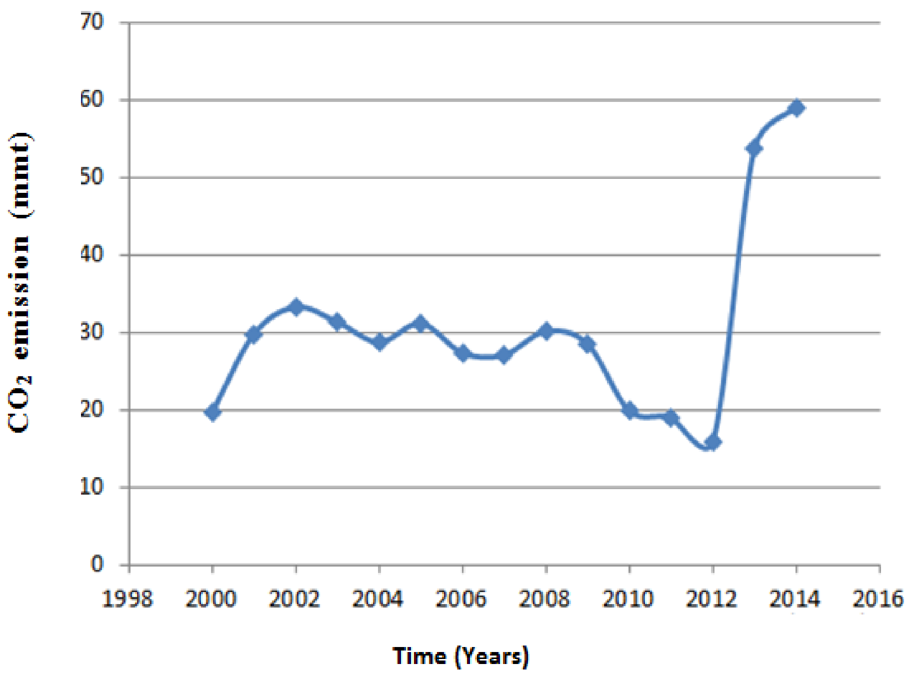

Figure 1. A Plot of CO_2 emission in Nigeria from 2000 to 2014.

there is an increment of CO_2 emissions every year. Instead, the graph depicts fluctuations of the CO_2 emissions over the period of the 15 years, that is, there is decrease in some years and increase in others in agreement with the CO_2 emission estimated for Nigeria by Olivier et al. (2015), and this is the trend for many other countries including the USA, South Africa, Algeria except China and Egypt which experience consistent increments with each passing year while UK experiences a consistent decrease with each passing year.

However, it is observed in Figure 1 that from the CO_2 emission estimate of 19.83 mmt in 2010 to 58.97 mmt in 2014, there is over 73% increment of CO2 emission in Nigeria which is far higher than the range of ±0.1% to ±10% variation of CO_2 emissions for most countries including Nigeria (85.40 mmt in 2010 and 93.88 mmt in 2014) as estimated by Olivier et al. (2015).

This lucidly indicates that CO_2 emissions in Nigeria from petroleum products are based on the data of these products that are made available by the Federal Government Agencies, and that there is urgent need for great improvement on our database on petroleum products. It is for this same reason that the total CO_2 emission estimate of 454.13 mmt was obtained here from the use of PMS, AGO and HHK between 2000 and 2014. This is also remarkably small when compared to the one done by Olivier et al. (2015) obtained for the same period, and not just because the latter work was for the totals of fossil fuel use and industrial processes.

Figure 2 shows the total amount of CO_2 emitted into the atmosphere by each petroleum product over the fifteen years period between 2000 and 2014. The figure shows that the use of PMS introduced 73.60% of CO_2 into the atmosphere. This is distantly followed by AGO with a value of 15.60%, and HHK with a value of 10.80% which is clearly the lowest emitter of CO_2 among the three products in Nigeria. The high percentage from the PMS is because the main transportation system in Nigeria with a rapidly growing population depend on PMS while power generation especially from generators have been on the increase owing to the epileptic supply of power in the country. This is in agreement with the observation that CO_2 emission is related to economic growth (Friedlingstein et al., 2010).

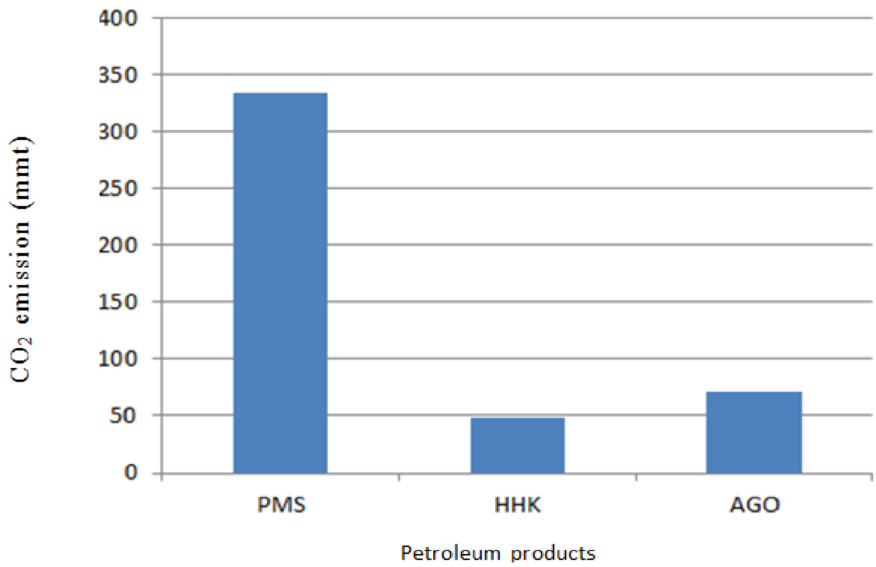

Figure 2. Total amount of CO2 emitted each petroleum product from 2000 to 2014.

One captivating aspect of this modified Reference Approach is that it can also be used to easily obtain the CO_2 emissions in a region, state or town once their apparent consumptions can be determined. For example, it was used to obtain the CO_2 emissions in Abraka, and when compared with World Health Organization (WHO) minimum standard to cause health challenges, the study observed that Abraka was not under threat of any health hazard due to the CO_2 concentration owing to the consumption of petroleum products in the town (Ofomola et al., 2010).

The implication is that with the modified Reference Approach, the study will not only be able to obtain the green house gases emissions inventory in Nigeria but also for the various states and even towns. This will make it easy for the country to strategize on both national, regional and state methods to reduce the GHG emissions. In 2005, one of the methods adduced to sequester CO_2 emission in oil producing countries is to inject the gas into oil reservoirs which will be able to store away 90% of the atmospheric CO_2 and help to improve oil recovery (Akpojotor and Akporhonor, 2005).

The additional benefit of this method is that the proceeds from the increased recovered oil can help in offsetting the cost of this method of sequestration thereby making the oil reservoir one of the best sites for CO_2 sequestration (Wang et al., 2014; Cooney et al., 2015). The Niger Delta region of Nigeria has a lot of oil wells, and therefore has great potential to symbiotically benefit from the environmental protection and economic benefit from this method of geological sequestration of CO_2. This open study that requires a collaboration between the academia and the oil industry can be kickstarted either at state level or regional level.

CONCLUSION

In this study, a modification of the Reference Approach of estimating the amount of CO_2 that is emitted in n-litres of fuel and the prospect of using this formulation to obtain CO_2 emission inventory in Nigeria is demonstrated. This approach was used to determine the amount of CO_2 in Nigeria from the three major petroleum products (PMS, HHK and AGO) supplied across the country as reported by the NNPC. The method can in principle be extended to other petroleum products. Further, the method can also be extended to obtain the emissions of the so-called non-CO_2 gases' (methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and SF6) which constitute roughly one-third of total CO_2 equivalent emissions based on 100-year global warming potentials. Accomplishing such extensions will make it easy for us to prepare a more reliable estimates of our CO_2 emissions. However, all these extensions can only be achieved through a committed collaboration between the academia and other national bodies including, and especially those that are to provide official data of all the petroleum products needed for the apparent consumptions.

ACKNOWLEDGEMENT

The authors appreciate the very useful discussion at the preliminary presentation of this study at the Third National Conference of the Faculty of Science, Delta State University, Abraka from 30 June to 3 July, 2015. They also thank the authorities of NNPC for the availability of the data used in this study.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Akpojotor G. E. andAkporhonor, T. (2005). Global Warming; Methods to sequester the increasing emitted CO_2 in Nigeria. Proceedings of the International Conference on Science and Technology, FUT, Akure, Nigeria. Pp. 460-463

Akpojotor G.E. and Ofomola, M.O. (2009). Database of CO2 emission in Nigeria; A Preliminary Report. African Journal of Physics 2, 267-279.

Albert F.C. (1987). Man-made source of carbon dioxide. Heinemann Educational Books Ltd, London. pp10-12.

Andres R. J., Boden T. A., Bréon F. M., Ciais P., Davis S., Erickson D., Gregg J. S., Jacobson A., Marland G., Miller J., Oda T., Olivier J. G. J., Raupach M. R., Rayner P. and**Treanton K.** (2012) A synthesis of carbon dioxide emissions from fossil-fuel combustion. Biogeosciences Discuss 9, 1299-1376.

Bolsen T., J. N. Druckmanand **Cook F. L.** (2015) Citizens', Scientists', and Policy Advisors' Beliefs about Global Warming. The ANNALS of the American Academy of Political and Social Science 658, 271-295.

Coffel E. and **R. Horton R.** (2015) Climate change and the impact of extreme temperatures on aviation. Weather Clim. Soc., 7, 94-102.

Cook J., Nuccitelli D., A Green S. A., Richardson M., Winkler B., Painting R., Way R., Jacobs P. and**Skuce A.** (2013) Quantifying the consensus on anthropogenic global warming in the scientific literature. Environ. Res. Lett. 8 (2013) 024024 (7pp)

Cooney G., Littlefield J., Marriott J. and**Skone T. J.** (2015) Evaluating the Climate Benefits of CO2-Enhanced Oil Recovery Using Life Cycle Analysis.Environ. Sci. Technol. 49 (12), 7491–7500

FGN(2009) Federal Government of Nigeria legal notice on publication of 2006 census final results. FGN Official Gazette.

Friedlingstein P., R.A. Houghton, G. Merland, J. Hackler and **T.A. Boden** (2010). Update on CO_2

emissions. Nature Geosci., 3: 811-812.

Goldenberg S. (2015). 2014 officially the hottest year on record. http://www.theguardian.com/environment/2015/jan/16/2014-hottest-year-on-record-scientists-noaa-nasa.

Guendehou S. G.H. and**Ahlonsou E. D.** (2003). Greenhouse gas inventories in West Africa relevant issues and strategy for improving the quality. http://www.coalinfo.net.cn/coalbed/meeting/2203/papers/economics/EC002.pdf

IPCC (1995). Inter-governmental Panel on Climate Change (IPCC) 1995 Report: Atmosphere, Climate and Environmental Information Programme, Climate Research Unit, University of East Anglia, Norwich, UK

IPCC (2006). Inter-governmental Panel on Climate Change (IPCC) National greenhouse gas inventories programme: Guidelines for National Greenhouse Gas Inventories. Institute for Global Environmental Strategies (IGES), Hayama, Japan.

IPCC (2007). Inter-governmental Panel on Climate Change (IPCC): Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

IPCC (2014). Inter-governmental Panel on Climate Change (IPCC) Climate Change 2014:Mitigation of Climate Change. Cambridge, UK: Cambridge University Press.

Kang M. S. and **Banga S. S.** (2013) Combating climate change: an agricultural perspective. Taylor and Francis Group, New York

Meinshausen M., Meinshausen N., Hare W., Raper S. C. B, Frieler K., Knutti R., Frame D. J. and **Allen M. R.** (2009) Greenhouse-gas emission targets for limiting global warming to 2°C. Nature 2009, 458, 1158–1162.

NNPC: http://www.nnpcgroup.com/PublicRelations/OilandGasStatistics/AnnualStatistcBulletin/MonthlyPerformance.aspx

NOAA (2015) National Centers for Environmental Information, State of the Climate: Global Analysis for August 2015, published online September 2015, retrieved on December 13, 2015 from http://www.ncdc.noaa.gov/sotc/global/201508.

NRC (2010).Advancing the Science of Climate Change.National Research Council.The National Academies Press, Washington, DC, USA.

Ofomola M. O., Akpojotor G. E. and**Igherighe E. C.** (2010). Measurement of CO_2 Emission in Abraka and its Health Implications. Proceedings of the Conference of Sustainable environmental Peace and Security in the Niger Delta held at the Delta State University from February 22 – 24, 2010, pp339 - 346.

Olivier J.G.J., Janssens-Maenhout, G., Muntean, M. Peters and **J.H.A.W.** (2015). Trends in global CO_2 emission: 2015 report, JRC report 98184. PBL Netherlands Environmental Assessment Agency, PBL Netherlands Environmental Assessment Agency, The Hague. http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf

Parish Agreement (2015). Paris Agreement under the United Nations Framework Convention on Climate Change at the Conference of the Parties Twenty-first session held in Paris from 30 November to 11 December, 2015.

Perrings C.(2010). Biodiversity, Ecosystem Services, and Climate Change: The Economic Problem. The International Bank for Reconstruction and

Development/THE WORLD BANK, Washington, D.C, U.S.A.

Rahmstorf S. and **Coumou D.** (2011) Increase of extreme events in a warming world. PNAS 108, 17905–17909.

Ravindranath N.H. and**Ostwald M.** (2007). Carbon Inventory Methods Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Roundwood Production Projects.Springer Netherlands.

Riazi M. R. (2005). Characterization and Properties of Petroleum Fractions. ASTM International.

Rosen A. M. (2015).The Wrong Solution at the Right Time: The Failure of the Kyoto Protocol on Climate Change. Politics & Policy, Volume 43, 30-58

Small K.A. and**Kazimi C.** (1995).On the cost of air pollution from motor vehicle. J. Transp.Econ.Policy 29:7-32.

Speight J. G. (2015). Handbook of Petroleum Product Analysis.John Wiley & Sons, Inc.

Wang H., Liao X, Dou X, Shang B, Ye H., Zhao D., Liao C. and **Chen X.** (2014). Potential Evaluation of CO2 Sequestration and Enhanced Oil Recovery of Low Permeability Reservoir in the Junggar Basin, China. Energy Fuels 28 (5), pp 3281–3291.

William B. (2010). Climate Change, Fragmentation, and the Challenges of Global Environmental Law: Elements of a Post-Copenhagen Assemblage University of Pennsylvania Journal of International Law 32(2): 457-550.

WMO (2015). World Meteorological Organization (WMO) 2015 likely to be Warmest on Record, 2011-2015 Warmest Five Year Period. https://www.wmo.int/media/content/wmo-2015-likely-be-warmest-record-2011-2015-warmest-five-year-period

World Bank (2014). Nigeria. http://www.worldbank.org/en/country/nigeria

World DataBank (2015). CO_2 emissions (metric tons per capita) http://data.worldbank.org/indicator/EN.ATM.CO2E.PC.