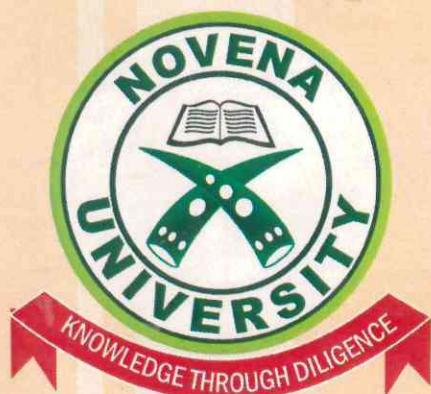




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TOWARDS REGULATION OF AVIATION EMISSION IN NIGERIA:
A STUDY ON THE ENVIRONMENTAL IMPACT OF AVIATION
EMISSION AND THE CONTROL LAWS.

Murtala Ganiyu A. Murgan and Maizatun Mustapha**

Key words: Study, Regulation, Aviation Emission, Environmental Impact, Control Laws.

ABSTRACT

All over the world, aviation transportation is observed to be undergoing steady increase largely due to globalization of world economy and economic growth which have made air transportation affordable for a large number of populations in the world. The increase in growth of air transportation has led to increase in volume of aviation emission being discharged on the earth surface. These emissions however, cause severe consequences on the global environment in form of pollution of the atmosphere, stratosphere and lithosphere with high level of greenhouse gases like carbon dioxide, carbon monoxide, nitrogen oxide and others. The potential threat of aviation emission to the global environment is said to be much and will continue to increase unless it is regulated.

This paper examines the constituents of aviation emission and the emerging impact of aviation emission on the environment in Nigeria. It also makes an overview of the international and national laws for reduction of aviation in Nigeria. A doctrinal research approach is applied to collect information from primary and secondary sources on the above. The research finds that the constituents aviation emission have adverse local and global effects on the environment and require effective control through application of domestic legislations.

1. INTRODUCTION

Increase global access air transportation has increased aviation emission and pollution.¹ Green house gasses like carbon dioxide, carbon monoxide, nitrogen oxide and others are usually emitted into the atmospheric environment² by air

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¹ David Freestone and Charlotte Streck, *The Legal Aspect of Carbon Trading*, Kyoto, Copenhagen and beyond, Oxford University press, 2009, at. 27.

² Id.

craft and aerospace engines as a result of their combustion activities. The earth environment encompasses the entire earth surroundings where human, animals and non-living things live to achieve their life desires. In addition, it is the atmospheric surroundings where combustion and emission activities of air craft and aerospace engines take place.³ During aircraft combustion process, air craft burns fossil fuels such as jet "A" for (turbine aircrafts) or AV gas for (piston air craft),⁴ releases gaseous substance which contains carbon dioxide CO₂, carbon monoxide (CO), water vapour, sulphur dioxide SO₂, nitrogenous oxide NO_x, un-burnt hydro carbons, soot and aerosol into the atmosphere.⁵ Accumulation of this carbon emission being released in large quantity by several aircrafts on international and domestic flights, over a long period of time, contributes in no small measure to trans-boundary and domestic pollution of the atmospheric environment, which later contribute to global warming and depletion of the ozone layer with serious environmental consequences on human lives, animals and plants.⁶

The primary products of aircraft combustion process whereby aviation fuel or aviation kerosene is sprayed and burnt in the chamber of aircraft are carbon dioxide and water vapour which constitute salient form of aviation emission.⁷ There is also the presence of nitrogen oxide and sulphur oxide, the emission coming out of these gases are characterised as green house gases because when emitted into the atmosphere they trap the infrared radiation from the earth surface and make earth surface become warmer than before.⁸ The process of global warming of the earth surface which is equally enhanced by too much release of aviation emission into the environment takes place when certain gases which are below the atmosphere absorb the infrared radiation being sent down on the earth through energy from the sun. The direct energy from the sun which appears in form of light and cloud is being absorbed on earth through certain gases called greenhouse gases, which are naturally present below the earth surface. Reasonable quantity of greenhouse gases will

³ Saadu, H.I, Mustapha, I.A, & Akanbi K.O, "Climate Change: Legal Response to Aviation Emission in Nigeria", in *Law and Climate Change*, Egbewole W.O, Etudaiye M.A, & Olatunji, O.A (Ed), (Faculty of Law, University of Ilorin) 2011, 291. Also, see further elaborate discussion on the environmental impact of aviation and the control law in one of the authors unpublished thesis, Murtala Ganiyu, *International Legal Regime on Reduction of Aviation Emission and its Implementation in Nigeria* (Unpublished PhD thesis, Ahmad Ibrahim Kulliyah of Laws, International Islamic University, Malaysia), 2016.

⁴ Id.

⁵ Address Doppelheuer, Aircraft emission parameter modelling (Air and Space Euro 34 Doppelhar) <<http://www.ease.eu.int>, viewed 6th Feb. 2014.

⁶ Id.

⁷ Saadu, H.I, Mustapha, I.A, & Akanbi, K.O, "Climate Change: Legal Response to Aviation Emission in Nigeria," in *Law and Climate Change*, Egbewole W.O, Etudaiye M.A, & Olatunji, O.A (Ed), (Faculty of Law, University of Ilorin) at p. 292., (2011).

⁸ Omaka C.A, *Environmental Regulations in Nigeria: Understanding the National Environmental Standards Regulations Enforcement Act 2010*, 23.

keep the atmosphere in normal warm temperature but excessive release of greenhouse gases into the atmosphere through burning of fossil fuel in the aircraft and other sources too much in the air, which cannot be absorbed by the earth surface. The heated earth surface in turn sends the heat energy back into the air space (upper atmosphere) which finally result in global warming of the earth environment.⁹ Concerning the process of depletion of ozone layer, the release of gaseous substance called aviation emission on the upper atmosphere by aircraft and aerospace engines on domestic and international flights has a direct impact on the depletion of ozone layer in the upper atmosphere. The consequences of these green house gas emissions are acid rain; melting of glaciers; skin cancer; air borne diseases destruction of lives; animals and plants.¹⁰

All over the world, aviation transportation is observed to be increasing steadily due to globalization of the world economy and economic growth. These have made air transportation affordable for a large number of populations in the world.¹¹ However, the increase in growth of air transportation has led to increase in volume of aviation emission being discharged on the earth surface. The high volume emission have serious consequences on the global environment, in form of pollution of the atmosphere, stratosphere and lithosphere with high level of greenhouse gases like carbon dioxide, carbon monoxide, nitrogen oxide and others.¹² It has been observed that aviation emission constitutes the fastest growing source of anthropogenic green house emission. This is because aviation emission from annex 1 countries rose by 67% between 1991 and 2005¹³ and is estimated to rise by as much as 90% when aviation emissions from non-annex 1 countries are included for the period.¹⁴ It has also been observed that about 3% of both the United States and European Union's (EU) total greenhouse gas emission are from aviation emission.¹⁵ The E.U has forecasted that current growth in trend of emission from international flights using E.U's airports will increase by over 150% over 1990 level.¹⁶ This prediction is corroborated by the information in the table 1.1.1 below. Further, it has been observed that the share of aviation to

⁹ Id.

¹⁰ David MC et al Reducing Green House Gas Emission from aviation and Marine Transportation in sustainable Energy pathways Programme and Institute, University of California, at. 4.

¹¹ David Freestone and Charlotte Streck, *The Legal Aspect of Carbon Trading, Kyoto, Copenhagen and beyond*, Oxford University press, 2009, at. 27.

¹² Id.

¹³ Intergovernmental Panel on Climate Change (IPCC), *The Assessment Report 1999*, <<http://www.ipcc>> accessed on 20/1/15.

¹⁴ Id at 28.

¹⁵ Supra note 13.

¹⁶ David, M.C. et al, n. 7, at. 5.

total global transportation emission is larger if non carbon dioxide emissions are added. The overall impact of aviation emission is however; potentially double in the case of aircraft in the air because aircrafts emit greenhouse gases directly into the atmosphere.¹⁷

TABLE 1.
GLOBAL AVIATION DEMAND (In billion km)

Year:	1990	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Quantity	200	800	1200	2000	3500	4000	5000	6000	7000	8000	9000	10000

Table 1.1.1 shows the increasing trend of global aviation demand (1990-2100) in billion Km¹⁸

The environmental effect of aviation emission is said to be more proved when one compares the rate of increase in carbon dioxide (CO₂) emission and increase in average temperature observed over entire planets. Since 1860, the beginning of industrial era, the average temperature on the surface of the earth has increased by 0.8°. The sudden rise in average temperature since the start of industrial era is said to be abnormal compared with trends, both in view of its relative amplitude and the speed of change on geological time scale.¹⁹ Therefore, scientific studies have suggested that reducing global emission by 50 to 80 percent below 1990 levels by year 2050 is necessary in order to stabilize the climate and avoid most destructive impacts of climate change.²⁰

Nigeria, being one of the countries involved in aviation transportation and a member of the International Aviation Organization (ICAO), also shares from the impact of aviation emission on her environment. Although, Nigeria claims not to be one of the great aviation emitters like the developed countries, reports have shown that Nigeria's national and international air travel markets expanded over the years with corresponding volume of aviation emission being released.

Table: 1.2
CIVIL AVIATION STATISTICS ON AIR PASSENGERS CARRIED BY NIGERIA.

¹⁷ Id.

¹⁸ Vedantham .A. & Oppenheimer .M. Aircraft Emission and the Global Atmosphere University Pennsylvania, at. 5 <scholarly common repository open.edu/cgi/view content.cgi?article1061&context=librarypapers http%3A%2Fscholar.goggle.com.my%2Fscholargoogle.com.Environmental Defensefund1994> viewed on 18/4/2014.

¹⁹ Id.

²⁰ Supra note 13. See also supra note 5 for a detailed discuss on the topic.

Year	2009	2010	2011	2012
Nigeria	1,365,343	4,197,375	4,793,913	4,716,148

The total number of air passengers carried by Nigeria between 2009 & 2012 is hereby shown in the above table.²¹

Reports have also indicated that the coastal areas and some other parts of Nigeria have been experiencing the impact of global warming emanating from effect of aviation emission. This thus necessitates the need for Nigeria to join the international legal response to reduction of aviation emission.²² Further to the above, the boundless nature of emission and the integrated nature of international civil aviation mean that effective action on global reduction of aviation emission requires committed efforts of all countries in the world. As such, Nigeria should take a serious action on reduction of aviation emission in order to have a clean and sustainable environment.

Therefore, the aims of this paper are to examine the constituents of aviation emission, the impact of aviation emission on the environment in Nigeria and to give an highlight of the international and national laws for its regulation.

2. DEFINITION OF AVIATION EMISSION

Aviation emission can be explained as the gaseous pollutants emitted by air craft and aerospace engines as a result of their combustion activities. According to Oxford Advance Learner's dictionary of English, aviation emission is the sending out of carbon dioxide and other gases into the atmosphere by aircraft.²³ Also, according to the report of Global Aviation Emission Inventories, aviation emissions are described as the smoke pollutants or gases from aircraft which originate from fuel burnt in air craft engines.²⁴ Further, the Kyoto Protocol to the United Nations Frame work Convention on Climate Change, though did not define aviation emission , brings to our awareness about the existence and limitation of aviation emission when it states in article 2 (2)²⁵ that; "parties shall pursue limitation of reduction of emission of greenhouse gases not controlled by Montreal protocol from aviation by working through International Civil Aviation Organization. In all

²¹ Data.worldbank.org/ indicator/is. AIR. PSGR viewed 16/12/2014.

²² Ikechi Ukoh, "Nigeria, Fastest Air Travel Market in Africa"(Aviation Watch, This Day Newspaper 2013 Sept 27), at. 6.

²³ Hornby A.S, Oxford Advance Dictionary, International Student Edition, Oxrord University Press 2012 at 45.

²⁴ ANCAT/CC2, Global Aircraft Emission Inventories for 1991,1992 and 2015,Report by the ECAC/ANCAT and EC Working Group Ed R Gardener ISBN 92828-2914-6 Netherlands 1998..

²⁵ Kyoto Protocol to the United Nations Framework Convention on Climate Change, UN. DOC ECCCKP/1977 at 21.

activities involving aircraft combustion, aircraft releases gaseous substance which contains carbon dioxide CO₂, carbon monoxide(CO), water vapour, sulphur dioxide SO₂, nitrogen oxide NO_x, unburnt carbons, soot and aerosol into the atmosphere, through the burning of fossil fuel such as jet A for (turbine aircrafts) or Av gas (for piston aircraft)²⁶. Therefore, the above shows that the emitted pollutants from aircraft emanating from the burning of the various gases above, are referred to as aviation emission.

3. Scope of aviation emission

In a broad sense, the scope of aviation emission under a typical aviation industry, extends beyond emission from air craft engines and aviation technologies to include emissions from ground airport vehicles and those used by passengers and staff to access airport, as well as through emission generated by production of energy used in airport buildings, the manufacture of aircraft and construction of airport infrastructure.²⁷ However, for the purpose of this research, our focus of aviation emission shall be limited to emissions from civil aviation aircraft engines and aerospace engines only and even excluding military aircrafts. Specifically, this study will focus on emission emanating from civil aviation air craft engines being accounted and reported for under the regulations of International Civil Aviation Organization, which is the body responsible for regulation of aviation emission.

4. The components of aviation emission

By nature, aviation emission is in the form of gaseous pollutants which are made up of greenhouse gases and other pollutants. The role of Greenhouse gases which form the major part of aviation emission is explained below:

4.1. Greenhouse gases

According to Oxford Advanced Dictionary of English²⁸, Green house in technical context, is used to explain the atmosphere play in warming the earth surface. Short solar radiation passes through the atmosphere and absorbed by earth surface, this is then re-emitted and reflected back to the atmosphere by gases like carbon dioxide,, methane, nitrous oxide, ozone etc which are known as greenhouse gases. Also, the Special Assessment Report (1999)²⁹, of

²⁶ Saadu, H. I, Mustpha I. A, & Akanbi K. O, "Climate Change, Legal Response to Aviation Emission in Nigeria" in Law and Climate Change, Egbewole W.O, Etudaiye M.A, & Olatunji, O. A, (Ed), (Faculty of Law, University of Ilorin) 2011 at 291.

²⁷ Pachuri P. K. and Reiseinger A. (ed), Climate Change Synthesis Report. Contribution of Working Group I, 11 and 111 to the Fourth Assessment Report of the Inter Governmental Panel on Climate Change, (IPCC, Geneva, Switzerland, 2007) 104

²⁸ Hornby A.S, Oxford Advance Dictionary, International Student Edition, at 85 (Oxford University Press, 2012).

²⁹ Intergovernmental Panel on Climate Change (IPCC), The Assessment Report 1999, <<http://www.ipcc>> accessed on 20/1/15.

Intergovernmental Panel on Climate Change while reporting on the effect of aviation emission on global warming, refers to greenhouse gases as the cause of global warming. According to the report, such greenhouse gases as carbon CO₂, nitrogen oxide NO_x water vapor H₂O, Sulphate aerosol and soot cause global warming when emitted from air craft engines. Further, according to Thorton J. Beckwith S, greenhouse gases which act to maintain the earth's relative warm temperature. But too much of trapping of the warmth from the sun in the lower atmosphere caused by too much presence of greenhouse gases such as carbon dioxide, methane, nitrous oxide and others in the lower atmosphere leads to global warming.³⁰ Generally, greenhouse gases (GHGs) are a term used for gases which cause warming of the earth, although (GHGs) production occurs naturally, greenhouse gases are majorly produced by burning of fossil fuel such as coal, oil and gas, petrol, and kerosene.³¹ The use of fossil fuel which has contributed immensely to industrialization and aviation development has also caused a steady increase in the release of high level carbon gases and other pollutants into the atmosphere. These greenhouse gases when emitted into the atmosphere, are like blankets, and are known for trapping heat in the atmosphere instead of allowing it to radiate back in to the space. As a result of this, the atmosphere is over heated at an abnormal rate and this leads to global warming and a change in weather pattern.³²

In combustion process, aviation fuel (kerosene) is sprayed at high pressure into the combustion chamber of the jet engine where it mixes with hot high pressure air supplied by the compressor and when ignited, the products of this process are carbon dioxide and water vapor which characterize the greenhouse gases, because when emitted into the atmosphere they enhance natural greenhouse effect by trapping the infra red radiation from the earth surface.³³ The greenhouse effect is a natural phenomenon that warms the earth to support life and without it, the earth temperature will be a frozen -180c (Celcius) instead of normal/average of +150c.³⁴ The greenhouse effect is believed to cause abnormal warming of the atmosphere leading to melting of the polar ice caps and flooding of the low land mass. The major greenhouse gases and other pollutants which form the components of aviation emission and contribute to global warming and other atmospheric changes are explained as follows:

³⁰ Thorton J, and Beckwith, Environmental law, Sweet and Maxwell, Lodon 2010, at 3.

³¹ Hassen J. E, Defusing the Global Warming Time Bomb, Scientific American publication vol. 12 No7, Washington DC, 2000, at 68.

³² Id.

³³ G.P Brasseur et al, "European Scientific Assessment of the atmospheric effects of air craft emissions" Vol. 22 No 13 (2001) Atmospheric Environment pub, 2332.

³⁴ Paul Stephen Dampsey, "Trade and Transport policy in Inclement Skies: The Conflict Between Sustainable Air Transportation and Neo classical Economics," (2000) 65 J Air & L Com, 639.

4.2. Carbon dioxide (CO₂)

Carbon dioxide is a gaseous pollutant in aviation emission which contributes to global warming and climate change. It is estimated that the current world wide fleet of air craft produces about 2 to 3% of the fossil fuel released into the atmosphere.³⁵ According to report, the combustion of one kilogram of aviation emission kerosene directly results in emission of about 3160 grams of CO₂ into the atmosphere. Carbon dioxide (CO₂) is believed to have a very long atmospheric residence time (approximately 100 years) and CO₂ emitted from air craft becomes well mixed with CO₂ from other fossil fuel sources.³⁶ Since the effect of CO₂ on climate change is direct and depends on atmospheric concentration, aviation emission of CO₂ will continue to be a matter of environmental concern in view of projected growth in aviation emission.

4.3. Nitrogen Oxide (NO_x)

Nitrogen Oxides are part of greenhouse gases. Nitrogen oxides and oxygen are readily formed by direct reaction of nitrogen and oxygen in high temperature combustion process that occurs in jet engine aircraft because air contains 78% of nitrogen and 21% oxygen.³⁷ This combustion process produces several oxides of nitrogen like nitric oxide (NO_x) and nitrogen dioxide (NO₂) both termed as (NO_x). This nitrogen oxide (NO_x) is known to have great influence in the chemistry of troposphere and atmosphere especially in ozone production and destruction processes.³⁸ A natural occurrence of gas in the atmosphere which about 80 -90% reside in the stratosphere is known as ozone. This is produced by reaction of oxygen molecules and ultra violet radiation (UV) from the sun in a process called photodissociation.³⁹ Chemical reaction in a pollution free atmosphere ensures a balance between production and destruction of ozone which leads to a steady state of abundance of gas in the stratosphere and this is called ozone layer.⁴⁰ The ozone layer doubly acts as the shield that protects biological system on the earth surface from damaging ultra violet radiation from the sun and also acts as a greenhouse gas but its efficiency in this role depends on its altitude and latitude. Therefore, a discharge of nitrogen oxide in the upper stratosphere from aviation emission, has a profound effect

³⁵ Joyce E. Penner et al, eds, *Aviation and Global Atmosphere*; Special report of Inter Governmental Panel on climate Change, Cambridge UK, Cambridge University Press 1999, at 3.

³⁶ Id at 4.

³⁷ Supra note 27 at 23. Joyce E. Penner et al, eds, *Aviation and Global Atmosphere*; Special report of Inter Governmental Panel on climate Change, Cambridge UK, Cambridge University Press 1999, at 3.

³⁸ Id.

³⁹ Albritton et al, "Global Atmospheric Effects of Aviation: Reports of the Proceeding of The Symposium," (2001), NASA Publications Washington DC, 8.

⁴⁰ Id.

upon atmospheric ozone. In addition, nitrogen oxide emissions below cloud level are washed out of the atmosphere as acid rain.⁴¹

4.4. Methane

Methane is another pollutant of aviation emission among the greenhouse gases. Though, not emitted in large quantity like carbon dioxide, methane also plays an important role in atmospheric changes through reactions with nitric oxide and other hydro carbon products. Methane is known to represent 15% to 20%⁴² of man-made additions to global warming, despite the fact that methane only lasts for a period of ten years in the atmosphere, it absorbs twenty to thirty times more heat than carbon dioxide. Methane has warming effect on the atmosphere and too much presence of methane in the atmosphere from aircraft emission has global effect on climate change.⁴³

4.5. Water Vapour (H₂O)

Water vapour is a pollutant which constitutes an active radiative gas in aviation emission, therefore, additional water vapor in the atmosphere can directly modify the radiative capacity of the earth by enhancing greenhouse effect.⁴⁴ Water vapour which is another primary product of combustion in air craft jet engine however has its effect on the atmosphere influenced by its altitude. The potential climatic effect of water vapour emission by air craft in this respect depends on the relative contribution of the emission to the background water vapour level in the atmosphere.⁴⁵ Water vapour H₂O, is emitted by very large air craft in flight at high altitude. Emission of water vapor from aircraft engines in conjunction with soot and sulphur compounds, form condensation nuclei⁴⁶ and trigger additional cloud formation in the atmosphere which indirectly contributes to radiative forcing⁴⁷ and climate change. Condensation nuclei forms when soot particles present in the air craft emissions are activated, these condensed water vapour keeps growing in size until clouds are formed. These

⁴¹ J. L. Cornish, J. A. Nicel & A. D. Groenewe, "Transport Canada: the Greening of aviation (Montreal)" (1996) QC Transportation Development Centre, 28.

⁴² Barret M, Aircraft Pollution: Environmental Impacts And Future Solutions, WWWR Research paper publications, London 2007 at 7

⁴³ Id at 8

⁴⁴ G. P. Brasseur et al, "European Scientific Assessment of the atmospheric effects of air craft emissions" Vol. 22 No 13., at p. 33 (2001) Atmospheric Environment pub, 2332.

⁴⁵ Id.

⁴⁶ Condensation nuclei means cloud compression, cloud cluster or gathering of cloud.

⁴⁷ Radiative Forcing (RF) is a change in average net radiation at the top of troposphere resulting in solar or infra red radiation. It is a measure of warming and the rate of energy per unit area of the globe as measured at the top of the atmosphere and its expressed in unit of watts per square metre. When radiative forcing is evaluated positive, it will lead to warming of the atmosphere but when negative, it will have cooling effect on the atmosphere see Green Growth and the Future of Aviation, paper prepared for 27th Round table on sustainable development, Organization for Economic Cooperation and Development, London 2012 at 5

clouds called condensation trails or contrails may not stay long and may be persistent in the atmosphere based on the background temperature and high humidity level.⁴⁸ Whenever the air is super saturated with water and temperature is below freezing point, formation of persistent contrail with longer residence period in the atmosphere takes place. Water vapour is considered in determining radiative balance and chemical composition of atmosphere because of the dramatic role it plays in polar ozone loss through formation of polar stratospheric cloud.⁴⁹

4.6. Sulphur (Oxide SO_x)

Some amount of sulphur about 0.04 – 0.05 % is contained in a standard jet engine fuel (Aviation kerosene).⁵⁰ In a combustion process, the oxidation of fuel sulphur leads to production of sulphur dioxide (SO₂) which further reacts with other species in the exhaust of plane to produce sulphur trioxide (SO₃) and possibly sulphuric acid (H₂SO₄).⁵¹ The atmosphere shall be affected by these oxides of sulphur by increasing sulphate aerosol level, thereby enhancing heterogeneous processing of halogen reservoir gases and by reactivating carbon soot particulate to bring about condensation nuclei which will bring about an increase in the formation of contrails and cirrus clouds.⁵²

4.7. Carbon monoxide (CO)

Carbon monoxide is a poisonous gas contained in aviation emission. It is not a greenhouse gas contributing to climate change, but a product of incomplete combustion with a particular concern to the health of people in urban environment. CO reduces the atmosphere's hydroxyl content which acts as nature's detergent. Carbon monoxide is known to be a common irritant when emitted as a surface level pollutant, it is primarily generated by aircraft at low engine power level at idle or taxi time by aircraft.⁵³

4.8. Products of incomplete Combustion

Due to incomplete combustion of fuel, aircraft engines emit a number of effluents which include volatile organic compound (VOCs) such as benzene, toluene formaldehyde and 1,3 butadiene.⁵⁴ There are also non methane hydro

⁴⁸ A.W Brewer, Condensation Trails vol.1, Weather publication, 1964 at 34
⁴⁹ Id.

⁵⁰ R.C Brown et al, "Air craft sulfur emissions and the formation of visible contrails," (200) Vol. 3603 Geography Research Letters, 23

⁵¹ Id.

⁵² Id.

⁵³ Albritton et al, "Global Atmospheric Effects of Aviation: Reports of the Proceeding of The Symposium," at pp. 67-68 (2001), NASA Publications Washington DC, 8.

⁵⁴ Andress Doppelheuer, Aircraft emission parameter modelling (Air and Space Euro 34 Dopelliar) <<http://www.ease.eu.int>, viewed 6th Feb. 2014. Dampsey n 6 at 645.

carbons (HC) such as alkynes aldehydes and aromates, carbon monoxide (CO) and carbon soot (smoke).⁵⁵ Soot is generated at high engine power level while hydro carbon and carbon monoxide are generated at low engine power level. The quantity emitted by any air craft engine however depends on the combustion efficiency of the engine. The atmospheric effects of products of incomplete combustion are however mostly localized. For instance, soot and unburnt hydro carbons are responsible for poor air quality and smog around airport while carbon monoxide is a common irritant emitted as a surface level pollutant. As a matter of fact initial concern about atmospheric impact of air transport focused on these localized environmental problems.⁵⁶

5. THE IMPACT OF AVIATION EMISSION IN NIGERIA

The 1999 constitution of Federal republic of Nigeria defined and listed aviation in matters of exclusive legislative list schedule II part 1 item 3 as "aviation including air ports, safety of aircraft and carriage of passengers and goods by air".⁵⁷ Aviation plays a great role in socio-economic life of Nigeria in the sense that it provides fast means of taking people to their destinations in large number. It allows goods and services to be transported to their destinations in large quantities. It promotes tourism and also serves as a good source of employment to a lot of people. The participation of Nigeria in the global aviation transportation and the steady increase being witnessed in the industry made it possible for Nigeria to derive from the benefits of aviation in the following: In 2011 alone, Nigeria recorded over 4.7 million air passengers traffic across the country with a total amount of N225 billion tickets sold. Between 1993-2009, about 1,286 billion kilograms of cargo were recorded in 19 airports in the country, while a total of 60,000 employees were employed in 2011.⁵⁸

In addition to the above, it is further observed that as a result of globalization of world economy and economic growth which made air transportation available to many people, Nigeria's participation in aviation transportation became more visible and expanded tremendously in many respects; between 1964 and 2014 Nigeria has a total of 25 airports, out of which, 6 are international airports. Also, 3 Nigerian air lines are presently operating international routes while 21 foreign airlines are operating in Nigeria.⁵⁹ Relevant aviation statistics have also shown that Nigeria aviation

⁵⁵ Id.

⁵⁶ Supra note 53 at 10.

⁵⁷ Okechuku Effoduh, "Aviation Reform in Nigeria, How well So far?, Round table on Aviation and Space Law Trends," (2013) Nigerian Institute of Advanced Legal Studies (NAILS) Abuja, 14.

⁵⁸ Id.

⁵⁹ Id.

industry recorded a rapid increase in the total number of air passengers carried between 2009 and 2012 as follows: In 2009, Nigeria carried 1,365,343 air passengers, in 2010, it was 4,197,375 air passengers and in 2012, Nigeria also carried 4,716,148 air passengers.⁶⁰ The significance of all the above is to show that the volume of aviation transportation has tremendously increased in Nigeria. However, it is also significant to know that despite the benefits of aviation, the industry generates a lot of emission from the aircrafts which has negative impact on the environment. Also, it is significant to know that the increase in volume of international and domestic air transportation in Nigeria has brought about a corresponding increase in the release of aviation emission into the environment in Nigeria, with a series of negative impact on the environment. Buttressing the above, it has been reported that the increased air traffic and modernization achieved in air craft technology since 1960s, culminated in the use of jet and supersonic aircraft, the activities of these new supersonic aircraft and older aircraft are said to have negative impact on the environment and also cause a lot of public concern.⁶¹

The impact of aviation emission on the local environment particularly, the vicinity of airports in Nigeria is known to be negative and many. Aircraft emission causes poor air quality in airport environment in Nigeria and also causes various human health problems such as bronchitis and asthma. This is because a mixture of aircraft pollutants called sulphur dioxide (SO₂) and soot which eventually becomes aerosol, affects air quality and causes serious respiratory diseases when emitted by aircrafts at the airports in Nigeria.⁶² Another local impact of aviation emission is acid rain. It has been established that when pollutants from aircraft engines known as sulphur dioxide and water vapour mix, they form sulfuric acid. This formation when finally washed down from below the earth surface is known as acid rain and this has serious effects of pollution of the water, soil, vegetation, farm production, and corrosion of metals, monuments and buildings in the environment around the airports in Nigeria.⁶³

Aviation emission has led to discharge large volume poisonous gas which has effects on the lives of people and the airports environment in Nigeria. This is made possible because the mixture of poisonous aircraft engine pollutants known as carbon monoxide and products of incomplete combustion has serious effects on human health and the environment around

⁶⁰ Data.worldbank.org/indicator/is.AIR.PSGR viewed 16/12/2014.

⁶¹ Annastacia Aver Gbem, "Air Law in Nigeria: Problem and Prospect" (LLM thesis, Institute of Air and Space Law, MC Gill University, Montreal Canada,)1997, 54.

⁶² Saadu H.I, Mustapha I.A & Akanbi K.o, n1 at 293

⁶³ Usman B.A & Tunde A.M, "Climate Change and Sustainable Development in Nigeria: Planning for Climate Resilient Cities" in Law and Climate Change in Nigeia, Egbewole O.A, Etudaiye A.M, & Olatunji O.A, (Faculty of Law, University of Ilorin, 2011), 114.

the airports. This carbon monoxide mixture is known to reduce atmosphere's hydroxyl or ability to clean out pollution⁶⁴.

Significantly, aviation emission is also responsible for formation of cirrus cloud and haze which lead to poor visibility for aircraft and vehicles around the airports in Nigeria and also cause destruction of soil in the environment. This is because, water vapour H_2O , during combustion process in aircraft engine emission when at high altitude, precipitates in to contrail and cirrus cloud with serious impact on visibility and warmth of the environment. Even though, the full impact of water vapour on the atmosphere is still subject to further research,⁶⁵ the magnitude of the impact of haze and poor visibility at the airports on the aviation sector in Nigeria is best captured in the Nigerian Meteorological Agency (NIMET) 2010 climate review report as follows:

"In aviation, the year 2010 witnessed instances of flight disruption as a result of weather condition. During the month of march, there were severe dust hazy spell that led to reduction in aviation visibility between 200m-800m for several days, causing a lot of flight disruption. The flights in Lagos, Abuja, Kano, Kaduna, Minna, Maidug-uri, Sokoto, Enugu, Owerre, Port Harcourt and Calabar airports were disrupted while some flights were completely cancelled. Between Jan - Dec 2010, There were reported cases of early morning fog in Lagos, Port Harcourt, Owerri and Jos which reduced horizontal visibility between 200m-800m and these resulted in flight delay at the affected airports. Also thousands of Europe bound Nigerian passengers were stranded at the Murtala International airport (MMIA) Lagos. This harsh weather condition disrupted a number of inbound and out bound flights at the Murtala Airport."⁶⁶

Also, aviation emission is recognized as being responsible for prevalence of lungs irritant which has bad effect on the health of people living in the airport in the airports environment in Nigeria.. This is made possible as unburned hydrocarbons in aircraft engine emission remain bounded to each other with some hydrogen atoms forming unburned carbons. These molecules react with nitrogen oxide in the presence of sunlight to form ozone which is a lung resistance⁶⁷.

However, despite the various ways which aviation emission has negatively impacted on the environment, it has been established that most people are still ignorant about the adverse environmental impact of aviation

⁶⁴ Supra note 62 at 295.

⁶⁵ Id.

⁶⁶ NIMET Climate Review Bulletin 2010, Nigerian Meteorological Agency, Abuja, 2010. <<http://www.nimet.ng.org>> accessed on 6/4/2015.

⁶⁷ Supra note 62 at 39.

emission. This is obvious from the increasing construction of residential building near air ports in Nigeria. This practice is however found to have serious health implication on the lives of people and the environment around the airports in Nigeria.⁶⁸ Importantly, it should be noted that the impact of aviation emission on the environment in Nigeria is vast and this will continue to be more as long as air transportation and its attendant discharge of aircraft engine emission continue to increase. Therefore, there is need to put a check on the rising profile of aviation emission in order to overcome hazardous health condition and continuous degradation of environment around the airports in Nigeria.

As regards the global impact of aviation emission in Nigeria, it should be known that the global impact of aviation emission in Nigeria is climate change which is occasioned by global warming. Although, it is argued in some quarters that Africa and indeed Nigeria, need not care about climate change because, they are not among the top green-house gas emitters, as they produce negligible green-house gases and that issues of climate change, should be dealt with by the developed countries who majorly caused the problem. Unfortunately, this notion is wrong because Africa is the only continent that will probably suffer most from consequences of climate change if the global problem remains unsolved.⁶⁹

Aviation emission impacts on climate change in Nigeria through global warming, which can be described as a long term increase in average temperature and scientifically shown to emanate from increase of carbon dioxide in the atmosphere by human activities.⁷⁰ Carbon dioxide (CO₂) is said to be most notorious for warming the earth as it accounts for 35% of the contribution of aviation emission towards climate change. Carbon dioxide emission from aircraft engines is produced from burning of fossil fuel from aircraft, the amount of CO₂ emitted is a direct function of fuel consumption and this gas can remain in the atmosphere for 100 years. Based on the significant warming effect of carbon dioxide, the Intergovernmental Panel on Climate Change (IPCC) estimated that aviation's total climate impact is 2-4 times that of its carbon dioxide emission alone.⁷¹

In Nigeria, the meteorological Agency (NIMET) has reported that weather is changing gradually for the worse because of impact of climate change caused by Green House Gases like carbon dioxide and others, which will continue to affect soil, food production and its cost generally. It was also reported that global weather change affects Nigerians through change in

⁶⁸ Id.

⁶⁹ Supra note 62 at 293.

⁷⁰ Id.

⁷¹ Id at 294.

temperature resulting in desertification and draught in Northern sahel region to increase precipitation and rise in sea level in the coastal area which will have several consequences on agriculture, infrastructure, health, water resources and ecosystem.⁷²

NIMET gave a comprehensive report on weather and climate change effects on Nigeria in 2010, as follows:

"A review of climate change over Nigeria in 2010 has shown that warmer than normal conditions prevailed over greater part of the country in the north and north central states. The outbreak of cerebrospinal meningitis that was reported in states like kaduna Bauchi, Jigawa, Gombe, Zamfara etc may have been associated with the above temperature in those parts of the country. In particular, the normal rainfall amounts in the year in the country were generally higher than long term mean value except in places like Kwara state, leading to flood and opening of dams. These extreme events resulted in dislo Cation of families, destruction of farmland, infrastructure and loss of lives"⁷³

Other aircraft engine pollutants that are known to also have impact on climate change in Nigeria include Nitrogen oxide NO_x , Water vapour H_2O and particulates,⁷⁴ nitrogen Oxide (NO_x) emissions emanates from high altitude flown large jet air liners around the tropopause. NO_x emissions are known to be particularly effective in forming ozone (O_3) in the upper troposphere. At high altitude of 18-13 km, NO_x emission is known to result in greater concentration of ozone than surface NO_x emission and this in turn, has a greater global warming effect. The effect of ozone is however regional and local, it is unlike the effect of carbon dioxide which is global.⁷⁵ Nitrogen emission reduces ambient level of methane, another green-house gas resulting in climate cooling effect but this will not offset the ozone forming effect of nitrogen oxide emission. It is now established that aircraft sulphur and water emission in the atmosphere tend to deplete ozone, partially offsetting the nitrogen oxide induced ozone increases. Generally, the major ozone depleting substance are (volatile organic compounds, carbon monoxide, carbon dioxide, chlorofluorocarbons, methane, nitrous oxide etc.) which lead to serious assault on planet's life support system and could have long time effect on human health animal life and the plants that support the food chain.⁷⁶ This aviation

⁷² NIMET Report On Climate Review Bulletin 2010, Nigeria Meteorological Agency, Abuja, <<http://www.nimet.ng.org>> accessed on 13/4/15.

⁷³ Id at 3.

⁷⁴ Supra note 63 at 41.

⁷⁵ Id at 294.

ozone impact is found to affect Nigeria due to fast increase in her air transportation. However, it is said that all the above effects have not been quantified and the problem doesn't apply to aircraft that fly lower in the troposphere i.e. light aircraft but applicable to big jet air liner.⁷⁷

Water vapour is another aircraft pollutant that has global warming impact on climate change. Water vapour (H₂O), is a Green House Gas discharged by very large aircraft at high altitude. Under certain atmospheric conditions, water vapour forms condensation trails and visible lines that form in the cold, humid atmosphere and are known to have a global warming effect (possibly of less significance than carbon dioxide emission or nitrogen oxide induced effects).⁷⁸ Emission of water vapour by aircraft engines at high altitude during continuous air transportation has been known to have climate impact on Nigeria.

Particulates are known to be least significant pollutants which release soot and sulphate particles. Soot is known to absorb heat and has a warming effect, sulphate particles reflect radiation and have a small cooling effect, they also influence the formation and properties of clouds.⁷⁹ It should be noted however, that all combustion aircraft shall release some amount of soot. It has been observed global warming effect from particulates like soot also applies to Nigeria through continuous emission from air transportation activities.⁸⁰

To buttress the above, it has been observed that the global impact of climate change to which aviation emission greatly contributed, has started to be noticed in Nigeria particularly, in Lagos, Ilorin, Abuja, and part of Bayelsa Rivers Delta, Sokoto, Kebbi and Zamfara state between 2000 and 2012 respectively.⁸¹ The impact which comes in form of excessive rain fall, flood and severe weather condition in many parts of Nigeria, calls for a serious action on reduction of aviation emission. This aspect, shall however, be carefully examined in the subsequent chapter.

6. THE CONTROLLAWS IN NIGERIA

In realisation of the impact and bad consequences of increasing aviation

⁷⁶ Id, 295.

⁷⁷ Vedantham .A. & Oppenheimer .M. Aircraft Emission and the Global Atmosphere University Pennsylvania, at. 5 <scholarly common repository open.edu/cgi/view content. cgi?article1061&context=librarypapers http%3A%2Fscholar.goggle.com.my%2Fscholargoogle.com.Environmental Defensefund1994> viewed on 18/4/2014.Fashina-bombata H.A, n16,514.

⁷⁸ Paul Stephen Dampsey, "Trade and Transport policy in Inclement Skies: The Conflict Between Sustainable Air Transportation and Neo classical Economics," (2000) 65 J Air & L Com, 639.

⁷⁹ Id at 7.

⁸⁰ Annastacia Aver Gbem, "Air Law in Nigeria: Problem and Prospect" (LLM thesis, Institute of Air and Space Law, MC Gill University, Montreal Canada,)1997,54.

⁸¹ Usman B.A &Tunde A.M, "Climate Change and Sustainable Development in Nigeria: Planning for Climate Resilient Cities" in Law and Climate Change in Nigeia, Egbewole O.A, Etudaiye A.M,& Olatunji O.A, (Faculty of Law, University of Ilorin,2011),116.

emission on the environment, the international community responded to the adverse atmospheric effects of aircraft engine emission in two ways: One approach was to control aviation emission through ratification of international conventions and protocols by member states. The notable convention and protocol for this are the United Nations Framework Convention on climate change, UNFCCC (1992) and the Kyoto protocol to the UNFCCC (1997).⁸² Under Public International Law principle, such convention and protocol are to be signed, ratified and domesticated by member states to become implemented as part of the domestic Acts of a state.⁸³ The other approach has been to address reduction in aviation emission directly from air craft engines through the regulatory regime of International Civil Aviation Organization (ICAO). The regime include the Standard Recommended Practices on air craft engines (SARPs) and other regulations contained in annexe 16 volume II of the Chicago convention 1944. The ICAO regulations equally need adoption into national regulations for the purpose of implementation by member states, in line with ratified convention.

The ICAO is the global organization responsible for regulation of international civil aviation. Its functions include making laws on international standard and best practices in aviation, which are to be implemented among member states. Based on this approach, the International Civil Aviation Organization (ICAO) has since June 1981 adopted a continually updated international standard and recommended practices on aircraft engine emission in exercise of its laws making power under article 37 of the Chicago Convention on international civil aviation 1944. The SARPs contained in annex 16 vol. II call for prevention of international oil venting and established standard for air craft emission control. Added to this, annex 16 volume II of Chicago convention limits certain aircraft emission through engine certification process, depending on the age and type of aircraft. It also established highly technical process for measuring emissions. The emissions under ICAO control include, smoke, hydro carbon, carbon dioxide CO₂ and Nitrogen Oxide NO₂ from new engines.⁸⁴

In Nigeria, it has been observed that the growing influence in both national and international aviation business, made Nigeria to adopt international Conventions and protocols which brought about review of Nigerian aviation policy matters between 1999 and 2012, with the aim of

⁸² Mankata Y.O. Nyanpong, Regulation of Air craft engine emission from International Civil Aviation, (LLM thesis, Institute of Air Space Law, Faculty of Law, MC Gill University, Montreal Canada 2005), at. 3.

⁸³ AbdulGafur, H. Public International Law: A practical Approach (3rdEdn) Malaysia, Sweet and Maxwell Asia (2011), at. 78.

⁸⁴ I at 4.

achieving global standard in aviation environment practices.⁸⁵ The application of convention to aviation industry in Nigeria is however enhanced by the provisions of section 12 of the Constitution of Federal Republic of Nigeria and section 30 of the Civil Aviation Act, with a combined effect that while the Nigerian Civil Aviation Act adopts the provisions of Chicago Convention on regulation of aircraft engine emission, the constitutional provision validates it.⁸⁶ The existing domestic legislations on aviation practice in Nigeria include the Nigerian civil Aviation Policy 2001, Nigerian Civil Aviation Act, No 6, 2006 and Nigerian Civil Aviation Regulations 2012, Vol.1&11 and the Nigerian Civil Aviation Regulations 2015. The general expectation is that these regulations if properly implemented, will serve a lot to effect reduction in aviation emission and guarantee safe and sustainable environment in Nigeria.

CONCLUSION

The paper has carefully examined the concept of aviation emission, the constituents of aviation emission, as well as local, trans- boundary and global impact of aviation emission. Further, the paper discussed about the major existing the international and domestic legislations on reduction of aviation emission in Nigeria.

It is found from the above study that aviation emission is made up of various contaminants with severe health effect and severe local, regional and global environmental impact. It is also found that contrary to the claim that aviation emission only contributes 2% of the total global emission and thus has little impact on climate change, aviation emission has a significant impact on climate change both locally and globally and this impact will continue to increase as a result of global increase in aviation transportation, It has also been found that aviation's tendency to continue to grow above 2% will constitute serious threat to the environment. It was further established that the impact of burning aviation fuel at altitude is about double that of burning same fuel on ground with higher environmental impact. It has been noted that the impact of the mixture of emission from aircraft goes beyond radiative effect of CO₂ alone, as the mixture of such species was calculated to be two or four times more than exhaust of carbon dioxide alone from aircraft, this mixture is however known for causing radiative forcing.

Also, it has been found that as long as globalization of industry and commerce increases, the fast growth of aviation sector is expected to continue. Added to the above, various reports have pointed to the fact that future scenario

⁸⁵ Saadu, H.I, Mustapha, A.I & Akanbi O.K n3 at298. Saadu, H.I, Mustapha, I.A, & Akanbi, K.O, "Climate Change: Legal Response to Aviation Emission in Nigeria," in Law and Climate Change, Egbewole W.O, Etudaiye M.A, & Olatunji, O.A (Ed), (Faculty of Law, University of Ilorin) 2011.

⁸⁶ Id at 297.

of air transportation and aviation emission shall continue to rise. The report of International Air Transport Association (IATA) 2010, indicated that air travel and freight volume has increased tremendously and predicted 16 billion travellers and 400 million tons of cargo for air lines in 2050.⁸⁷ The Intergovernmental Panel on Climate Change (IPCC), in its fourth assessment report, put total air transport carbon dioxide at 280million tonnes (mt) in 2005 and later predicted that such emission will be 594mt in 2010, 860mt in 2020, 1262mt in 2030 and 2377 in 2050.⁸⁸ The importance of these reports is to show that as a result of continuous fast growth in global air transportation, aviation emission will continue to grow in future and this will constitute a serious threat to the environment unless a decisive action is taken towards reduction in the global volume of aviation emission. The paper also found that the UNFCCC 1992, the Kyoto Protocol to UNFCCC 1997 and the ICAO International standards regulations of Annex 16 Vol II of Chicago Convention 1944 are the international laws put up at the United Nations level for achieving reduction in aviation emission, while the Nigerian Civil Aviation Act 2006, the Nigerian Civil Aviation Regulations 2012 are the major existing domestic legislations for regulation of aviation environment in Nigeria. It is therefore recommended that these domestic legislations should effectively implement the ICAO international standards in order to guarantee effective reduction in aviation emission in Nigeria.

⁸⁷ Anu Vendatham & Michael Openheimer, n49,6. Vedantham .A. & Oppenheimer .M. Aircraft Emission and the Global Atmosphere University Pennsylvania, at. 5 <scholarly common repository open.edu/cgi/viewcontent.cgi?article1061&context=librarypapers http%3A%2Fscholar. goggle.com.my %2Fscholargoogle.com. Environmental Defensefund1994> viewed on 18/4/2014.

⁸⁸ Id.