Contributions of Vehicular Traffic to Carbon Dioxide Emissions in Kaduna and Abuja, Northern Nigeria

Peter Ndoke NDOKE[1], Uduak George AKPAN[2], Mary Egiganya KATO[2]

[1]*Department of Civil Engineering, Federal University of Technology, Minna*
[2]*Department of Chemical Engineering, Federal University of Technology, Minna, NIGERIA*
jemeandoke@yahoo.com, ugaekon@yahoo.co.uk, marykato@yahoo.com

Abstract

The quantity of carbon dioxide (CO_2) contributed by automobile emissions to the environment was determined at some areas in Kaduna and Abuja in Northern Nigeria. Five census stations were selected in each of the two towns. In Kaduna, Jabi road in Ungwan Rimi, Kawo Motor park, Stadium round-about, Sabo and Kasuwa (Kaduna Main Market), were selected, while Asokoro (behind ECOWAS), Area One junction, A.Y.A. junction, Wuse market bus-stop, and Mabushi round-about were selected for Abuja. A gas sampling pump and tubes that could detect carbon dioxide were used to detect the quantity of CO_2 in the environment at a certain time. The results obtained show a variation in the amount of CO_2 in the environment. Areas with relatively heavy congestion show a high concentration of CO_2, while areas with minimal traffic show a lower concentration of CO_2. Sabo in Kaduna has an average concentration of 1840 ppm being the highest, while Asokoro (behind ECOWAS), Abuja has the least average concentration of 1160 ppm. Review of literature showed that increasing CO_2 levels have adverse effects such as the Greenhouse Effect, which may lead to Global Warming, as well as a number of other climatic events. These concentrations are still not high enough to cause any serious health effects but they provide a baseline study for Policy makers and Town planners.

Keywords

Carbon dioxide, Pollution, Concentration, Traffic, Emissions

Introduction

One of the most important human impacts on our environment is the relatively rapid increase in atmospheric carbon dioxide caused by our profligate use of fossil fuels, as well as several activities which produce CO_2. The rise in carbon dioxide (CO_2) is more rapid than at any time in the past, due to the increase in industrial activities [1]. Although CO_2 is not toxic, its release is of interest as small increase of CO_2 concentration in the atmosphere can result in increase in ambient temperature and consequent climatic changes [2].

CO_2 levels have increased substantially since the Industrial Revolution, and are expected to continue doing so [3]. It is reasonable to believe that humans have been responsible for much of this increase, due to an increased dependence on machines and equipment that burn fossil fuels; such as automobiles and generators, as well as enhanced chemical processes carried out in factories and power plants.

CO_2 is an essential ingredient in the cycle of life on earth. Plants directly use CO_2 in the process of photosynthesis, where, combined with water, it is converted into sugars and oxygen. Plants use the sugars to fuel their growth, and animals breathe in the oxygen, consume plant matter, and exhale CO_2. The more CO_2 available, the better plants grow. Carbon dioxide only directly becomes a problem to animal life, including humans, if atmospheric concentrations continue to grow to toxic levels.CO_2 is emitted by natural and human-induced activities. The most common natural source is respiration. CO_2 emission due to human activities is pinpointed to three major causes: transportation, industry, and power plants. Transportation, however, contributes a greater percentage of CO_2 emissions as a result of the combustion of fossil fuels. Another source is fire, used for firewood cooking, bush burning, and refuse disposal. The environment absorbs CO_2 from human and natural activities. These are known as 'sinks'. Sinks are reservoirs that keep a chemical element from another part of its cycle. They include the atmosphere, ocean and land. On land, trees are the main absorbers of CO_2 – through the process of photosynthesis. Unfortunately, their efficiency is being reduced due to deforestation practices, thereby causing a greater amount of carbon dioxide to be absorbed by the atmosphere.

Motor vehicles are major sources of air pollutants. As industrialization and technological development continue, there will be a corresponding increase in income and hence cities will experience a greater increase in the number of vehicles on the roads. If vehicles continue to increase, it will become imperative that more attention be paid to vehicular pollutants, most especially CO_2 which is a direct product from the combustion of fossil fuels. It has been postulated that for every gallon of oil consumed by a motor vehicle, about 19 pounds of carbon dioxide goes directly into the atmosphere. In other words, for a typical fill up at the service station (estimated at 15 gallons of petrol) about 300 pounds of carbon dioxide are eventually released into the atmosphere [4].

The basic process by which carbon dioxide is released from automobiles is through combustion of fossil fuels, or petroleum. The reaction of alkanes with oxygen to form CO_2, water and heat is the chief reaction occurring in the internal combustion engine of motor vehicles. Most motor fuels are combusted by mixing the liquid fuel with stoichiometric amounts of air in an internal combustion chamber. This mixture is pressurized then ignited by either a sparking device or by the cylinder–compression heat. Products of combustion consists of CO_2, water vapour, nitrogen, oxygen, nitrogen oxides, sulphur oxides, particulate matter, carbon monoxide and unburned hydrocarbons [5].

Carbon dioxide is a colourless gas. Its density at 25^oC is 1.98 kgm^{-3}, about 1.5 times that of air. The CO_2 molecule (O=C=O) contains two double bonds and has a linear shape. It has no electrical dipole. As it is fully oxidized, it is not very reactive and in particular not flammable [6]. At concentration of 2,500 ppm to 5,000 ppm, CO_2 can cause headaches. At extremely high levels of 100,000 ppm, people lose consciousness in ten minutes, and at 200,000 ppm, CO_2 can lead to death [7].

In Nigeria, there has been rapid increase in population from 3,340,000 in 1950 to 38, 159,000 in 1990 and by 1995, there were about 40 million people living in Nigerian cities and towns. This population increase has led to the migration of individuals from the rural to the urban areas. Cities all over the world present opportunities and limitations. As in the case of Nigeria and many other developing countries, large population concentration and the rapid growth of urban centres pose serious problem in the provision and management of services and the entire living environment [8]. The various opportunities offered by cities are therefore accompanied by problems of congestion, environmental degradation, unemployment, poverty, violence and all sorts of environmental risks. Traffic is a function of activities. Good roads aid accessibility and functionality of any environment. But the problem, especially in Nigeria, is that (in the last few years) nearly all roads in many cities as well as many inter-city expressways and highways have become impassable due to lack of maintenance [9].The more developed areas in towns and cities naturally tend to generate a great deal of movement. But they have become so congested with new buildings - houses, offices, shopping centres, banks and so many new structures that movement within them and to them is always difficult.

Justification

It cannot at this stage, be certain of what an increase in CO_2 levels will cause in future, but an awareness of the possible effects is necessary to educate people on likely events, especially extreme weather events such as global warming, which can lead to drastic climate changes. This will either produce a decrease in the extravagant use of fossil fuels, or even a substitute for fossil fuels in the near or far future.

Since the beginning of the Industrial Revolution, the atmospheric concentrations of CO_2 have increased considerably, as well as those of other greenhouse gases. This increase in concentration is likely to accelerate the rate of climate change, i.e. an indirect implication of global warming.

Put simply, global warming may be explained as follows: the earth's climate is driven by a continuous flow of energy from the sun. This energy arrives mainly in the form of visible light. About 30% is immediately scattered back into space, but most of the 70% which is absorbed passes down through the atmosphere to warm the earth's surface. The earth sends this energy back out into space in the form of infrared radiation. Being much cooler than the sun, the earth does not emit energy as visible light. Instead, it emits infrared or thermal radiation. 'Greenhouse gases' in the atmosphere block the infrared radiation from escaping directly from the surface into space. This is known as the 'greenhouse effect' [10].

The main greenhouse gases are water vapour, carbon dioxide (CO_2), ozone, methane, nitrous oxide and the chlorofluorocarbons. Levels of these gases are rising as a direct result of human activity. Apart from global warming, greenhouse gases are also responsible for the phenomenon known as ozone layer depletion. It is predicted that the global average temperature will rise by about $2^{o}C$ ($3.6^{o}F$) by the year 2100 if current emission trends continue [3].

CO_2 is being generated in ever increasing amounts in part due to the increase in the population of the earth, in part due to the clearing of forests (and thus to less use of CO_2 in photosynthesis) and in part to increased combustion of fossil fuels. If this increase becomes severe, it could enhance the greenhouse effect, leading to the global warming trend. This warming might be enough to melt part of the polar ice caps and raise the level of the oceans and turn part of the now temperate zones into deserts [5].

Materials and experimental procedures

Materials

The experiment was carried out using gas detection tubes and sampling pump manufactured by RAE Systems Inc.This is a piston type hand pump that draws a fixed volume of gas, selectable at either 50ml or 100ml, by rotating the handle. A tight vacuum seal is formed by a greased plunger gasket. The tapered rubber inlet accommodates a range of tube diameters for different types of tubes. The inlet filter prevents glass pieces and dust from entering the shaft. An end-of-flow indicator in the handle turns white when the gas sampling is complete. A pump stroke counter is rotated to keep track of the number of strokes completed.

Experimental Procedure

The detection tube was broken at both ends using the tube tip-breaker, and then inserted into the sampling pump according to the arrow shown on the tube. Then a sample volume of 50ml was selected. The handle was pulled quickly until it stopped at ½ strokes, which indicated 50ml. This was left for a sampling time of 1 minute to allow the air to be drawn through the tube. When the flow of air was complete, the end-of-flow indicator was completely bright to show that air-sampling was complete. After the completion of the sampling time of 1 minute, the colour of the reagent in the tube changed from white to light yellow. The length of the colour change was measured and recorded. Another sampling volume was taken and the procedure repeated. This was done after an interval of 5 minutes from the first sampling. Several readings were taken using this procedure and the averages for each period for each day calculated.

Results

The average hourly concentration of carbon dioxide at stations in Kaduna and Abuja are shown in Figures 1 and 2. Meanwhile a daily average of the concentrations at the various stations is given in Table 1.

Table 1. The average daily concentrations of CO_2 in all the Stations

Sample station	Average concentrations (ppm)
JABI ROAD	1170
KAWO	1710
STADIUM R/ABOUT	1780
SABO	1840
KASUWA	1630
ASOKORO	1160
AREA 1 JUNCTION	1360
A.Y.A. JUNCTION	1530
WUSE MARKET	1380
MABUSHI R/ABOUT	1520

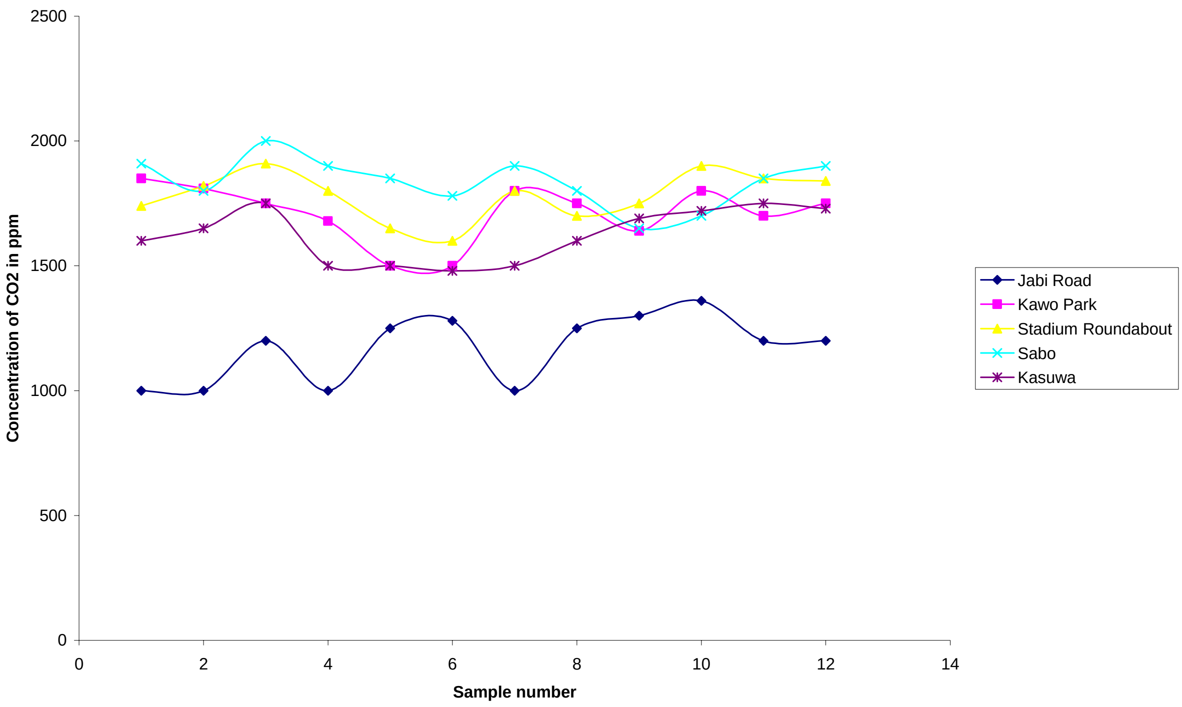

Figure 1. Average Hourly concentration of CO_2 in Kaduna

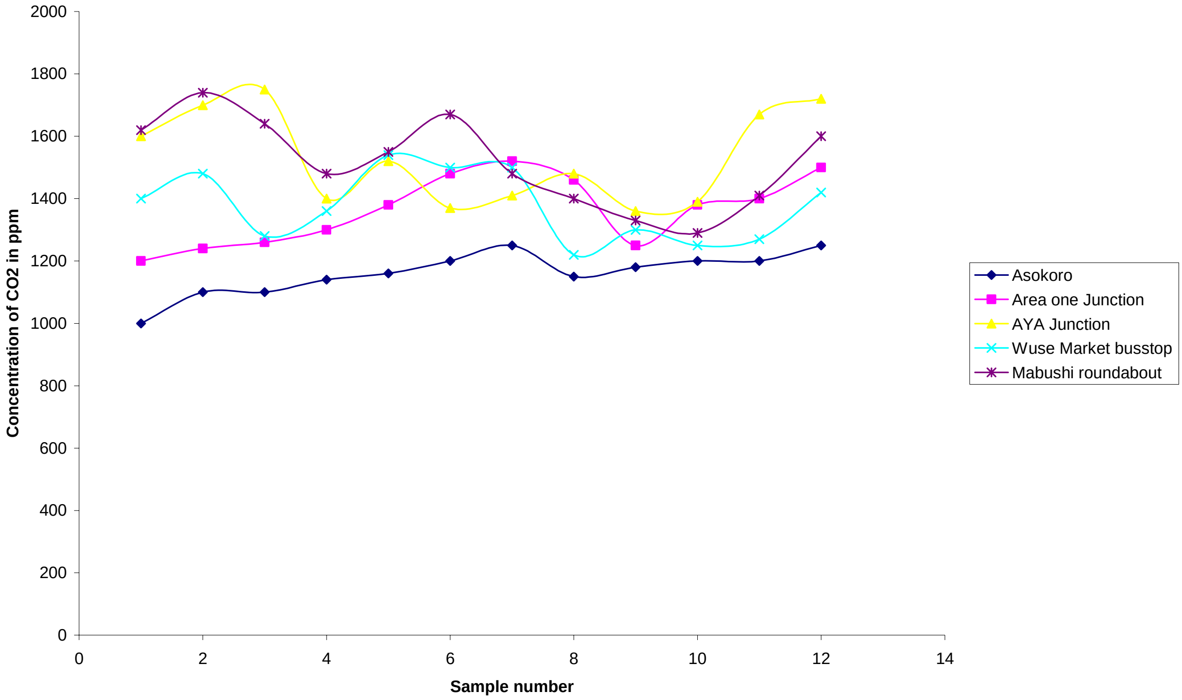

Figure 2. Average Hourly Concentration of CO_2 in Abuja

Discussion of Results

Comparison with Standard Values

The Nigerian Ambient Air Quality Standard does not provide limits for CO_2. However, a table showing the composition of clean, dry air near sea level gives the concentration of CO_2 in mole percent as 0.0350. The atmosphere contains carbon dioxide in variable amounts, usually 3 to 4 parts per 10,000 [11].

Analysis of Data based on Results

The results obtained for the selected project areas - Kaduna and Abuja - show a higher concentration of CO_2 in Kaduna, compared to values obtained in Abuja. This is because Kaduna is a more industrialized area than Abuja. Industries located in Kaduna include; NNPC, Ideal Flour Mills, Sunglasses, United Nigerian Textiles Ltd., Nigerian Breweries Plc, International Beer & Beverages Industry, etc.

The results obtained in each area give a remarkable relationship between congestion and concentration of CO_2 in that area. The control areas used are areas which are relatively quiet with minimal vehicular activity. Therefore, the values obtained here are far less than those obtained at heavily congested areas. These values, for the congested areas, were obtained at high peak periods, between the hours of 3.00 - 6.00 p.m. when the areas were considerably busy. The high values indicate that with increase in vehicular concentration, there will also be a high level of CO_2 emitted in the atmosphere due to the combustion of petroleum products.

Relationship between Variables

Figures 1 and 2 showed the concentration of CO_2 against time for Kaduna and Abuja respectively. A separate curve exists for all five census stations in each area. The curves obtained show a fluctuation in the values. This is because every vehicle has an individual contribution to the CO_2 concentration level in the atmosphere, and this in turn is affected by meteorological conditions, such as wind speed, wind direction, and precipitation, which can cause dispersion of air pollutants; and topographic factors, which include valleys, oceans, lakes, foliages, and even man-made elements like bridges and roads. This just means that the concentration of CO_2 at any given time is never constant. However, the more congested areas have the higher carbon dioxide concentrations in the atmosphere, and vice versa.

Conclusions

The quantity of carbon dioxide in the environment presently is not only due to automobile emissions. It is affected by other factors such as electricity consumption, manufacturing and construction industries, petroleum refining as well as other chemical-based industries, and even residential areas. But the bulk of the entire quantity is contributed by the transportation sector.

From data obtained during this research, it is clear that there is more carbon dioxide emitted in areas with a greater congestion of vehicles compared to areas with minimal traffic. These high levels of carbon dioxide concentrations obtained show that with increase in congestion and number of vehicles passing a given area at any time, there would be an increase in the quantity of carbon dioxide emitted, due to the combustion of fossil fuels.

On the average, the data show higher values of carbon dioxide concentration for heavily congested areas: 1840 ppm for Sabo, Kaduna, 1780 ppm for Stadium round-about, Kaduna, and 1530 ppm for A.Y.A. Junction, Abuja – and lower values of carbon dioxide concentration for areas with minimal traffic – 1170 ppm for Jabi road, Kaduna, and 1160 ppm for Asokoro (behind ECOWAS), Abuja. According to Greiner (1995), this quantities are not high enough to cause health hazards but as vehicular traffic grows in number and age, the quantity of carbon dioxide that will be released in the near future in these cities will be enough to make the government of the day worry. Nigeria can no longer afford to continue ignoring the potential impacts of the global climate change response measures on its oil-based economy; it is in its interest to begin to introduce measures to reduce its greenhouse gas emissions, due to the negative impacts of climate change on its economic, social and environmental resources. It is imperative that full attention is paid to ways through which the Nigerian economy can be diversified and steered away from fossil fuels both in terms of production and consumption. Only such a strategy will save the country's economy from certain collapse in the event of implementation of climate change abatement measures.

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